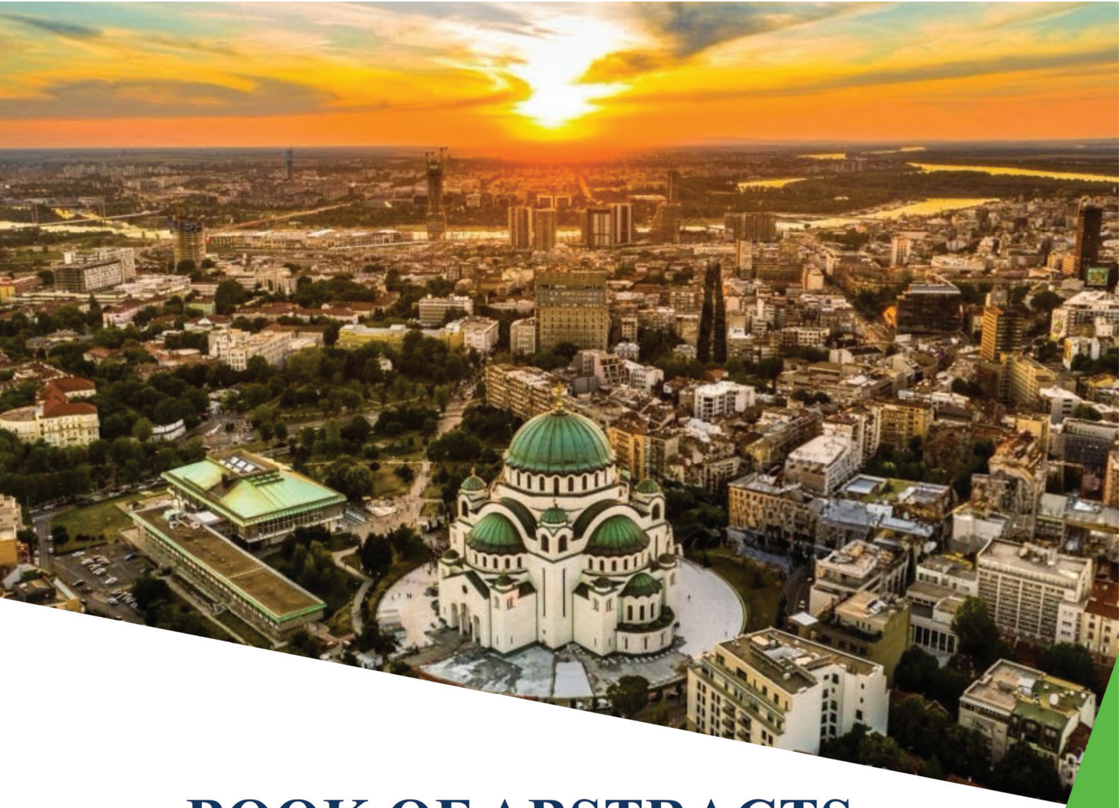

BOOK OF ABSTRACTS

First International Conference on Medical, Pharmaceutical and Cosmetic Chemistry, Household and Industrial Chemistry, Forensic and Analytical Chemistry

Belgrade, Serbia 5 May 2026

2026
ChemInno
When Science Meets Industry

Celebrating 65 Years of the Institute of General and Physical Chemistry

65 YEARS OF EXCELLENCE
Institute
of General and Physical Chemistry

First International Conference
on Medical, Pharmaceutical and Cosmetic Chemistry,
Household and Industrial Chemistry, Forensic and Analytical Chemistry
ChemInno 2026

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on Medical, Pharmaceutical and Cosmetic Chemistry,
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BOOK OF ABSTRACTS

Belgrade, Serbia, 5 May 2026

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First International Conference on Medical, Pharmaceutical and Cosmetic Chemistry, Household and Industrial Chemistry, Forensic and Analytical Chemistry - ChemInno 2026

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65 YEARS OF EXCELLENCE
Institute
of General and Physical Chemistry

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2026
ChemInno
When Science Meets Industry

Celebrating 65 Years of the Institute of
General and Physical Chemistry

This book contains the abstracts of
8 plenary lectures
21 invited lectures
184 poster contributions,
accepted for presentation at
the First International Conference on Medical, Pharmaceutical and Cosmetic Chemistry, Household and Industrial Chemistry, Forensic and Analytical Chemistry
ChemInno 2026

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CONTENT

SESSIONS

1. Physical Chemistry in Applied Science and Technology

2. Pharmaceutical Formulations, Aesthetic Medicine

3. Biotechnology, Medical & Cosmetic Chemistry

4. Household Chemistry and Materials for Industry

5. Sustainable Chemistry & Green Formulations

6. Forensic & Analytical Chemistry

7. Technological & AI-driven digital innovations

8. Chemical Safety, Regulation, Standards & Knowledge Transfer

8:00 – 9:00	**REGISTRATION**		
9:00 – 9:20	**OPENING CEREMONY** The Obilić Choir - the National Anthem of Serbia Dr. Stevan Blagojević, Institute of General and Physical Chemistry Ministry of Science, Technological Development and Innovation Prof. Dr. Darija Kisić, Director, Science Fund of the Republic of Serbia Dr. Saša Lazović, Director, Innovation Fund of the Republic of Serbia The Obilić Choir - “Ovo je Srbija”		
9:20-9:35	**Promotion video of the Institute of General and Physical Chemistry**		
9:35 – 10:15	**PANEL DISCUSSION** Jadranka Mirković – BIO4 Campus; Nevena Veljković – Genial; Sanja Krstić – Lab Queen; Danilo Vujošević – Continental; Goran Bijelić – Tecnalia; Rade Surudžić – Elixir		
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Dr. Sanja Krstić

Founder of Lab Queen

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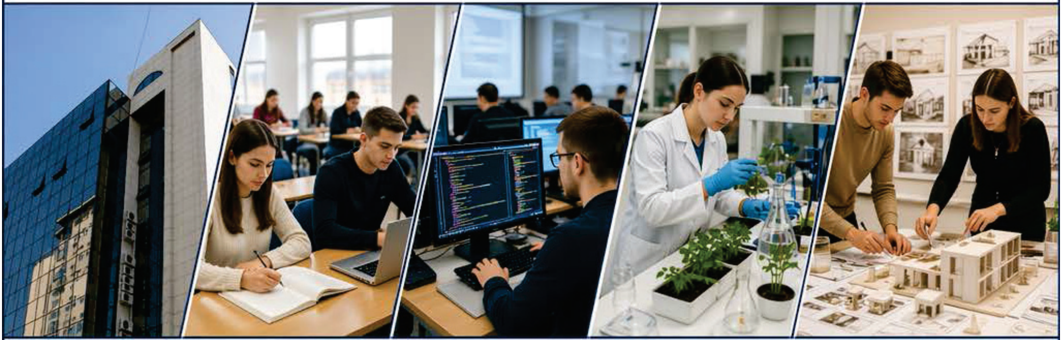


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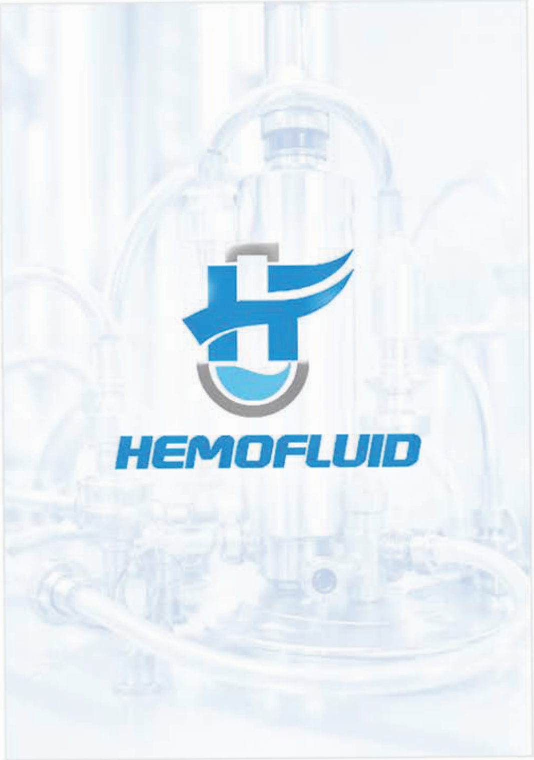
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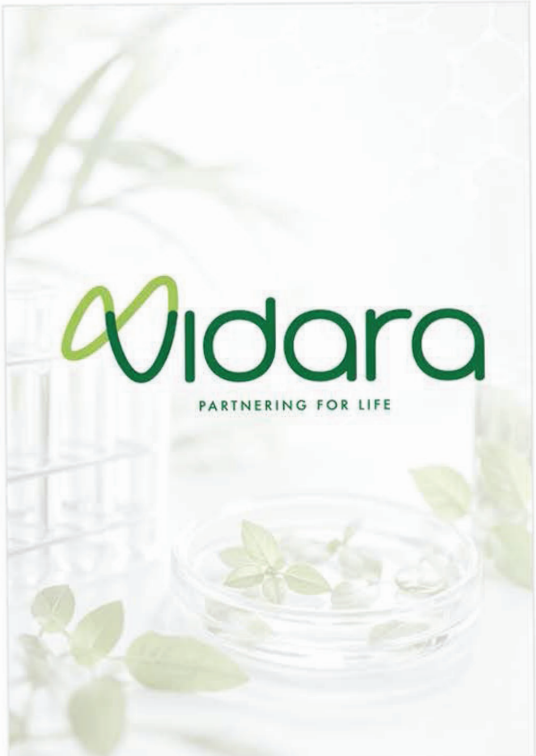
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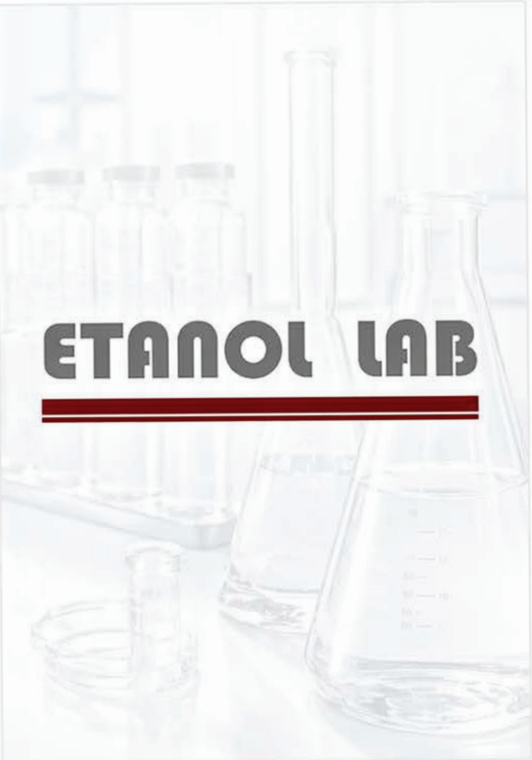
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M. Bigović , M. Kaluđerović, A. Malović, Đ. Nakarada, Ž. Jaćimović

P1.5 Alkaline electrolyzer with asymmetric electrolytes and nickel electrodes modified by spontaneous galvanic replacement
Z. D. Bošković, N. A. Tričković, I. A. Pašti

P1.6 Optimization of Hydrogen Storage in Metal Hydrides via Thermal Enhancement
I. Chabani, A. Zereg, N. Lebaal, D. Khamari

P1.7 Efficient Removal of Pb(II) Using Modified Lignocellulosic Biomass (IOS): Adsorption Behavior and Mechanism
J. Dimitrijević, J. Petrović, M. Simić, M. Koprivica, I. Mikavica, M. Ercegović, S. Jevtić

P1.8 From Cations to Oxyanions: Hybrid Zeolite-Alginate Beads as High-Performance Adsorbents for Advanced Water Treatment
J. Dimitrijević, J. Petrović, M. Simić, M. Koprivica, A. Jovanović, S. Jevtić

P1.9 Synthesis of cobalt ferrite nanoparticles via citrate sol-gel auto-combustion: effect of fuel-to-metal ratio on structural and magnetic properties
B. Drakul, M. Tadić, M. Đošić, A. Mraković

P1.10 Advancing Carbon Capture Technologies: CO_2 Adsorption on Zeolite 13X
A. M. Đorđević, M. Krpić, A. Milošević, J. Radivojević, Ž. Nikolić, M. Marčeta Kaninski, V. Nikolić

P1.11 DFT Insight into Adsorption-Dominated Methylene Blue Removal on V_2O_5 Nanopowders
T. Đorđević, T. Vulić, J. P. Georgijević

P1.12 Carbonized PANI/TiO_2 nanocomposites as efficient photocatalyst for degrada tion of herbicide Lindane and azo dye methyl orange
B. Gajić, N. Radić, M. Ilić, M. Radoičić, J. Kovač, G. Ćirić-Marjanović, J. Ekar, S. Stojadinović, Z. Šaponjić

P1.13 Polypyrrole/TiO_2 Nanocomposites with Antimicrobial Activity: Structural, Morphological, and Theoretical Insights
B. Gajić, D. Marković, D. Sredojević, J. Potočnik, T. Barudžija, G. Ćirić-Marjanović, Z. Šaponjić, M. Radoičić

P1.14 Examination of surface morphology after processing of nano-layer thin films by femtosecond laser pulses
B. Gaković, S. Petrović, D. Milovanović, C. Siogka, E. Stratakis

P1.15 NiZn/Ti and Au-Modified NiZn/Ti Electrocatalysts for Enhanced Hydrazine Oxidation Reaction in Alkaline Media
T. Ganti, A. Balčiūnaitė, J. Vaičiūnienė, L. Tamašauskaitė-Tamašiūnaitė, E. Norkus

P1.16 Nickel on carbon electrocatalysts Ni/C derived from ionic liquid precursors for efficient water splitting
J. Georgijević, I. Perović, S. Mitrović, S. Brković, M. Pijović Radovanović, P. Laušević, M. Seović, B. Šljukić

P1.17 O_2 plasma for liquid water-free micro- nanofibrillated cellulose production
M. Imani, K. Dimić-Mišić, M. Kristoffer, L. Huy Quang, P. Gane

P1.18 Zeolite-Supported Highly Active Zinc Oxide for Multifunctional Applications
A. Janaćković, S. Blagojević, S. Jevtić

P1.19 High efficiency of selected zeolites in the purification of contaminated water

A. Janaćković, J. Protić, I. Kijačić, K. Stajić Trošić, A. Marelj, N. Milutinović Merhi, M. Jovanović

P1.20 Structural Insight into Gliclazide Polymorphism: Theoretical Prediction of Novel Conformational States

G. V. Janjić, B. Stanimirović, M.Petković Benazzouz

P1.21 Impact Ionisation and Gain study in High-Aspect-Ratio 3D Silicon Detectors produced in 8-inch CMOS technology at IME-CAS for Fast Timing and Radiation-Hard Applications

G. Lastovicka-Medin, J. Krol, G. Kramberger, M, Rebarz

P1.22 Microcrystalline Cellulose-Doped Polyvinyl Alcohol Membranes: Enhanced Ionic Conductivity and Durability for Alkaline Water Electrolysis

S. Maslovara, K. Dimić Mišić, M. Marčeta Kaninski, V. Nikolić, M. Gasik

P1.23 Modeling Drug–Membrane Interactions: Agomelatine Case Study

M. Matijević, V. Vlatković, S. Lazović, D. Obradović

P1.24 Electrocatalytic activity of Pt_1Pd_1/C (2 wt.%) for the oxygen reduction reaction in acidic medium

N. Milutinović Merhi, Y. Aykut, D. Mladenović, A. Bayrakçeken, D. M. F. Santos, B. Šljukić

P1.25 Suppression of hydrogen evolution reaction activity on nickel by trace iron impurities in alkaline electrolyte

S. Mitrović, I. A. Pašti, S. Brković, J. Georgijević, P. Laušević, M. Seović, I. Perović

P1.26 Spinel ferrite and metal oxide nanoparticles integrated with graphene oxide for advanced energy storage

Ž. Mravik, S. Jovanović, M. Jelić, M. Milićević, M. Milanković, P. Stolić, D. Petković, Z. Jovanović

P1.27 Hierarchical High Entropy Architectures for Efficient Oxygen Evolution Catalysis

F. Mumtaz, A. Balčiūnaitė, L. Tamašauskaitė-Tamašiūnaitė, E. Norkus.

P1.28 Physico-chemical properties of ZrO_2-Gd_2O_3 ceramics obtained by SPS process

N. Obradović, J. Živojinović, A. C. Feltrin, A. Đorđević, W. G. Fahrenholtz

P1.29 Novel functionalized Nb_2C MXenes for Electrochemical Energy Storage Applications
I. Pešić, N. Gavrilov, D. Lončarević, M. Popović, M. V. Pergal

P1.30 Controlled Modification of Ti-Based Thin Films for Bioactive Surface Applications
S. Petrović, N. Božinović, K. Savva, J. Potočnik, M. Novaković, D. Pjević, E. Stratakis

P1.31 Investigation of the Effects of Bleaching Sunflower Oil Using Silica Gel of Different Granulations
Z. Petrović, N. Zekić, A. Radulović, D. Kešelj, S. Begić, T. Botić, Z. Stojanović

P1.32 The energetics theory of poly(lactide) impact on cell metabolism
M. M. Plavšić, M. B. Plavšić

P1.33 Energetics of drug delivery into cells: the comparisons of drug filled poly(lactide) nano- particles absorption, with the membrane proteins transfer of the drugs, by symport mechanism
M. M. Plavšić

P1.34 Modeling of the kinetics of H_2^+ BeH^+, BF^+ at low/high energy of the incident electron with application in fusion plasmas and material processing field
N. Pop, E. Djuissi, H. Riyad, J. Zs Mezei, I. F. Schneider

P1.35 Ag-Zeolite-Based Electrochemical Sensors for Efficient Monitoring of Nitrite and Nitrate in Water Systems
K. Radinović, N. Cvjetićanin, R. Hercigonja, I. Stojković Simatović, B. Šljukić

P1.36 Synthesis of two structurally distinct amorphous $NaAlSiO_4$ phases by zeolite Na-LTA thermal transformation route
A. Radulović, S. Matijašević, M. Simonović, M. Jovanović, N. Romčević, V. Dondur

P1.37 Cumulative Effects and Threshold Evolution in Femtosecond Laser Processing of Nimonic 263
B. Rajčić, D. Milovanović, M. Zamfirescu, A. Šutulović, S. Petronić

P1.38 Influence of Mo and Sb Doping in TiO_2 Nanotubes on the Performance of Pt-Based Catalysts

B. Rajčić, V. Nikolić, Z. Šaponjić, J. Kovač, S. Maslovara, M. Marčeta Kaninski, D. Milovanović

P1.39 Evaluating Extraction Methods for Potentially Toxic Elements Bioavailability at Illegal Landfills

D. Relić, J. Mitić, M. Pucarević, I. Kodranov, Lj. Aleksić, S. Mančić, T. Milićević

P1.40 From citrus waste to energy storage: lemon peel derived activated carbon for supercapacitor applications

M. Seović, S. Mitrović, S. Brković, J. Miletić Vukajlović, P. Laušević, M. Pijović Radovanović, I. Perović

P1.41 Cobalt–nickel on reduced graphene oxide as a nanosized bifunctional oxygen electrode in alkaline media

D. Tomić, A. Nastasić, K. Radinović, L. Rakočević, D. Stanković, B. Šljukić, J. Milikić

P1.42 Influence of Pd:Fe Ratio on the Capacitive Behavior of Pd–Fe Supported Carbon Aerogels in Alkaline Medium

D. Tomić, K. Radinović, M. Samancı, A. Bayrakçeken, N. Gavrilov, D. M. F. Santos, B. Šljukić

P1.43 Modeling the Adsorption of Methylene Blue and Crystal Violet on Zeolite-Based Geopolymers

D. Trajković, J. Dikić, A. Popović, D. Živojinović

P1.44 Heterogenous support green materials characterization and use in organic synthesis demonstration set

S. Tufegdžić, M. Ćalić, D. Mara, D. Sladić

P1.45 Efficient Alkaline Seawater Splitting Using a 3D Ni–Mn/Ti Bifunctional Electrocatalyst Pair

J. Vaičiūnienė, S. Barua, A. Balčiūnaitė, D. Upskuvienė, L. Tamašauskaitė-Tamašiūnaitė, E. Norkus

P1.46 Turn Waste into Good Taste

S. Zlatanović, D. Micić, F. Pastor, S. Ostojić, S. Gorjanović

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P2.1 Can rosacea-prone skin be soothed by a face mask applied immediately after a Platelet-Rich Plasma therapy - a case study
J. Batinić, B. Mijajilović, D. Radulović, S. Đukić, V. Maksimović

P2.2 Effect of liposomal encapsulation on the radical-scavenging activity of the thiocarbohydrazide-derived Schiff base
M. Bigović, Đ. Nakarada, N. Prlainović, M. Kaluđerović, M. Mojović

P2.3 Investigation of the stability of solid emulsion containg olive oil
S. M. Blagojević, M. Kalaba, N. Pejić

P2.4 Personalised topical therapy as innovative approach in sensitive skin
D. Dragaš Milovanović, M. Filipović, S. Đukić, J. Bašić, D. Pecarski

P2.5 Application of Platelet-Rich Plasma and biomimetic peptides in anti-aging treatment of skin prone to erythematotelangiectatic rosacea - a case study
S. Đukić, M. Filipović, J. Bašić, D. Dragaš Milovanović, D. Pecarski

P2.6 Could emulsifiers that form a lamellar phases be considered as suitable stabilizer for emulsion containing liposome-encapsulated plant exosomes?
M. Filipović, M. Tasić Kostov, M. Lukić

P2.7 Method development for *in vivo* characterization of the quality of the *in situ* formed hypromellose films
S. Milinković, M. Lukić, Lj. Đekić

P2.8 Royal Jelly: Chemical Composition, Biological Activities and Pharmaceutical Potential
S. Muhić, M. Ibišević, E. Karić, M. Šljivić Husejnović, E. Cilović Kozarević, A. Smajlagić, I. Nešić

P2.9 UV-Vis properties and sun protection factor of peppermint seeds ethanol extracts
M. Petrović, M. Jovanović, D. Kiperović, S. Veljović

P2.10 Concentration of reduced glutathione and malondialdehyde in the rat’s liver tissue with experimentally made dyslipidemia
B. Simić-Polić

P2.11 Cytotoxicity and antimicrobial potential of spent gin botanicals
D. Tenji, M. Petrović, J. Marinković, T. Ganić, N. Tomić, I. Vulin, M. Jovanović

P2.12 Stretches in pregnancy: prevalence, prevention and attitudes of pregnant and postpartum women - a cross-sectional study
V. Vuković, M. Ignjatović, S. Masnikosa, D. Pecarski

P2.13 A Novel Stabilized Ethosomal Gel for Enhanced Delivery of Bioactive Compounds
Š. Kunej, A. Grafy

Session 3. Biotechnology, Medical and Cosmetic Chemistry

P3.1 Arbutin incorporated biodegradable films based on gelatin and sodium caseinate complex coacervate for cosmetic application

M. Bosnić, J. Fraj, L. Petrović, J. Milinković Budinčić, S. Bučko, Lj. Spasojević, J. Katona, J. Ostojić, Ž. Radonić

P3.2 Baby Skincare Products: Benefits vs Risks

T. Cilia Attard, L. Giovannelli, S. Blagojević, N. Petrović, J. Tubić Vukajlović, N. Jasnić, A. Krstonošić, A. Žarković, T. Tosti, E. Attard

P3.3 Determinaton of antioxidative activity of Eryngium amethystinum L methanolic extracts using EPR technique and incapsulation into liposome particules

M. Duran, Đ. Nakarada, B. Kukavica, R. Suručić, B. Tubić, N. Vojinović, R. Škrbić, M. Mojović

P3.4 Low energy nanoemulsions with ferulic and caffeic acid –Formulation optimisation and antioxidant activity

A. Gledović, N. Simović, A. Janošević Ležaić, S. Savić

P3.5 A Novel Small-Molecule Fluorescent Probe for Live Imaging of Lipid Droplets in Cells and Zebrafish

M. Grozdanić, J. Dinić, M. Jović, A. Podolski-Renić, A. Divac Rankov, M. Ljujić, M. Pešić, I. M. Opsenica, Ž. Selaković

P3.6 Engineering of a bifunctional fusion protein (3.5-scFv-β-Lactamase) for detection of TNT-Like compounds

Đ. Ignjatović, A. Radulović, N. Zelenović, M. Jovanović, M. Simonović

P3.7 Bioactivity of wine concentrates from European Merlot grape varieties in human keratinocytes

G. Ilić, A. Jovanović, M. Jovanović Krivokuća, I. Beara, A. Pirković

P3.8 Targeting FFAR3 with microbiota-derived propionate: a molecular dynamics perspective on Parkinson's disease modulation

B. S. Ilić

P3.9 Microbiota-derived indole-3-propionic acid disrupts Aβ42 aggregation: molecular insights toward neuro-motor preservation in Alzheimer's disease

B. S. Ilić

P3.10 Green Extraction of Propolis using Orange Peel Oil: Chemical and Thermal Characterization

J. Ilić Pajić, A. Miladinović, M. Volić, N. Obradović, A. Grujić, V. Ćosović, J. Stajić-Trošić

P3.11 Bone tissue engineering–oriented 3D-printed biocomposites based on interpenetrating networks and multi-doped mesoporous bioactive glass

T. Jakovljević, T. Matić, V. Ugrinović, M. Papić, B. Ljujić, T. Vlajić Tovilović, M. Radunović, Đ. Veljović

P3.12 Encapsulation of bioactive compounds into zeolite structures with potential application in the food industry

A. Kalušević, M. Veljović, V. Nedović, D. Pecarski

P3.13 Anthracenyl Schiff base Pd(II) complexes as promising antimicrobial agents

A. Kandić, T. A. Petrović, M. Dimitrijević, J. Timotijević, S. Nikolić, J. Poljarević, Lj. Mihajlović

P3.14 Rhenium(V)-Apigenin Complex: Structure and Anticancer Activity

A. Kandić, S. Nikolić, J. Poljarević, Lj. Mihajlović

P3.15 Safety assessment of cocoa shell for potential application in the confectionery industry

J. Laličić-Petronijević, M. Stevanović, L. Pejić

P3.16 Chemical characterization of Rosa Don Juan (climbing rose) essential oil from the Kruševac region (Serbia)

D. Manjenčić, M. Vasić, P. Pravdić, M. Deljanin, D. Todorović, M. Tomić, V. Mićić, V. S. Jovanović

P3.17 Valorization of thermostable fruit fillings application in artisanal chocolate production

D. Mihajlović, J. Marković, B. Mijailović, M. Stevanović, J. Laličić-Petronijević

P3.18 Antimicrobial Activity of Cold-Pressed *Cannabis sativa* Seed Oil in Wound Treatment Against *Pseudomonas aeruginosa*
M. Milojković, I. Popović, M. Waisi, M. Marinković, J. Radivojević, B. Božilović, H. Waisi

P3.19 Biodegradation of Synthetic Polymers by Novel Hafnia Strains Isolated from the Gastrointestinal Tract of Common Carp (Cyprinus carpio)
F. Maksim Mišić, N. Rajić, M. Popović

P3.20 Antioxidant activity and EPR-assessed penetration of liposome-loaded Black Goji berry extract
Đ. Nakarada, M. Jovanović, M. Mojović

P3.21 Thermal Behavior of Dried Red Cabbage Waste Pulp and Juice: Correlation with Chemical Composition
S. Ostojić, S. Zlatanović, D.Micić

P3.22 Thermoanalytical Characterization of Emulsions
S. Ostojić, D. Micić, S. Zatanović

P3.23 Synthesis and *in silico* evaluation of novel tetralone/benzylpiperidine derivatives
D. Perminova, M. Krunić, J. Penjišević, I. Jevtić, D. Andrić

P3.24 Electrochemically cross-linked Zn-alginate films with oregano essential oil: Physicochemical properties, antioxidant and antimicrobial activity
P. Polukova, A. Gledović, S. Savić, J. Antić-Stanković, A. Janošević Ležaić

P3.25 Antioxidant activity of *Ficus carica* L. leaf extract using EPR spectroscopy
N. Preradović, Đ. Nakarada, K. Radotić, D. Spasojević, J. Simonović Radosavljević, M. Mojović

P3.26 Polyphenol-Based Nanoparticles from *Picea omorika* (Pančić) Purkyně Needles: Synthesis and Biomedical Potential
N. Preradović, M. Barić, D. Spasojević, A. Popović Bijelić, K. Radotić, J. Simonović Radosavljević

P3.27 From Biochemistry to Cosmetology: Epigenetic Approaches for Safe Anti-Aging Skin Treatments
J. Savić, A. Božić, J. Arsić, D. Brkić, M. Stamenović

P3.28 Low light Stress Modulates Redox Metabolism in *Chlamydomonas acidophila* Pm01
F. Sekereš, J. Danilović Luković, I. Santrač, V. Ćurić, M. Tanović, M. Žižić, M. Dimitrijević, S. Kovačević, M. Stanić, I. Spasojević

P3.29 Cloning and Expression of a Recombinant Monovalent Anti-TNT scFv Antibody
M. Simonović, A. Radulović, I. Vuković, V. Nešić, M. Jovanović

P3.30 Selective Uptake and Biosorption of Rare Earth Elements in *Chlamydomonas acidophila* Strains
M. Tanović, M. Dimitrijević, M. Stanić, M. Žižić, J. Danilović Luković, S. Kovačević, I. Santrač, V.Ćurić, I. Spasojević

P3.31 Use of Cosmetic and Wellness Treatments Among Young Adults
M. Trajkov, G. Grbić, Lj. Šimpraga

P3.32 The use of cosmetic products in massage therapy
M. Trajkov, D. Marinović, I. Mitrović

P3.33 Synthesis and Characterization of Chitosan/Starch/Gelatin Composite Hydrogels Reinforced with Calcium Hydroxyapatite for Biomedical Applications
N. Urošević, V. Ugrinović, Đ. Veljović

P3.34 Influence of extraction solvent on different parts of Galanthus nivalis L. for antioxidant properties
V. Veličković, G. Đelić, A. Ćirić, M. Pavlović, M. Luković

P3.35 Taxifolin inhibits endovascular differentiation of human trophoblast cells
A. Vilotić, G. Ilić, A. Pirković, M. Jovanović Krivokuća

P3.36 Disruption of Monoamine Oxidase Enzymes by SARS-CoV-2 Spike Protein: From Molecular Insights to Potential Health Implications
L. Vrban Đerek, J. Mavri, R. Vianello

Session 4. Household Chemistry and Materials for Industry

P4.1 Chemical degradation and mechanical behavior of fabrics intended for medical uniforms under repeated washing cycles with commercial detergents (Warp Direction Analysis)

D. Đorđić, V. Petrović, A. Milosavljević, J. Stepanović Profirović, S. Pačavar

P4.2 The effect of different heat treatments on the antioxidant properties of pepper (*Capsicum annuum* L.) during ajvar production

D. Mihajlović, J. Marković, M. Veljović, J. Rajić, A. Kalušević

P4.3 Stability of carotenoids during long-term freezer storage of heat-treated pumpkin (*Cucurbita maxima*)

D. Mihajlović, J. Marković, T. Dobričanin, B. Rabrenović, L. Pejić, E. Ivanović, N. Banjac

P4.4 Impact of key synthesis parameters on zeolite 4A quality

B. R. Simonović

Session 5. Sustainable Chemisty and Green Formulations

P5.1 The Potential of Pharmaceutical Waste-to-Energy Conversion by Incineration
D. Brkić, A. Božić, J. Savić, J. Arsić, M. Stamenović

P5.2 From Waste Paper to Functional Foams: Chemical-Free Recycling via Laser Deinking
K.Dimić-Mišić, S.Petronić, B. Rajčić, A. Janaćković, M. Gasik, D. Milovanović

P5.3 Sustainable Surface Flow Calcium Carbonate and Micro-Nanofibrillar Cellulose NO_x Reaction Filter: road vehicle and remote mini-vehicle monitoring for urban NO_x air pollution assessment
K. Dimić-Mišić, N. Barać, M. Imani, Đ. Janaćković, P. Uskoković, E. Barceló, P. Gane

P5.4 Sustainable Cosmetic Formulations:Self-Preserving Cleansers and Toners Based on Agro-Waste-Derived Ingredients
A. Ćirić, Lj. Đekić, M. Lukić

P5.5 Ultrasound-assisted extraction of bioactive components from apricot kernels using a natural deep eutectic solvent
M. Đorić, B. Đorđević, M. Kostić, V. Petković, A. Jović, M. Miladinović, O. Stamenković

P5.6 Extraction of amygdalin from plum kernel waste using choline chloride-based deep eutectic solvents
M. Đorić, B. Đorđević, M. Kostić, V. Petković, A. Jović, M. Miladinović, O. Stamenković

P5.7 Eco-Engineered Biochar Carbons for Next-Gen Microsupercapacitors
K. Gočanin, D. Mladenović, Y. Aykut, N. Milutinović Merhi, K. Radinović, A. Bayrakçeken, B. Šljukić Paunković

P5.8 Strawberry and Raspberry Pomaces as Potential Sources of Bioactive Compounds: Phytochemical Characterisation, Antioxidative Activity, and Biopotential Validation
S. Hourani, J. Vukosavljević, R. Ždero Pavlović, B. Pavlić, B. M. Popović

P5.9 DoE-based optimization of extraction conditions for a selected raspberry variety using natural deep eutectic solvents.
S. Ivanović, K. Simić, L. Popović, J. Ljujić, I. Sofrenić, B. Anđelković

P5.10 Identification of potential anti-aging markers in urban forest waste from the Košutnjak forest via HPTLC profiling and targeted enzyme inhibition
Đ. Ivković, P. Todorović, J. Beloica, N. Avramović, I. Lavadinović, S. Obradović, P. Ristivojević

P5.11 Sustainable removal of metformin using ZnO nanoparticles synthesized from Inula Helenium plant extract
K. Jovanović, K. Hainz, S. Bognár, D. Šojić Merkulov

P5.12 Determination of Total Phenolics and Antioxidant Activity in Berry Fruits Using DPPH and Electrochemical (HPMC) Assays
M. Jovanović, I. Kodranov, N. Guconić, A. Radulović, M. Simonović

P5.13 Solid-Phase Extraction of Manganese lons from Natural Lake Waters Using Clinoptilolite Zeolite
H. Junuzović, M. Stefanović, K. Smiljanić, A. Selimović, A. Odobašić, H. Keran, I. Šestan, M. Ahmetović, E. Mehmedović, S. Begić

P5.14 Green NADES-based extraction of bioactive compounds from blackberry pomace: enhanced recovery and biological activity
N. Kićović, Đ. Krstić, J. Trifković, P. Ristivojević

P5.15 A Comparative Greenness Assessment of Analytical Methods for Synthetic Cathinones Determination Using the AGREE Metric
E. Kostić, M. Martinović, M. Vujović

P5.16 Regeneration and reusability of novel magnetic resin for Ni(II) removal: Effect of different desorbing agents
M. Maletin, J. Nikić, S. Vasiljević, J. Pešić Bajić, A. Tubić, J. Agbaba

P5.17 Elderberry as a Natural Source for Antioxidant and UV-Protective Agents
M. Martinović, I. Nešić, V. Tadić, A. Žugić

P5.18 Implementation and analysis of different heat exchanger types for utilizing alkaline electrolysis waste heat
S. Maslovara, S. Petronić, M. Jarić, F. Maksim Mišić, M. Marčeta Kaninski

P5.19 Operational Challenges of Agropellet Combustion in Domestic Heating Systems
V. Matijašević , V. Pocajt

P5.20 Blockchain in Advancing Handling of Sustainable Electronic Waste
V. Nikolić, S. Singh Chouhan, M. Gasik, K. Dimić-Mišić, M. Marčeta Kaninski, S. Maslovara, V. Spasojević Brkić

P5.21 Recent Advances in Phosphate Removal and Recovery from Wastewater
Đ. Ogrizović, M. Delić, I. Jelić, M. Šljivić Ivanović, M. Đolić

P5.22 Sustainable synthesis of ZnO nanoparticles using grape pomace extract for photocatalytic degradation of metformin and glyphosate
M. Pajić, K. Hainz, S. Bognár, D. Šojić Merkulov

P5.23 Towards advanced water purification: graphene-based adsorbents for cadmium removal
J. Pešić Bajić, J. Nikić, M. Šolić, M. Maletin, A. Tubić, J. Agbaba, M. Watson

P5.24 Adsorption performance of rosehip seed-derived biochar for the removal of methylene blue
M. Z. Petković, M. R. Miladinović, B. S. Đorđević, M. D. Kostić, O. S. Stamenković

P5.25 Mineral carbonation of phosphogypsum using carbon dioxide
M. Petković, M. Miladinović, B. Đorđević, M. Kostić, A. Bijelić, Lj. Veselinović, A. Stanković, O. Stamenković

P5.26 The effect of pretreatment of lavender flowers with deep eutectic solvents on the essential oil yield
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PLENARY LECTURES

***Dr Zoran Žujović** is a Principal Research Fellow at the Institute of General and Physical Chemistry (1990-2001 and 2023 -), Belgrade (IGPC) and Honorary Academic in the School of Chemical Sciences at Auckland University, Auckland (2023 -). He received BSc, MSc and a DSc degrees from the University of Belgrade. From 2001-2002 Zoran was a Postdoctoral Research Fellow in the National High Magnetic Field, Tallahassee, the USA and Academia Sinica, Taiwan. From 2002-2023, he worked in the School of Chemical Sciences, Auckland University as a Senior Research Fellow. His current research interests lie in the development and application of multinuclear solid-state nuclear magnetic resonance spectroscopy to a range of inorganic and organic materials. He published more than 100 papers in peer-reviewed journals. Dr Zoran Žujović has been involved in collaborative projects with various research groups in Serbia, New Zealand the USA, the UK, Germany and Croatia.*

Molecular Blueprints for Charge Transport: Probing the Semicrystalline Morphology of Poly(caprolactone)-*graft*-Oligo(3-hexylthiophene) by using Solid-State NMR

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The production of advanced materials today aims to steadily improve their biodegradability and transience to address the global issue of ever-increasing electronic waste. We showed that the transience of conducting polymers can be achieved by covalently attaching poly(3-hexylthiophene) (P3HT) to a gelatin backbone [1]. Building on this, we synthesized the graft copolymer P(CL-*co*-AVL)-*g*-O3HT, featuring an oligo(3-hexylthiophene) (O3HT) branch grafted onto a modified poly(ε-caprolactone) P(CL-*co*-AVL) backbone (Figure 1) [2]. The objective was to combine the electrical properties of O3HT with the (bio)degradable characteristics of the polymer, while maintaining the ordered lamellar structures observed in non-grafted O3HTs. However, it is challenging to fully understand structure-function relationships in P(CL-*co*-AVL)-*g*-O3HT due to the presence of two macromolecular species and its structural complexity.

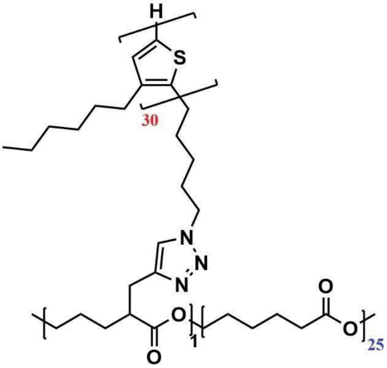

Figure 1. Chemical structure of P(CL-*co*-AVL)-LD-*g*-O3HT-30

Cross-polarization magic angle spinning (CP MAS) and related solid-state NMR relaxation methods have proved useful for investigating structure, stereo/regioregularity, and molecular dynamics in various poly(3-alkylthiophenes) (P3ATs) and related materials [3].

The CP MAS spectra suggest that a number of *alkyl* chains in the O3HT ordered phase reorganise to some extent in a less-ordered phase in the graft copolymer. Proton rotating frame relaxation $T_{1\rho}(^1H)$ data imply that the *alkyl* side chains become entangled and co-crystallized (or intimately mixed) with the P(CL-*co*-AVL) backbone. At the same time, the *thiophene* segments in O3HT form small, rigid domains within the graft copolymer. Both domains have similar proton rotating-frame relaxation constants, $T_{1\rho}(^1H)$ (ca. 5 ms), suggesting that the thiophene regions are *homogeneous* at scales ≤ 5 nm in *both* materials. Also, the internal mobility of the O3HT

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aromatic chain is conserved in the graft copolymer, and the π-π stacking and consequently "electronic environment" is preserved after grafting. Two CP time constants, $T_{CH,}$ for the thiophene parts are detected in both materials. T_{CH} values for longer components (3-5 ms) indicate more efficient polarization transfer in the graft copolymer, suggesting a greater proportion of more rigid/crystalline thiophene segments. T_{CH} values of the shorter components (100-140 µs) suggest similar spin and morphological characteristics in the thiophene segments in both the oligomer and graft copolymer. Although the overall motion of the thiophene rings is apparently the same in both materials, it appears that they are packed in a denser, more ordered, and rigid semicrystalline form in the graft copolymer. Compared to O3HT, the graft copolymer backbone is much more efficient at limiting the mobility of thiophene rings, probably due to the tighter packing or better crystallization.

To closely explore mobility and packing, the non-quaternary suppressed (NQS) technique was employed. Two dipolar dephasing time constants, T_{dd}, are detected for both samples. The short component, ca. 20 µs, is present to a greater extent in the graft copolymer, whereas the longer component, ca. 70 µs, is present to a lesser extent. Thus, it seems that thiophenes are much more free to rotate or vibrate in O3HT. The P(CL-co-AVL) backbone "promotes" the majority of the thiophene units into a rigid lattice (which does not necessarily have to be crystalline). It can be concluded that the P(CL-co-AVL) backbone does not automatically only produce more crystals, but it does create a stiffer matrix, too.

Our findings reveal that the alkyl chains integrate with the biodegradable backbone. At the same time, the thiophene units form rigid, semicrystalline clusters. In this way, the necessary stacking for efficient charge transport is relatively maintained. This result demonstrates that biodegradability and electrical performance can be achieved in the P(CL-*co*-AVL)-*g*-O3HT graft copolymer.

Acknowledgements
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Danijela Pecarski, PhD

President of the Academy of Applied Studies Belgrade & Senior Research Associate

Dr. Danijela Pecarski is a distinguished specialist in pharmaceutical technology and a Senior Research Associate with over 25 years of expertise in clinical pharmacology and dermocosmetics. She completed her undergraduate studies at the University of Belgrade, Faculty of Pharmacy, and further specialized in Pharmaceutical Technology at the Military Medical Academy (VMA) in Belgrade. She earned her PhD in Clinical Pharmacology from the University of Kragujevac, Faculty of Medical Sciences.

Currently serving as the President of the Academy of Applied Studies Belgrade, Dr. Pecarski also holds the rank of Senior Research Associate at the Faculty of Medical Sciences, University of Kragujevac. Her professional journey uniquely bridges the gap between academic research and the dermo-cosmetic industry, where she has been actively involved in high-level product formulation and production since 2007.

Her prolific scientific contribution includes two national technical solutions, over 15 papers published in top-tier international journals, and more than 40 conference presentations worldwide. She is the author of the prominent academic textbook *"Applied Cosmetology"* and serves as the Editor-in-Chief of the scientific journal *Education and Research in Health Sciences*.

Beyond her research and clinical expertise, Dr. Pecarski is a key figure in Serbian educational policy, contributing to Ministry of Education working groups for higher education financing and dual education. Her current research focuses on innovative topical formulations featuring essential oils for the advanced treatment of wounds and inflammatory skin conditions.

Dermal Engineering: The Role of Biomimetic Lipids and Smart Signaling Substances in Restoring the Compromised Skin Barrier

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Aim: The skin barrier is a sophisticated biological shield, traditionally modeled as a "bricks and mortar" structure. In clinical conditions such as eczema, rosacea, or following aggressive dermatological interventions (e.g., Isotretinoin and prolonged corticosteroid therapy), this architecture often collapses. Such disruption leads to a "house without walls" scenario, characterized by excessive Transepidermal Water Loss (TEWL) and a high risk of inflammatory rebound. This study aims to evaluate the efficacy of "smart formulations" based on the biomimetic 3:1:1 lipid ratio and signaling substances in reconstructing both the structural and functional integrity of the skin.

Methods: The study utilizes a dermal engineering framework focused on molecular-level repair. The methodology evaluates the application of an equimolar ratio of Ceramides (50%), Cholesterol (25%), and Free Fatty Acids (25%). A specific focus is placed on Ceramide EOP (Ceramide 1), which functions as a "molecular rivet" to ensure inter-lamellar cohesion and prevent structural sliding. The research emphasizes the superiority of Multi-Lamellar Emulsion (MLE) technology, which organizes bio-identical lipids into thin, crystalline sheets that mimic the human stratum corneum. Furthermore, the role of pH optimization (4.7 - 5.5) was analyzed as a critical enzymatic "on-switch" for endogenous lipid synthesis and barrier acidification.

Conclusions: Effective restoration of a compromised barrier requires a strategic transition from passive occlusion to active molecular reconstruction. The 3:1:1 lipid triad provides the necessary "hardware" (structural materials), while biomimetic signaling peptides and Niacinamide act as cellular "software" (biological instructions) for self-repair. Unlike standard petroleum-based ointments that merely create a temporary surface film, MLE-based smart formulations integrate directly into the inter-corneocyte spaces. This approach effectively minimizes TEWL, prevents the rebound effect after steroid therapy, and re-establishes the skin as a "functional fortress" capable of autonomous defense.

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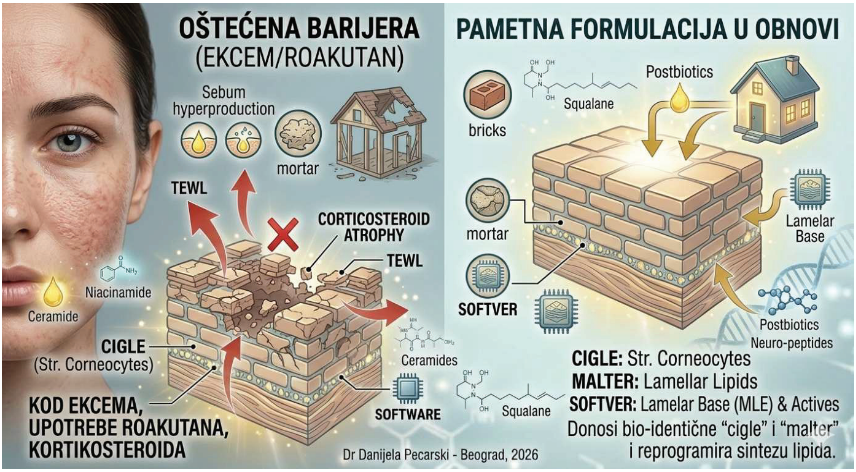

Figure 1. The "House without Walls" metaphor: visualizing the collapse of the lipid matrix and its reconstruction through smart substances. (Concept visualized using AI assistance).

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Postdoctoral Researcher

Supercritical CO_2 Processing and Functional Materials

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Dr. Jelena Pajnik is a Postdoctoral Researcher in Chemical Engineering, specializing in supercritical CO_2 technologies for sustainable extraction, material processing, and the functionalization of materials with bioactive compounds. She obtained her PhD in Chemical Engineering from the University of Belgrade in 2018.

She is currently affiliated with the Technical University of Munich, where her research focuses on advanced biopolymer-based materials, including biopolymer aerogels and zeolite/biopolymer composites with bioactive properties. Her work explores the use of green supercritical fluid technologies for extraction, drying, impregnation, and controlled-release applications, particularly for natural bioactive compounds such as cannabinoids and polyphenols.

Prior to her current academic position, Dr. Pajnik gained industry experience in Germany in the field of e-mobility, contributing to applied engineering and industrial development projects.

Dr. Pajnik is actively involved in several research projects in Germany and in international collaborations, focusing on the development and optimization of scalable, sustainable supercritical CO_2 processes for industrial applications. Her current work includes developing supercritical CO_2-based systems for advanced biomaterials.

Functional Porous Polymer–Zeolite Composites as Carriers for Bioactive Compounds

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Conventional disinfection methods, such as chlorination and ozonation, remain the dominant approaches for water treatment but are increasingly challenged due to the formation of toxic disinfection by-products. These limitations have driven the search for sustainable, environmentally friendly alternatives. In this context, porous biomaterials have attracted particular attention, as their high surface area, tunable pore structure, and adsorption capacity enable efficient loading and gradual release of active compounds, making them promising candidates for advanced antimicrobial and water treatment applications.

In this study, chitosan-based porous beads with and without the incorporation of natural zeolite were developed as functional carriers for pure menthol and *Mentha piperita* extract to obtain materials with antibacterial properties. Chitosan-based beads were processed using green supercritical carbon dioxide (scCO_2) in a two-step approach. First, scCO_2 drying was applied at 100 bar and 45 °C to preserve the pre-formed highly porous structure of the beads, while avoiding the use of organic solvents. In a second step, scCO_2 impregnation was performed at 100 bar and 40 °C to load active compounds into the porous matrix, enabling efficient and uniform incorporation.

The obtained chitosan-based beads exhibited high loading capacities, demonstrating the effectiveness of scCO_2 impregnation for loading of bioactive compounds into porous matrices. Structural characterization by SEM and BET analysis confirmed the formation of porous structures. Loaded chitosan-based samples were subjected to re-extraction in hexane to assess the composition of incorporated compounds, which was subsequently analyzed by GC–MS. In addition, thermal properties were investigated to assess material stability. FTIR analysis verified successful incorporation of zeolite and interactions within the composite matrix. GC–MS was used to analyze the composition of desorbed compounds.

Antibacterial studies confirmed the activity of the loaded materials. Release studies in aqueous media demonstrated that zeolite incorporation significantly influences both loading capacity and release kinetics. The developed porous chitosan–zeolite beads show strong potential as tunable carriers for natural bioactive compounds, particularly in sustainable antimicrobial and water treatment applications.

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***Dr. Stevan Blagojević** is a physicochemist and Director of the Institute of General and Physical Chemistry in Belgrade, with more than 30 years of experience at the interface of scientific research and industrial application. He obtained his B.Sc. and M.Sc. degrees in Physical Chemistry from the University of Belgrade, and completed his Ph.D. in 2014, focusing on nonlinear chemical dynamics and oscillatory reactions.*

He has spent his entire professional career at the Institute of General and Physical Chemistry, where he progressed from a researcher in electrochemistry to Head of the Detergents Laboratory, and later to senior management positions, including Technical Manager and Deputy Director. Since 2016, he has served as Director of the Institute, leading its strategic development as a nationally recognized research and development organization. His scientific work spans nonlinear systems, electrochemistry, and colloidal chemistry, with an emphasis on modeling and understanding complex physicochemical processes.

In parallel with his academic career, he has developed extensive long-term collaborations with industry, acting as a consultant and project leader for leading regional and international companies in the fields of detergents, cosmetics, and specialty chemicals. His work includes formulation development, process optimization, implementation of new raw materials, and support in scaling products from laboratory to industrial production. He has also been actively involved in regulatory aspects, including chemical safety, product labeling, and compliance with international standards, as a certified chemical advisor and lecturer.

Through his combined scientific and industrial engagement, he has contributed to bridging fundamental research with real-world applications, particularly in the development of innovative chemical products and technologies. He is an active member of professional organizations and has participated in numerous national and international research projects and scientific events.

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Physical Chemistry in Household Cleaning Formulations Development

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The development of modern household cleaning formulations is fundamentally rooted in principles of physical chemistry, which govern the behavior, efficiency, and stability of complex multicomponent systems. This work highlights the critical role of physicochemical parameters in the rational design and optimization of cleaning products, with a particular focus on surfactant systems, interfacial phenomena, and formulation stability.

Cleaning performance is primarily driven by interfacial processes such as wetting, emulsification, dispersion, and solubilization. Surface tension reduction, controlled by surfactant structure and concentration, directly influences the ability of formulations to penetrate and remove hydrophobic soils [1]. The selection and combination of anionic, nonionic, amphoteric, and cationic surfactants enable synergistic effects, leading to enhanced detergency and improved tolerance to water hardness and varying pH conditions [2]. Critical micelle concentration (CMC), hydrophilic–lipophilic balance (HLB), and micelle structure are key parameters that dictate solubilization capacity and cleaning efficiency. In addition to interfacial properties, bulk physicochemical characteristics such as pH, ionic strength, and rheology significantly impact formulation performance. Alkalinity plays a crucial role in the saponification and hydrolysis of fatty soils, while buffering systems ensure stability and compatibility with various surfaces. The presence of builders, chelating agents, and polymers further enhances cleaning efficiency by controlling hardness ions, preventing redeposition, and stabilizing dispersed soil particles [3]. Stability considerations are equally important in formulation development. Phase behavior, including microemulsion formation and phase separation dynamics, is governed by thermodynamic and kinetic factors. The use of hydrotropes, solvents, and viscosity modifiers ensures long-term stability, optimal flow properties, and user-friendly application [4]. Advanced analytical techniques such as surface tension measurements, zeta potential analysis, dynamic light scattering, and rheological characterization are essential tools for understanding and optimizing these systems. Environmental and regulatory aspects increasingly shape formulation strategies. Biodegradability, reduced toxicity, and compliance with global regulations require a careful balance between performance and sustainability. The application of green chemistry principles, including the use of renewable raw materials and environmentally benign surfactants, is becoming a standard in formulation design [5].

In conclusion, the integration of physical chemistry principles into formulation development enables a systematic approach to designing efficient, stable, and environmentally acceptable household cleaning products. A deep understanding of interfacial and bulk phenomena allows formulators to tailor products for specific applications, ensuring optimal performance under diverse usage conditions.

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His research focus includes: interaction liquids and heat with porous media, nanoscale phenomena printing, environmental sciences and composite biomaterials.

He has authored over 400 scientific publications and is a named inventor on more than 300 corporate patents.

Composite design for the circular economy: embracing sustainable filler-cellulose interactive bioproduct composite regeneration

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Circular economy in the field of standard composites has proven to be difficult if not almost impossible to implement. One example is the case of fossil oil-based polymers with a one-time use in packaging, which present a challenge in respect both to collection and recycling, with barriers arising from the need to select separate polymer chemistries. The result has been, according to the OECD, that just 9 % of the world's plastic is recycled, with the remaining being incinerated, going to landfill, or directly polluting the environment [1].

Cellulose is nature's most abundant sustainably sourceable polymer. Its incorporation into composites, however, has mainly been limited to that of a strengthen fibre in standard oil-based polymer formulations. Cellulose is naturally strongly hydrophilic, and so the incorporation with hydrophobic oleophils is wrought with problems of poor dispersibility and the need to surface modify the cellulose chemically, or in some cases adopting plasma treatment, to achieve sufficient dispersion, adding complexity and cost [2].

More recently, 100 % cellulose and, newly, functional cellulose-mineral filler composites have been constructed in a collaboration between Aalto University and the University of Belgrade. In this context two main novel approaches, both of which can use virgin cellulose, waste printing and writing papers or packaging, or reject/biproduct agricultural cellulose, for example, have been found to yield a range of advanced materials. The two processes will be illustrated in the presentation, and the resulting materials produced discussed:

i. Adsorption of ultrafine calcium carbonate filler particles on cellulose nanofibrils branching from micro nanofibrillated cellulose (MNFC), and, similarly, on cellulose nanocrystals (CNC), by using controlled gel strain-induced properties in aqueous suspension [3].
ii. Regeneration of cellulose using a cellulose solution in environmentally friendly ionic liquid followed by recrystallisation and polymerisation in a water bath to form spun fibres and extruded films [4, 5].

The presence of functional filler can enhance product stiffness, impact strength and, due to their opacifying effect, protect light-sensitive goods. These bioproduct composites enter the circular economy directly within the same product cycle (nested) or indirectly forming a fractal-like extended process and application network (catenated), in which the after-use or biproduct material can be regenerated in principle infinite times via process II and constitute the feedstock for other equally valorising applications.

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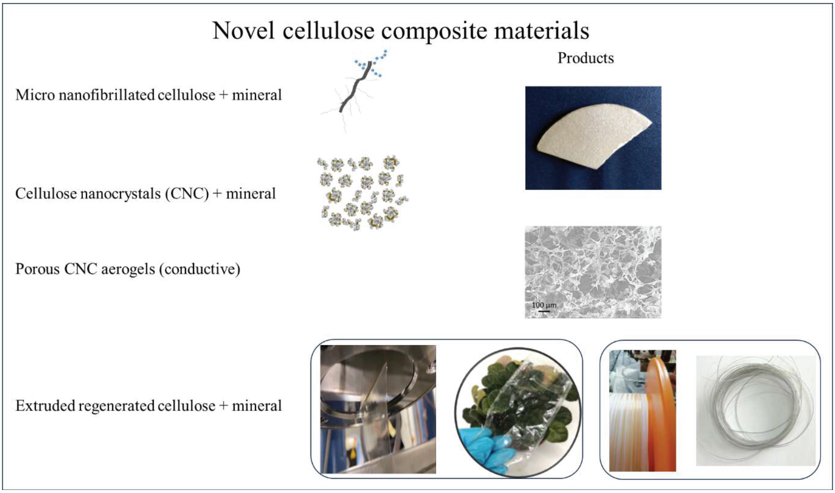

Figure 1. Novel sustainable regeneratable cellulose-mineral composites creating circular economy

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Dr. Dimić has authored more than 85 publications in international peer-reviewed journals, with over 1,600 citations. He has been included in the 2024 and 2025 Stanford/Elsevier Top 2% Scientists List. In addition to his research, he has extensive teaching experience at both undergraduate and graduate levels and has supervised numerous bachelor's, master's, and doctoral theses. He has participated in several national and international research projects and has completed study visits and research stays at institutions across Europe, Israel, the United States, and Argentina.

He is also actively involved in the scientific community, serving as a reviewer for over 40 international journals and as a guest editor for several special issues.

From Molecular Structure to Biological Activity: Quantum Chemistry and Molecular Modeling in Forensic Science

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The invited lecture presents recent advances in the application of computational chemistry to the forensic study of psychoactive substances. The first part of the lecture focuses on the use of quantum-chemical methods, particularly density functional theory (DFT), for detailed structural characterization and prediction of spectroscopic properties of illicit drugs and their analogs. These approaches enable reliable simulation and assignment of IR, NMR, UV-Vis, and mass spectra, which is especially valuable when reference standards are unavailable or experimental data are incomplete. Using selected recent examples, this paper demonstrates how theoretical calculations can support and complement forensic experimental analysis, thereby contributing to the identification of new and emerging psychoactive substances.

Particular attention is given to the study of intermolecular interactions in complex systems relevant to real forensic samples. By combining DFT calculations with topological analysis of electron density and molecular dynamics simulations, it is possible to examine how active pharmaceutical ingredients interact with common adulterants and excipients such as caffeine, paracetamol, and various sugars. These interactions, often dominated by hydrogen bonding and other weak noncovalent forces, can influence both the system's stability and its spectroscopic signals. Molecular dynamics simulations of multi-component systems provide additional insight into the dynamic nature of these interactions, revealing preferred binding motifs and allowing estimation of interaction energies under conditions that more closely resemble real samples.

The lecture then moves beyond structural and physicochemical characterization toward the question of biological activity. In this context, molecular docking has been applied to investigate the binding of fentanyl to a relevant receptor model, with the obtained binding poses compared to those observed in available reference structures. In parallel, docking studies of methylenedioxynitazene and a series of its derivatives have been conducted to explore how structural modifications affect binding behavior. While the analysis of these systems is still ongoing, the preliminary results already point to consistent trends in ligand–receptor interactions and highlight key structural features that may be important for activity.

Taken together, these examples illustrate how different computational approaches can be used in complementary ways, from accurate molecular structures to intermolecular interactions in complex mixtures to models of biological recognition. Such a workflow reflects the types of questions that increasingly arise in forensic science, where new substances appear rapidly and often without sufficient experimental characterization. By combining quantum-chemical calculations with molecular docking and molecular dynamics, it becomes possible to obtain a more complete picture of both the identity and potential behavior of these compounds, providing useful support for their interpretation in forensic investigations.

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Dr. Nevena Veljković *is a Principal Research Fellow and entrepreneur in the field of bioinformatics and health data science, focused on the analysis and interpretation of complex biomedical data, including omics and single-cell technologies. She received her doctorate at the Faculty of Technology and Metallurgy, University of Belgrade. She is the founder and director of the company Genial d.o.o., which develops solutions for the analysis of complex data in the context of drug discoveries and biomolecules.*

As a Principal Research Fellow at the Vinča Institute of Nuclear Sciences, she actively participates in research in bioinformatics and computational biology. She is the author and co-author of more than 70 scientific papers published in international journals, with work centred on the application of computational methods in biomedicine and has an h-index of 27 (according to Google Scholar).

She has been a lecturer at the University of Belgrade, where she taught at Master's and PhD level in genomics and bioinformatics. She is also active in the health-tech community, participating as a speaker at conferences focused on the digitalisation of healthcare and the application of artificial intelligence in biomedical research. In recent years, her work has been particularly focused on medical data, clinical studies and patient safety, with the aim of improving decision-making through reliable and regulatory-compliant data analysis.

From Expert Workflows to Scalable Biomedical Analytics: Bridging Science and Industry

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Modern omics (high-throughput biomolecular) technologies generate massive volumes of complex data, placing them on par with fields such as astronomy and particle physics in terms of scale. Yet, the way these data are analysed remains largely expert-driven and fragmented. Analytical tools are predominantly developed in academic environments, where methods are designed and validated, but only a subset reaches the level of robustness required for industrial use. Even then, their adoption is limited by the need for significant coding expertise, lack of integration, and reliance on public platforms that fall short in meeting data protection and regulatory standards.

This talk will outline the key technological and organisational steps required to move from expert-driven, custom workflows to scalable, standardised, and secure analytical platforms ready for deployment in the life sciences industry.

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***Marijana Milosavljević**, graduated pharmacist, specialist in cosmetology, cosmetics safety assessor. Founder and owner of the company MNS Centar, whit main activity with the safety assessment of cosmetic products. Since 2005, she has been building her career in the cosmetics industry, first as the head of the galenic laboratory of the company Kirka Pharma, and then as a teacher of professional subjects, cosmetology, pharmaceutical technology and pharmacognosy at the Pharmacy and Physiotherapy School. In 2013, she completed her specialization in Cosmetology at the Faculty of Pharmacy in Belgrade. She was also an expert associate at the Higher School of Health Sciences in Zemun in 2017. Member of the working group for amending and supplementing the Regulation on special sanitary conditions that must be met by facilities providing hygiene, care and beautification of the face and body, Ministry of Health of the Republic of Serbia in 2018. Since 2021, she has been a chemical advisor. She also completed the Safety Assessor Course 2022. Safety assessment of Cosmetic in the EU, Vrije Universiteit Brussel. She was also the first president of the Association of Aesthetics and Health Preservation Professionals EstetikPro from 2014-2017. She is the author and co-author of published works, as well as continuing education courses. She is currently involved in the safety assessment of cosmetic products at the international level.*

Endocrine disruptors between science and law

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Endocrine disruptors are exogenous substances or mixtures that alter the function of the endocrine system and cause adverse effects on the health of a healthy organism or its offspring. They affect metabolism, development, reduced activity of the reproductive system and immunological changes. They can be toxic in small doses. They act by imitating hormones and binding to the same receptors, blocking natural hormones from performing their function, reducing hormone levels or affecting the sensitivity of our body to other hormones. This leads to the development of various health problems such as reduced sperm quality and fertility, sexual organ disorders, premature puberty, changes in the nervous system, metabolic problems, diabetes, obesity, cardiovascular problems, and neurological disorders (1). Cosmetic products are one source of endocrine disruptors. Endocrine disruptors are also found in household chemicals, toys and many other products. The widespread use of these products has led to increased concern of their presence in products (2). ECHA has included endocrine disrupting substances as substances of very high concern under the REACH Regulation and is under constant review. There are no specific prohibitions for endocrine disruptors in the Cosmetics Regulation 1223/2009. When a potential endocrine disruptor is classified as a CMR substance, Article 15 of the Cosmetics Regulation, i.e. Article 9 of the Regulation on Cosmetic Products of the Republic of Serbia, applies and the substance is prohibited for use except in exceptional cases regulated by law. The use of endocrine disruptors that are not classified as CMR substances is defined in Article 13 of the Cosmetics Regulation, which requires the opinion of the SCCS Commission (3,4, 5). Substances used in cosmetic products that are potential endocrine disruptors are parabens, benzophenones, homosalate, melatonin, resorcinol, cyclomethicone, 4-methylbenzylidene-camphor and 3-benzylidene-camphor. There are other raw materials such as phthalates, aluminum salts, nanoparticles, perfluorinated raw materials. ECHA introduced new hazard classes for endocrine disruptors in 2023. It is expected that the cosmetics industry will also take this into account when assessing the safety of cosmetic products in the coming years (3).

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INVITED LECTURES

***Janez Cerkovnik, PhD**, is a Professor of Chemistry at the University of Ljubljana, Faculty of Chemistry and Chemical Technology. He received his chemistry degree in 1987 and completed his PhD in Chemistry at the University of Ljubljana in 1993, under the supervision of Prof. Božo Plesničar, focusing on reactive intermediates formed during low-temperature ozonation of organosilicon compounds. As a postdoctoral researcher, he worked as a research associate with Professor Gary H. Posner at Johns Hopkins University in Baltimore, MD, USA. His main research interests include studying reaction mechanisms involving oxygen, ozone, hydrogen peroxide, and polyoxides as oxidants. Recently, he has also been developing chemical tools to predict reactivity in different chemical systems.*

Stabilizing molecules with hydrogen-bond acceptors: Co-crystallization as a valuable strategy in crystal engineering

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Crystal engineering uses noncovalent interactions such as hydrogen and halogen bonds, σ-hole interactions, π–π stacking, and van der Waals forces to create supramolecular structures with specific properties.[1] Hydrogen and halogen bonds are particularly important because of their strength and directionality, enabling predictable and rational crystal design.

Sensitive and reactive molecules can be selectively stabilized by pairing them with suitable coformers,[2] as these assemblies often exhibit improved crystallinity and thermal stability. This approach allows for changing the state of reagents;[3] stabilizing hazardous or unstable compounds for safer handling and longer shelf life;[4,5] and improving the physicochemical properties of pharmaceuticals.[6] The key to these benefits is hydrogen bonding, valued for its versatility in forming a wide range of donor and acceptor motifs. Acceptors typically act as Lewis bases, such as oxygen atoms with lone pairs.

We present a versatile stabilization method based on co-crystallization with strong hydrogen-bond acceptors as coformers. This strategy is exemplified by trapping higher homologues of water and hydroperoxides as cocrystals with organopnictogen(V) oxides (Figure 1),[7] demonstrating a general strategy to stabilize and analyze reactive, temperature-sensitive species.

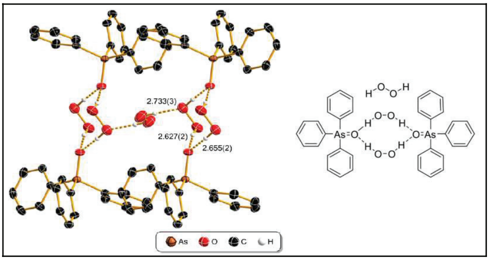

Figure 1. Single-crystal XRD structure of cocrystal **$[Ph_3AsO\cdot H_2O_2]_2\cdot H_2O_2$**.

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***Prof. Ljubica Vasiljević** is a full professor of chemistry at the University of East Sarajevo, Faculty of Technology in Zvornik, with over 25 years of experience spanning academia, industrial practice, and applied research. She obtained her undergraduate degree in Organic Chemistry from the University of Novi Sad, and later completed her M.Sc. and Ph.D. studies in chemical engineering and chemistry, focusing on zeolite synthesis, crystallization processes, and material characterization.*

She began her professional career in industry at the alumina plant "Birač" in Zvornik, where she worked as an engineer and later as Head of the Central Laboratory, gaining extensive experience in industrial processes, quality control, and laboratory management. This early engagement in industry strongly shaped her applied research approach and expertise in chemical technologies and process optimization.

Since 2010, she has been fully engaged in academia at the University of East Sarajevo, where she progressed through all academic ranks to full professor. She teaches courses in organic chemistry and biochemistry and has been actively involved in mentoring students and developing study programs. Her scientific work covers a wide range of topics, including chemical technology, environmental protection, characterization of biologically active compounds, and ecological monitoring.

In addition to her teaching and research activities, she has played a significant role in institutional and project-based work, including leadership in laboratory accreditation processes, participation and coordination of national and international projects, and involvement in university governance bodies. She is the author of more than 80 scientific papers, several university textbooks, and a book chapter published by Springer.

Her career is characterized by a strong integration of academic knowledge with industrial and environmental applications, particularly in the fields of materials, chemical processes, and sustainable development. She is an active member of professional organizations and contributes to initiatives related to quality systems, environmental protection, and sustainable energy.

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Synthetic zeolites – key materials in chemical processes and industry

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This paper provides a retrospective analysis of the role of synthetic zeolites as pillars of modern applied chemistry, with a special emphasis on the contributions of the Institute of General and Physical Chemistry. While the Institute celebrates 65 years of existence, the foundation for zeolite production technology in the region was established four decades ago, positioning the IGPC as a scientific generator of industrial innovation.

Zeolites are crystalline aluminosilicate materials with a well-developed three-dimensional porous structure. Due to their specific physicochemical properties, they find wide application in modern science and industry. This paper provides an overview of the structure, classification, synthesis methods, and applications of zeolites, with a particular focus on the differences between natural and synthetic forms. Due to their uniform structure and higher adsorption capacity, synthetic zeolites offer significant advantages over natural ones, especially in environmental applications. Various synthesis methods are analyzed, including hydrothermal processes, alkaline activation, and combined methods with alkaline fusion, which enable the production of zeolites with pre-engineered characteristics. Special emphasis is placed on the application of zeolites in the detergent industry, wastewater treatment, the removal of heavy metals and organic pollutants, heterogeneous catalysis, agriculture, and modern medicine. The paper highlights future directions in zeolite development within the context of green energy, sustainable development, and cost-effectiveness, confirming the inextricable link between fundamental physical chemistry and industrial growth.

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Dr. Milica Lukić is an Associate Professor at the Department of Pharmaceutical Technology and Cosmetology, Faculty of Pharmacy, University of Belgrade. She is a pharmacist and researcher with extensive expertise in dermopharmaceutical and cosmetic product development, with a particular focus on colloidal systems, natural ingredients, and evidence-based evaluation of cosmetic efficacy and safety.

She obtained her Doctor of Medical Sciences degree in 2014 at the University of Belgrade. Her academic career has been closely linked to the Faculty of Pharmacy, where she progressed from teaching associate to assistant professor. Throughout her career, she has been actively involved in both undergraduate and postgraduate teaching, contributing to courses in pharmaceutical technology, cosmetology, and related interdisciplinary areas, while also mentoring numerous student research projects.

Dr. Lukić's scientific work is primarily oriented toward the development and characterization of topical formulations, including emulsions, micro- and nanosystems, and innovative delivery systems based on natural surfactants such as alkyl polyglucosides. Her research integrates physicochemical characterization, in vitro and in vivo performance testing, and bioengineering methods for skin assessment. In recent years, her work has increasingly focused on sustainable cosmetics, including waterless formulations and the valorization of agricultural waste materials as functional cosmetic ingredients, aligning with current environmental and circular economy principles.

She has participated in numerous national and international research projects, including collaborations with German research institutions, and is currently involved in projects exploring value-added products derived from agro-industrial waste. She has also completed several research stays at the University of Tübingen, contributing to her international scientific experience.

Dr. Lukić is the author and co-author of a significant number of scientific publications in high-impact international journals, as well as book chapters and conference contributions. Her work covers a broad range of topics, including formulation design, skin delivery, stability assessment, and the relationship between formulation structure and product performance. She is also an active reviewer for several international scientific journals in the fields of cosmetology, pharmaceutical technology, and biomaterials.

In addition to her academic and research work, Dr. Lukić is committed to continuous professional development and interdisciplinary practice. She is a licensed integrative body psychotherapist, reflecting her interest in the connection between skin health, well-being, and psychodermatology. She actively participates in educational programs, workshops, and professional training, contributing to the advancement of both scientific knowledge and practical competencies in the field.

Through her work, Dr. Lukić contributes to bridging fundamental research and practical application in cosmetic science, with a strong emphasis on innovation, sustainability, and evidence-based practice.

Defining the Boundaries Between Medicinal Products and Cosmetics in Aesthetic Practice

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The rapid expansion of aesthetic practice has blurred the traditional boundaries between cosmetic and medicinal products, creating significant regulatory, clinical, and ethical challenges. In the European Union and Republic of Serbia, cosmetic products are defined as substances intended for application to external parts of the human body with the primary purpose of cleansing, perfuming, protecting, or altering appearance, without exerting significant physiological effects [1]. In contrast, medicinal products are characterized by their therapeutic or preventive claims or by their ability to restore, correct, or modify physiological functions through pharmacological, immunological, or metabolic mechanisms [2].

The distinction between these categories is not always straightforward, particularly in cosmetic and aesthetic dermatology where products may exhibit overlapping functions. Classification is determined based on intended purpouse, use, claims (presentation), and mode of action (function), which will be presented in this lecture [3]. In aesthetic practice, this distinction has profound implications for product development, marketing, safety evaluation, and legal compliance, but also directly affects which professionals are legally permitted and competently trained to perform specific procedures. The category to which a product belongs (cosmetic, medical device, or medicinal product) often determines the scope of practice. However, in real-world settings, borderline products – such as chemical peels, microneedling serums, depigmenting agents, or products used in mesotherapy – challenge these boundaries, as their mechanism of action, depth of penetration, and claimed effects may blur the line between cosmetic care and medical intervention. This creates several key challenges: (i) regulatory ambiguity, where the same product may be classified differently across jurisdictions or depending on its claims; (ii) professional responsibility and liability, as improper use of a product outside one's legally defined scope may result in adverse effects and legal consequences; (iii) competency and training gaps, since the safe application of certain borderline products requires advanced knowledge of skin physiology, pharmacology, and risk management; and (iv) ethical considerations, particularly when marketing claims or client expectations exceed the scientifically supported effects of a cosmetic product. Furthermore, the increasing availability of high-potency active substances in cosmetic formulations raises concerns about their misuse in non-medical settings.

In conclusion, clearly defining the boundary between cosmetic and medicinal products is essential for ensuring safe, effective, and legally compliant aesthetic practice. Professionals must rely on a thorough understanding of regulatory criteria, mechanisms of action, and scope of practice to minimize risks and uphold ethical standards. Ultimately, an evidence-based and well-regulated approach is key to protecting both patient safety and professional integrity in modern aesthetic care.

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She began her professional career in 2014 at the Specialized Laboratory for Testing Insulating Oils and Papers at the Nikola Tesla Electrical Engineering Institute as a Research Associate. During this period, she participated in national and international research projects, focusing on the application and diagnostics of advanced analytical and instrumental methods (GC-ECD, GC-FID, U-HPLC, FTIR, Karl Fischer coulometry). Her work included validation and verification of analytical methods, evaluation of measurement uncertainty, and analysis of proficiency testing results (PT/RRT schemes). She contributed to product development that resulted in an international patent application and to the implementation of new methods for testing the mechanical properties of cellulose insulation within the Institute's practice. In 2021, she joined the pharmaceutical company Alkaloid d.o.o. Belgrade as an Analyst, where she was responsible for determining the content of active substances, identification and quantification of impurities in medicinal products, as well as dissolution and drug release testing.

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Guidelines for Monitoring Skin Barrier Parameters in the Evaluation of Cosmetic Product Efficacy

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In the rapidly growing cosmetic market, ensuring the safety, reliability, and efficacy of products has become a top priority. Compliance with international guidelines such as EEMCO, SCCS, OECD, and COLIPA (Cosmetics Europe) is essential for manufacturers to guarantee consumer safety and support product performance claims.

Monitoring skin barrier parameters, the first line of defense against external factors, is crucial for assessing product effects. This study provides a concise overview of skin structure and epidermal barrier function, highlighting key biophysical parameters such as transepidermal water loss (TEWL), stratum corneum hydration (SCH), and skin surface pH, which are fundamental for monitoring skin condition and functionality.

As a practical example, the study evaluates *Da! by Dahlia Beauty Sleep Night Cream*, demonstrating its efficacy through *in vivo* instrumental measurements. The results, obtained from a pilot study with five participants and a main study with twenty participants, show a significant increase in skin hydration as well as a decrease in TEWL values, thereby confirming the product's effectiveness in supporting skin barrier integrity.

Emerging technologies and digital systems, including artificial intelligence tools, offer novel approaches to skin parameter monitoring. The absence of international guidelines for AI in skin assessment highlights the importance of developing standardized technical, ethical, and clinical protocols to enhance result reliability and confidence in modern cosmetic testing.

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Nanocarriers for Bioactive Compounds: Bridging Research and Real-World Performance

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Lipid nanocarriers, particularly liposomes, have emerged as versatile and efficient platforms for delivering bioactive compounds by improving their solubility and stability, enhancing bioavailability, and enabling controlled and targeted delivery across pharmaceutical and cosmetic applications. Despite extensive formulation advances, quantitative evidence for the functional advantages of encapsulation under biologically and clinically relevant conditions remains surprisingly sparse. Here, we present a systematic, multi-model investigation of liposomal delivery benefits, assessed through an integrated suite of physicochemical and biophysical methods applied to structurally and functionally distinct bioactive payloads.

Using electron paramagnetic resonance (EPR) spectroscopy combined with a liposomal integration strategy, we demonstrate that water-insoluble antioxidants can be rigorously characterized against biologically relevant radical species - conditions unattainable in conventional aqueous assays - revealing significant radical scavenging activity that is otherwise inaccessible. For encapsulated non-steroidal anti-inflammatory drugs, liposomal formulation yields prolonged drug release kinetics, substantially enhanced dermal bioavailability, and markedly reduced systemic exposure, as established by *in vitro* release profiling and *ex vivo* Franz cell permeation studies. EPR imaging (EPRI) was employed to track the spatial distribution of spin-labeled tretinoin liposomes in porcine skin, providing direct tissue-level evidence of deep-layer penetration that cannot be resolved from bulk permeation data alone. Similarly, liposomal systems loaded with cannabinol and Inonotus obliquus (Chaga) antioxidant extracts retain substantial radical scavenging capacity post-encapsulation, with EPRI confirming superior diffusion through semi-solid media relative to unencapsulated controls.

These findings establish that no single analytical method is sufficient to demonstrate the real-world benefit of nanocarrier-based delivery. A convergent evaluation framework - integrating EPR spectroscopy, EPRI, Raman spectroscopy, Franz diffusion cells, and *in vivo* measurements - is required to fully characterize nanosystem performance from the molecular to the macroscopic scale. EPRI emerges as a particularly powerful technique for direct in-tissue nanosystem tracking, offering spatial resolution and sensitivity that are unmatched by conventional methods. These results provide a robust analytical foundation for the rational design, development, and validation of liposomal delivery systems across pharmaceutical, dermatological, and cosmetic applications.

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Throughout her career, Dr. Dikić has been actively involved in numerous research projects, including national projects, EUREKA, HERD, and several bilateral projects. Currently, she is the principal investigator of the bilateral project between the Republic of Serbia and the Federal Republic of Germany entitled "Antibacterial zeolite/biopolymer composites for water disinfection". Her scientific work is focused on the synthesis and characterization of porous materials, particularly natural and synthetic zeolites. She has been intensively investigating the use of zeolites for the removal of heavy metal ions from aqueous solutions and the use of saturated sorbents as antimicrobial agents. The synthesis of polymer–zeolite composites with antibacterial properties is also one of the topics of her research.

Dr. Dikić is the author or co-author of more than 20 publications in international peer-reviewed journals and numerous presentations at national and international conferences, reflecting a consistent and significant scientific contribution to her field. She has been appointed as a Guest Editor of the Special Issue "Novel Applications of Zeolites in Adsorption Processes" in "Processes", supporting the dissemination of zeolite materials as adsorbents. In 2024, her work was recognized among the top 10% of scientists in Serbia.

Zeolite-based materials as novel antibacterial agents

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The growing demand for environmentally safe and sustainable water disinfection treatments has significantly increased the need for the development of advanced functional materials as alternatives to conventional chemical treatments. Over the past decade, the rapid emergence of antibiotic-resistant pathogenic bacteria has become a critical global challenge, limiting the effectiveness of existing antimicrobial strategies. Among a wide range of pathogens, *Escherichia coli* and *Staphylococcus aureus* are of particular concern due to their prevalence in healthcare-associated infections and their strong ability to develop resistance.

A major factor contributing to bacterial resistance is the formation of biofilms, which provide strong protection against antibiotics and disinfectants. Because of their well-defined porous structure, high ion-exchange capacity, and the possibility of surface functionalization, zeolites have emerged as highly promising materials for antibacterial applications. Metal-loaded zeolites, as well as zeolite/biopolymer composites impregnated with plant-derived active agents, represent an important class of multifunctional materials with enhanced antimicrobial properties.

This paper presents the results obtained by investigating the antibacterial effect of metal-modified zeolites (metal: Zn, Ni, Cu and Ag). The results indicate that metal-enriched zeolites can be effectively used as alternative antibacterial agents. Among the studied materials, Zn- and Ni-modified zeolites exhibited lower antibacterial activity, whereas Cu- and especially Ag-modified zeolites demonstrated significantly higher efficiency against all tested bacterial strains. The antibacterial effect is primarily attributed to the controlled release of metal cations from the zeolite surface, which interact with bacterial cells and lead to their inactivation [1,2].

In addition, the preparation of zeolite/biopolymer composites and their ability to serve as matrices for loading bioactive compounds were investigated. The results showed that these composites are efficient carriers for bioactive components, providing improved stability and significant antimicrobial activity. The combination of zeolites with biopolymers enables the preparation of environmentally friendly and multifunctional materials with enhanced applicability in water treatment systems [3,4].

Overall, the obtained results demonstrate that zeolite-based materials, metal-modified zeolites and their biopolymer composites, represent promising next-generation antibacterial systems with significant potential for application in sustainable water disinfection technologies.

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Her research interests focus on developing modern systems for extended or controlled delivery of both conventional and unconventional biologically active substances, including the creation of cellular drug carriers based on erythrocytes and erythrocyte membranes. Additionally, her research involves introducing advanced biophysical methods into medical research (such as characterizing erythrocytes, immunoglobulins, and immune complexes) and investigating the biological effects of minerals and plant extracts.

As part of her applied research activities, Ivana Drvenica has initiated innovative studies to optimize methods for stabilizing hemoglobin from sustainable sources-slaughterhouse blood, with the aim of developing a dietary supplement containing highly bioavailable heme iron for the prevention or treatment of hypochromic anemia.

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Tailoring Natural Zeolite through Mechanical Activation for Targeted Biomedical Applications

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The promising potential of submicron- and nanosized zeolites in biomedical applications has sparked interest in systematically studying how their surface properties influence protein and ion adsorption behavior, particularly in biological fluids or their mimetics [1,2]. Our study investigates a natural Serbian zeolite from the "Igroš-Vidojevići" deposit on Kopaonik, which was mechanically activated through grinding in a vertical laboratory planetary ball mill for durations ranging from 0 to 60 minutes (Z_0', Z_15', Z_30', and Z_60'). A comprehensive physicochemical characterization of both non-activated and activated zeolite particles was conducted using techniques such as X-ray crystallography, scanning electron microscopy (SEM), Fourier-transform infrared spectroscopy (FTIR), differential scanning calorimetry (DSC), and laser diffraction analysis (DLS). We measured the ion exchange capacity of different zeolite concentrations (10, 1, and 0.1%) by analyzing changes in the concentrations of iron, calcium, magnesium, ammonia, bicarbonate, and phosphate in several isotonic solutions/cell culture media, as well as in peripheral blood sera from healthy individuals and in fetal calf serum (FCS). Further biological effect analysis was performed using zeolite-pretreated physiological saline (0.9% NaCl) and 10% FBS in 0.9% NaCl on the hemoglobin spectral characteristics and osmotic fragility of human erythrocytes. The results indicate that mechanical activation significantly influences the properties of zeolite, revealing both adsorption and ion-release capabilities, as well as effects on erythrocytes that depend on zeolite concentration and the medium used. This research offers valuable insights for the innovative use of activated zeolites in targeted biomedical applications.

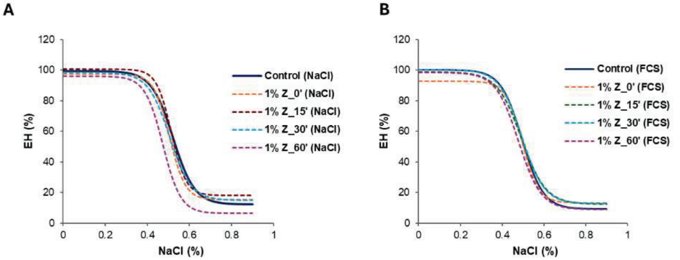

Figure 1. Osmotic fragility of erythrocytes incubated with activated zeolite pretreated solutions of 0.9% NaCl or 10% FCS in 0.9% NaCl. The results are expressed as the extent of hemolysis (EH) in % per decreasing concentration of NaCl solution

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She has participated in numerous national and international scientific projects and is the author of 23 publications in scientific journals, 2 chapters in book and numerous conference contributions.

Influence of nanomaterials on bacteria

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Nanomaterials have gained the attention of the scientific community due to their diverse application. These materials represent a promising approach in combating antibiotic-resistant bacterial strains. Nanoceria (NC) particles consisting of cerium oxide (CeO_2) have been used as carriers for targeted drug and gene delivery, as an antidiabetic and antibacterial agent, and for tissue engineering [1]. NC can offer a new strategy to combat resistant bacteria, while on the other hand the leakage of NC into the environment, as a result of its extensive use, can lead to a growing threat to beneficial microbes.

Gram-negative bacteria *Pseudomonas aeruginosa* are well known for their ability to grow in different environments due to their great adaptability and metabolic diversity. *P. aeruginosa* is widespread, opportunistic pathogen which may cause severe infections in immune-compromised patients. This becomes a therapeutic challenge since it can quickly develop resistance to antibacterial agents. An environmental isolate of the Gram-negative bacterium *P. aeruginosa* san ai was used as a model organism for the study and deeper understanding of the impact of nanomaterials.

In order to identify the influence of NC on the processes of *P. aeruginosa* metabolism of the main biomolecules, and preservation of redox homeostasis, changes in the total proteome were monitored, coupled with changes in the profile of targeted secondary metabolites.

Quantitative proteomics approach (nLC-MS/MS platform coupled with bioinformatics) found that proteins associated with redox homeostasis, biosynthesis of amino acids, and lipid catabolism were upregulated. Proteins from outer cellular structures were downregulated, including transporters responsible for peptides, sugars, amino acids and polyamines, and the crucial TolB protein of the Tol-Pal system, required for the structural formation of the outer membrane layer. In accordance with the altered redox homeostasis proteins, an increased amount of pyocyanin, a key redox shuttle, and the upregulation of the siderophore, pyoverdine, responsible for iron homeostasis, were found.

Production of extracellular molecules, e.g., pyocyanin, pyoverdine, exopolysaccharides, lipase, and alkaline protease, was significantly increased in *P. aeruginosa* san ai exposed to NC. Overall, NC at sublethal concentrations induces profound metabolic changes in *P. aeruginosa* san ai and provokes increased secretion of extracellular virulence factors [2].

Acknowledgements
Nanoceria was synthesized and characterized by Ljiljana Živković from the Vinča Institute of Nuclear Science, University of Belgrade.

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Beyond Platinum: Anticancer Activity of Cu(II), Sn(IV), and Ruthenium Complexes

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Metal-based coordination compounds have emerged as promising alternatives or complements to conventional platinum-based anticancer agents. This study introduces a series of Cu(II), Sn(IV), and ruthenium complexes, designed and characterized for their in vitro cytotoxic activity against selected human cancer cell lines. Cu(II) complexes, featuring Schiff base or N,N,O-donor ligands, exhibit potent DNA binding and redox-mediated ROS generation, driving significant growth inhibition and apoptosis-like cell death [1]. Sn(IV) derivatives, stabilized by chelating or macrocyclic ligands, display enhanced lipophilicity and membrane permeability, which correlate with superior antiproliferative effects and selective toxicity toward tumor cells [2]. Ruthenium complexes both Ru(II) and Ru(III) show efficacy against cisplatin-resistant models, likely through combined DNA interactions, redox modulation, and disruption of cellular redox balance [3]. Comparative analysis across these metal systems uncovers distinct structure-activity relationships, demonstrating how metal center, oxidation state, and ligand design can be optimized for anticancer potency, selectivity, and mechanistic diversity. These results position Cu(II), Sn(IV), and Ru coordination compounds as strong candidates for next-generation metal-based chemotherapeutics (Fig. 1).

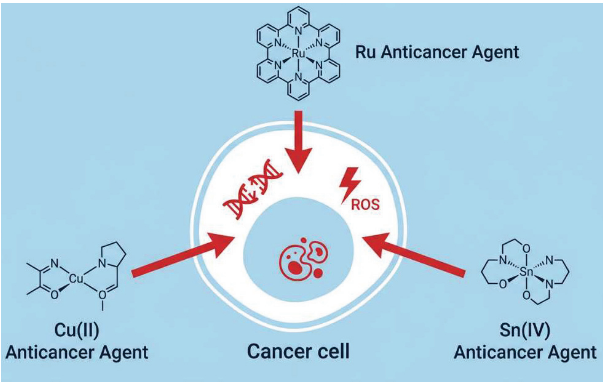

Figure 1. Schematic illustration of the anticancer potential of Cu(II), Sn(IV), and Ru complexes targeting a cancer cell.

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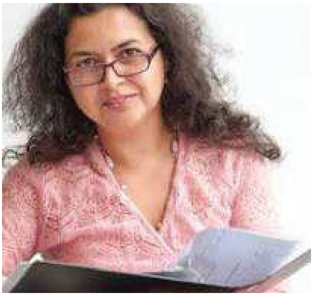

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Structural defects analysis of layered double hydroxides for biomedical applications

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Photodynamic (PDT) and photothermal therapy (PTT) offer promising non-invasive alternatives for cancer therapy using nanoparticles with photoluminescent properties as photosensitizers and photothermal agents, respectively. Photosensitizers generate reactive oxygen species (ROS), while photothermal agents convert light to heat, destroying cancer cells with minimal resistance [1]. These mechanisms may act independently or synergistically, depending on laser source, pH, oxygen, temperature, or structural defects.

In this work we propose, using bioinspired MgAl and CoAl layered double hydroxides (LDH), with or without structural defects, to induce tumor cell death via ROS pathways.

Samples were synthesized by co-precipitation from Mg^{2+}, Co^{2+}, and Al^{3+} chlorides at a 2:1 M^{2+}/M^{3+} molar ratio. Structural defects were introduced via alkaline treatment with 2M NaOH. XRD confirmed typical LDH structures, while treated samples showed slight peak shifts indicating strain-induced lattice contraction [2]. FTIR spectra revealed strong CO_2 adsorption at ~1360 cm^{-1}, suggesting defect formation, such as Co^{+}–VO, which retain CO_2 through electron transfer from CO_2 to Co atom vacancies [3-4]. Additionally, micropores may contribute to CO_2 retention due to high surface area and stronger interactions [5]. PL spectra (excitation at 380 nm) revealed structural defects with emissions at 400–500 nm for MgAl and 450–650 nm for CoAl [6]. These findings support the potential of engineered defects in LDH for PDT applications.

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Biofilm in industrial water systems: Challenges in Detection, Monitoring, and Remediation

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Biofilm formation in industrial water systems constitutes one of the most persistent and economically consequential challenges confronting different manufacturing sectors. Structured microbial communities adhering to surfaces within process equipment, pipelines, heat exchangers, and water distribution networks resist conventional cleaning procedures, leading to cascading consequences including reduced thermal transfer efficiency (15–30% losses), unplanned production downtime (24 hours to 7 days per event), product contamination resulting in costly batch rejections and market recalls, with significant human health risks. The global economic impact across these sectors is estimated to exceed $5 billion annually.

This work provides a comprehensive review of current biofilm detection methodologies, encompassing traditional laboratory techniques alongside rapid on-site detection tools. Critically, it also addresses biofilm identification techniques on open surfaces—providing a complete toolkit for both closed and open production environments. A systematic comparison evaluates each technique against criteria for sensitivity, specificity, time to result, cost, and practical applicability, and includes a complete listing of relevant GMP guidelines and international standards.

The work examines emerging sensor-based in-line detection technologies enabling real-time continuous monitoring. For each technology, the working principle, performance characteristics, and industrial readiness level are critically assessed.

Biofilm remediation strategies are reviewed across chemical treatments (comparing conventional strong detergents and oxidising biocides with enzymatic-based approaches targeting specific EPS components), thermal treatments, and other approaches.

Finally, it concludes that effective biofilm management requires a holistic strategy that integrates hygienic design principles, continuous sensor-based monitoring, validated multimodal cleaning protocols, and alignment with evolving regulatory frameworks. The transition from reactive to proactive biofilm management, enabled by digital monitoring technologies and data-driven decision-making, represents a critical pathway toward safer products, sustainable manufacturing, and regulatory compliance across the food, pharmaceutical, and cosmetics industries.

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Pan-Life-Carpet for Terrestrial Surface Restoration and Pollution Mitigation

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Anthropogenic activities, desertification, and natural hazards (e.g., floods and storms) increasingly lead to the degradation of terrestrial surfaces, particularly in sedimentary environments such as loess deposits. These processes contribute to enhanced particulate matter emissions, deterioration of air quality, and subsequent contamination of aquatic systems, ultimately affecting ecosystem stability and human health. In parallel, highly erodible and contaminated sites such as mining tailings represent persistent sources of soil, air, and water pollution.

In response to these challenges, we propose a novel nature-based solution termed the Pan-Life-Carpet (PLC) [1], designed for both restoration and stabilization of degraded and contaminated land surfaces. The concept is grounded in the BLOCDUST theory [2] and the Synergosis framework [3], emphasizing synergotic interactions among biotic and abiotic components.

The PLC integrates selected strains of cyanobacteria, photosynthetic, nitrogen-fixing microorganisms with high resilience to extreme conditions, with biodegradable carriers and hygroscopic polysaccharide matrices (e.g., alginates and agar-like substances). This composite system enhances water retention, supports microbial growth, and accelerates the formation of biocrusts, which are critical for surface stabilization of degraded lands in arid and semi-arid environments.

Unlike conventional mitigation approaches relying on pollutant bioaccumulation, our recent work shifts focus toward ecological stabilization. In contaminated systems such as mine tailings, the proposed PLC employs autochthonous microbial strains with low heavy metal accumulation capacity, combined with additional biological components (bacteria, fungi, moss spores, and plant seeds), to enhance particle binding, promote biocementation and surface stabilization, ultimately supporting biodiversity development. This strategy reduces pollutant mobility and prevents their transfer into surrounding ecosystems, particularly aquatic environments.

The PLC platform has been evaluated through multiple research initiatives, demonstrating its versatility across different environmental contexts, from loess sediment restoration to mine tailing stabilization. Ongoing developments include structural optimization of the PLC components (biodegradable materials and polysaccharide matrices) to enhance water retention and biomass density.

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After completing his undergraduate studies in chemistry, he joined Belinka Perkemija's Research and Development department, where his role evolved from R&D Technologist to Sector Head, reflecting a progressive expansion of technical and leadership responsibilities. He has over 6 years of hands-on experience in industrial R&D, focusing on the development of value-added hydrogen peroxide-based formulations, advanced process technologies, and sustainable chemical solutions.

His technical expertise spans Design of Experiments (DoE), formulation and process optimization, scale-up from laboratory to production, and structured technology transfer into manufacturing environments. A significant part of his work is dedicated to sustainable chemical innovation, including the development of hydrogen peroxide systems, carbon capture and utilization (CCU) technologies, intensified gas–liquid processes, and emerging hydrogen-related process concepts. His research approach is inherently interdisciplinary, combining chemical science with process engineering, material considerations, environmental performance, and industrial feasibility.

Andrej is (co-)author of one granted patent and multiple international patent applications (PCT, EP, national level), covering innovative purification processes, detergent formulations, reaction systems, and process equipment. Several of these innovations have received national innovation awards from economic and scientific institutions, underscoring their technological relevance and industrial impact.

In his current role, Andrej leads the Development sector with full organizational responsibility across R&D, Materials Management, Product Management, and Technological Development. He defines and executes development strategy, ensures alignment of market, regulatory, and customer requirements with robust technical solutions, and oversees the structured transfer of products and technologies into production. His role includes direct accountability for cross-functional coordination and performance across these functions, enabling predictable delivery, clear governance, and effective decision-making throughout the development lifecycle.

Beyond internal leadership, Andrej plays a key role in Belinka Perkemija's international research and innovation activities. He serves as the company's Legal Entity Appointed Representative (LEAR) for the EU Funding & Tenders Portal and leads the organization's participation in EU-funded research and innovation programs, including Horizon-type projects. In this role, he contributes to the strategic positioning of industrial R&D within European innovation frameworks and supports long-term capability building through collaborative research.

*His work is characterized by an **interdisciplinary approach**, combining chemical science, process engineering, sustainability assessment, and industrial decision-making. Andrej is particularly focused on building **robust, high-performance development organizations**, strengthening development processes, and ensuring long-term value creation through technically sound, sustainable innovations.*

A 3-in-1 Hydrogen Peroxide-Based Liquid Detergent for Effective Low-Temperature Laundering

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The increasing adoption of low-temperature household laundering programs (<40 °C), driven by European sustainability objectives, has significantly reduced the microbiological efficacy of conventional detergents. Insufficient hygiene under these conditions promotes biofilm formation in washing machines and allows pathogenic microorganisms to persist on textiles. Current hygiene concepts often rely on the combined use of detergents, disinfectants, and machine cleaners—frequently based on chlorine or quaternary ammonium compounds—resulting in increased chemical consumption and environmental burden.

This contribution presents a market-ready 3-in-1 liquid detergent, covered by an international patent application, that integrates cleaning performance, textile disinfection, and washing machine hygiene into a single all-in-one product, thereby reducing the overall number of chemicals required for effective laundering. The formulation is based on hydrogen peroxide as an environmentally favourable active substance, decomposing into oxygen and water while delivering strong antimicrobial performance. The formulation concept, stabilization strategy, and activation mechanism are protected under international patent application WO 2025/215046 A1.

The key technological advancement lies in the long-term stabilization of hydrogen peroxide within a complex detergent matrix and its controlled activation during the washing cycle, enabling in situ generation of reactive oxygen species in synergy with selected surfactant systems. This approach enables effective antimicrobial action even at reduced washing temperatures.

Antimicrobial efficacy and hygiene performance were evaluated by independent laboratories in accordance with the relevant European EN standards applicable to laundry disinfection and washing-machine hygiene. Among these, testing at accredited laboratory according to EN 17658 confirmed that the detergent achieved log reductions ≥6 against tested bacteria and yeast under realistic low-temperature laundering conditions. The overall test program verified reliable disinfection performance, effective suppression of laundry-associated and biofilm-forming microorganisms, and preservation of high washing efficiency.

All ingredients of the detergent are fully biodegradable, and the formulation is free from chlorine-based compounds and quaternary ammonium compounds, substantially reducing environmental impact and improving material compatibility. The product is registered as a biocidal product in Slovenia, demonstrating regulatory compliance and readiness for broader EU market introduction under the Biocidal Products Regulation.

By combining cleaning performance, antimicrobial efficacy, and washing machine hygiene in a single biodegradable formulation, this patent covered 3-in-1 solution establishes a new benchmark for sustainable low-temperature laundering and represents an attractive platform for industrial partnerships, licensing, and co-development in the detergent and home-hygiene sectors.

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With his rich expertise in Leaching, Nanoparticles, Kinetics, Nanoparticle Synthesis, Wastewater Treatment, and various other skills, Dr. Stopić has made significant contributions to numerous research projects. His research has been supported by the EU, DFG, EU/NRW, and BMBF, leading to advancements in areas such as the integrated treatment of industrial wastes, development of sustainable exploitation schemes for Europe's rare earth ore deposits, and nanoparticle morphology in aerosol synthesis.

Dr. Stopić has also collaborated with several industry partners, such as Outotec, Bayer MaterialScience, and Cronimet, on projects ranging from high-pressure leaching of lateritic ore to recycling of zinc from waste dust.

Sustainable Chemistry with Green Formulations in Transformation of Bauxite Residues in Metals

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Bauxite residue, also known as red mud (RM) is waste produced during alumina production in Bayer process in Factory Nova Alumina, Zvornik. It is posing a significant threat to the environment due to its high alkalinity, fine particle size and complex structure various compounds. This study presents a sustainable, approach to its utilization, with focus on the recovery of valuable metals such as titanium and iron using sustainable metallurgical operations such as reduction with hydrogen, leaching, filtration, solvent extraction and electrowinning. Different green formulation was presented via decarbonizing technologies. Firstly, red mud was subjected to hydrogen reduction in order to selectively remove iron, which can be used and transferred in the steel industry. Separation of iron and solid residue was done using magnetic property of iron and magnetite. Solid residue is further processed in acid leaching with high pressure of oxygen in an autoclave. The obtained leaching efficiency of titanium was above 95 %. Leaching process optimizes various process parameters to extract titanium in the form of titanium oxy sulphate as well as iron and aluminium. Solvent extraction was used for purification of the acidic solution based on titanium producing ammonium titanium fluoride. The remaining solid residue, primarily composed of calcium sulphate and silica, was evaluated for potential use as an adsorbent in wastewater treatment. The final step is molten salt electrolysis for production of titanium. This innovative process demonstrates an efficient method of bauxite residue utilization with near zero waste concept, offering a promising solution to both environmental and industrial challenges.

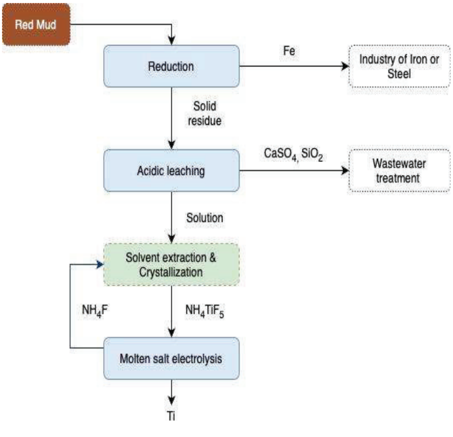

Figure 1. Proposed research strategy for transformation of bauxite residues in titanium and iron

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This proposed strategy is still under investigation at the laboratory scale and offers certain advantages over traditional titanium extraction technologies, that use titanium chloride as a starting material.

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Green extraction of bioactives from fruit and vegetable by-products for food Applications

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Food industry waste generates significant environmental and economic burdens, including financial costs, resource contamination, and greenhouse gas emissions, highlighting the urgent need for sustainable waste management solutions[1]. The lecture will be focused on the research dedicated to valorization of bioactives from fruit and vegetable by-products and their incorporation into food and cosmetics products using green extraction approaches (Figure 1). Fruit and vegetable by–products were valorized by extracting bioactive pigments with edible Natural Deep Eutectic Solvents (NADES), followed by characterization of bioactive content, antioxidant activity, antimicrobial effects, antidiabetic, and anti-obesity potential, and Caco-2 cytotoxicity. The most potent green extracts were selected, and their applicability as natural food additives in cookies[1] and candies was evaluated.

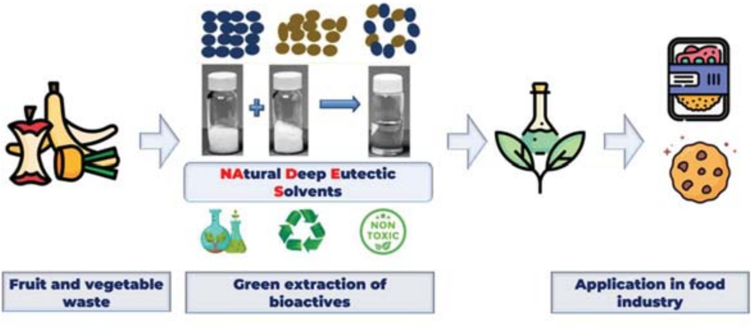

Figure 1. Valorization of fruit and vegetable waste using green extraction.

The lecture will also emphasize the integration of NADES-derived green extracts obtained from fruit and vegetable waste into calcium alginate biofilms as a model for sustainable active food-packaging systems. Comprehensive evaluation of antioxidative, anti-browning, and antimicrobial activities against foodborne pathogenic bacteria, together with detailed structural characterization, demonstrates that selected NADES–extract combinations significantly enhance the bioactivity of the films. As a result, these biofilms provide improved protection for perishable foods. This lecture will highlight a sustainable, circular approach for converting food waste into high-value bioactive ingredients with multifunctional applications in food, cosmetics, and active packaging systems.

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Corn stover-derived biocomposites: Enabling circularity in material development

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The study investigated the production and end-of-life performance of innovative biocomposite materials, produced using ground corn stover (CS) short fibers combined with three different biopolymer matrices: starch, alginate and poly(hydroxybutyrate-*co*-hydroxyhexanoate), PHBH, branded as SferiCorn. The new biocomposite materials were produced without any synthetic additives. Comprehensive characterization including analyses of thermal behavior (DSC/TGA), swelling capacity, chemical structure (FTIR), morphology (SEM), and degradation under composting, hydrolytic, and enzymatic conditions were done. Findings revealed that the choice of matrix significantly shaped both material properties and degradation pathways: starch-based composites degraded quickly in composting and aqueous environments, alginate-based composites showed moderate degradability, while PHBH-based composites demonstrated enhanced stability. The results arised from the charactrerization and degradation patterns served for the selection of the best candidate in terms of mechanical properties, biocomposites with PHBH in this case, for product prototyping. As a proof-of-concept and a key innovation, a coat-hanger prototype was created, emphasizing a sustainable, scalable design that avoided synthetic additives and replaced conventional plastics and metals with a circular, bio-based alternative [1]. In addition, within a circular bio-economy framework, SferiCorn composites were upcycled into bacterial nanocellulose (BNC) supporting waste managaments approach which transforms agricultural residues, that would otherwise be discarded, into high-value, sustainable materials. Based on a screening cradle-to-gate carbon estimate, the SferiCorn PHBH biocomposite reached ~900g CO_2 e/kg composite, corresponding to ~50% of the carbon footprint of conventionally used polypropylene.

This work highlights the valorization of agricultural waste and demonstrates the potential of corn stover in application-specific biocomposites with customizable end-of-life destiny, advancing both sustainability and circular material innovation.

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His primary field of scientific research within Analytical Chemistry is separation methods. In recent years, he has been intensively involved in food chemistry, with a special focus on polyphenols. These secondary plant metabolites are excellent markers for assessing botanical and geographical origin, primarily of honey and bee products, grapes and wine, as well as fruits and vegetables. His most recent research is devoted to the application of polyphenols in medicine. More than ninety of his publications refer to food analysis, while over forty are dedicated to honey and bee products such as propolis, bee bread, and pollen.

He is one of the founders of the Innovation Center and the Center of Excellence of the Faculty of Chemistry, and he was also the Head of the Laboratory for Food Authenticity.

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Polyphenols of domestic grapevine variety from Serbia

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Polyphenols represent an important group of secondary metabolites. Grapevines are a rich source of these biologically active compounds, which are key determinants of grape and wine quality, and play significant roles both in plant physiology as well as in human health [1]. The polyphenolic composition of grapes varies markedly among varieties and berry tissues [2]. Furthermore, the study of polyphenols can provide valuable information about the botanical and geographical origin of grapes, which is of great importance for quality assessment.

Within the framework of this research, the polyphenolic profiles of several indigenous grape varieties were investigated in detail, including **Prokupac, Plovdina, Smederevka, Black and White Tamjanika, Kreaca, and Vranac**. The obtained results were compared with those of well-known international grape varieties, **Cabernet Sauvignon** and **Chardonnay**.

The results showed that the indigenous varieties are exceptionally rich in these compounds. In particular, **Prokupac** and **Vranac** exhibited very high levels of flavan-3-ols, while the anthocyanin content in these varieties exceeded the levels found in **Cabernet Sauvignon** [3]. Finally, the polyphenolic profiles of **Vranac grapes** were compared with those of **one-year-old wine produced from this grape variety,** which is highly relevant for optimizing wine production with respect to polyphenol content [2].

These findings contribute to the characterization of regional grape varieties and highlight differences in the distribution of polyphenolic compounds between grapes and the corresponding wines. Such differences reflect transformations occurring during the winemaking process and provide valuable insights for optimizing polyphenol content in wines.

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New Frontiers and Sustainable Strategies for Next-Generation Latent Fingerprint Visualization

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Latent fingerprint (LFP) visualization remains a key method for personal identification in forensic science, yet many conventional techniques rely on toxic materials and show limited sensitivity on complex or aged samples. This review highlights emerging, sustainable strategies for next-generation LFP visualization, focusing on polymer-based systems, eco-friendly materials, and advanced nanostructured formulations that improve detection sensitivity and evidential value. Recent advances include physical, physico-chemical, and optical methods utilizing (bio)polymers, fluorescent systems, polymer micelles, and functional nanomaterials designed to interact with fingerprint residues such as sweat, lipids, and amino acids [1,2]. While traditional powder dusting remains widely used due to its simplicity and low cost, recent studies demonstrate that polymeric materials can significantly improve sensitivity and visualization quality through tailored chemical interactions with fingerprint residues (Figure 1a) [3]. Fluorescent polymer matrices and dye-doped biopolymers (e.g., starch-based systems) provide improved contrast, stability, and reduced toxicity. Polymer micelles and conjugated polymer nanoparticles enable multicolor emission and high-resolution ridge visualization under UV light. Additionally, nanostructured polymers and carbon-based nanomaterials enhance detection via high surface area, selective binding, and strong fluorescence [4-7].

Beyond currently explored materials, sustainable strategies are gaining increasing importance in forensic chemistry. One promising direction is the use of recycled poly(ethylene terephthalate) (PET) obtained via glycolysis processes, which produces oligomers and monomers that can serve as precursors for functional polymeric materials or fluorescent matrices used in fingerprint visualization (Figure 1b) [8]. Another promising approach involves zeolite-based materials, which offer high surface area, tunable porosity, and strong adsorption, enabling efficient interaction with fingerprint residues (Figure 1c). Importantly, many natural zeolites can protect and stabilize DNA against environmental stress (UV, hydrolysis, heat), suggesting that zeolite-based developers could allow simultaneous fingerprint visualization while maintaining DNA for further analysis [9-11].

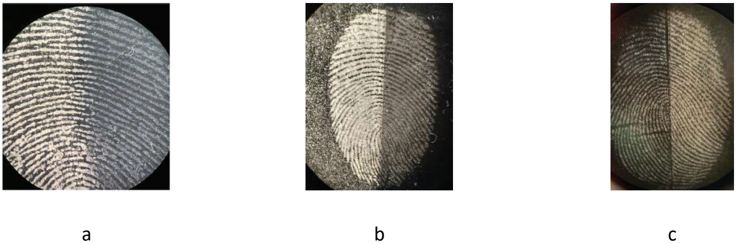

Figure 1. Visualization of latent fingerprints using: a) chitosan-based, b) PET-based; and c) zeolite-based powders (left-hand sides on each LFM).

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Overall, polymeric and nanostructured materials represent a rapidly advancing field, offering environmentally responsible and highly efficient alternatives for LFP visualization, despite the absence of a universal method.

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Her research interests focus on laser-induced breakdown spectroscopy (LIBS) and its applications in plasma diagnostics, material characterisation, and spectral line shape analysis. She has been involved in the NOVA2LIBS4fusion project, dedicated to advancing LIBS diagnostics of fusion reactor plasma-facing components, funded by the Science Fund of the Republic of Serbia. More recently, her work has expanded into forensic applications of laser-induced plasma, including the acoustic-based detection of explosive traces in collaboration with ENEA Frascati Research Center, Italy.

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Acoustic Signatures in LIBS based Detection of Explosive Traces

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The rapid and reliable detection of explosive traces remains a pressing challenge in forensic science and public security. This lecture presents a novel approach to explosive identification that exploits the acoustic signal generated when a nanosecond laser pulse (30 mJ, 1064 nm) interacts with trace residues on a silica wafer - a method operating alongside Laser-Induced Breakdown Spectroscopy (LIBS) [1,2].

When the laser pulse strikes a solid target, it creates a plasma and propagating shockwave captured by a nearby microphone. Explosives, specifically PETN, RDX, and HMX, produce a measurably faster pressure wave rise, greater amplitude, and broader wavefront compared with inert substances such as soils, carbonates, and ash. These differences become especially clear after subtracting a reference signal from the cleaned substrate, isolating the true material response.

Four signal features were identified as diagnostic and combined in a Linear Discriminant Analysis (LDA) framework, allowing classification of all three explosive types with zero false positives. HMX was correctly distinguished from PETN and RDX in approximately 90% of cases. Detection limits were estimated at 15 ng, 9.6 ng, and 18 ng for PETN, RDX, and HMX respectively - competitive with portable instruments such as ion mobility spectrometry. A key limitation was that explosives deposited via wet transfer resisted laser vaporisation, preventing reliable detection up to 30 ng.

The lecture will cover the underlying physical principles, signal processing methodology, statistical classification, and implications for forensic field deployment.

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He obtained his undergraduate degree from the Faculty of Chemistry and Chemical Technology in Maribor and pursued postgraduate studies at the Faculty of Chemistry and Chemical Technology, University of Ljubljana. During his doctoral studies, he conducted research as a young researcher at the National Institute of Chemistry in Ljubljana, where he established a strong academic foundation in chemistry and chemical engineering.

His professional focus has been on materials science, particularly on zeolite-based materials and their industrial applications. At Silkem, he is actively engaged in research and development of advanced functional materials. His work includes the synthesis, optimization and shaping of zeolite materials for applications such as adsorption and catalysis.

In addition, he has been involved in collaborative research projects with academic and research institutions, contributing to effective knowledge transfer between industry and academia. Tomaž Fakin is also a co-author of several scientific and technical publications, covering topics such as zeolite synthesis, post-synthesis modification and the granulation of functional materials.

Zeolites – Small pores, Great Solutions

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Zeolites are crystalline aluminosilicate materials characterized by their well-defined microporous frameworks, high surface areas, and remarkable ion-exchange and adsorption properties. Their unique structures, composed of interconnected tetrahedral units forming uniform channels and cavities on the molecular scale, enable highly selective interactions with a broad spectrum of chemical species. This lecture examines the fundamental structural characteristics of zeolites and highlights how their “small pores” underpin “great solutions” across diverse scientific and industrial applications.

Low-silica zeolites (LTA, FAU) have a well-established industrial legacy, however, their development continues to evolve. The persistent emergence of novel applications highlights their versatility and adaptability, positioning them as key materials in addressing modern technological and environmental challenges. Despite their mature industrial presence, low-silica zeolites are far from static materials. On the contrary, they are currently experiencing renewed scientific and industrial interest, largely driven by the demand for sustainable and efficient technologies. Advances in materials science and improved understanding of structure–property relationships have opened pathways to novel and increasingly sophisticated applications.

For industrial deployment, zeolites and molecular sieves must be transformed from fine crystalline powders into mechanically robust, shaped bodies with well-defined mass transport properties. Consequently, forming and granulation processes such as extrusion, pelletization, spray drying, and granulation are therefore critical steps in enabling their practical use in fixed-bed reactors, adsorption columns, and separation units. These processes typically require the incorporation of binders (e.g., clays, alumina, or silica) to enhance mechanical strength, however, binder selection and content must be carefully optimized to minimize pore blockage and preserve intrinsic microporosity. Recent developments have focused on the fabrication of binder-free or self-bonded zeolite bodies, as well as hierarchical structuring approaches that introduce meso- and macroporosity to enhance diffusion and accessibility of active sites. Additionally, control over particle size, shape, and porosity distribution plays a crucial role in determining pressure drop, thermal stability, and overall process efficiency. As a result, modern forming strategies are increasingly application-specific, aiming to balance mechanical integrity with optimal adsorption and catalytic performance, thereby effectively bridging the gap between laboratory-scale materials and industrial implementation.

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Digital Tools for Knowledge Transfer – CSD4NCI Workshop

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Digital tools are essential for supporting the development of key 21st-century competencies, enabling the efficient handling, analysis and communication of increasingly large and complex datasets. The Cambridge Structural Database (CSD) is the world's largest crystallographic repository, containing over 1.4 million crystal structures, supported by a suite of applications (CSD Portfolio) designed for efficient data management.[1] Beyond its primary role, the CSD can also be viewed as an extensive database of noncovalent interactions. These interactions are fundamental to many areas of modern chemistry, including catalysis, materials design, drug discovery, and crystal engineering.[2]

To support the knowledge transfer in this field through the use of digital tools, we have developed a workshop (Figure 1) that introduces students to the complex and diverse world of noncovalent interactions via the CSD Portfolio. The project, entitled *Empowering Chemistry Students to Discover Noncovalent Interactions via the Cambridge Structural Database – CSD4NCI Workshop*, is supported by the Cambridge Crystallographic Data Centre (CCDC) through CCDC Engagement Grants initiative. Within this framework, we demonstrate how cheminformatics analysis of CSD data – primarily using ConQuest and Mercury – can convert dispersed structural information into generalizable principles on noncovalent interactions. In this way, our workshop highlights how digital tools can facilitate effective knowledge transfer across diverse areas of chemistry where such interactions play a critical role.

Figure 1. CSD4NCI Workshop and how to access its contents.

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POSTER PRESENTATIONS

Session 1
Physical Chemistry in Applied Science and Technology

Nanosized molybdenum copper deposited on carbon nanotubes as a bifunctional oxygen electrocatalyst

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Electrochemical energy technologies such as alkaline fuel cells and metal-air batteries depend heavily on the oxygen reduction reaction (ORR) and oxygen evolution reaction (OER). Noble metal-based catalysts, including platinum for ORR and iridium-ruthenium oxides for OER, demonstrate outstanding catalytic activity, their widespread application is limited by high cost and scarce availability. These challenges have driven extensive research toward the design of alternative electrocatalysts that combine low cost, high efficiency, and facile, scalable synthesis, to enable more economically viable applications.

This study presents a detailed investigation of nanosized molybdenum-copper catalysts supported on carbon nanotubes (MoCu/CNT) for bifunctional oxygen electrocatalysis in alkaline media. The prepared MoCu/CNT catalyst exhibited activity toward both OER and ORR. For the OER, an onset potential of 1.64 V and a current density of 33 mA cm^{-2} at approximately 2.0 V were achieved. In the case of ORR, a mixed two- and four-electron transfer pathway ($n \approx 2.7$) was identified, along with a diffusion-limited current density of about 2.3 mA cm^{-2} at 0.4 V and 3600 rpm. Overall, the obtained electrochemical performance is in good agreement with previously reported values for similar systems [1-3]. MoCu/CNT catalysts represent a promising and economically viable alternative to conventional noble-metal-based electrocatalysts such as Pt and IrO_2, owing to their facile, fast, and cost-effective synthesis.

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Effect of Electrolyte Medium on the Capacitive Properties of Pd/CA and Pd–Fe_2O_3/CA Systems

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Electrochemical capacitors are promising devices for fast energy storage, with their performance strongly depending on the electrode material and the electrolyte environment. Three-dimensional carbon aerogels (CAs) are highly porous, lightweight, and conductive materials, which provide an excellent framework for metal nanoparticles and facilitate efficient ion transport [1,2]. In this study, two carbon aerogel-based materials, Pd/CA and Pd–Fe_2O_3/CA, were investigated for the charge storage in three different electrolytes: 3 M KOH, 1 M Na_2SO_4, and 1 M H_2SO_4.
Cyclic voltammetry measurements were performed at different scan rates, and specific capacitance values were calculated. For Pd/CA, the highest capacitance was observed in 3 M KOH (780 F g^{-1} at 20 mV s^{-1}), followed by 1 M Na_2SO_4 (240.8 F g^{-1}) and 1 M H_2SO_4 (120.8 F g^{-1}). The Pd–Fe_2O_3/CA sample showed lower capacitance values in all electrolytes: 102.2 F g^{-1} in 3 M KOH, 76.7 F g^{-1} in 1 M Na_2SO_4, and 53.4 F g^{-1} in 1 M H_2SO_4.

These results indicate that the capacitive performance strongly depends on both the catalyst composition and the electrolyte environment. Pd/CA showed superior charge storage, especially in alkaline conditions, which highlights the importance of catalyst - electrolyte compatibility in the design of high-performance supercapacitor systems.

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The Specific Surface Area and Porosity Modulation of Clay Materials with Graphene Nanoplatelets

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The specific surface area (SSA) and porosity of clay-based materials strongly influence their properties and potential applications. The properties of clay materials depend on particle arrangement and microstructure, which are commonly evaluated using techniques based on gas adsorption [1]. Previous studies have shown that the SSA of graphene nanomaterials, which is closely correlated with their pore structure, plays a key role in determining the performance of composite systems [2]. In this study, clay/graphene composites were prepared to investigate the effect of incorporating graphene nanoplatelets on the properties of the clay. Graphene nanoplatelets with controlled flake sizes were mixed with a kaolinite-based clay powder, and their influence on porosity and specific surface area was assessed using nitrogen gas adsorption at 77 K. The SSA was calculated using the Brunauer–Emmett–Teller (BET) method in the appropriate relative pressure range (P/P_0), while pore structure characteristics were derived from the adsorption–desorption isotherms. The results suggest that the incorporation of size-selected graphene nanoplatelets alters the physicochemical properties of kaolinite-based materials, enabling the controlled tuning of clay properties. Such tunability opens new possibilities for designing clay-based construction materials with enhanced moisture buffering, thermal insulation, and adsorption performance, as well as for applications in catalysis and environmental adsorption technologies.

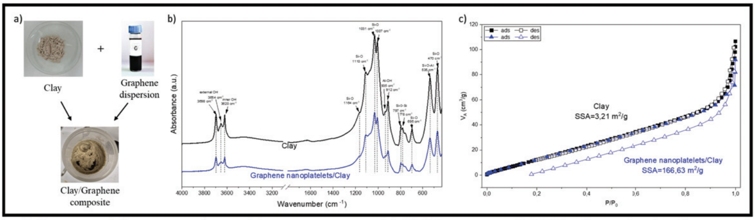

Figure 1. a) Images of the composite and its components; **b)** FTIR spectra; **c)** BET adsorption isotherms of clay and graphene/clay composite.

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Comparison of different methods for the synthesis of Schiff bases of aldehydes with thiocarbohydrazide

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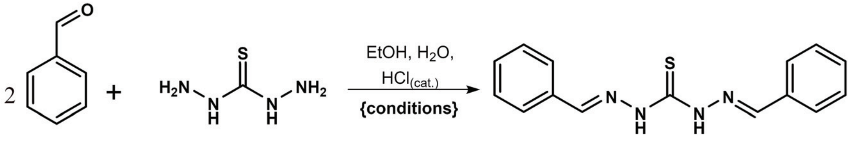
Schiff bases are condensation products of primary amines with carbonyl compounds. The functional group of these compounds is an azomethine group. They have potential applications as ligands in coordination chemistry, but also in the field of bioorganic chemistry due to their possible antimicrobial, antitumor and antioxidant activity. Thiocarbohydrazide (TCH) is an organic compound with the chemical formula $NH_2NH–CS–NHNH_2$, which is a thiourea derivative in which both amino groups are replaced by hydrazine groups. The most favorable conditions for the reaction are achieved when the pH is between 3 and 5.

In our experiment, we examined obtaining 1,5-*bis*(phenylmethylidene)carbonthiohydrazide in the reaction of benzaldehyde with thiocarbohydrazide, using two methods: conventional (thermal) and ultrasound. High-intensity ultrasound, when passing through the material, causes acceleration of chemical reactions, increases the rate of diffusion, disperses aggregates, and also destroys enzymes and microorganisms. The course of the reaction was monitored by thin layer chromatography (TLC). UV light, *p*-anisaldehyde reagent (PAA), and 50% sulfuric acid solution were used to detect the spots, after which the plates were heated on a stove for better detection. The equation for the described reaction is presented in Scheme 1.



Conditions and yelds:
1) 80°C, 3 h (P = 64,5%)
2) ultrasound, 25°C, 20 min; A=60%, pulse mode = 100% (P = 97,6%)

***Scheme 1**. Reaction between benzaldehyde and thiocarbohydrazide under different conditions*

In the classical method, benzaldehyde and a drop of concentrated HCl were added to the clear thiocarbohydrazide solution. A mixture of aldehyde and amine is heated for 3 hours at reflux. After crystallization and removal of the solvent, followed by recrystallization from absolute ethanol, the final product was obtained in a yield of 64,5%.

In ultrasound method, benzaldehyde was added to the carbohydrazide solution with the addition of a catalytic amount of concentrated hydrochloric acid, and the mixture was further stirred with the help of an ultrasonic probe (Figure 1, a). Using an ultrasound probe, ultrasound is transmitted directly into the solution. After 20 minutes, at an amplitude of 60% and a pulse mode of 100%, the reaction mixture is poured into a beaker and left overnight to evaporate most of the solvent. Already during the first few minutes of cooling, the separation of white fluffy crystals can be observed (Figure 1, b). The rest of the solvent was removed by vacuum filtration, and the crude crystalline substance was

Miljan Bigović – 0000-0003-2300-3063, Marija Kaluđerović – 0009-0007-5800-3107, Đura Nakarada – 0000-0002-0154-6430, Željko Jaćimović – 0000-0002-2905-4526 recrystallized from absolute ethanol (5 mL of ethanol was added to 1 g of the crude substance). The product was obtained in the form of a pale yellow powdery substance, with a yield of 97.6%.

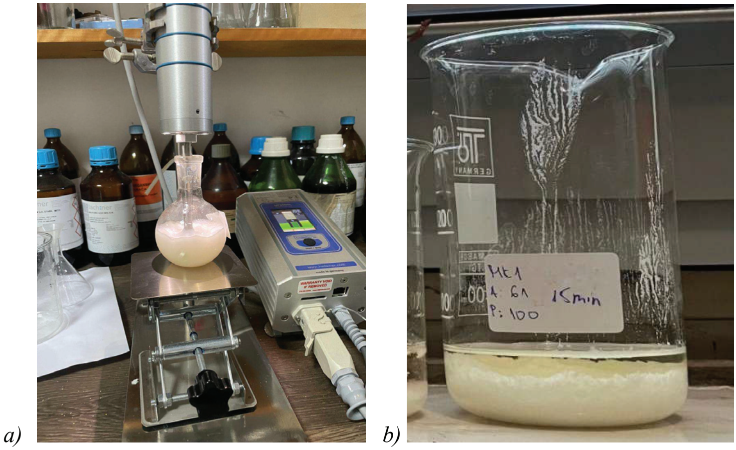


***Figure 1**. a) Ultrasonic probe synthesis equipment. b) Crystallization of crude product*

Based on the experimental data obtained, it can be concluded that the ultrasonic method enables significantly higher yields and higher efficiency compared to the conventional method, which requires a longer time and gives lower yields. From everything previously stated, it can be concluded that the application of an ultrasonic probe represents a significantly more efficient and practical approach to the synthesis of Schiff bases compared to conventional methods.

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Alkaline electrolyzer with asymmetric electrolytes and nickel electrodes modified by spontaneous galvanic replacement

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This study challenges the conventional catalyst-centered approach to alkaline water electrolysis by emphasizing the importance of simultaneous electrolyte optimization. In traditional systems, both electrodes operate in a single electrolyte, which imposes a compromise because the hydrogen evolution reaction (HER) and oxygen evolution reaction (OER) are governed by distinct adsorption energetics, interfacial electric fields, and surface redox processes. As a result, identical electrolyte conditions are inherently suboptimal for both half-reactions. To overcome this limitation, an alkaline electrolyzer was developed that enables independent optimization of the anodic and cathodic environments using two distinct electrolytes separated by an ion-permeable, molecule-impermeable membrane. This configuration allows precise adjustment of reaction conditions for HER and OER, leading to improved overall energy efficiency. The system employs nickel electrodes due to their stability in alkaline media and low cost, which are further modified by galvanic deposition of thin noble metal layers – platinum on the cathode (Figure 1, left) and rhodium on the anode (Figure 2, left). This approach reduces overpotentials, enhances catalytic activity, and minimizes the use of noble metals. The proposed electrode-electrolyte co-design strategy results in improved energy efficiency, catalyst durability, and operational flexibility compared to conventional alkaline electrolyzers. Additionally, the galvanic modification method is rapid, requires no binders or high-temperature treatment, and enables immediate electrode use. This concept is broadly applicable and can be extended to other electrochemical systems beyond alkaline electrolysis.

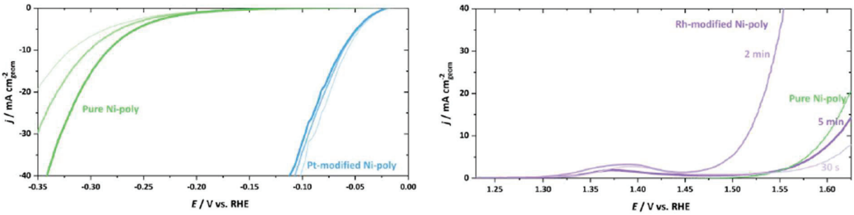

Figure 1. HER activity of Pt-modified Ni cathode (left) and OER activity of Rh-modified Ni anode (right)

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Optimization of Hydrogen Storage in Metal Hydrides via Thermal Enhancement

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This study investigates the optimization of hydrogen storage performance in metal hydride systems through geometrical modifications and the integration of nanofluids as heat transfer enhancement agents. Metal hydrides represent a promising solid-state hydrogen storage solution; however, their practical application is often limited by slow reaction kinetics and insufficient thermal management. In this work, through a numerical study maintained by COMSOL software, we explore the combined effect of geometric design alterations of the storage reactor and the use of nanofluids to enhance heat and mass transfer within the system, Figure 1. Numerical simulations are conducted to evaluate the influence of these parameters on hydrogen absorption kinetics and overall storage efficiency. The results demonstrate significant improvements in thermal performance and storage capacity, offering valuable insights for the design of more efficient hydrogen storage systems.

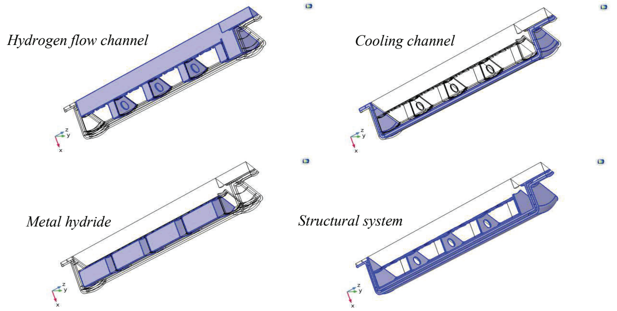

Figure 1. Illustration of the studied model.

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Efficient Removal of Pb(II) Using Modified Lignocellulosic Biomass (IOS): Adsorption Behavior and Mechanism

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Lead contamination in water systems poses a serious environmental and health risk, necessitating the development of efficient and sustainable removal strategies. In this study, modified lignocellulosic biomass (IOS) was evaluated as an adsorbent for Pb(II) removal from aqueous solutions. The biomass was treated using deep eutectic solvents, resulting in increased availability of functional groups and enhanced surface reactivity. Structural characteristics indicate a heterogeneous and porous surface suitable for adsorption processes. Batch adsorption experiments revealed high affinity toward Pb(II), with adsorption capacities in the range of **146.373 mg g^{-1}**, depending on experimental conditions. Rapid uptake was observed in the initial phase, followed by a slower approach to equilibrium, indicating a combination of surface adsorption and diffusion-controlled processes. Kinetic analysis showed that the adsorption follows the pseudo-second-order model, while equilibrium data suggest favorable adsorption behavior on heterogeneous active sites. The process is strongly influenced by pH, which affects both Pb(II) speciation and surface charge of the adsorbent. The adsorption mechanism involves surface complexation with oxygen-containing functional groups, supported by ion exchange and electrostatic interactions. Compared to raw biomass, IOS exhibits significantly improved adsorption performance. These results confirm that modified lignocellulosic biomass represents an efficient, low-cost, and environmentally friendly material for Pb(II) removal from aqueous systems.

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From Cations to Oxyanions: Hybrid Zeolite-Alginate Beads as High-Performance Adsorbents for Advanced Water Treatment

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The efficient removal of chemically diverse pollutants from wastewater requires adsorbents capable of interacting with both cationic and anionic species under batch and continuous conditions. In this study, hybrid zeolite-alginate beads (ANZ-alg) were developed as multifunctional adsorbents for the removal of Pb(II) and Cr(VI), representing model cationic and oxyanionic contaminants. The material was synthesized by immobilizing APTES-modified clinoptilolite within a calcium alginate matrix, combining ion-exchange capacity, surface functionalization, and structural stability. SEM analysis revealed a heterogeneous and porous structure with well-dispersed zeolite particles, ensuring high accessibility of active sites. TG/DTG analysis and swelling tests confirmed satisfactory thermal stability and preservation of the gel matrix integrity in aqueous environments. Batch adsorption experiments showed high maximum adsorption capacities of 141.36 mg g^{-1} for Pb(II) and 72.90 mg g^{-1} for Cr(VI). The adsorption kinetics followed a pseudo-second-order model, while thermodynamic parameters indicated a spontaneous and favorable process. The pH significantly influenced adsorption performance by governing surface charge and speciation of pollutants. FTIR analysis before and after adsorption confirmed the involvement of key functional groups (–OH, $–NH_2$, and Si–O–Si) in pollutant binding. Continuous flow experiments demonstrated stable column performance, with well-defined breakthrough curves and effective adsorption capacities of approximately 89.20 mg g^{-1} for Pb(II) and 54.5 mg g^{-1} for Cr(VI), indicating efficient mass transfer and high bed utilization. The adsorption mechanism is pollutant-dependent and involves multiple interactions: Pb(II) removal is dominated by ion exchange and surface complexation, while Cr(VI) adsorption is governed by electrostatic attraction toward protonated amine groups, along with specific surface interactions. These results demonstrate that ANZ-alg is a highly efficient and structurally stable adsorbent capable of removing both cationic and oxyanionic pollutants, showing strong potential for application in advanced batch and continuous water treatment systems.

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Synthesis of cobalt ferrite nanoparticles via citrate sol-gel auto-combustion: effect of fuel-to-metal ratio on structural and magnetic properties

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Cobalt ferrite ($CoFe_2O_4$) is an important magnetic oxide with a spinel structure, whose coercivity and magnetization can be adjusted by changing the synthesis conditions.

In this work, cobalt ferrite nanoparticles were synthesized using a modified citrate sol gel auto-combustion method. Aqueous solutions of iron and cobalt nitrate/acetate precursors were used, while citric acid served as complexing agent and fuel. The precursor was heated on a hot plate, causing the solvent to evaporate and form a gel, which then underwent a self-propagating combustion reaction. The process resulted in the decomposition of the organic matrix and formation of a porous oxide powder. Obtained products were ground into fine powders and annealed at 750 °C for 3 hours to enhance the crystalinnity. The fuel-to-metal ratio (φ), defined as the molar ratio of citric acid to total metal ions ($Fe^{3+} + Co^{2+}$), was varied as 1.3, 2.2, and 3.0.

Structural and magnetic properties were examined using X-ray Powder Diffraction (XRPD) and Vibrating Sample Magnetometry (VSM), while crystallite sizes were estimated using the Scherrer equation. X-ray diffraction analysis confirmed the formation of a spinel $CoFe_2O_4$ in all samples. The crystallite sizes estimated via Scherrer equation were in the range of approximately 50-70 nm for the annealed samples, and 15-30 nm prior to annealing, depending on the fuel-to-metal ratio. The intermediate fuel ratio resulted in the largest crystallite size post annealing, and the results demonstrate that the fuel-to-metal ratio influences both the initial particle formation and the thermal growth of the $CoFe_2O_4$ nanoparticles. The obtained magnetic properties of the annealed samples showed that the saturation magnetization M_S remained relatively stable, ranging from 69.4 to 72.3 emu/g, confirming the formation of a well-defined spinel phase.

While the samples with fuel-to-metal ratios φ of 1.3 and 2.2 showed relatively low intrinsic coercitivity values (Hci of 170.75 Oe and 145.60 Oe, respectively), a significant increase to 501.27 Oe was observed for the φ = 3.0 value. This strong enhancement suggests increased structural disorder and stronger domain wall pinning, likely arising from combustion in fuel-rich conditions. The proposed approach provides a facile and efficient route for controlled synthesis of nanoparticles with tunable magnetic properties.

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Advancing Carbon Capture Technologies: CO_2 Adsorption on Zeolite 13X

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The continuous increase in atmospheric CO_2 concentration, driven by anthropogenic activities, represents a major environmental challenge and has intensified the development of carbon capture technologies. Among them, adsorption-based processes, particularly within direct air capture (DAC) and carbon capture and utilization (CCU) concepts, have attracted significant attention due to their potential for efficient CO_2 separation and reuse. In this study, zeolite 13X granulate was developed with specific binder concept and investigated as a potential adsorbent for CO_2 capture from air under dynamic conditions. Experiments were performed using a fully controlled EnviroFIL test station, which enables precise regulation of gas composition and operating parameters, as well as continuous monitoring of outlet gas concentration. The adsorption performance was evaluated through breakthrough analysis, allowing determination of breakthrough time and calculation of adsorption capacity. In addition, cyclic stability of the material was assessed using a temperature swing adsorption (TSA) approach, enabling repeated adsorption–desorption operation. The obtained results demonstrate that zeolite 13X exhibits strong affinity toward CO_2 at low concentrations relevant for air capture, with stable and reproducible performance over multiple cycles. These findings confirm the potential of zeolite 13X as an effective adsorbent for direct air capture applications and contribute to the development of sustainable carbon capture technologies.

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DFT Insight into Adsorption-Dominated Methylene Blue Removal on V_2O_5 Nanopowders

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Vanadium pentoxide (V_2O_5) is often presented as a visible-light photocatalyst for dye removal [1], but dye loss does not necessarily mean photocatalytic degradation. It can also come from adsorption. To test this, we combined dye-removal experiments, adsorption measurements, and DFT calculations for V_2O_5 powders prepared by calcination and hydrothermal synthesis, together with commercial V_2O_5. Among the three dyes tested, methylene blue (MB) gave the clearest result. Methyl orange was obscured by vanadate leaching, while rhodamine B showed mixed behavior. For MB, V_2O_5-C and commercial V_2O_5 each removed about 96% of the dye in both light and dark experiments, while V_2O_5-HT removed about 87% under light and 93% in the dark. So illumination had little effect on MB removal. The adsorption results were consistent with pseudo first order behavior. DFT pointed in the same direction: PBE+U gave a 2.18 eV band gap for V_2O_5, matching the measured optical gap of V_2O_5-C, and the MB^+ frontier orbitals were delocalized. Together with the negative V_2O_5 surface charge at neutral pH, this points to electrostatic adsorption as the main removal pathway [2]. In short, MB removal on V_2O_5 is dominated by adsorption, not by visible-light photocatalysis.

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Carbonized PANI/TiO_2 nanocomposites as efficient photocatalyst for degradation of herbicide Lindane and azo dye methyl orange

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In recent years, growing environmental concerns have driven significant interest in developing efficient photocatalysts for sustainable applications, with particular emphasis on the rational design of hybrid nanocomposites that enable enhanced charge separation and tailored surface functionalities to improve overall photocatalytic performance.

In this study, nanocomposites based on the conductive polymer polyaniline (PANI) and colloidal TiO_2 nanoparticles, both carbonized and non-carbonized, were synthesized and their efficiency in the photocatalytic degradation of organochlorine herbicide, such as lindane, and the azo dye methyl orange (MO) was evaluated. The presence of PANI in the composite enhances charge carrier separation, allowed the utilization of both UV and visible light, and improved the overall photocatalytic activity of TiO_2 nanoparticles.

PANI/TiO_2 nanocomposites were prepared through chemical oxidative polymerization of aniline (ANI) in the presence of TiO_2 nanoparticles, using three TiO_2/ANI molar ratios (10, 30, and 50), followed by carbonization at 650 °C. The morphology and structure of the composites were characterized using scanning electron microscopy (SEM), transmission electron microscopy (TEM), Raman spectroscopy and X-ray Diffraction (XRD), while XPS analysis revealed that nitrogen content was highest in samples with a TiO_2/ANI molar ratio of 30:1. Raman and XRD analyses confirmed the presence of TiO_2 nanoparticles in different crystalline phases, which influenced the efficiency of the photocatalytic degradation. Raman analysis also indicated the transformation of PANI from the emeraldine salt form into disordered carbon material.

Among the tested samples, PANI/TiO_2 nanocomposites with an initial TiO_2/ANI molar ratio of 30:1, in both non-carbonized and carbonized forms, exhibited the highest photocatalytic activity in the degradation of MO and lindane. During the degradation process, the carbonized form of the PANI/TiO_2 nanocomposites showed significantly higher photocatalytic activity for lindane, achieving 90% conversion after 60 min of illumination. The oxidative degradation pathways of lindane and MO follow a pseudo-first-order reaction model.

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Polypyrrole/TiO_2 Nanocomposites with Antimicrobial Activity: Structural, Morphological, and Theoretical Insights

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Conducting polymers combine electronic performance, processability, and tunable molecular design, enabling their use in a wide range of applications, including antimicrobial coatings. Polypyrrole (PPy) is particularly attractive due to its high electrical conductivity, environmental stability, simple synthesis via chemical oxidative polymerization, and inherent biocompatibility. However, pristine PPy has limitations in mechanical strength, stability, and charge transport. To address these issues, PPy/TiO_2 nanocomposites were developed, offering improved morphology, electronic structure, and functional properties, including enhanced biological activity.

In this study, PPy/TiO_2 nanocomposites were synthesized via *in situ* oxidative polymerization of pyrrole (Py) in the presence of colloidal TiO_2 nanoparticles, using controlled PPy/TiO_2 molar ratios (40 and 10). The materials were characterized by scanning electron microscopy with energy dispersive spectroscopy (SEM/EDS), Fourier transform infrared spectroscopy (FTIR), Raman spectroscopy, and X-ray diffraction (XRD) to determine their morphology, composition, and structure. To gain insight into PPy–TiO_2 interactions at the molecular level, density functional theory (DFT) calculations were performed using an anatase TiO_2 cluster model with pyrrole oligomers, allowing analysis of binding energies, charge transfer, frontier molecular orbitals, and density of states. The antimicrobial activity of the nanocomposites was evaluated against *Escherichia coli* and *Staphylococcus aureus*, with emphasis on concentration- and time-dependent effects.

By combining experimental and theoretical results, a clear structure–property–activity relationship was established, highlighting the synergistic effect of individual components in the hybrid nanocomposites.

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Examination of surface morphology after processing of nano-layer thin films by femtosecond laser pulses

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Composite materials in the form of nano layer thin films (NLTFs), consisting of alternating layers, are widely used in modern technology because of their unique properties that cannot be found in the bulk material constituents [1]. Among NLTFs, NLTFs composed of Ti in combination with Al, Ni, Zr and Nb form a broad group. They have found applications in microelectronics, biotechnology, neutron and soft X-ray optics, shape memory films, micro-junction solutions, catalysis, sensing, etc. Laser processing of materials is a unique non-contact method which has had broad applications. Spatially, laser pulses, with pulse durations from a few femtoseconds to ten picoseconds, known as ultra-short laser pulses (USLP), are suitable for micro and nano processing. This is due to the well-known facts [2] that in the case of application of USLP irradiations, thermal diffusion is suppressed and the heat affected zone is reduced, even in materials with high thermal conductivity such as metals. Consequently, material processing with USLPs is extremely precise, collateral damage is minimized, and there is no need for post-processing.

The interaction of USLP with NLTF films has been presented. The experimental samples were produced with deposition nanometer metal layers on Si substrate using ion-sputtering. The samples were composed of more than five alternating bi-layers (Ni/Ti, Ti/Al, Nb/Ti) [3,4]. Single and multi-pulse irradiations were done in air with focused and linearly polarized 170 fs laser pulses carrying different pulse energies. Effects of laser induced composition and morphological changes were monitored by microscopy techniques and profilometry. Depending on the number of pulses and their energies, the following results were obtained: (i) with single pulses partial/selective ablation of upper layer/layers from NLTFs, without ablation of the whole thin film was registered, and (ii) with multi pulses irradiation, the laser induced periodical surface structures (LIPSS) were formed. After single pulse selective ablation of the upper layer from NLTFs, as well as after multi pulses LIPSS formation, morphology and compositional changes were examined by scanning electron microscopy. Profilometry was used for quantitative measurements of depths of irradiated areas and LIPSS periodicity.

Experimental insights into the ablation of NLTFs using ultra-short laser pulses are essential for expanding potential applications and for validating current theoretical models describing USLP-material interactions.

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NiZn/Ti and Au-Modified NiZn/Ti Electrocatalysts for Enhanced Hydrazine Oxidation Reaction in Alkaline Media

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Despite its classification as a highly toxic and hazardous compound, hydrazine has emerged as a promising fuel for low-temperature alkaline fuel cells due to its clean reaction pathway. Upon oxidation, hydrazine generates only harmless and non-toxic byproducts, namely nitrogen and water. Its high theoretical potential of 1.56 V and energy density of 5.5 kWh L^{-1} make it an attractive fuel choice for such systems. The present study involves the synthesis and systematic evaluation of transition metal-based catalysts, including NiZn/Ti and Au−NiZn/Ti, for their activity for hydrazine oxidation reaction (HzOR) in an alkaline electrolyte. The catalysts were fabricated using a two-step process involving electrodeposition and leaching. Subsequently, gold crystallites with a loading of 19.2 µg cm^{-2} were introduced via galvanic displacement. The morphology and composition of the fabricated catalysts were characterized using a variety of analytical techniques, including scanning electron microscopy, X-ray diffraction, and inductively coupled plasma-optical emission spectroscopy. The electrochemical performance of the resulting electrocatalysts was evaluated using cyclic voltammetry and chronoamperometry in a solution of 0.05 M N_2H_4 and 1 M NaOH within an electrode potential range of -1.2 to 0.6 V (vs. SCE) at a scan rate of 50 mV s^{-1}. The electrochemical surface area of both electrocatalysts was determined from CVs recorded in 1 M NaOH under non-faradaic potential region at scan rates ranging from 10 to 100 mV s^{-1}. Additionally, electrochemical impedance spectroscopy measurements were conducted in 0.05 M N_2H_4 and 1 M NaOH over a frequency range of 10,000 Hz to 0.1 Hz at various potentials to assess charge transfer characteristics. The Au-modified electrode demonstrated higher hydrazine oxidation activity in comparison with the unmodified NiZn/Ti electrode. The chronoamperometric measurements further confirmed the stability of the electrocatalysts under operating conditions. The results of this study demonstrate that the Au–NiZn/Ti electrocatalyst is an efficient and promising anode material for the hydrazine oxidation reaction in hydrazine-based fuel cell systems.

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Nickel on carbon electrocatalysts Ni/C derived from ionic liquid precursors for efficient water splitting

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Nickel on carbon (Ni/C) electrocatalysts were synthesized via direct carbonization of Ni-containing ionic liquids (ILs) [1,2], using choline- and imidazolium-based ILs as single-source precursors. This approach enabled the simultaneous formation of metallic Ni nanoparticles and heteroatom-doped carbon matrices, yielding materials with distinct structural, textural, and electronic properties depending on the selected IL. Detailed physicochemical analysis using nitrogen sorption, X-ray diffraction (XRD), Raman spectroscopy, scanning and transmission electron microscopy (SEM/EDS, TEM), and X-ray photoelectron spectroscopy (XPS) verified the successful formation of face-centered cubic Ni nanoparticles homogeneously dispersed within mesoporous carbon matrices. Pronounced differences were observed in specific surface area, degree of graphitization, defect density, Ni dispersion, and the presence of N- and O-containing surface functionalities. The electrocatalytic performance of the synthesized Ni/C catalysts was evaluated toward the hydrogen evolution reaction (HER) and oxygen evolution reaction (OER) in alkaline medium. Among the investigated samples, Ni/C(Hm), derived from a hexylmethylimidazolium ionic liquid, exhibited the best HER activity, characterized by the lowest charge-transfer resistance and a favorable Tafel slope, which was attributed to its high surface area and defect-rich carbon structure. In contrast, Ni/C(Ch), derived from choline chloride, showed superior OER performance, delivering the lowest onset potential, the lowest overpotential at 10 mA cm^{-2}, the smallest Tafel slope, and excellent operational stability. The results demonstrate that the nature of the ionic liquid precursor strongly influences charge-transfer kinetics, surface heterogeneity, and mass-transport properties, enabling tunable control over the electrocatalytic behavior of Ni/C materials. Overall, this results highlights the potential of ionic-liquid-based synthesis as an effective strategy for designing bifunctional, noble-metal-free electrocatalysts for efficient alkaline water splitting and sustainable hydrogen production.

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O_2 plasma for liquid water-free micro- nanofibrillated cellulose production

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Nanocellulose, a renewable bio-based material, has gained attention due to its strength, biodegradability, and versatility across applications such as packaging, construction, composites, and electronics. However, large-scale production is limited by aqueous processes requiring toxic chemicals and/or energy-intensive mechanical fibrillation, yielding low-solid, highly viscous gel-like suspensions that are difficult to handle and costly to transport. In this work, we revisit our prior work developing a liquid water-free approach for cellulose micro- and nanofibrillation using dielectric barrier discharge (DBD) oxygen plasma pretreatment, eliminating the need for oxidising chemicals and water. The intermediate product can then be transported cost-effectively in the dry state. Subsequent controlled ultrasonication in aqueous suspension readily provides final fibrillation to produce micro- nanofibrillated cellulose (MNFC) in-situ with tunable solids content. This study extends our prior work by investigating the influence of environmental conditions—specifically fibre moisture content and fibre thickness—on plasma treatment efficiency and subsequent fibrillation behaviour. Results show that fibre thickness strongly influences fibril morphology, while moisture content has minimal impact on plasma-induced surface modification, highlighting the robustness and scalability of this sustainable pretreatment method.

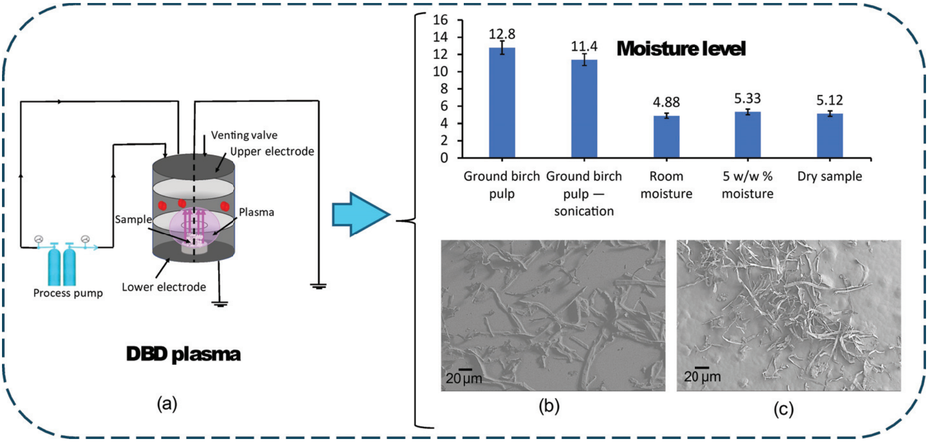

Figure 1. Schematic illustration of plasma pretreatment (a) and its effect on intermediate product fibre diameter (µm) developed under varied moisture level conditions: scanning electron microscopy (SEM) images of ground birch pulp (b) and example plasma-pretreated intermediate dry sample (c).

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Zeolite-Supported Highly Active Zinc Oxide for Multifunctional Applications

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Zinc oxide (ZnO) is an inorganic compound characterized by unique physicochemical, electronic, and optical properties, which have attracted significant scientific and industrial interest in recent decades. It is widely used across various industries, including ceramics, paints, plastics (as a UV stabilizer), cosmetics, sunscreens, batteries, and flame-retardant materials. Due to its antibacterial properties, ZnO is also applied as an antimicrobial additive, particularly in animal feed. However, its most significant application is in the rubber and tire industry, where it serves as the most efficient activator in the vulcanization process.

With the continuous growth of industrial production, the demand for ZnO is steadily increasing. Although zinc is an essential element for living organisms, excessive concentration can exhibit toxic effects, especially in aquatic environments. According to regulatory frameworks such as those established by the European Chemicals Agency (ECHA) and the U.S. Environmental Protection Agency (EPA), strict limits have been imposed on zinc concentrations in water and industrial applications. Additionally, recent European Union regulations have significantly reduced the permitted levels of zinc as an antimicrobial feed additive, while further reductions in ZnO use in the rubber industry have been proposed. Zeolites are on the other hand already used as animal feed additive and its further use in tire and rubber industry are in consideration.

In this study, highly active zinc oxide particles were deposited onto a zeolite carrier, resulting in a multifunctional material suitable for use both as an animal feed additive and as a vulcanization activator in tire production. Primarly synthetized zinc-oxide particles were 10-15 nm in size, while the final composite particles were in the submicron range. By combining the properties of the carrier material and highly active zinc oxide particles, a multifunctional product for dual use was developed, leading to reduced zinc oxide consumption due to its higher specific surface area. Its enhanced activity is attributed to the large specific surface area of the particles (>40 m^2/g) and their dispersion on the zeolite surface, which promotes more efficient mixing in both processes.

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High efficiency of selected zeolites in the purification of contaminated water

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Contamination of aquatic systems represents a serious environmental and public health concern, particularly in the context of nuclear accidents and inadequate radioactive waste management. Among the most significant radionuclides in aquatic environments, ^{137}Cs (cesium-137) and ^{90}Sr (strontium-90) are of particular concern due to their high aqueous mobility, long half-lives, and pronounced bioavailability, facilitating their rapid migration through ecosystems and entry into the food chain.

This work presents a comprehensive and critical assessment of the most effective natural, synthetic, and functionalized zeolites for the removal of radionuclides from aquatic systems, based on a systematic evaluation of recent literature. Among natural zeolites, clinoptilolite stands out as the most efficient and industrially relevant material for cesium removal, owing to its favorable pore structure, high ion-exchange selectivity, chemical stability, and wide availability. In contrast, chabazite and mordenite exhibit a higher affinity toward divalent cations such as Sr^{2+}, which can be attributed to differences in framework topology and charge distribution. Furthermore, synthetic and surface-modified zeolites demonstrate enhanced performance in complex systems due to improved selectivity, controlled pore architecture, and optimized exchange sites. The dominant removal mechanism is governed by selective ion exchange, whereby exchangeable cations in the zeolite framework (Na^+, K^+, Ca^{2+}) are replaced by radionuclides from solution, with additional contributions from adsorption within the microporous network and, in certain cases, surface complexation. The selectivity toward Cs^+ and Sr^{2+} is strongly influenced by ionic radius, hydration energy, and dehydration kinetics: the relatively low hydration energy and suitable ionic size of Cs^+ facilitate its efficient incorporation into zeolitic channels, whereas the higher hydration energy and divalent nature of Sr^{2+} require specific framework environments and charge densities for effective exchange.

Removal efficiencies reach 90–99% for Cs^+ and 70–99% for Sr^{2+}, depending on zeolite type, modification, competing ions, and physicochemical conditions. Zeolites represent a robust, cost-effective, and scalable solution for radionuclide removal from aquatic environments. Their high selectivity, structural versatility, and operational stability make them highly suitable for both emergency response and long-term environmental remediation applications. These findings contribute to the rational selection and optimization of zeolitic materials for advanced water treatment technologies targeting radioactive contaminants.

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Structural Insight into Gliclazide Polymorphism: Theoretical Prediction of Novel Conformational States

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Gliclazide is a cornerstone sulfonylurea therapy for type 2 diabetes, where its effectiveness is dictated by polymorphism. Traditionally, distinct crystal packings (Forms I, II, and III)[1] are known to govern the drug's dissolution and bioavailability. However, our research, utilizing Cambridge Structural Database (CSD) analysis and quantum-mechanical calculations, unveils a more complex landscape: conformational polymorphism. Beyond simple structural variations, we identified that the gliclazide molecule itself adopts different shapes. Specifically, we analyzed the orientation of groups relative to the azabicyclo ring (pseudoaxial vs. pseudoequatorial) and investigated rotational isomerism around the S–N and N–N bonds (Figure 1). Our findings reveal two distinct rotamers around the S–N bond separated by a high energy barrier. Collectively, these structural nuances yield four potential conformers. To determine their biological relevance, we performed molecular docking against the sulfonylurea receptor 1 (SUR1), the primary target for insulin regulation in pancreatic beta cells.[2] Crucially, the results demonstrated that only the axial conformers exhibit potential activity (Figure 1). This discovery fundamentally broadens our understanding of gliclazide's structural properties, proving that molecular geometry is just as vital as crystal packaging for maintaining glucose homeostasis.

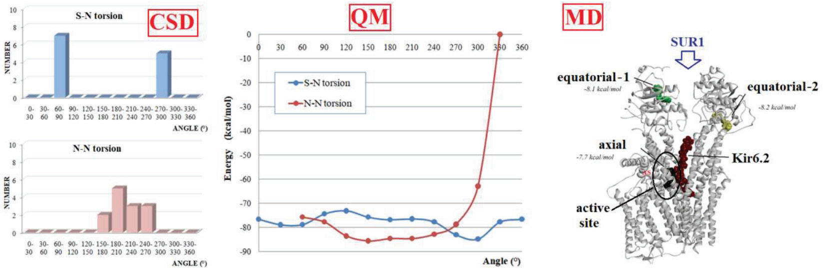

Figure 1. Results of crystallographic (CSD) and quantum-mechanical (QM) analysis and molecular docking (MD).

Acknowledgements
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Impact Ionisation and Gain study in High-Aspect-Ratio 3D Silicon Detectors produced in 8-inch CMOS technology at IME-CAS for Fast Timing and Radiation-Hard Applications

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The 3D silicon (Si) detector has demonstrated excellent spatial and temporal resolution under extreme radiation conditions. It is therefore considered a strong candidate for the upgrade of pixel systems in LHC experiments such as ATLAS and CMS (innermost layers), as well as LHCb (VELO), and represents a promising technology for the future development of the FCC-hh.

The primary research direction for 3D pixel detectors in the coming years is the improvement of spatial and temporal resolution. In this context, the IME-CAS 8 inch - CMOS technology offers a significant advantage, enabling the fabrication of 3D silicon devices with electrode diameters as small as 0.5 µm. This allows for aspect ratios (depth-to-diameter) exceeding 70, which is substantially higher than what can be achieved with CNM and FBK technologies. A higher aspect ratio enables shorter device geometries, while the small diameter of the central n+ electrode leads to the formation of a strong electric field in its vicinity. This facilitates electron impact ionization, making it possible to achieve internal gain without the need for a dedicated highly doped gain layer, as it is required in Low Gain Avalanche Diodes (LGAD). Significantly smaller drift distance between n+ and p+ electrode reduces traping in heavily irradited device (defect induced traps) increasing the radiation hardness.

This study has two distinctive parts. Firstly, we present the performance of multi-arrays of 3D cylindrical silicon microdetectors/pixels (10x10), each of them with a diameter of 10 µm and an active width of 30 µm, suitable for fast timing applications in both high-energy physics (HEP) and medical research (microdosimetry). This device is interesting also from the point of impact ionisation study vs fluency. 3D central (n+) electrode has a diameter of 1um and reaches depth of 25 um, while the circled (p+) electrode has a depth of 43,5 µm. The pitch between adjacent pixels is 200 µm in both horizontal and vertical directions. In the second part we show the results from our study on an array of 5x5 3D cells; each cell is 35x35 µm^2 large with an active width of 30 µm. The central n+ electrode has diameter of 0.5 µm and deopth of 25 µm; the p+ electrode in square shape has a width of 1µm. Using TPA-TCT technique we ingestigated gain in both irradiated and non-irradiated sample as a function of bias, starting with 10 pJ of fs-laser pulse power. Depth profile of gain and timing performance were systenatically studied.

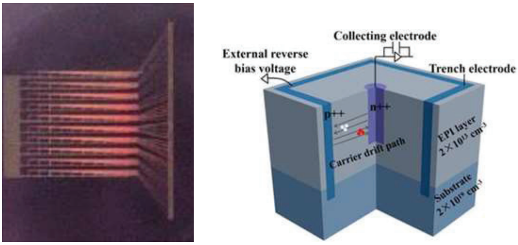

Figure 1. Microscopic image of Multi – array of 3D cylindrical IMECAS microdetectors b) 35x35 um^2 IMECAS 3D cell with 0.5 n+ central 3D electrode and p+ trench electrode in square shape.

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Microcrystalline Cellulose-Doped Polyvinyl Alcohol Membranes: Enhanced Ionic Conductivity and Durability for Alkaline Water Electrolysis

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The development of polyvinyl alcohol (PVA)–cellulose composite membranes represents a promising approach to improving the performance of alkaline electrolysis systems and other electrochemical applications [1]. In this study, microcrystalline cellulose (MCC) was synthesized and incorporated into PVA membranes to enhance their ionic conductivity, mechanical strength, and water retention. The MCC was produced from bleached softwood sulphate pulp through controlled acid hydrolysis performed in a 2.5 dm^3 metal reactor using 1.5% H_2SO_4 (based on oven-dry cellulose) under 10% pulp consistency at 160 °C. The hydrolysis reaction was terminated when the degree of polymerization (DP) reached approximately 390, followed by cooling, filtration on a 90-mesh wire sieve, and thorough washing of the product. The incorporation of MCC into the PVA matrix significantly improved the functional characteristics of the membranes. The resulting composites exhibited ionic conductivity as high as 238 mS cm^{-1}, along with enhanced mechanical durability and water retention capacity. These properties make the PVA–MCC membranes well-suited for use in alkaline electrolysis systems, where stable ionic transport and structural integrity are essential [2].
Beyond their performance improvements, the use of PVA-based membranes provides additional advantages, including low cost, environmental sustainability, and easy processing. The results demonstrate that combining renewable cellulose with synthetic PVA offers an effective way to balance performance and sustainability in electrochemical membrane design. This research underscores the potential of bio-based PVA–cellulose composites as highly efficient, durable, and eco-friendly alternatives for next-generation alkaline electrolysis and energy conversion technologies.

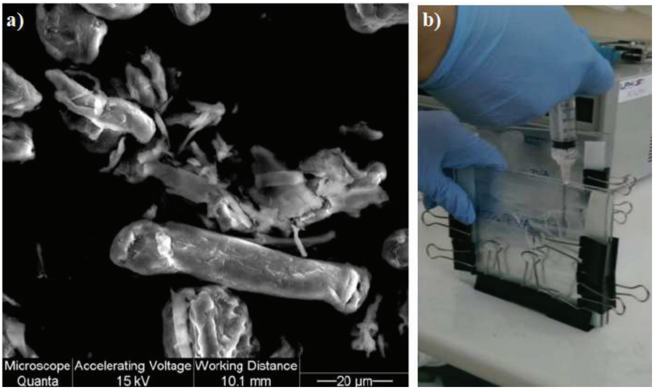

Figure 1. a) SEM Image of microcrystalline cellulose, b) schematic representation

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Modeling Drug–Membrane Interactions: Agomelatine Case Study

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Computational and mathematical modeling, supported by experimental data, provides valuable insights into the biological behavior of drugs and their analogues. In this study, an integrated approach combining *in silico* simulations and experimental IAM.PC chromatography was applied to evaluate the membrane permeation of agomelatine and its desmethyl impurity, aiming to achieve a more comprehensive understanding of their interactions with phospholipid membranes. Membrane permeability was assessed using MembranePlus™ 3.0 software[1], employing a PAMPA-based passive diffusion model under physiologically relevant conditions (pH 7.4).[2] Key molecular descriptors, including lipophilicity (LogD), hydrogen bonding capacity, and ionization state, were incorporated, as they critically influence interactions with phospholipid environments. The evaluated parameters included *Permeability*, *Conc Membrane Total*, *Conc Apical Free*, and *Conc Basolateral Free*, while IAM.PC retention factors were used as biomimetic experimental descriptors reflecting interactions with the stationary phase. Simulation results showed a time-dependent increase in permeability and membrane accumulation for both compounds, accompanied by a decrease in apical free concentrations (from ~10 μM to <2 μM) and a corresponding increase in basolateral concentrations (from 0 to >5 μM), indicating continuous passive diffusion. The desmethyl impurity exhibited higher permeability and apparent permeability values than agomelatine (P*ermeability* ≈ 2.5–3.0 × 10^{-6} cm/s vs. ≈ 1.5–2.0 × 10^{-6} cm/s), suggesting more efficient membrane transport, while overall membrane partitioning remained comparable (*Conc Membrane Total* ≈ 3–6 μM). These computational findings were consistent with IAM.PC retention data, where the impurity showed slightly lower retention than agomelatine (k ≈ 2.2–2.4 vs. ≈ 2.6–2.8 at 40% ACN), reflecting weaker but more dynamic phospholipid interactions. These results demonstrate that integrating *in silico* modeling with IAM.PC chromatography enables a comprehensive understanding of membrane affinity and transport behaviour for both parent compounds and their analogues, revealing that structurally related impurities may exhibit significantly different permeability profiles.

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Electrocatalytic activity of Pt_1Pd_1/C (20 wt.%) for the oxygen reduction reaction in acidic medium

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The oxygen reduction reaction (ORR) is a fundamental electrochemical process essential to the operation of fuel cells and metal-air batteries. Its slow kinetics and complex multi-electron pathways, involving multiple adsorbed intermediates, represent a major obstacle to the efficiency of these systems, making the development of highly active catalysts a central challenge in electrochemical energy research. Platinum-based materials remain the benchmark electrocatalysts for the ORR; however, their scarcity and cost drive the search for viable alternatives. Bimetallic systems have emerged as particularly promising candidates, leveraging synergistic metal-metal interactions to tune electronic structure and surface properties toward enhanced activity. Among these, carbon-supported Pt-Pd catalysts are of special interest, as Pt-Pd interactions modify the local electronic environment of active sites, offering a cost-effective pathway to competitive ORR performance [1].

In this work, the electrochemical performance of a Pt_1Pd_1/C catalyst toward the oxygen reduction reaction (ORR) in acidic medium (1 M H_2SO_4) was investigated using cyclic voltammetry and linear sweep voltammetry with a rotating disk electrode. The electron transfer number was determined via Koutecky–Levich analysis, providing mechanistic insight into the reaction pathway. The Pt_1Pd_1/C catalyst exhibited an electron transfer number of 3.9, indicating that the reaction predominantly proceeds via a four-electron pathway. A Tafel slope of 77.6 mV dec^{-1} was obtained, suggesting favorable reaction kinetics. The onset potential was 0.756 V, while the half-wave potential ($E_{1/2}$) was approximately 0.645 V. For comparison, a commercial Pt/C catalyst (20 wt.% Pt) was evaluated under identical conditions, showing an electron transfer number of 4.02, a Tafel slope of 92.6 mV dec^{-1}, and an onset potential of 0.730 V. The results indicate that the Pt_1Pd_1/C catalyst exhibits improved catalytic activity and more favorable kinetics compared to the commercial Pt/C under identical conditions.

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Suppression of hydrogen evolution reaction activity on nickel by trace iron impurities in alkaline electrolyte

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Over recent years, several studies have reported the effect of trace amounts of iron on the catalytic performance of nickel electrodes for the oxygen evolution reaction (OER), while its influence on the hydrogen evolution reaction (HER) remains a subject of debate [1], [2]. In this study, we investigated the impact of Fe impurities on HER activity in a 1 M KOH solution using a high-purity polycrystalline nickel electrode as the cathode. To evaluate the influence of such impurities under controlled conditions, a "clean" system was first established using ultra-pure deionized water and analytical-grade chemicals to obtain a reliable baseline for the intrinsic activity of the nickel disk electrode. Subsequently, Fe impurities were introduced gradually, with increasing concentrations. The obtained results are presented in Figure 1, where it can be observed that the addition of approximately 46 ppm of Fe leads to a measurable decrease in HER activity compared to the pure system.

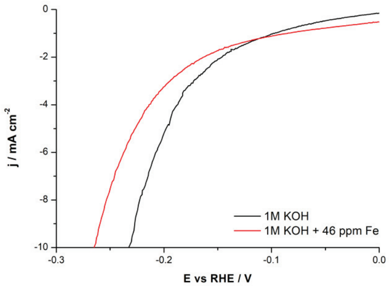

Figure 1. Polarization curves of HER activity for polycrystalline nickel in two different systems

Based on the presented polarization curves, the presence of Fe impurities results in a clear decrease in HER activity, as evidenced by the shift in overpotential from −232.9 mV to −264.8 mV at a current density of 10 mA cm^{-2}. This increase in overpotential (~32 mV) suggests a deterioration in the reaction kinetics, potentially associated with surface modification of the nickel electrode or competitive adsorption effects induced by iron species. Importantly, the observed sensitivity of HER performance to relatively low Fe concentrations highlight the critical role of electrolyte purity in electrochemical measurements. These findings provide a strong foundation for further systematic investigations into the influence of iron concentration, as well as other trace contaminants, on HER catalytic behavior and electrode surface properties.

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Spinel ferrite and metal oxide nanoparticles integrated with graphene oxide for advanced energy storage

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In recent years, transition metal oxide nanoparticles (NPs) have attracted considerable attention as active materials for supercapacitor applications due to their rich redox chemistry, structural versatility, and high theoretical capacitance. Among them, spinel ferrites such as cobalt ferrite, zinc ferrite, manganese ferrite, and nickel ferrite, as well as simple oxides like nickel oxide and cobalt oxide, stand out as particularly promising candidates owing to their multiple oxidation states and favorable electrochemical activity. These materials enable fast and reversible faradaic reactions, contributing significantly to pseudocapacitance. However, despite their advantages, metal oxide NPs often suffer from poor electrical conductivity and limited ion transport, which restrict their rate capability and overall electrochemical performance. To address these limitations, integration with conductive carbon-based materials has proven to be an effective strategy. In this context, graphene oxide (GO), with its high surface area and abundance of oxygen-containing functional groups, serves as an excellent support matrix, facilitating uniform nanoparticle dispersion and improved charge transfer. In this work, we focus on the synthesis and characterization of GO-based nanocomposites incorporating a range of transition metal oxide NPs, including cobalt, zinc, manganese, and nickel ferrites, as well as nickel and cobalt oxides, aiming to enhance their electrochemical performance for supercapacitor applications. For this purpose, a hydrothermal treatment was used to obtain the nanoparticles as well to prepare the composite of GO and NPs. Galvanostatic charge/discharge (GCD) measurements in two-electrode setup were employed to evaluate specific capacitance. The results clearly showed that composite of GO and 15 wt.% of cobalt ferrite nanoparticles synthesized with dihydrocaffeic acid (DHCA) as a surfactant are the most promising candidate from the point of view of reversibility, specific capacitance and stability. These findings highlight the crucial role of both composition and nanoparticle surface modification in tailoring the electrochemical performance of GO-based composites. The presence of dihydrocaffeic acid (DHCA) as a surfactant likely promotes improved dispersion of cobalt ferrite nanoparticles within the GO matrix, ensuring better interfacial contact and more efficient charge transfer pathways. Additionally, the optimized loading of 15 wt.% appears to provide a favorable balance between the availability of redox-active sites and the preservation of conductive pathways within the composite.

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Hierarchical High Entropy Architectures for Efficient Oxygen Evolution Catalysis

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The development of robust electrocatalysts from earth abundant elements remains a central challenge for scalable green hydrogen production. High entropy materials (HEM's) have recently attracted considerable attention in catalysis because of structural defects and diverse active sites. Most high entropy catalysts reported so far are equimolar single phase systems, leaving hierarchical and non equimolar designs largely unexplored [1].

In this work, we design a hierarchical high entropy electrocatalyst with NiCoFeMnMo composition. The sulfide core is directly grown on Ni foam through hydrothermal synthesis, followed by the formation of an ultrathin high entropy layered double hydroxide (LDH) shell through an adsorption limited secondary step. Moreover, electrochemical activation using cyclic voltammetry (CV) induces controlled surface reconstruction, converting the LDH layer into an oxyhydroxide catalytic interface while preserving the underlying conductive sulfide framework [2, 3].

Compositional screening shows that non equimolar metal ratios outperform equimolar high entropy compositions. In the optimized catalyst, Mo is maintained at about 8–10 at.% and Mn at ~15 at.%, while the other metals remain close to equal proportions. During electrochemical activation, partial Mn dissolution and enrichment of Mo at the surface are expected to create defects rich surfaces with improved accessibility of catalytic sites.

Electrochemical measurements indicate that the hierarchical catalyst exhibits efficient oxygen evolution reaction (OER) in alkaline media. The optimized electrode achieves an overpotential of approximately 129 mV at 10 mA cm^{-2} and sustains current densities up to 200 mA cm^{-2}. Repeated electrochemical cycles indicates that hydrogen evolution activity initially declines when measured alone, but is restored after OER scans. Thus, suggesting that OER driven surface reconstruction activates and stabilizes the catalytic interface. Overall, this study introduces a hierarchical high entropy engineering in which a conductive sulfide core supports a dynamically reconstructed oxyhydroxide surface for efficeient OER.

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Physico-chemical properties of ZrO_2-Gd_2O_3 ceramics obtained by SPS process

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Gadolinium-zirconate is one of the rare-earth compounds that attracts attention owing to high thermal and chemical stability, and radiation resistance. Its unique physico-chemical properties make it a promising material for the fabrication of thermal barrier coatings, catalysts, sensors, and ionic conductors. ZrO_2 and Gd_2O_3 powders were mixed in a molar ratio that corresponds to the compound $Gd_2Zr_2O_7$, and mechanically activated in a high-energy ball mill for 15, 30, or 60 min. Pellets were then spark plasma sintered. Phase composition and microstructure of milled powders and sintered specimens were characterized. Phase-pure $Gd_2Zr_2O_7$ was obtained after sintering at 1600 ^{o}C. Densities and microstructures after sintering were correlated with electrical, mechanical and thermal measurements.

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Novel functionalized Nb_2C MXenes for Electrochemical Energy Storage Applications

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The increasing demand for flexible, lightweight, and skin-compatible energy storage systems has accelerated the development of advanced functional materials with high electrical conductivity and rapid ion transport. Among emerging 2D materials, MXenes have attracted significant attention due to their tunable surface chemistry and outstanding electrochemical performance. In particular, niobium carbide (Nb_2C) MXene represents a promising candidate owing to its metallic conductivity, favorable ion diffusion kinetics, and suitability for integration into next-generation wearable energy storage devices. In this work, Nb_2C MXene was synthesized via a minimally intensive layer delamination (MILD) method and subsequently functionalized with selected organosilanes to tailor its surface properties. X-ray photoelectron spectroscopy (XPS) confirmed the successful ething of the MAX phase. Scanning electron microscopy coupled with energy-dispersive spectroscopy (SEM-EDS) revealed a well-delaminated layered structure and homogeneous elemental distribution, along with morphological changes induced by the functionalization. The change in elemental composition was also confirmed by EDS. BET results revealed that Nb_2C MXene is a mesoporous material. The electrochemical performance was evaluated using cyclic voltammetry (CV) and electrochemical impedance spectroscopy (EIS) in an alkaline electrolyte. The results demonstrate improved capacitive behavior and enhanced charge transfer properties upon functionalization, highlighting the importance of surface engineering in MXene-based electrodes. These findings provide valuable insights into the structure–property relationships and support the potential application of Nb_2C MXenes in flexible and high-performance wearable supercapacitors for next-generation electrochemical energy storage.

Acknowledgements
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Controlled Modification of Ti-Based Thin Films for Bioactive Surface Applications

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This study explores a combined approach to tailor the functional properties of Ti-based thin films by femtosecond laser pre-patterning of silicon substrates, followed by Ti/Zr/Ti thin-film deposition. Conical microspike structures were first fabricated on silicon in an SF_6 atmosphere using femtosecond laser pulses, producing uniform high-aspect-ratio features with an average height of ~2 µm, an opening angle of ~40°, and a density of 1.3×10^7 cm^{-2}. Subsequently, nanocomposite Ti/Zr/Ti thin films, incorporating a 10 nm Zr interlayer, were deposited by ion sputtering onto the structured surfaces.

Comprehensive characterization revealed that the resulting films exhibit modified surface morphology, chemical composition, wettability, and optical properties. The formation of predominantly oxidized globular agglomerates (~1 µm) within interspike regions contributed to increased surface roughness and enhanced hydrophilicity. Optical measurements showed improved performance, including a ~20% increase in reflectivity relative to pre-patterned silicon and an optical band gap of 2.35 eV. Furthermore, wettability and reflectivity were effectively tuned through external stimuli such as UV irradiation and thermal annealing, with annealing promoting additional hydrophilicity via oxidation and hydroxylation processes.

The adopted strategy, laser structuring of the substrate before thin-film deposition, successfully mitigates excessive ablation typically associated with direct laser processing of thin films, enabling preservation of compositional integrity and functional performance. The results demonstrate that the synergistic combination of ultrafast laser texturing and nanocomposite thin-film deposition provides a versatile platform for engineering surfaces with controllable wetting and optical properties. This approach shows strong potential for applications in photonics, sensing, photovoltaics, and bioactive surface design.

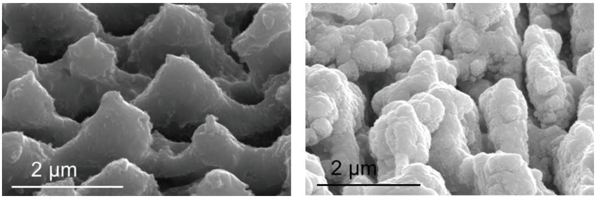

Figure 1. SEM micrographs: (a) laser-processed silicon surface at the fluence of 0.21 J cm ^{2} and (b) deposited Ti/Zr/Ti thin film on laser pre-patterned silicon

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Investigation of the Effects of Bleaching Sunflower Oil Using Silica Gel of Different Granulations

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Sunflower oil is one of the highest-quality and most widely used edible vegetable oils, and its production involves the physical bleaching operation using various types of commercial bleaching earth. In this study, samples of silica gel with different particle size ranges (40–63 µm, 35–70 µm, 40–125 µm, and 60 –200 µm), produced by Zeochem d.o.o. Zvornik, were used for the bleaching of crude sunflower oil produced by Victoriaoil Šid. These silica gels are characterized by a well-developed porous structure and a high specific surface area. Characterization of the silica gel samples was performed using modern analytical techniques (XRD, FTIR, SEM-EDS, BET, and the laser method for particle size distribution determination). Bleaching of sunflower oil under laboratory conditions was carried out under the following parameters: bleaching agent dosage (1.0% w/w, 2.0% w/w, 3.0% w/w), temperature of 95°C, and a duration of 30 minutes.

The effects of bleaching sunflower oil using silica gel were compared with those obtained using commercial bleaching earth. The fatty acid composition (GC-FID) and selected physicochemical characteristics of sunflower oil before and after bleaching (soap content, chlorophyll and phosphorus content, and peroxide value) were determined. The characterization results showed that the investigated silica gel samples possess an amorphous structure, while in the commercial bleaching earth, in addition to smectite and quartz phases, peaks characteristic of phyllosilicate minerals (palygorskite) were identified. The specific surface areas of the silica gel samples are significantly higher than that of the commercial bleaching earth (by 2.26 to 2.94 times); however, the average pore diameter is smaller (by 1.16–1.67 times). The particles of the silica gel samples exhibit irregular shapes, and the d_{50} values of the silica gel samples are higher than that of the commercial bleaching earth (by 1.33–1.86 times).

Bleaching of sunflower oil resulted in the removal of soaps and a reduction in chlorophyll and phosphorus content. Gas chromatography (GC-FID) analysis revealed that crude sunflower oil contains seven saturated fatty acids (SFAs) with a share of 10.63%, four monounsaturated fatty acids (MUFAs) with a share of 33.82%, and two polyunsaturated fatty acids (PUFAs). Bleaching of sunflower oil resulted in only minor changes in their proportions, and the effects of bleaching with silica gel and commercial bleaching earth were similar. Further research should be continued under laboratory and semi-industrial conditions using different laboratory and process parameters.

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The energetics theory of poly(lactide) impact on cell metabolism

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Poly lactic acid (PLA) (more accurate name is poly(lactide) because of the ester groups, dominating the structure), is the most widely utilized polymer in medicine nowadays, with about 7 hundred thousand tons, produced per year [1-3]. It is an ester analog of the polypeptides, but its dipole moment is much smaller. It was synthetized first by W.H. Carothers in 1932 and P.J. Flory (who was his young collaborator- than) wrote the first paper on its structure-properties relations. That all was based than on the theoretical interests only, because PLA ester groups hydrolyze, exposed to moisture, leading to the material decomposition. But later, when development of targeted drug release and polymer implants started, those PLA properties generated ideas for the design of materials, temporally strong and rigid, e.g. to support a damaged tissue in a body, but to decompose later, due to body liquids action, when the tissue is regenerated. The PLA decomposition products e.g. lactic acid can be further metabolized to CO_2 and H_2O, what all is biocompatible. In those early period of research we made (with our collaborators and students) a series of such materials varying the PLA chains constitution, configuration, molecular weight and crystallinity, rigidity, and the following stability what attracted quite of attention in sci. community. But that time in sci. community the attention has been focused mainly on appropriate properties of PLA as the material, lass to the mechanisms following in the body after contacts with PLA. Later appeared in the literature reports, on chronic inflammation and excessive fibrosis, with encapsulation of treated parts, after clinical treatments already completed. The first theories offered explanations in terms of the local pH change due to PLA decomposition, activating the immune cells with further generation of chronic inflammations. But, applications of pH changing methods didn't help much, so, recently, the new theories on immune cells genetic changes, due to the contacts with PLA products appeared. In our theoretical model the focus is on the PLA degradation products interactions with cell membranes where ATPase proteins control much of the membrane transport process into the cells but, also the increased bioenergetics (ATP) levels in amorphous and crystalline PLA treated cells by prolonged contacts. So we obtained from transport calculations of PLA products by Mitchell method the functional dependence of its metabolism changes depending on both, pH and Krebs cycle dynamics changing [3-5].

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Energetics of drug delivery into cells: the comparisons of drug filled poly(lactide) nano- particles absorption, with the membrane proteins transfer of the drugs, by symport mechanism

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The first targeted drug release products, were offered to the marked in 1952 by the group from SK&F Comp. having some sugars as the carrier. Soon have been recognized the advantages of the poly(lactide) (PLA) as the material for both, encapsulation and nano-particles [1,2], following the further progress in polymer field development. But, besides numerous important similarities with plastics technology, the formation and evolution of those materials is based a bit on different principles [1-3]. Besides the use as capsules for antibiotics its use for adjuvants and vaccination components and also for medical diagnostics devices, imaging, as substrates employed for sensors, catalyst carriers has been found in medicine. pharmaceutical, food and beverage industry, also as additive carriers in everyday life nutrition, as cosmetics components , for skin and leather care etc. In all of that, PLA nano-particles (PLAnP) require some special attention. The first question one asks is whether PLAnP can be internalized by the cells. Several steps are involved in that process. The first is generated by the adhesion energy to the cell membrane. The second steps needs energy for wrapping the PLAnP by the part of the membrane E_{def} what includes bending and stretching of the membrane. If the surface of membrane part involved in those processes is S , the membrane surface tension generated in that way can be described by :

$$\sigma_{\mathrm{SMb}} = \frac{\partial E_{\mathrm{def}}}{\partial S_{\mathrm{seg}}} = \kappa_S \frac{S - S_0}{S_0} \qquad (1)$$

with bending modulus κ_S , what can be further related to deformation (measured by distances $h(\mathbf{r})$ from the referent plane over S) using Holfrich Hamiltonian [2,3] :

$$H = \int_{S_{\mathrm{Mb}}} d r \qquad (2)$$

On the other hand, the membrane protein transport of drugs by symport mechanism, use the energy from of the electrochemical potential of the membrane generated by ADP hydrolysis in membrane proteins and the pH difference inside the cell with pH in its environment, according to Mitchell model. Moreover the essential difference is also in the dynamics of those two processes: the symport process starts instantly as the drug is injected to the cell environment, but PLAnP require besides the time for absorption into cell also the time for decomposition inside it, as experiments show. For example the amount of absorbed drug for 24 hours by symport is 80% while for nano-transport 50% with all other conditions the same. Of course, it is only one component of the efficiency evaluation, because sometimes prolonged absorption is more desirable for the curing process. Besides, PLAnP degradation products can interfere with cell metabolism as discussed in the other paper of this author at the Conference.

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Modeling of the kinetics of H_2^+ BeH^+, BF^+ at low/high energy of the incident electron with application in fusion plasmas and material processing field

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Cross sections and Maxwell rate coefficients for reactive collisons between electrons and Beryllium monohydride cations were computing using the Multichannel Quantum Defect Theory (MQDT) on extended energy/temperature range, up to 12 eV/30000 K [1] based on the previous results obtained for BeH^+ [2], BeD^+ [3] and BeT^+ [4] cations with the incident electron below the dissociative threshold, 2.7eV. The results in terms of rate coefficients has been uploaded to CollisionDB for each isotopologues of BeH^+. These data are usefully in the modelling of the kinetics of various cold ionized media of fundamental and applied interest. High energy collision between electrons and BeH^+ procedure is applied to study H_2^+ /HD^+ at high energy of incident electron. New dissociative states and couplings are generated.

Mixed ro-vibrational transitions (RVT) and dissociative recombination (DR) rate coefficients, as an extension of our previous studies [5-6], for the 30 ro-vibrational, are provided for H_2^+, HD^+ at low energy of incident electron [7]. New computations on extended energy/temperature range, are ongoing.

On the other hand boron fluoride (BF_3) containing plasmas are important for applications in the field of material processing. BF_3 and Ar/BF_3 plasmas are used for p-type doping in the semi-conductor industry. BF^+ ion can represent a significant fraction of the ions produced when working at high power density discharge conditions for which BF_3 dissociation and dissociative ionization are strongly enhanced [8].

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Ag-Zeolite-Based Electrochemical Sensors for Efficient Monitoring of Nitrite and Nitrate in Water Systems

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The increasing awareness of water quality and environmental protection has led to the development of efficient analytical methods for the detection of inorganic pollutants, particularly nitrate and nitrite ions in aqueous systems. Among various approaches, electrochemical sensing techniques are especially attractive due to their simplicity, rapidity, and cost-effectiveness [1]. Zeolites are crystalline aluminosilicate materials characterized by well-defined porous structures, large surface areas, and high ion-exchange capacity, which make them highly suitable for electrochemical sensing applications [2]. In recent years, metal-modified zeolites, especially those containing Ag^+ ions, have attracted significant attention as electrocatalytic platforms for the detection of nitrite and nitrate ions in aqueous systems, due to their ability to enhance electron transfer and improve analytical performance [3].

In this study, AgA, AgX, and AgY zeolites were used to prepare composite electrodes with carbonized polyaniline (c-PANI). These zeolites were chosen because they contain the same extra-framework cation (Ag^+), but differ in the Si/Al ratio, which affects the electronegativity of the aluminosilicate framework and the number of charge-balancing cations within the zeolite channels, thereby influencing their sorption and catalytic properties. The electrochemical performance of the prepared electrodes was investigated using cyclic voltammetry in 0.1 M H_2SO_4 as the supporting electrolyte, as well as in the presence of 10 mM $NaNO_3$ or $NaNO_2$, showing characteristic redox peaks. Among the studied materials, the AgY-based electrode and its composite with c-PANI exhibited the best performance, demonstrating improved sensitivity and low detection limits (0.1–1 mM), confirming the beneficial role of both the zeolitic structure and conductive carbon components in the development of efficient sensors for monitoring nitrate and nitrite in aqueous systems.

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Synthesis of two structurally distinct amorphous NaAlSiO$_4$ phases by zeolite Na-LTA thermal transformation route

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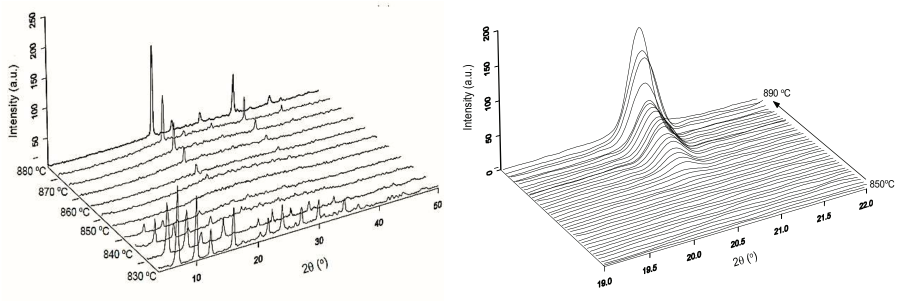
Thermal transformation of zeolite Na-LTA represents an effective route for the synthesis of advanced aluminosilicate materials. During heating, the low-density zeolite crystalline framework undergoes structural collapse and reorganization, leading to the formation of intermediate amorphous phases and high-temperature crystalline polymorphs. In this study, structural evolution of Na-LTA was investigated in the temperature range 25 - 1680 °C with the aim of characterizing amorphous intermediates formed during heating. Two structurally distinct amorphous NaAlSiO$_4$ phases were obtained: one by framework collapse at 850 °C and the other by melting at 1680 °C, in the literature referred as low density (LDA) and high density (HDA) amorphous phases, respectively. X-ray powder diffraction (XRPD) confirmed the loss of long-range order in both cases. However, Raman spectroscopy revealed significant difference in medium-range order between the two amorphous phases. The LDA phase retains structural features of the parent zeolite, as indicated by the presence of Raman bands corresponding to four-, six-, and eight-membered rings, along with the formation of three-membered rings, suggesting partial framework rearrangement and preservation of zeolite domains. In contrast, the HDA phase represents a fully disordered thermal glass, with no detectable ring structures, indicating complete structural collapse. The observed difference demonstrates polyamorphism in the NaAlSiO$_4$ system, where amorphous phases of identical composition exhibit distinct structural organization depending on formation conditions. Additionally, the LDA phase acts as a metastable intermediate, transforming into crystalline carnegieite- and nepheline-type phases upon further heating. These findings provide insight into the mechanisms of zeolite thermal transformation and are relevant for the controlled synthesis of functional ceramic and glassy materials.



(a) (b)

Figure 1. In situ XRPD analysis of (a) thermally induced phase transformation of zeolite Na-LTA and (b) low-temperature carnegieite crystallization from the amorphous phase, illustrated by the characteristic diffraction peak (211)

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Cumulative Effects and Threshold Evolution in Femtosecond Laser Processing of Nimonic 263

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This study investigates femtosecond laser-induced surface modification of the Ni-based superalloy Nimonic 263, focusing on morphological evolution and incubation-controlled ablation behavior under different atmospheric conditions. Experiments were performed using ultrashort laser pulses (775 nm, ~200 fs) over a range of pulse energies and pulse numbers, in ambient air and nitrogen-rich environments.

The laser-material interaction is governed by nonequilibrium energy transfer processes, where rapid electron excitation is followed by energy transfer to the lattice, leading to localized melting and ablation. Surface morphology, analyzed by scanning electron microscopy (SEM), reveals a transition from near-threshold periodic structuring (LIPSS) to melt-dominated ablation with increasing pulse number and energy. At low fluences, surface modification is primarily driven by interference effects and cumulative absorption, while higher fluences result in crater formation, melt dynamics, and material redistribution.

The surrounding atmosphere significantly influences the ablation process by affecting plasma behavior, oxidation, and redeposition. Nitrogen-rich conditions favor more stable structuring and efficient material removal, whereas air promotes partial redeposition and surface smoothing at high pulse accumulation.

The evolution of damage threshold fluence with pulse number follows incubation behavior, indicating progressive enhancement of absorption due to cumulative defect formation. The results highlight the importance of pulse accumulation and environmental conditions in controlling surface modification mechanisms. These findings provide insight into ultrafast laser processing of Ni-based superalloys and contribute to the optimization of surface engineering strategies for advanced applications.

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Influence of Mo and Sb Doping in TiO_2 Nanotubes on the Performance of Pt-Based Catalysts

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This study presents a comparative investigation of molybdenum- and antimony-doped TiO_2 (Mo-TiO_2 and Sb-TiO_2) nanoparticles synthesized from titania nanotubular precursor as catalyst supports for Pt-based electrocatalysts intended for application in direct ethanol fuel cells. A previously developed scalable synthesis strategy for interactive catalyst supports was employed for the preparation of Mo- and Sb-modified TiO_2 nanostructures, enabling controlled incorporation of dopant species into the TiO_2 lattice and the formation of high-surface-area nanomaterial supports.

The structural and morphological characteristics of the synthesized materials, as well as the corresponding Pt-supported catalysts, were examined using X-ray diffraction (XRD) and scanning electron microscopy (SEM). These analyses provided insight into the crystalline structure, phase composition, and surface morphology of the doped TiO_2 supports, as well as the dispersion and distribution of Pt nanoparticles on their surfaces. The obtained results indicate that doping with transition metal species influences the physicochemical properties of TiO_2, including structural ordering and surface characteristics relevant for catalytic applications.

The electrocatalytic behavior of the prepared Pt/Mo-TiO_2 and Pt/Sb-TiO_2 systems was evaluated toward the ethanol oxidation reaction (EOR) under acidic conditions and compared with that of a commercial Pt/C catalyst. The results suggest that the nature of the dopant significantly affects catalyst performance, likely through modification of metal-support interactions, surface electronic properties, and the availability of active sites. Differences in catalytic response between Mo- and Sb-doped systems highlight the importance of dopant selection in tuning catalyst efficiency.

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Evaluating Extraction Methods for Potentially Toxic Elements Bioavailability at Illegal Landfills

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In our investigation of soils contaminated with inorganic pollutants (As, Cd, Co, Cr, Cu, Ni, Pb and Zn), we applied a variety of operationally defined extraction methods. These approaches are designed to align with specific environmentally binding phases of potentially toxic elements, enabling a more comprehensive understanding of the contamination profile In addition to *aqua regia*, three single-step extraction methods were employed to isolate distinct elemental fractions within the soil samples: 2M HNO_3 extraction, which is widely acknowledged as a less aggressive approach for estimating pseudo-total element content; 1M CH_3COONH_4 extraction, commonly applied in the initial stage of sequential extraction protocols to target the most bioavailable fraction of elements; and 0.43M CH_3COOH extraction, also utilized in sequential extraction procedures, which focuses on readily mobilizable and bioavailable elemental fractions. Both the *aqua regia* and 2M HNO_3 extraction procedures provide estimates of the pseudo-total element content present in the samples. These methods were selected based on their established relevance in environmental studies and their ability to differentiate between total and bioavailable element fractions. In contrast, ammonium acetate and acetic acid extractions are typically used to represent the most bioavailable fractions of elements. The research was conducted across two soil depths collected at illegal landfill sites, specifically 0–30 cm and 30–60 cm, within the Vojvodina region of the Republic of Serbia [1]. By analyzing these layers, we aim to assess the distribution and extractability of toxic elements at varying soil depths. Although 2M HNO_3 can estimate pseudo-total element content, a 1-hour extraction yielded about 70% and higher for Cu and Pb compared to aqua regia, while other elements were significantly lower. Ammonium acetate and acetic acid extractions produced similar but lower results than 2M HNO_3. Acetic acid extracted more As than nitric acid or ammonium acetate, with the highest yield compared to aqua regia.

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From citrus waste to energy storage: lemon peel derived activated carbon for supercapacitor applications

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Activated carbons synthesized from waste lemon peel show significant potential as high-performance, cost-effective electrode materials for aqueous supercapacitors, with both chemical (H_3PO_4) and physical (CO_2) activation methods producing hierarchical porous structures.

Structural characterization revealed that phosphoric acid activation generates a hierarchically porous carbon framework with high surface area and dominant mesoporosity, which is further improved by CO_2 treatment.

Electrochemical studies conducted in 1 M H_2SO_4 electrolytes demonstrated that the combined H_3PO_4/CO_2-activated carbon exhibits superior capacitive performance, good rate capability and stable cycling behavior.

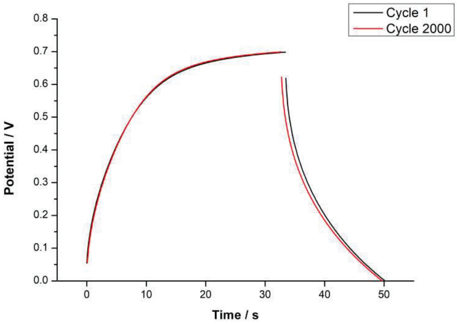

Figure 1. Galvanostatic charge–discharge (GCD) curves of LP-derived materials recorded in 1 M H_2SO_4 electrolyte at a constant current density of 10 A g^{-1}

These results highlight waste lemon peel as a promising and sustainable precursor for high-performance supercapacitor electrode materials. The galvanostatic charge – discharge (GCD) curves shown in the Figure 1 correspond to extended cycling over a prolonged period, encompassing several thousand seconds and numerous consecutive cycles [1]. Almost identical charge and discharge profiles suggest minimal degradation or loss of active surface area, pointing to outstanding long-term electrochemical durability.

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Cobalt–nickel on reduced graphene oxide as a nanosized bifunctional oxygen electrode in alkaline media

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Oxygen evolution reaction (OER) and oxygen reduction reaction (ORR) present the main reactions in environmentally friendly technologies such as metal-air batteries. However, a major limitation of these reactions is their inherently sluggish kinetics. In addition, the most active electrocatalysts (such as iridium–ruthenium oxides for OER and platinum-based materials for ORR) are costly and limited in natural abundance. Hence, it is important to produce low-cost, highly active electrocatalysts for these reactions [1].

Herein, a detailed investigation of nano-sized cobalt nickel electrocatalysts on reduced graphene oxide (CoNi/rGO) for OER and ORR was presented. The onset potential (E_{onset}) of 1.64 V and overpotential (η_{10}) at 10 mA cm^{-2} of 450 mV were observed during OER. On the other hand, CoNi/rGO exhibits high ORR activity, with an almost direct four-electron mechanism, an E_{onset} of 0.81 V, and a Tafel slope of 75 mV dec^{-1}. These results are better or comparable to similar literature reports [2,3]. This behavior during OER/ORR could be a consequence of the synergic effect offered by cobalt and nickel, along with rGO. All things considered, this catalyst could be a potential candidate for environmentally friendly metal-air batteries.

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Influence of Pd:Fe Ratio on the Capacitive Behavior of Pd–Fe Supported Carbon Aerogels in Alkaline Medium

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Three-dimensional carbon aerogels (CA) offer a highly porous, conductive and lightweight structure that allows for uniform dispersion of metal nanoparticles and efficient ion transport, making them excellent candidates for supercapacitor electrodes [1,2]. In this study, Pd-Fe nanoparticles at different ratios were deposited on CA to investigate the influence of metal composition on capacitive performance in 3 M KOH.

Three samples were prepared and designated as Pd-Fe/CA-1, Pd-Fe/CA-2, and Pd-Fe/CA-3, with compositions of 44.8 wt% Pd/5.4 wt% Fe, 23.0 wt% Pd/26.0 wt% Fe, and 41.0 wt% Pd/22.2 wt% Fe, respectively. Cyclic voltammetry measurements were performed, and specific capacitance values were calculated.

The results revealed a strong dependence of the capacitive behavior on the metal composition. Pd–Fe/CA-1 showed the highest specific capacitance of 232.5 F g^{-1} at 20 mVs^{-1}, while Pd–Fe/CA-2 and Pd–Fe/CA-3 showed significantly lower values of 22.53 F g^{-1} and 95 F g^{-1}, respectively. The superior performance of Pd–Fe/CA-1 is attributed to the dominant contribution of Pd to charge storage. At the same time, the presence of Fe may affect the electronic environment and overall electrode properties. These findings demonstrate that careful tuning of metal composition is key to optimizing the capacitive properties of Pd–Fe catalysts on carbon aerogel, providing clear insight into the design of supercapacitor electrodes.

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Modeling the Adsorption of Methylene Blue and Crystal Violet on Zeolite-Based Geopolymers

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The textile industry represents one of the largest polluters today. Special attention has been drawn to synthetic organic dyes due to their stability in the presence of light, heat, and resistance to biodegradation. Their presence in the environment leads to significant disturbances of the natural balance and has an extremely negative impact on living organisms and humans. In humans, these compounds can cause skin irritation, nausea, respiratory problems, increased heart rate, diarrhea, vomiting, and cancer [1]. For all these reasons, industrial wastewater must be adequately treated before being discharged into natural recipients. Although there are many methods, such as membrane filtration, ion exchange, and reverse osmosis, adsorption represents one of the simplest and most economical approaches [2]. Among the wide range of adsorption materials, natural zeolites, which are inorganic porous materials, are nowadays intensively used in adsorption processes. However, although zeolites as adsorbents offer a number of good properties, their application is limited in real industrial systems due to their powder form, and the particles tend to agglomerate during use. The main goal of this study is to overcome these limitations and synthesize a zeolite-based material in granular form that can later be used in industrial practice. For this purpose, alkaline activation of the natural mineral clinoptilolite was performed in order to obtain zeolite-based geopolymer beads. The obtained materials were used as adsorbents for cationic organic dyes, methylene blue and crystal violet. The investigation of the adsorption properties of the synthesized geopolymers was carried out by varying adsorption parameters as a contact time, process temperature, and initial dye concentration. The removal efficiency of crystal violet ranged from 94.9% to 96.8%, while for methylene blue it ranged from 57.1% to 86.7% at room temperature, for initial concentrations of 25 and 150 ppm, respectively. The experimental results were analyzed using pseudo-first-order and pseudo-second-order kinetic models, as well as Langmuir and Freundlich adsorption isotherm models. The adsorption process was additionally described by mathematical modeling. The obtained equations showed a high ability to predict adsorption capacity based on process parameters ($R^2 = 0.9876$; $F = 700.92$; $p < 0.001$), where initial concentration and dye type were identified as the most significant factors affecting the adsorption process. These results indicate a high potential of the synthesized materials for the application in continuous reactor systems, as well as in real industrial wastewater treatment plants.

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Heterogenous support green materials characterization and use in organic synthesis demonstration set

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In this work, two commercially available materials zeolite (clinoptilolite) and bentonite from the domestic market were evaluated as starting points for catalyst development. Zeolites are widely used as adsorbents (e.g., water removal) and ion-exchange materials (e.g., water softening), and can be tailored for organic transformations (1). Bentonite clays, commonly applied as filtration aids in the food industry, have also been reported to promote formation of certain organic molecules (2). Both materials were used in powder form. To correlate physicochemical properties with catalytic activity, a reaction set with benzaldehyde as common reactant was designed. The water adsorption capacity of zeolites and swelling behavior of bentonite guided the selection of condensation reactions, namely Claisen–Schmidt and Knoevenagel condensations in absolute ethanol. The following properties of these materials were examined: loss on drying; pH and total dissolved solids (TDS) of 5 % aqueous suspensions; cation exchange capacity (CEC) via methylene blue; and adsorption of methylene blue and benzaldehyde as common reactant used in our reactions. Fluorescent dye interactions were studied in solution and on powders to estimate surface functionality distribution. ATR-FTIR spectra were recorded before and after reactions. Crude product mass was recorded, and samples were analyzed by GC–MS after dilution in dichloromethane. Results show that under the selected conditions expected to work for Claisen–Schmidt reaction the corresponding reaction products were not observed but instead benzaldehyde diethyl acetal was the main detected product (with bentonite 53.7% and with zeolite 14.3% in the extract). Interestingly zeolite also showed conversion to benzoic acid (15.4%). In the Knoevenagel runs the expected product was obtained using both bentonite (21.1%) and zeolite (4.5%). Under Knoevenagel reaction conditions with zeolite diethyl acetal of benzaldehyde was again the dominant product in the extract (21.1%). Interestingly in our runs bentonite had better conversion efficiency, higher product yields and overall more predictable reactivity then zeolite.

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Efficient Alkaline Seawater Splitting Using a 3D Ni–Mn/Ti Bifunctional Electrocatalyst Pair

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Hydrogen (H_2) is widely regarded as a promising alternative to fossil fuels and is often referred to as a "fuel of the future" due to its high gravimetric energy density, natural abundance, versatility, and environmentally benign combustion with zero carbon emissions. However, large-scale green H_2 production via water splitting places significant demand on limited freshwater resources. In this context, seawater, which constitutes ~96.5% of Earth's total water reserves, represents a sustainable alternative electrolyte for hydrogen production.

In this study, we report a facile one-step synthesis of bimetallic nickel-manganese (Ni–Mn) electrocatalysts supported on a titanium (Ti) substrate via electrochemical deposition using a dynamic hydrogen bubble template (DHBT) method. The prepared catalysts were evaluated as bifunctional electrocatalysts for the hydrogen evolution reaction (HER), oxygen evolution reaction (OER) and overall water splitting in alkaline seawater (ASW, 1.0 M KOH + natural seawater). Electrochemical measurements were conducted at a scan rate of 10 mV s^{-1} over a temperature range of 25–75 °C. The optimized 3D Ni–Mn/Ti electrocatalyst, containing ~44 wt% Ni and ~56 wt% Mn, exhibits excellent HER activity, requiring an overpotential of only 79 mV to reach a current density of 10 mA cm^{-2} at 25 °C. In contrast, the 3D electrocatalyst, containing ~87 wt% Ni and ~13 wt% Mn, demonstrates superior OER performance, requiring an overpotential of only 388 mV to achieve the same current density. A two-electrode alkaline seawater electrolyzer assembled with Ni_{44}–Mn_{56}/Ti as the cathode and Ni_{87}–Mn_{13}/Ti as the anode only requires a cell voltage of 1.619 V to reach 10 mA cm^{-2} and outperforms a noble metal-based system (Pt||Ni_{87}–Mn_{13}/Ti), which requires 1.694 V under identical conditions. Furthermore, the Ni_{44}–Mn_{56}/Ti||Ni_{87}–Mn_{13}/Ti system exhibits negligible potential degradation over 10 hours of continuous operation.

These results demonstrate that the developed bifunctional 3D Ni–Mn/Ti electrocatalyst system possesses excellent activity, durability, and structural stability, highlighting its strong potential for practical large-scale hydrogen production from natural seawater.

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Turn Waste into Good Taste

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The food processing industry generates large quantities of by-products, especially in fruit and vegetable processing for juice production, creating environmental and economic challenges. Pomace, obtained as a residual material after juice extraction from fruits and vegetables is often underutilized despite being a rich source of dietary fiber, phenolic compounds, and other bioactive molecules. The valorization of such waste streams into functional food ingredients represents a key strategy within sustainable and circular food systems. The results presented here are part of the *WasteBridge* project No 7439, funded by the Science Fund of the Republic of Serbia, which focuses on transforming agro-industrial waste into value-added food products. Research conducted within the *WasteBridge* project, supported by previously published studies, demonstrates that pomace flours possess significant functional and nutritional potential. Apple pomace flour obtained by industrial dehydration shows high antioxidant activity, as well as antidiabetic and anti-obesity potential, mainly due to its rich polyphenolic profile and dietary fiber content (Gorjanović et al., 2020). Additionally, thermal analysis confirmed that apple pomace flour exhibits satisfactory stability during food processing conditions (Zlatanović et al., 2019a).

The incorporation of pomace flours into food products has yielded promising results. High substitution levels (up to 75%) of wheat flour with apple pomace flour in cookies were achieved without compromising technological performance, while significantly improving nutritional quality (Zlatanović et al., 2019b). Furthermore, the addition of apple and beetroot pomace flour to jelly candies enhanced their fiber content, antioxidant capacity, and functional properties, while maintaining acceptable sensory characteristics (Gorjanović et al., 2024).

Overall, pomace flours demonstrated a strong potential to improve the nutritional profile of food products, particularly by increasing dietary fiber content to levels that enable “high fiber” claims and contribute to a more favorable carbohydrate-to-fiber ratio, which is associated with recognized health benefits. The findings from the *WasteBridge* project confirm that agro-industrial waste, particularly apple and beetroot pomace, can be successfully transformed into high-value functional ingredients. The integration of pomace flours into food products enhances their nutritional and functional properties while contributing to waste reduction and sustainability goals. This approach supports the development of circular economy models in the food industry. Future work should focus on broader industrial applications and long-term health impact assessments.

Acknowledgements

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Session 2
Pharmaceutical Formulations, Aesthetic Medicine

Can rosacea-prone skin be soothed by a face mask applied immediately after a Platelet-Rich Plasma therapy - a case study

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Rosacea is a chronic inflammatory skin disorder with a pathogenesis that remains incompletely understood. Its clinical presentation typically includes facial erythema, telangiectasia, papules, pustules, and ocular involvement. Genetic predisposition, immune system dysregulation, neurovascular abnormalities, the presence of microorganisms such as *Demodex mites*, and environmental triggers including ultraviolet radiation, alcohol intake, smoking, air pollution, psychological stress, and dietary factors such are considered important contributors to disease development and progression (1). Conventional treatment strategies frequently provide limited improvement and are associated with recurrence or side effects, which has encouraged exploration of new therapeutic approaches. Platelet-rich plasma (PRP), based on autologous platelet concentrates obtained from the patient's own blood, has emerged as a promising strategy to reduce inflammation, stabilize vascular changes and stimulate tissue repair (2). Given that the treatment involves injection of PRP into forehead, cheeks and chin, i.e. areas of the skin where rosacea symptoms are prominent, increased of sensitivity and skin redness could be expected. In order for the client to be satisfied with the immediate outcome of the treatment, a skin-soothing mask should be applied. The aim of this study was to evaluate the effectiveness of a commercial cosmetic face mask applied immediately after PRP therapy in a 56-years-old female client with mild erythematotelangiectatic rosacea characterized by dry, sensitive skin, diffuse centrofacial erythema with scattered telangiectasias, without pharmacological therapy for rosacea. Applied face mask contained a combination of different bioactive compounds including: *Rhodosorus marinus extract, Aloe Barbadensis Leaf Juice Powder, Chamomilla Recutita Flower Extract, Calendula Officinalis Flower Extract, Lactobacillus Ferment* and *Crocus Sativus Flower Extract*. These ingredients have been reported to possess antioxidant, anti-inflammatory and soothing properties. The client signed an informed consent and gave consent for the publication of pictures and discussion of her data. Photographs were captured and skin hydration, elasticity and sensitivity, were monitored using portable skin analyzer API 100, before treatment and after removal of the face mask. The treatment of the whole face involved injection of PRP, the injection sites include forehead, cheeks and chin using a 30G × 4 mm needle. A precise *point-per-point* technique was used for the face region, while the forehead region treated by the *nappage* technique. After the procedure, face mask was applied on the client's face and removed with water after 20 minutes. 30 minutes after removing of face mask photographs were captured and aforementioned parameters were monitored. Skin hydration and elasticity significantly increased, until skin redness significantly decreased even compared to the baseline. It can be concluded that applying a mask with appropriate ingredients can reduce skin redness after PRP treatment.

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Effect of liposomal encapsulation on the radical-scavenging activity of the thiocarbohydrazide-derived Schiff base

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Schiff bases derived from thiocarbohydrazide are widely studied due to their diverse biological activities, including pronounced antioxidant potential. In this work, the antioxidative properties of the Schiff base (*E*)-*N*′-[(*E*)-1-(2-hydroxyphenyl)ethylidene]-2-[1-(2-hydroxyphenyl)ethylidene]hydrazine-1-carbothiohydrazide were evaluated using electron paramagnetic resonance (EPR) spectroscopy by monitoring the scavenging of 2,2-diphenyl-1-picrylhydrazyl (DPPH) and hydroxyl (•OH) radicals. To investigate the effect of a lipid environment on its activity, (*E*)-*N*′-[(*E*)-1-(2-hydroxyphenyl)ethylidene]-2-[1-(2-hydroxyphenyl)ethylidene]hydrazine-1-carbothiohydrazide was incorporated into liposomes composed of dipalmitoylphosphatidylcholine (DPPC) using a modified thin-film hydration method followed by extrusion. EPR measurements revealed a pronounced radical-scavenging activity of the Schiff base in solution, reducing the DPPH signal by 69.53% and the •OH signal by 37.31%. After incorporation into DPPC liposomes, the antiradical activity toward DPPH was reduced to 46.12%, while the scavenging of hydroxyl radicals remained comparable (34.38%). The observed reduction in DPPH activity in the liposomal formulation likely reflects partial shielding of the Schiff base within the lipid bilayer, limiting its accessibility to the radical species, whereas the reactivity toward hydroxyl radicals appears less affected.

These findings demonstrate that (*E*)-*N*′-[(*E*)-1-(2-hydroxyphenyl)ethylidene]-2-[1-(2-hydroxyphenyl)ethylidene]hydrazine-1-carbothiohydrazide retains significant antioxidative activity after incorporation into lipid vesicles, suggesting that liposomal systems may serve as suitable carriers for Schiff bases while modulating their interaction with reactive species. Such formulations could be relevant for future biomedical and pharmaceutical applications where controlled antioxidant activity in membrane-like environments is desirable.

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Investigation of the stability of solid emulsion containg olive oil

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Solid emulsions are widely used in cosmetic formulations, particularly in facial creams, where physicochemical stability and sensory performance are essential, to ensure product quality and compliance with regulatory requirement [1,2]. The incorporation of natural lipids such as olive oil is of significant interest due to their emollient and antioxidant properties [3], however their influence on emulsion stability must be carefully evaluated [4].

The aim of this study was to investigate the effect of olive oil content (0.1 – 1.0% w/w) on the stability of model oil–in–water (O/W) solid emulsions. Five formulations were prepared with identical base composition, differing only in olive oil content (0.1%, 0.25%, 0.5%, 0.75% and 1.0%). Emulsions were produced under controlled homogenization conditions (10,000 rpm, 5 min) at 70 °C, followed by gradual cooling. Stability was evaluated using a combination of viscosity (rotating viscometer method, 25 °C) and pH measurements (25 °C), centrifugation tests (3.000 rpm, 30 min) and laser diffraction analysis for the determination of the particle size [5].

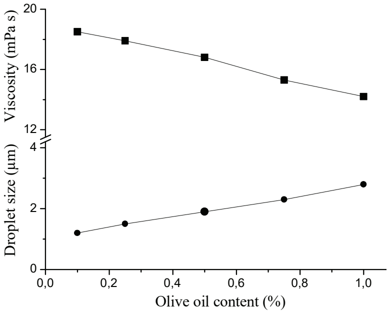

Figure 1. Viscosity and droplet size in formulations with different olive oil content.

Initial droplet size (Fig. 1) ranged from 1.2 ± 0.3 µm (0.1%) to 2.8 ± 0.6 µm (1.0%). After accelerated storage (40 °C, 28 days), samples with ≤ 0.5% olive oil showed minimal droplet growth (< 10%) and no visible phase separation. In contrast, formulations containing 0.75% and 1.0% exhibited droplet coalescence (increase up to 25%) and slight creaming. Results of viscosity measurements (Fig. 1) indicated a decrease from 18.500 mPa s (0.1%) to 14.200 mPa s (1.0%), suggesting a weakening of the internal structure with increasing oil content. pH values remained stable (5.4 – 5.7) across all samples during storage. Centrifugation tests confirmed the highest stability for formulations containing up to 0.5% olive oil, with no phase separation observed.

This study provides a practical formulation guideline for the incorporation of olive oil into stable cosmetic emulsions intended for facial applications.

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Personalised topical therapy as innovative approach in sensitive skin

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Background: Sensitive skin is a common condition in both dermatology and cosmetic practice. It is usually presented with burning, tingling, tightness, redness, or discomfort after exposure to topical products, environmental factors, or cleaning procedures. the impaired skin barrier function, increased permeability, and low level inflammation are most common causes of it. Topical products used in everyday use are not always suitable for all patients.

Objective: To present importance of more personalised approach when choosing proper cosmetical formulations.

Method: A focused review of recent literature was used to investigate what patients carateristics may affect effects of standard topical formulations and active ingredients that are commonly used in sensitive skin. Interest was given to barrier repair agents, calming compounds, and anti-inflammatory substances that may give skin relief and improve tolerance as final result.

Results: Literature review shows that well designed topical formulations can improve hydration, reduce transepidermal water loss, and decrease sensations of irritation and discomfort. Ingredients such as niacinamide, panthenol, ceramides or anti irritant compounds may contribute to barrier recovery and symptoms control. The efficacy is not only related to the active ingredient itself, but also to the whole formulation, including carriers, concentration and avoidance of irritating substances. Moreover, the unique characteristics of skin function, especially across different ethnic skin phenotypes based on defined genotypes, are considered key to shaping future clinical and pharmacological treatments as the foundation of personalized skincare.The personalised barrier oriented products can improve hydration and reduce irritation in patients with compromised skin function.

Conclusion: Personalized topical therapy for sensitive skin is a practical approach where ingredients are chosen based on skin type, barrier condition, tolerance, and symptoms, helping to improve results, increase patient satisfaction, and support long-term use of skincare products.

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Application of Platelet-Rich Plasma and biomimetic peptides in anti-aging treatment of skin prone to erythematotelangiectatic rosacea - a case study

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Rosacea is a chronic, inflammatory skin disease that primarily affects centrofacial region (cheeks, nose, chin, central forehead). Depending on rosacea subtype, it encompassing various combinations of signs and symptoms characterized by remissions and exacerbations - flushing episodes, persistent erythema, inflammatory papules and/or pustules, telangiectasia, burning or stinging, plaques, dry appearance, edema, ocular manifestations and phymatous changes. The most common approach to treating rosacea is to avoid causative factors and use appropriate cosmetic products, while the choice of oral and/or topical medications and aesthetic and/or cosmetic procedures depends on the subtype of rosacea (1). When it comes to aesthetic anti-aging procedures, the biggest problem is choosing an adequate and effective procedure, satisfactory to the client, that will not lead to a worsening of rosacea symptoms. An example of such a procedure is platelet-rich plasma (PRP) therapy – therapy with an autologous blood product rich in growth factors and cytokines. Potential of PRP therapy to promote tissue regeneration, enhance collagen synthesis and stimulate cellular proliferation is well documented. In addition to skin rejuvenation, PRP therapy has shown significant efficacy and safety in the treatment of rosacea (2). Regarding actives, biomimetic signaling peptides involved in extracellular matrix production which improve the firmness and elasticity of the skin are often used in different anti-aging aesthetic and cosmetic treatments. The aim of this study was to evaluate the effectiveness of a combination of PRP and biomimetic signaling peptides in anti-aging treatment of a client with diagnosed mild erythematotelangiectatic rosacea. For that purpose, a split-face study was conducted in a 56-years-old female client with mild erythematotelangiectatic rosacea characterized by dry, sensitive skin, diffuse centrofacial erythema with scattered telangiectasias, small pores, uniform skin texture and facial mimic wrinkles, without pharmacological therapy for rosacea. The client signed an informed consent and gave consent for the publication of pictures and discussion of her data. Photographs were captured and skin hydration, elasticity, sebum content, sensitivity (skin redness), pore and wrinkle appearance were monitored using portable skin analyzer API 100, before treatment and 14 days after treatment. The treatment of the whole face involved injection of PRP, the injection sites include forehead, cheeks and chin using a 30G × 4 mm needle. A p recise *point-per-point* technique was used for the face region, while the forehead region treated by the *nappage* technique. After the procedure, serum with biomimetic peptides was applied only to the left side of the client's face. After 14 days, skin hydration and elasticity significantly increased, skin sensitivity and appearance of wrinkles significantly decreased compared to the baseline on both sides of the face, while a reduction in the appearance of wrinkles was observed on the side of the face treated with peptides. It can be concluded that the application of peptides, even after PRP, does not cause worsening of rosacea symptoms, and that the combination of PRP and biomimetic signaling peptides provides more pronounced anti-aging effects compare to PRP monotherapy when it comes to the appearance of wrinkles on skin prone to erythematotelangiectatic rosacea.

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Could emulsifiers that form a lamellar phases be considered as suitable stabilizer for emulsion containing liposome-encapsulated plant exosomes?

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Plant exosomes are a class of phospholipid bilayer membrane vesicles that transfer variety of signal molecules from cell to cell and play a crucial role in intercellular communication. Although offer a wide range of cosmetic effects, in order to express their efficacy, they have to remain stable in cosmetic products, so liposomes may be suitable carriers for them (1). As carriers' liposomes are used to improve stability and delivery of cosmetic actives allowing their extended and targeted dermal release. However, formulation of cosmetic products with liposomes implies careful selection of cosmetic excipients, especially emulsifier(s). Emulsifier(s) may interfere with the mechanical stability of liposomes and may lead to their solubilization. Example of liposome-friendly emulsifier is hydroxystearyl alcohol and hydroxystearyl glucoside that stabilizes emulsions forming lamellar gel network (2). The aim of this study was to investigate whether other "popular" emulsifiers – claimed by manufacturers to form the liquid crystal lamellar structures within emulsions – can be considered suitable stabilizers for emulsions with liposomes. To accomplish this, four placebo oil-in-water creams (only difference in used emulsifier) and four active samples (the corresponding placebo cream with liposome-encapsulated plant exosomes, PhytoCellTec™ Exosomes) were prepared and characterized by means of electrical conductivity, polarization microscopy and rheology. Selected emulsifiers were: Cetearyl Glucoside, Cetearyl Alcohol (samples F1 and F1a), Cetearyl Olivate, Sorbitan Olivate (samples F2 and F2a), Potassium Palmitoyl Hydrolyzed Wheat Protein, Glyceryl Stearate, Cetearyl Alcohol (samples F3 and F3a) and Sucrose Polystearate, Hydrogenated Polyisobutene (samples F4 and F4a). All obtained samples had different color and viscosity and active samples were more viscous than corresponding placebo samples, with samples F4 and F4a differing the most. Electrical conductivity measurements confirmed that all samples, except F4 and F4a, were multiphase/mixed emulsion systems. Micrographs revealed randomly distributed distorted Maltese crosses and birefringence at the oil droplets border ("onion rings") within all samples, indicating lamellar phases. Also, they showed the difference in the colloidal structure between placebo and active samples. Within active samples intact liposome-similar structures could be observed close to the "onion rings" in the continual aqueous phase (immobilized within the network of lamellar phase of the system). Continual rheology has shown that all samples, except F4, exhibited "shear-thinning" (pseudoplastic) flow behavior with thixotropy. Addition of the liposomes has led to increase in viscosity of the active samples, with slight change of the rheological behavior, especially for samples F4 and F4a. The study confirmed that selected emulsifiers could be classified as exosomes-in-liposome-friendly and suitable stabilizers for emulsion containing them.

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Method development for *in vivo* characterization of the quality of the *in situ* formed hypromellose films

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Film-forming solutions (FFSs) enable the *in situ* formation of a polymeric film on the skin, prolonging drug residence time and improving user compliance (1). However, standardized methods for *in vivo* assessment of film quality remain limited. This study aimed to develop and demonstrate a methodology for the *in vivo* evaluation of films formed from FFSs.

The methodology was optimized for investigations on the volar side of the forearm (3 × 3 cm^2) by evaluating three application amounts (60, 80, and 100 mg/9 cm^2) under controlled conditions (21 ± 1 °C, 40 ± 5% RH). FFS spreading and film compactness were visually assessed, while drying time was determined using the glass plate touch method, with the endpoint defined as the absence of visible residue (1). The selected optimal application amount was used as a standardized condition for subsequent *in vivo* evaluation of film quality and skin compatibility. *In vivo* film stability was assessed over 24 h using a semi-quantitative scoring system (0–3, where 0 represented the poorest and 3 the best film quality) for integrity, flaking, cracking, and peeling. Skin compatibility was evaluated using non-invasive measurements of *stratum corneum* hydration (SCH), transepidermal water loss (TEWL), skin friction and erythema index (EI) at baseline and after removal of the film applied for 24 h, with untreated skin as the control (2). The developed framework was applied to six hypromellose-based FFSs differing in macrogol 400 concentration (2.5%, 2.75%, and 3%) and water/isopropanol ratio (1:1 and 2:1).

Results showed that 100 mg/9 cm^2 provided optimal spreading, uniform film formation, and satisfactory compactness with acceptable drying time. All formulations met the predefined criterion of rapid film formation (< 10 min), with 1:1 water/isopropanol FFSs drying faster (approximately 5.9 min) than 2:1 FFSs (approximately 7.5 min). Film integrity, cracking, and peeling increased nearly linearly over time, while flaking remained negligible. After 5 h, differences between formulations became more evident (Figure 1), with films containing lower plasticizer concentrations (2.5% and 2.75%) and a higher proportion of isopropanol showing better integrity. Biophysical parameters returned to baseline values after film removal ($p > 0.05$), indicating full recovery of skin barrier function (Figure 2). The developed methodology enables structured *in vivo* evaluation of *in situ* film formation, demonstrating that film compactness and performance vary with formulation parameters and therefore require prior standardization of application amount and drying time to ensure reliable assessment of film quality. Integrating visual assessment with a semi-quantitative scoring system allowed reliable evaluation of time-dependent changes in film integrity and differentiation between formulations. Overall, the proposed framework provides a reproducible approach for standardized evaluation of FFSs under conditions relevant to practical application, supporting their rational development and optimization.

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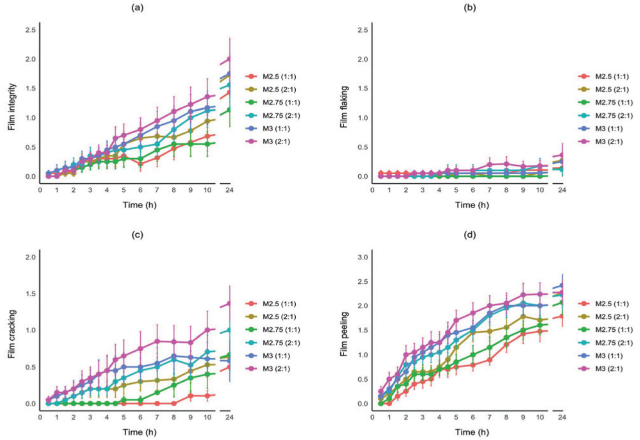

Figure 1. *In vivo* assessment of film quality (0–3) over 24 h: (a) integrity, (b) flaking, (c) cracking, and (d) peeling

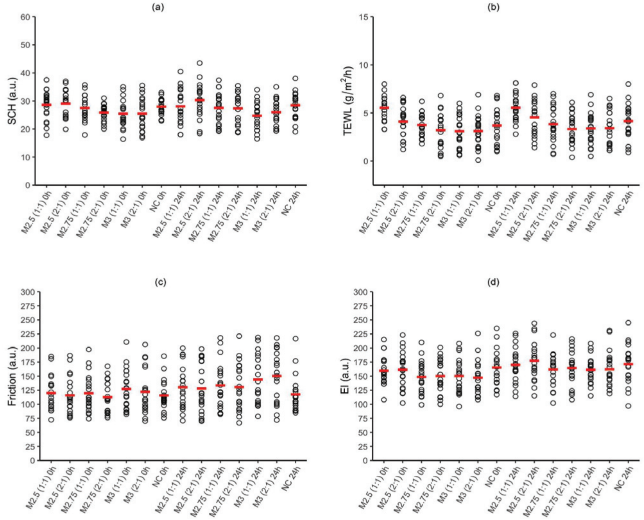

Figure 2. Skin biophysical parameters at baseline (0 h) and after 24 h exposure to the film (24 h): (a) SCH, (b) TEWL, (c) friction, and (d) EI, in comparison with non-treated control (NC)

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Royal Jelly: Chemical Composition, Biological Activities and Pharmaceutical Potential

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Royal jelly has attracted considerable attention in pharmaceutical research due to its com-plex chemical composition and wide spectrum of biological activities. Its major bioactive components, including major royal jelly proteins (MRJPs), bioactive peptides, and 10-hydroxy-2-decenoic acid (10-HDA), contribute to its antimicrobial, antioxidant, anti-inflammatory, and antitumor properties. These characteristics make royal jelly a promising candidate for the development of novel therapeutic agents.

In pharmaceutical applications, royal jelly has shown potential as an adjuvant in cancer therapy, where doses of 5 g/day over 30 days have been associated with reduced chemotherapy-induced toxicity and improved patient quality of life. Additionally, its antimicrobial properties suggest possible use in the formulation of topical agents for wound healing and oral health products, particularly due to its effectiveness against periodontal pathogens. The strong antioxidant capacity of royal jelly also supports its application in preventing oxidative stress-related diseases.

Furthermore, royal jelly demonstrates potential in drug delivery systems and functional formulations, where its bioactive compounds may enhance therapeutic efficacy while minimizing side effects. Its natural origin and broad biological activity profile position it as a valuable ingredient in the development of nutraceuticals, functional foods, and pharmaceutical products.

Despite promising results, further in vivo and clinical studies are required to fully establish standardized dosages, safety profiles, and mechanisms of action. Overall, royal jelly repre-sents a highly promising natural resource with significant potential in modern pharmaceutical applications.

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UV-Vis properties and sun protection factor of peppermint seeds ethanol extracts

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The use of the aerial parts of economically important aromatic and medicinal herb *Mentha × piperita* L., commonly known as peppermint, in the food, cosmetics and pharmaceutical industries is well established. In cosmetic preparations *M. piperita* is often recognized as ingredient of choice due to antimicrobial, anti-inflammatory, antioxidant, photoprotective, anti-aging and wound-healing properties [1,2]. However, peppermint seeds represent unexplored source of bioactive compounds. Only one research on peppermint seeds, published recently by our research group, is available and it reveals fatty acid and phenolic composition, antioxidant activity and cytotoxic properties of supercritical CO_2 extraction of peppermint seeds [3]. Research has also indicated that phenolic-rich extracts of peppermint may contribute to photoprotective effects by absorbing ultraviolet radiation and by mitigating UV-induced oxidative damage in biological systems, suggesting potential applications in natural sun-protection formulations [4]. This is the first study evaluating UV-Vis spectral properties of peppermint seed extracts prepared in 96% (v/v) and 70% (v/v) ethanol–water mixtures (P96 and P70) and calculating the sun protection factor (SPF) values. Both peppermint seeds extracts showed absorption in the UVA and UVB region (absorption peaks at 287 nm and 325 nm), revealing the presence of phenolic compounds and indicating potential to exert the ultraviolet filter function. P70 showed higher UV absorption properties is comparison to P96. Obtained spectra within the range of wavelength between 290 and 320 nm, was used for the SPF calculation. The obtained SPF of P70 was multiply superior (14.74) in comparison to P96 (3.43). Taking into account that plant extracts with ultraviolet absorbing potential may act synergistically with chemical filters, P70 has promising potential to be considered for incorporation in sunscreen or multifunctional products as natural, supporting sun protecting agent.

Acknowledgements

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Concentration of reduced glutathione and malondialdehyde in the rat's liver tissue with experimentally made dyslipidemia

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Introduction: Dyslipidemia as a risk factor of atherosclerosis generates free radicals. Anti-hyperlipidemias drugs from a statin group have pleotropic effects, one of which is anti-oxidative potential. It is proven that extract of articoka has anti- hyperlipidemias and anti-oxidative properties.

Research Goal: To determine whether food with high concentration of cholesterol can drive liver damage coming from oxidative stress, in a period of 10 days, and whether stanin and / or articoka therapy has anti-oxidative effect.

Methodology: Sample of 30 rats is divided into 5 groups (normally fed - NF, aterogenic fed - AF, aterogenic fed with atorvastatin therapy - AFAT, aterogenic fed with atervostatin and articoka therapy - AFAArT and aterogenic fed with articoka therapy - AFArT). As a sign of oxidative liver damage concentration of malondialdehyde (MDA) is measured with thiobarbituric acid method. Concentration of reduced glutathione (GSH) was an indicator of non-enzyme anti-oxidative protection which is measured with dinitroditionitrobenzoic acid in deproteinized supernatant method. Concentration of tissue parameters are expressed in grams of protein (Bradford method).

Results: MDA concentration was greater in the liver tissue of aterogenic fed rats compared to normally fed rats and rats receiving a therapy (NF 0.221±0.101 vs. AF 0.403±0.198 vs. 0.268±0.162 μmol/g of proteins, $P<0.05$). GSH concentration was the highest in the AFArT group and the lowest in the AF group.

Conclusion: Aterogenic food and dyslipidemia induced with it, made an increase of oxidative stress in the rat's liver tissue. Therapy with atorvastatin and articoka was the most efficient in preventing lipid peroxidation, while articoka has greatest effect in inducing non-enzyme anti-oxidative protection, measured through the concentration of reduced glutathione. Results revealed relationship between dyslipidemia and oxidative stress.

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Cytotoxicity and antimicrobial potential of spent gin botanicals

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Alcoholic beverage production represents one of the most prominent industries in the agri-food sector [1]. The by-products of gin distillation are spent gin botanicals (SGB). Although the specific components may differ, SGB contain juniper berries (*Juniperus communis* L.) as the base botanical, with other botanicals including orange peel (*Citrus sinensis* (L.) Osbeck), lemon peel (*Citrus limon* L.), cardamom seeds (*Elettaria cardamomum* (L.) Maton), anise seeds (*Pimpinella anisum* L.), cinnamon bark (*Cinnamomum verum* J. Presl), angelica root (*Angelica archangelica* L.), and coriander (*Coriandrum sativum* L.). Reportedly, about 30–40 pounds of spent botanicals are generated for every batch of gin (750–1000 liters) [2]. The typical approach for managing SGB relies on its incorporation into compost. Current trends in sustainability initiatives, as well as increased awareness of optimal resource use and by-products management presents the need to explore more added-value uses for SGB. The objective of this research was to investigate the SGB extract cytotoxicity and antimicrobial potential against human isolates and referent strains and to propose a novel SGB application. Cytotoxic effect of SGB extract on a human hepatocellular cell line, HepG2, was evaluated by MTT assay, whereas antimicrobial activity was analyzed by the broth microdilution method. The SGB extract exert an inhibitory effect on HepG2 growth (up to 59.66%). Growth inhibition was also detected on bacterial strains: *Staphylococcus aureus* ATCC BAA-1026, *S. aureus* ATCC 43300 MRSA, wound isolate, *S. aureus* Gp41 MSSA, blood isolate, *S. aureus* Gp29 MRSA and oral isolates, *Streptococcus mitis* and *Streptococcus mutans* (minimal inhibitory concentration, MIC=5.86±2.76 mg/mL; MIC=0.234±0.00 mg/mL; MIC=0.234±0.00 mg/mL; MIC=0.234±0.00 mg/mL; MIC=1.46±0.70 mg/mL; MIC=2.81±1.33 mg/mL, respectively). Accordingly, the SGB extract has promising potential as possible antimicrobial ingredient in soaps, solutions and mouthwash products, as well as in the coating of the orthodontic aligners.

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Stretches in pregnancy: prevalence, prevention and attitudes of pregnant and postpartum women - a cross-sectional study

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Striae (striae distensae) are common skin changes that most frequently occur in women, but they can also appear in men, particularly during puberty. Although they do not represent a health problem, they are considered aesthetic changes that may have a significant impact on the emotional status and quality of life of individuals affected by them. During pregnancy, due to hormonal changes and increased stretching of the skin, the incidence of striae is particularly pronounced.

The aim of this study was to examine the prevalence of striae and other skin changes among pregnant and postpartum women, as well as their attitudes toward prevention and treatment options, with the goal of improving preventive and therapeutic approaches in dermatology during and after pregnancy.

The research was conducted as a cross-sectional study examining the attitudes and behaviors of pregnant and postpartum women who experienced skin changes. The survey was anonymous and voluntary and was conducted on a random sample of 50 participants between June and July 2024. The study was carried out at the Obstetrics and Gynecology Clinic “Narodni front”. The collected data were analyzed using descriptive and inferential statistical methods.

The age of the participants ranged from 21 to over 50 years, with the largest percentage of participants (58%) belonging to the 31–40 age group. For 56% of the participants, this was their first pregnancy, 30% were in their second pregnancy, 10% in their third pregnancy, and 4% in their fourth pregnancy. Striae were not observed in 62% of participants, while 38% reported their occurrence. They were most commonly localized on the abdomen and thighs (36.8%). Regarding preventive skin care, 15.4% of participants began using appropriate products in the 6th week of pregnancy, 12.8% in the 20th week, and 10.3% in the 16th week, while only 5.1% started using such products from the very beginning of pregnancy. The majority of participants (87%) believe that striae can be treated, while 13% believe that this is not possible. As the most effective treatment method, 62.5% of participants reported the use of cosmetic products (creams, lotions, gels, oils, and serums), 35% reported laser therapy, while 2.5% considered microdermabrasion to be the most effective method.

The results of the study indicate a relatively high occurrence of striae during pregnancy, as well as the importance of informing pregnant women about prevention and treatment options. Education of pregnant women about proper skin care and modern dermatological methods may contribute to better prevention and improvement of quality of life during and after pregnancy.

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A Novel Stabilized Ethosomal Gel for Enhanced Delivery of Bioactive Compounds

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Transdermal delivery systems have attracted growing attention as an alternative to conventional topical and oral formulations, particularly for bioactive compounds with limited stability, low aqueous solubility, and poor bioavailability. Among these, polyphenolic compounds such as flavonols are of particular interest for their antioxidant and biological activities; however, their practical application is often hindered by instability and limited skin penetration. In this work, a stabilized ethosomal gel system was developed as a carrier platform to improve transdermal delivery of bioactive compounds.

The formulation is based on ethosomal nanovesicles composed of phospholipids and ethanol, incorporated into a gel matrix. A synergistic combination of flavonols and stilbenes was used to enhance vesicle stability, reduce aggregation, and prevent precipitation of the active compounds. The resulting system forms nanosized carriers that facilitate penetration through the stratum corneum and delivery into deeper skin layers.

A series of physicochemical and functional characterizations were conducted to evaluate the properties of the developed system. These included particle-size analysis, morphological characterization using scanning electron microscopy (SEM), stability assessment, and biological performance evaluation.

The results indicate that incorporating a flavonol–stilbene combination improves the stability of the ethosomal vesicles and supports the formation of a homogeneous, robust delivery system. The developed formulation shows promising characteristics for transdermal delivery applications and highlights the potential of stabilized ethosomal carriers as versatile platforms for delivering bioactive compounds.

Session 3
Biotechnology, Medical & Cosmetic Chemistry

Arbutin incorporated biodegradable films based on gelatin and sodium caseinate complex coacervate for cosmetic application

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Development of biodegradable alternatives for the plastic materials used in the cosmetic industry is widely researched due to the low biodegradability and biocompatibility of those materials. The aim of this research is to determine the possibility of incorporating a hydrophilic cosmetic active ingredient, namely arbutin, in biodegradable films based on the complex coacervate of gelatin and sodium caseinate intended for use as cosmetic masks or patches. Arbutin (A) is a hydroquinone glucoside, naturally present in various plants such as bearberry, marjoram and pears [1,2]. The application of A in cosmetics is based on its antioxidant, anti-inflamatory and antimelanogenic activity.

The films were prepared utilizing the casting method, with the required amounts of A incorporated so that its concentrations were 5, 7 and 9% of the total protein. Physicochemical properties of the films (moisture content, solubility in water, water retention and mechanical properties) were determined in order to assess the behavior of the films during application. The release of A from the films was determined in PBS (phosphate-buffered saline), pH 5.5, at room temperature and 200 rpm. The antioxidant activity of the films was assessed using a slightly modified DPPH assay.

Regarding physicochemical properties of the films, the moisture content of the films decreased with an increase in A concentration, while solubility in water increased. All of the films with A retained more water compared to the films without it, but the films with 9% A retained less water, similar to the moisture content. The addition of A influenced the mechanical properties of the films, decreasing the tensile strength and increasing the elongation at break, most prominently for the 5% A films. This could be due to the rearrangement of the protein chains due to the A incorporation, acting similarly to a plasticizer due to its hydrophilicity and relatively low molecular mass. Relatively high water retention of the films and hydrophilicity of the A have led to the release of up to 75% of the incorporated A within 20 min. The burst release occurred at 5 min, after which the concentration increased only slightly. This finding is important for the potential application as face masks or patches, as it shows that the *in vitro* release at the skin pH is relatively fast, which could enable higher absorption of A into the skin during application time. The films have exhibited high antioxidant activity, as DPPH radical scavenging ranged from 60 - 70% for different A concentrations.

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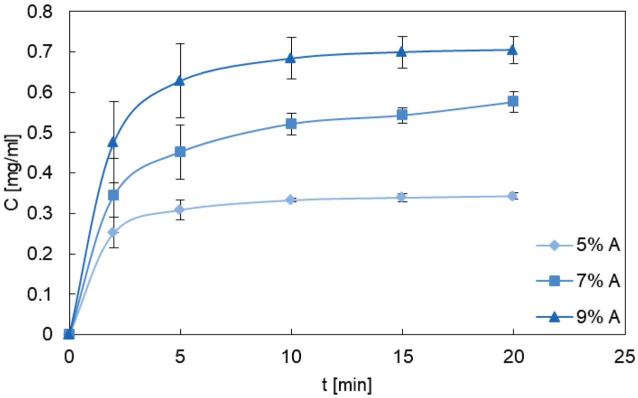

Figure 1. The release of arbutin from the films based on gelatin and sodium caseinate complex coacervate in PBS pH 5.5

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Baby Skincare Products: Benefits *vs* Risks

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Baby skincare products are used to cleanse, protect, and support infant skin. Their benefits include maintaining skin barrier integrity, reducing moisture imbalance, soothing inflammation, supporting skin repair, and helping prevent common skin problems [1,2]. However, hazards include possible skin irritation, allergic contact dermatitis, barrier disruption, and potential exposure to contaminants such as heavy metals and allergenic substances [3]. This study aimed to analyze baby skincare products for their constituents with potential beneficial and harmful effects.

Twenty-five baby skincare products from five brands, including shampoos, baby washes, body lotions, cradle cap and nappy rash products, were analyzed. Samples were categorized by unit price and tested in triplicate for total solids after drying at 80°C. Color was measured using CIELAB 1976 parameters, hue angle, and chroma. UV-Vis spectrophotometric analysis of the methanolic extracts derived from the products was carried out at 280, 420, 520, and 620 nm to obtain color intensity, tint and anthocyanin content. Total polyphenolic content was determined by the Folin–Ciocalteu assay using gallic acid standards. Antioxidant activity was assessed by the DPPH radical scavenging assay and IC_{50} calculation. Metal content was measured by MP-AES after acid digestion and ashing. Statistical analyses included ANOVA with Bonferroni post-hoc test, Spearman correlation, and Principal Component Analysis (PCA) at $p < 0.05$.

The costliest category is that for nappy rash products (0.14±0.04 €/mL), followed by cradle cap products (0.13±0.05 €/mL) and ~~at~~ the low-end shampoos and body washes (both at 0.04±0.01 €/mL). Polyphenolic content varied between groups. The highest content was found in cradle cap products (0.17±0.25%w/w) and the lowest in nappy rash products (0.04±0.01%w/w). The cradle cap products exhibited a wide range of polyphenolic contents. Conversely, the products showed more consistency with their antioxidant activities (432±22-600±76 mg/mL), with the lowest values exhibited by shampoos. The highest color intensities were obtained in nappy rash products and the lowest in cradle products (0.991±0.96 and 0.135±0.13, respectively). Conversely, shampoos exhibited very low tint ratios (0.46±0.27) compared to the others (>1.12±0.21)($p<0.01$). The anthocyanin content varied between 1.05±0.97 mg/kg in cradle cap products and 6.63±2.84 mg/kg in nappy rash products. CIELAB results were analyzed *via* PCA, and it was revealed that products clustered by category, as shown in Figure 1. The predominant heavy metal in baby skincare products was zinc (2.10±0.94 mg/g) compared to the rest (<0.178±0.01 mg/g) ($p<0.01$). This metal predominates in nappy rash products, where it is found in the form of zinc oxide or zinc gluconate. PCA analysis of heavy metals in baby skincare products revealed that a particular brand exhibited a

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high amount of As, Cr, Cu and Ni, compared to the rest. Though the products fall under different categories, it appears that the particular company uses a common ingredient in all products.
It can be concluded that the baby skincare products contain polyphenols and exhibit antioxidant activity. These may be in part attributed to citric acid and other organic acids, tocopherols and other natural products, such as terpenes, coumarins and plant extracts. On the other hand, such products also contain undeclared heavy metals, which may pose an issue in this vulnerable group. The only declared metal is zinc, generally found in nappy rash products [4]. Special attention should be considered with baby skincare products, given the fact that any product applied topically is absorbed efficiently and rapidly through the infants' skin due to the high surface area-to-volume ratio. Authorities should impose stricter regulations on baby skincare products.

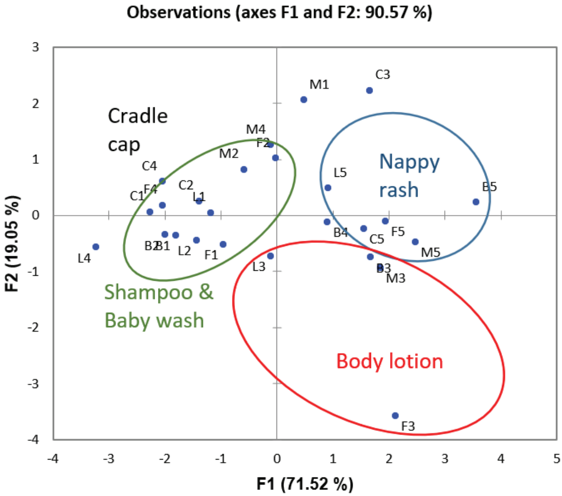

Figure 1. PCA observations plot for CIELAB parameters

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Determinaton of antioxidative activity of Eryngium amethystinum L methanolic extracts using EPR technique and encapsulation into liposome particles

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Eryngium amethystinum L. is a plant distributed in the central regions of the Balkan Peninsula and Italy. The aerial parts of this species are traditionally used in the ethnopharmacology of Western Balkan countries and Italy as diuretic and antimalarial agents, as well as in nutrition, where they are consumed in salads similarly to asparagus [1].

Leaves, stems, and flowers were separated and used for the preparation of methanolic extracts obtained by ultrasound extraction. The antioxidant activity of the extracts was evaluated using diphenyl-picryl-hydrazyl (DPPH), superoxide ($O_2^{\bullet -}$), and hydroxyl ($^{\bullet}OH$) radical scavenging assays. Among the tested samples, the leaf methanolic extract exhibited the highest antioxidant potential, with inhibition values of 55.03% in the DPPH assay, 86.67% in the hydroxyl radical scavenging assay, and 75.26% in the superoxide assay. Due to its pronounced activity, the leaf extract was selected for encapsulation into liposome nanostructures. Liposomes were prepared using phospholipids via the thin-film hydration and ultrasound sonication method, and their formation was confirmed by dynamic light scattering (DLS) analysis [2]. The liposome-encapsulated extract was further evaluated for its antioxidant activity using the same assays. The encapsulated extract exhibited inhibition values of 53.81% (DPPH), 56.54% ($^{\bullet}OH$), and 45.49% ($O_2^{\bullet -}$). Although a decrease in antiradical activity was observed after encapsulation—particularly in hydroxyl and superoxide radical scavenging assays—this reduction may be attributed to limited immediate availability of the active compounds due to their incorporation within the liposomal bilayer [3].

Despite this decrease, the formulation still demonstrated notable antioxidant activity, suggesting that liposomal encapsulation may provide protective effects and enable controlled release of bioactive compounds. Such systems represent a promising approach for enhancing the stability and potential bioavailability of *E. amethystinum* constituents, with prospective applications in pharmaceutical and nutraceutical formulations.

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Low energy nanoemulsions with ferulic and caffeic acid – Formulation optimisation and antioxidant activity

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Ferulic and caffeic acids, emerging natural raw materials with antioxidant properties, are promising candidates for treating oxidative stress that occurs daily in the skin due to various harmful factors such as UV radiation, air pollution, smoking, and stressful lifestyles. However, their use is limited by poor solubility, instability, and low bioavailability, highlighting the need for innovative formulations [1,2]. This study aimed to develop low-energy nanoemulsions as carriers for ferulic and caffeic acids, combined with new ingredients certified for natural cosmetics, and to assess antioxidant activity and nanoemulsion stability. Nanoemulsions were prepared using a low-energy phase inversion composition method at room temperature [3], providing an eco-friendly and cost-efficient procedure. Characterisation and stability assessment of the nanoemulsions were performed by measuring droplet size and size distribution, pH value, electrical conductivity, transparency percentage, and by conducting microscopic analysis. Antioxidant activity was evaluated using DPPH and ABTS assays, and absorption spectra of ferulic/caffeic acid solutions and corresponding nanoemulsions were investigated in the UV-VIS range. The results of formulation investigations revealed that a conventional surfactant mixture based on polysorbate 80 and sorbitan oleate was a superior choice compared to natural polyglyceryl esters. New raw materials certified for natural cosmetics – Emogreen L19 (emollient) and Euxyl ECO (multifunctional additive) – successfully replaced synthetic oils and additives. Optimal nanoemulsions with ferulic and caffeic acid had small droplet sizes below 40 nm, narrow droplet size distribution, and efficiently inhibited ABTS and DPPH free radicals (≥ 85%). These nanoemulsions absorbed UVB and UVA light due to the presence of ferulic or caffeic acid in their structure, confirming their potential use in sun protection cosmetic products. Based on the best stability and antioxidant activity it was concluded that the nanoemulsion containing caffeic acid and Euxyl ECO is the preferred formulation for further investigation.

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A Novel Small-Molecule Fluorescent Probe for Live Imaging of Lipid Droplets in Cells and Zebrafish

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Lipid droplets (LDs) are highly dynamic organelles that regulate lipid storage, energy homeostasis, and cellular stress responses. Because their accumulation is closely linked to metabolic reprogramming in cancer and other diseases, accurate visualization of LDs, especially across diverse biological models, is essential for understanding their roles. To address this need, we developed **1a**, a novel small-molecule fluorescent probe with simple synthesis that selectively labels lipid droplets *in vitro* and *in vivo*, offering good specificity, brightness, and photostability, and is readily detectable in the blue imaging channel.

Compound **1a** produces a punctate fluorescence pattern typical of lipid droplets and is effective across various cell models, demonstrating its versatility. Co-localization with established lipid droplet dyes such as Nile Red and BODIPY 493/503 confirms selective accumulation in lipid-rich structures. **1a** exhibits high specificity for lipid droplets, showing no overlap with membrane dyes such as CM-DiI or with mitochondria, ER, or lysosome markers. Importantly, **1a** fluorescence increased with lipid droplet content, with oleic acid-induced lipid accumulation producing a stronger signal. Additionally, **1a** enabled visualization of lipid-rich structures in zebrafish larvae, supporting its use in whole-organism imaging.

Together, these properties make **1a** a reliable fluorescent probe for visualizing and analyzing lipid droplets, offering a versatile method for studying lipid droplet-related processes across various biological systems.

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Engineering of a bifunctional fusion protein (3.5-scFv-β-Lactamase) for detection of TNT-Like compounds

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The development of functional recombinant antibody-based constructs requires careful integration of structural stability, proper folding, and preservation of biological activity. In this study, a bifunctional fusion protein was engineered by genetically linking the human-derived 3.5 single-chain variable fragment (scFv) with the enzyme β-lactamase, with the aim of generating a structurally and functionally stable recombinant molecule.

The gene encoding the 3.5-scFv was fused to the β-lactamase sequence and expressed in the periplasmic space of Escherichia coli, providing an oxidative environment favorable for correct disulfide bond formation. Following expression, the fusion protein was purified using Ni-NTA affinity chromatography, yielding up to 3 mg/mL of soluble protein. Protein integrity and expected molecular weight (55–60 kDa) were confirmed by SDS-PAGE and immunoblot analysis. Functional characterization demonstrated that the enzymatic domain retained catalytic activity after fusion, indicating that structural coupling of the antibody fragment and enzyme did not compromise protein functionality.

Overall, successful engineering and expression of the 3.5-scFv-β-lactamase fusion protein demonstrate the potential of integrated immunoreagents as compact and efficient biosensing tools. Such engineered systems are particularly suitable for rapid on-site detection of explosive residues in environmental and security applications. These constructs may serve as a structural basis for future development of biosensing platforms in forensic detection of nitroaromatic explosive residues. Their analytical performance and detection capabilities are further evaluated in a complementary study.

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Bioactivity of wine concentrates from European Merlot grape varieties in human keratinocytes

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Due to high polyphenol content, red wines and extracts derived from their by-products have demonstrated promising potential in skin care applications. Key benefits include the reduction of reactive oxygen species (ROS), which are known to contribute to skin aging [1]. In addition, polyphenols that are present in red wines have been shown to enhance wound healing in skin models [2,3].

This study investigated the antioxidative and wound healing potential of red wine concentrates derived from three Merlot wines of Serbian, North Macedonian, and Italian origin. The cytotoxicity of the concentrates was assessed in a range of concentrations (12.5, 25, 50, 100, 200, and 400 µg/mL) using MTT viability assay in human keratinocyte (HaCaT) cell line, while intracellular antioxidative activity was assessed by 2',7'-dichlorofluorescein diacetate (H2DCFDA) assay. The wound healing potential was evaluated using a cell scratch assay.

All examined concentrates showed no significant decrease in cell viability up to the concentration of 50 µg/mL after 24 h of exposure. The antioxidant potential of the concentrates at non-cytotoxic concentrations (12.5, 25, and 50 µg/mL) was further evaluated by their ability to reduce ROS levels in HaCaT cells co-incubated with 30 mM 2,2'-azobisisobutyramidinium chloride (AAPH). All concentrates significantly reduced oxidative stress at a concentration of 50 µg/mL. Furthermore, the cell scratch assay showed that all concentrates stimulate cell migration, with statistically significant wound area reduction obtained by North Macedonian and Serbian wines.

These findings suggest that the concentrates of European Merlot wines possess skin-beneficial antioxidant and wound healing properties, with no observed toxicity to skin cells up to high concentrations. They show significant potential as natural ingredients for cosmetic formulations aimed at preventing oxidative stress-induced skin damage. Evaluating the effects on more complex skin models will give deeper perspective on the potential use of these concentrates in treating skin conditions.

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Targeting FFAR3 with microbiota-derived propionate: a molecular dynamics perspective on Parkinson's disease modulation

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Short-chain fatty acids (SCFAs) produced by the gut microbiota have emerged as key mediators in gut-brain communication [1]. Among them, propionate has shown promising neuroprotective effects in experimental models of Parkinson's disease (PD), potentially via activation of the free fatty acid receptor 3 (FFAR3) [2]. Here, a molecular dynamics study is presented to elucidate the binding mode and interaction profile of propionate within the SCFA-binding pocket of FFAR3. Molecular dynamics (MD) simulations were performed using Desmond software (Schrödinger) on the active-state structure of FFAR3 (PDB ID: 8J21). The system was simulated for 100 nanoseconds under physiological pH (7.4). Propionate, modeled in its deprotonated form ($CH_3CH_2COO^-$), was docked into the SCFA-binding pocket of FFAR3. Key ligand-residue interactions were analyzed using fractional interaction profiles to determine hydrogen bond stability and occupancy. The MD trajectory revealed stable and recurrent hydrogen bonding between the carboxylate group of propionate and three critical amino acid residues: Tyr170 (occupancy: 0.75), Arg185 (1.55), and Arg258 (1.98). These interactions are consistent with known activation mechanisms of FFAR3 and suggest a robust affinity profile. Considering the established role of FFAR3 in neuromodulatory signaling, the observed interaction pattern provides a mechanistic basis for the reported neuroprotective effects of propionate and supports its translational potential in targeting motor dysfunction in PD. This work provides a structural and mechanistic foundation for the rational design of FFAR3-selective ligands and highlights propionate as a candidate scaffold in the development of gut-derived neurotherapeutics.

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Microbiota-derived indole-3-propionic acid disrupts Aβ42 aggregation: molecular insights toward neuro-motor preservation in Alzheimer's disease

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In addition to progressive cognitive impairment, Alzheimer's disease (AD) is increasingly associated with early motor dysfunction, reflecting deeper involvement of subcortical and motor-related neural circuits [1]. This study investigates the molecular interactions between gut microbiota-derived indole-3-propionic acid (IPA) and the amyloid-β42 (Aβ42) peptide, aiming to evaluate IPA's potential to inhibit pathological aggregation and contribute to novel microbiota-based strategies for AD prevention [2]. Molecular dynamics simulations were conducted in Desmond using the fibrillar structure of Aβ42 (PDB ID: 5OQV), at physiological pH 7.4 over a 100 ns timescale. The analysis focused on dominant non-covalent interactions between IPA and Aβ42, including hydrogen bonding, hydrophobic contacts, ionic interactions, and water bridges. Literature data were reviewed to contextualize the microbial origin of IPA and its neuroprotective relevance within the gut-brain axis [3]. Stable hydrogen bond interactions were observed between the carboxyl group of IPA and two basic residues in Aβ42: Arg5 (fraction interaction: 0.25) and Lys16 (0.75). In parallel, the nitrogen atom of the indole ring engaged in a hydrogen bond with Leu17 (0.30), while π-cation interactions were detected between the aromatic system of IPA and the side chain of Lys16 (0.22). These binding events localize within amyloidogenic domains of Aβ42 and are consistent with interference in β-sheet propagation and fibrillogenesis, as previously reported in experimental studies. These molecular findings support the role of IPA as a microbiota-derived modulator of Aβ42 aggregation, reinforcing its potential in the prevention of both cognitive and motor decline in AD. Given that gut bacteria such as *Clostridium sporogenes* naturally produce IPA, synbiotic modulation of the microbiota offers a promising, non-invasive therapeutic avenue. Moreover, the interaction profile of IPA provides a structural framework for the rational design of synthetic analogs with enhanced binding affinity and disease-modifying potential.

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Green Extraction of Propolis using Orange Peel Oil: Chemical and Thermal Characterization

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This study aimed to develop and evaluate a green, alcohol-free extraction system for propolis using orange peel essential oil (OPO) as a sustainable alternative to conventional solvents. OPO was isolated from citrus industry waste using hydrodistillation. It contains a high amount of d-limonene, a bio-based compound widely applied in food and represents a promising solvent for efficient propolis extraction. Chemical characterization of OPO and propolis dissolved in OPO (OPO-P) was performed using GC–MS and HPLC. GC–MS analysis detected a terpene-rich profile dominated by d-limonene (approximately 97%), with minor components including α-pinene, β-pinene, sabinene, 3-carene, and valencene. HPLC analysis confirmed the presence of phenolic compounds in OPO-P, including p-coumaric and ferulic acids at 0.109 mg mL^{-1} each, as well as citral in both samples OPO and OPO-P at 1.072 mg mL^{-1} and 0.944 mg mL^{-1}, respectively. Thermal behavior and stability were evaluated using TGA. Both samples were investigated at a heating rate of 20 °C/min. The results showed that pure OPO exhibited almost complete mass loss (99.98%) at 150.58 °C, whereas OPO-P showed a lower mass loss (93.98%) at 150.72 °C, indicating enhanced thermal stability due to the presence of propolis constituents such as waxes and phenolic resins. Overall, the results provided comprehensive characterization of the OPO-based extracts. The results demonstrate that OPO is an effective green solvent for propolis extraction, enabling efficient solubilization and preservation of bioactive compounds while enhancing thermal stability. This approach offers a sustainable alternative to conventional extraction systems and supports the valorization of citrus waste.

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Bone tissue engineering–oriented 3D-printed biocomposites based on interpenetrating networks and multi-doped mesoporous bioactive glass

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The repair of large bone defects remains a significant clinical challenge, requiring biomaterials that support bone regeneration while providing mechanical stability, interconnected porosity, infection control, and biocompatibility. Three-dimensional (3D) printing using mask stereolithography (mSLA) offers an advanced approach to fabricate materials with controlled architecture and composition in a rapid and reproducible manner [1].

In this study, composite hydrogels and scaffolds based on polyethylene glycol diacrylate, poly(methacrylic acid), and gelatin, incorporating multi-doped mesoporous bioactive glass (mMBG) particles were fabricated via mSLA. The mMBG particles, doped with Mg, Sr, Cu, and Zn and synthesized via a microemulsion-assisted sol-gel method, exhibited high specific surface area, well-developed mesoporosity, and excellent biocompatibility and bioactivity, while ciprofloxacin-loaded particles showed appreciable drug-loading capacity and pronounced antibacterial activity. To enhance scaffold performance, chitosan-based coatings enriched with mMBG particles and ciprofloxacin were applied. SEM analysis revealed the porosity and surface characteristics of both uncoated and coated scaffolds, confirming uniform particle distribution within the printed composite scaffold and coatings. The incorporation of mMBG particles improved the mechanical properties, while chitosan coatings allowed modulation of compressive strength, elastic modulus, and swelling behavior, yielding tunable physicochemical characteristics. Biological evaluation demonstrated high BM-MSC viability in indirect assays. Moreover, the combination of chitosan, mMBG particles, and ciprofloxacin in hydrogel coatings produced a synergistic antibacterial effect, achieving complete inhibition of *Staphylococcus aureus* growth.

Overall, the developed systems exhibit controlled architecture, mechanical integrity, biocompatibility, and strong antibacterial performance, indicating their potential for bone tissue engineering applications and related biomedical fields.

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Encapsulation of bioactive compounds into zeolite structures with potential application in the food industry

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In food processing, zeolites are primarily utilized as adsorbents and molecular sieves for the removal of undesirable compounds, including toxins, heavy metals, and moisture, thereby improving product quality and safety. A significant area of innovation in food industry is the incorporation of bioactive compounds by encapsulation as an essential way to overcome challenges such as low solubility, instability under processing and storage conditions, and poor bioavailability. Zeolite-based carriers have demonstrated high encapsulation efficiency and enhanced stability of hydrophobic compounds such as plant-derived antioxidants, primarily due to their porous crystalline structure and adsorption capacity [1,2]. Zeolites have emerged as promising inorganic carriers for the encapsulation of bioactive compounds due to their well-defined porous structure, high specific surface area, ion-exchange capacity, thermal stability, and tunable surface chemistry. In food-related systems, these properties make zeolites attractive for the protection, stabilization, and controlled release of sensitive bioactives such as polyphenols, essential oils, vitamins, antioxidants, aromas, and antimicrobial agents.

Compared with many organic encapsulation systems, zeolites offer superior resistance to heat and mechanical stress, which is particularly relevant for industrial food applications. In addition, surface modification of zeolites can enhance compatibility with hydrophobic or poorly soluble bioactives and enable more precise release behavior under specific pH, humidity, or ionic conditions [1,3]. Recent studies report encapsulation efficiencies exceeding 90% and significant improvements in thermal and chemical stability of encapsulated compounds.

Additionally, zeolites can enhance the antioxidant and antimicrobial activity of encapsulated compounds, further contributing to food preservation and safety. The zeolite-based carriers may support the incorporation of natural antimicrobials and antioxidants into active food packaging, edible formulations, and functional ingredients, thereby extending shelf life and preserving quality.

The systems that combine zeolites with alginate, chitosan or other biopolymers have shown improved mechanical stability, encapsulation efficiency, and controlled release profiles, indicating their potential for incorporation into food matrices and edible delivery systems [1,2].

Despite these promising developments, there are challenges remain regarding scalability, regulatory approval, and safety assessment for direct food applications. Future research should focus on optimizing synthesis methods, evaluating long-term biocompatibility, and integrating zeolite-based encapsulation systems into industrial food processes.

In conclusion, zeolites offer versatile solutions for encapsulation of bioactive compounds with application in food sector. Improving food quality, safety, and shelf life, with significant potential for future applications in smart packaging, functional foods, and green processing technologies, zeolites represent a highly promising material for eco-innovations in this sector. Increasing consumer awareness regarding the environmental and health impacts of purchased food products leads to a conscious, more natural, and sustainable life.

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Anthracenyl Schiff base Pd(II) complexes as promising antimicrobial agents

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Schiff base compounds are well known for their antibacterial properties, which are often enhanced through metal coordination. Notably, palladium-Schiff base complexes show strong antimicrobial activity, making them promising options for metallodrug development [1].

In this study, we report a series of four novel Schiff bases, along with one previously described ligand, and five newly synthesized Pd(II) complexes. The ligands were prepared *via* condensation of 9-anthracenecarboxaldehyde with various phenylenediamine derivatives, namely 4-methyl-1,2-phenylenediamine (L2), methyl 3,4-diaminobenzoate (L3), 4-chloro-1,2-phenylenediamine (L4), and 4,5-dimethyl-1,2-phenylenediamine (L5). All compounds were synthesized and comprehensively characterized using ^{1}H and ^{13}C NMR spectroscopy, IR spectroscopy, elemental analysis, and mass spectrometry. Additionally, molar conductivity measurements were performed to provide insight into their coordination behavior.

The antimicrobial activity of the synthesized compounds was evaluated *in vitro* against a panel of microorganisms, including three Gram-positive and four Gram-negative bacterial strains. Streptomycin and chloramphenicol were used as reference antibiotics to validate the assays and enable comparison. Among the tested compounds, complex **C2** (**$PdCl_2C_{37}H_{26}N_2$**) exhibited the most pronounced activity, with minimum inhibitory concentration (MIC) values of 0.002 mg/mL against E. coli, 0.001 mg/mL against S. enteritidis, and 0.005 mg/mL against P. aeruginosa. Furthermore, **C2** showed moderate antifungal activity against C. albicans (MIC = 0.16 mg/mL).

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Rhenium(V)-Apigenin Complex: Structure and Anticancer Activity

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A widely distributed plant-derived flavone, apigenin, is present in parsley, chamomile, celery, and numerous other dietary sources, and has been associated with a variety of biological activities relevant to human health [1]. Recently, high-valent oxo-rhenium(V) complexes have attracted considerable interest due to their chemical stability and their potential applications in therapeutic development [2].

This study describes the synthesis, structural characterization, and biological assessment of a new complex formed between apigenin and $ReOBr_3(PPh_3)_2$. The compound was obtained by reacting apigenin with $ReOBr_3(PPh_3)_2$ in acetone under reflux conditions, using a 1:1 molar ratio. Its structure and composition were established through standard spectroscopic techniques, including NMR and IR, along with X-ray diffraction analysis. A distorted octahedral geometry was observed around the Re(V) center, where apigenin coordinates via two oxygen atoms in an almost planar chelating arrangement.

Biological activity was evaluated by means of the resazurin reduction assay across several cancer cell lines. Notably, the Re–apigenin complex exhibited strong cytotoxic effects on the Jurkat cell line, while moderate activity was recorded against other tested lines. For Jurkat cells, IC_{50} values were found to be below 5 μM, suggesting an enhanced cytotoxic effect compared to apigenin alone.

Overall, binding of apigenin to the Re(V) center alters its biological properties and enhances its anticancer potential, highlighting oxorhenium(V) complexes as promising platforms for the design of new therapeutic agents.

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Safety assessment of cocoa shell for potential application in the confectionery industry

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Cocoa shell, traditionally regarded as a by-product and often discarded in cocoa producing countries, has become increasingly interesting in recent years due to the trend towards greater sustainability and waste reduction in the food industry. Its composition includes many constituents with functional properties, particularly phenolic compounds, theobromine, and a high amount of fiber. It contains fat with a lipid profile similar to cocoa butter. Cocoa shell has a strong brown colour and chocolate flavour, which enables its use as a natural colourant and flavouring. For this reason, it exhibits great potential for application, especially in confectionery – such as biscuits, cakes, chocolate muffins, and extruded snacks – to increase fiber content, provide antioxidant properties, or act as a fat replacer. Of particular interest is its potential implementation in chocolate production, which would maximise utilisation of cocoa beans within the same industry. However, as it is the bean's outer layer, its safety remains a concern due to potential environmental and processing contaminants. The aim of this study was to evaluate the chemical composition and safety of two cocoa shell samples of different origin for potential use in the confectionery industry: G (from Ghana) and T (from Togo). Chemical composition was determined using standard analytical methods, heavy metals (Pb, Cd, Cu, As) by ICP-MS, aflatoxin using ELISA, and microbiological stability according to current ISO protocols. Both samples exhibited low moisture content (3.0±0.02 % in G and 3.1±0.04 % in T), which is crucial for ensuring microbiological stability during storage. Total fat content was found to be 6.89±0.06 % in G and 5.29±0.08 % in T, confirming it as a minor component of the cocoa shell. In contrast, cocoa shells were found to be a significant source of protein, with sample G showing higher values (18.95±0.14 %) compared to sample T (17.08±0.12 %). The carbohydrate content was 5.34±0.14 % in G and 6.18±0.13 % in T. The cocoa shell was found to contain large amounts of cellulose (26.34±0.22 % in G and 26.07±0.10 % in T), and ash (8.03±0.08 % in G and 7.73±0.06 % in T). Theobromine content detected in the samples was 1.12±0.02 % in G and 1.04±0.01 % in T. The results for heavy metals revealed that Pb, Cd, and Cu amounts were higher in sample G (0.145 mg/kg, 0.121 mg/kg and 31.52 mg/kg, respectively) compared to sample T (0.085 mg/kg, 0.126 mg/kg, and 15.68 mg/kg, respectively), while presence of As was detected only in sample G (0.08 mg/kg). The total aflatoxins and aflatoxin B1 contents in both samples were below the limit of detection. In terms of microbiological stability, none of the tested microorganisms were detected except for aerobic mesophilic bacteria, which were present at 2.9×10^2 in G and 5.6×10^2 in T. All obtained values are in accordance with Serbian legislation, thus making the tested cocoa shell samples safe for further use.

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Chemical characterization of Rosa Don Juan (climbing rose) essential oil from the Kruševac region (Serbia)

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Essential oils have been known to mankind for hundreds, even thousands of years. Serbia abounds with a multitude of plants of different, even more diverse shapes, sizes, colors and scents. Many of them contain substances that are invisible to the eye and are hidden in the roots or in other parts of the plant. Those highly concentrated substances that give plants their aroma are called essential oils. Despite the existence of more than 37,000 different varieties of roses worldwide, there remains a significant interest and high relevance in rose breeding. The rose is the most beloved flower in the world, commonly named the "queen of flowers". Roses Don Juan (climbing rose) is widely used in perfumes and cosmetics industries because of its medicinal properties and pleasant odour. Since synthesis and accumulation of volatile compounds affected by flower harvest time, the current study was conducted to evaluate and followed of volatiles in the essential oil (EO) of Don Juan rose petals certain date harvested (the city of Kruševac, Serbia (43°34′48″N 21°20′2″E, collection period July 2025)). This study provides a detailed chemical characterization and safety evaluation of Rosa Don Juan (climbing rose) essential oil collected from the Kruševac region in central Serbia. Essential oils were extracted via hydro distillation and analyzed using gas chromatography-mass spectrometry (GC-MS) to determine their chemical compositions. The essential oil was isolated by hydrodistillation using a Clevenger-type apparatus, yielding 0.1–0.2%. The primary constituents identified were *Benzenemethanol, Citronellol, Geraniol,* with its presence and exact percentage define the chemical composition of a rose from specific geographic region. Gas chromatography–mass spectrometry (GC–MS) analysis revealed that oxygenated monoterpenes dominated the volatile fraction (around 30.00%). The obtained profile corresponds to an oxygenated monoterpene-rich chemotype and aligns with previously reported compositions of Rosa, while also contributing new regional phytochemical data. Inductively coupled plasma analysis confirmed very low concentrations of toxic metals, including Cd, Pb, Hg, As, and Ni, all below internationally recommended limits. The combination of a characteristic terpene profile and minimal metal contamination indicates good quality and safety of the investigated oil. These findings expand the phytochemical knowledge of Serbian medicinal flora and support the potential application of this essential oil in pharmaceutical, cosmetic, and food-related products.

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Valorization of thermostable fruit fillings application in artisanal chocolate production

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In the modern confectionery and bakery industry, thermostable fruit fillings offer a number of technological advantages, as well as health benefits. These semi-finished products are characterised by stable physico-chemical and sensory properties under both high and low temperatures. This means that their volume, shape, texture, taste, and aroma remain unchanged during baking, freezing, and thawing. They are used to fill various types of bakery products and pastry. Praline type artisanal chocolates are a luxury product consisting of a chocolate shell and a center that may include nuts, fruit filling, caramelised sugar, or various creams. Although neither excessively high nor low temperatures are used in the production of these treats, termostable fruit fillings can reduce the incidence of leakage, or interaction with the warm chocolate coating in case of poor cooling. The aim of this study was to produce praline type artisanal dark and milk chocolates using two types of thermostable fruit fillings: cherry (CF), and apricot filling (AF), as well as to determine the sensory quality of the finished product. The fillings were previously tested for soluble dry matter content (refractometric method), sorbic acid content (spectrophotometric method), pH value (potentiometric method), and total sugar content (Luff-Schoorl). The results showed that the soluble dry matter content was 42.5% and 46.7% for AF and CF, respectively, while the measured pH values were 3.26 for CF and 3.37 for AF. The determined sorbic acid content was 751.5 mg/kg in CF, and 756.8 mg/kg in AF. These values confirm compliance with Serbian legislation concerning additives, which sets the maximum permitted amount of sorbic acid at 1000 mg/kg. The total sugar content was observed in CF (33.85%), and in AF (35.38%). The produced artisanal chocolates were evaluated sensorially by trained panel (10) using the scoring method. The best scores were assigned to samples of dark artisanal chocolate in the praline type with CF (X_m=4,64), followed by samples of milk chocolate with CF (X_m=4,58), placing them in the category of excellent overall quality. The panelists considered that the natural tartness and acidity of the cherry was complemented by the balanced bitterness and sweetness of the dark chocolate, awarding them the best marks for both filling texture (X_m=4,60±0,21) and taste (X_m=4,70±0,23). The combination of AF with milk and dark chocolate was less appreciated and achived very good overall quality (X_m=4,44 for milk, and X_m=4,47 for dark shells), mostly due to the pronounced sweetness. The obtained results showed significant potential of thermostable fruit fillings usage in the production of artisanal praline-type chocolates as it can contribute to expanding the range of confectionery products.

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Antimicrobial Activity of Cold-Pressed *Cannabis sativa* Seed Oil in Wound Treatment Against *Pseudomonas aeruginosa*

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This study investigates the antimicrobial efficacy of cold-pressed oil derived from the seeds of industrial hemp (*Cannabis sativa*) when applied topically to wounds, with a particular focus on its activity against *Pseudomonas aeruginosa*, a clinically significant pathogen frequently isolated from infected wounds and known for its intrinsic resistance to multiple antibiotics. The oil was obtained via mechanical cold pressing, ensuring preservation of thermolabile bioactive compounds. Its chemical composition is characterized by a high content of polyunsaturated fatty acids (primarily linoleic acid and α-linolenic acid in an optimal ω-6/ω-3 ratio), along with tocopherols, phytosterols, and minor phenolic constituents, which are associated with membrane-disruptive, anti-inflammatory, and antioxidant properties.

The experimental protocol involved direct topical application of the oil onto wound surfaces, followed by microbiological sampling at defined time intervals. Swab samples were processed using standard cultivation techniques, including selective media for *P. aeruginosa*, colony-forming unit (CFU) enumeration, and confirmatory identification, with comparative analysis performed between treated and untreated (control) samples.

The results demonstrated a pronounced reduction in viable *P. aeruginosa* counts in treated wounds, indicating a significant inhibitory effect. In several cases, near-complete suppression of bacterial growth was observed after repeated applications. The antimicrobial mechanism is likely multifactorial, involving disruption of bacterial cell membranes by unsaturated fatty acids, interference with quorum sensing pathways, and modulation of the local oxidative environment.

These findings highlight the potential of cold-pressed hemp seed oil as a natural, biocompatible antimicrobial agent for wound care applications, particularly in the management of infections involving resistant Gram-negative bacteria such as *P. aeruginosa*. Moreover, the observed antimicrobial effect suggests that cold-pressed hemp seed oil may serve as a complementary therapeutic approach in reducing bacterial load and preventing chronic wound infection progression. Given the increasing global concern regarding antimicrobial resistance, such plant-derived alternatives offer promising avenues for adjunct or standalone therapeutic strategies. Further investigations are warranted to elucidate the precise mechanisms of action and validate efficacy through controlled in vivo and clinical studies.

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Biodegradation of Synthetic Polymers by Novel *Hafnia* Strains Isolated from the Gastrointestinal Tract of Common Carp (*Cyprinus carpio*)

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The accumulation of synthetic plastic waste, especially polyethylene (PE) and polystyrene (PS), is a major environmental problem due to their high chemical stability and resistance to natural breakdown. While microbial bioremediation provides a sustainable "green" alternative to traditional waste management, finding effective biocatalysts for stubborn polymers remains a top priority [1]. This study explores the degradative potential of two new *Hafnia* bacterial strains, *H. paralvei* UUNT_MP29 and *H. alvei* UUNT_MP41 [2], isolated from a unique biological niche: the intestinal tract of the freshwater common carp (*Cyprinus carpio*). As bottom-feeding omnivores, these fish are continuously exposed to microplastic ingestion, creating a selective environment for the evolution of specialized microbiota that can degrade polymers.

A multidisciplinary approach combining bioinformatics, growth kinetics, and advanced material characterization was used to assess the strains' ability to utilize PE and PS as their only carbon sources. Genomic analysis of the *H. paralvei* isolates identified key functional homologs involved in xenobiotic degradation, such as alcohol dehydrogenase (Adh) and 3-hydroxybutyrate dehydrogenase (HDH), suggesting specialized metabolic pathways for breaking down long-chain hydrocarbons. Experimental results showed strong biofilm formation and significant substrate utilization. Gravimetric analysis revealed weight losses of 16.88% for PS and 15.29% for PE over a 16-day incubation period, both following first-order reaction kinetics. Surface characterization with scanning electron microscopy (SEM) confirmed successful colonization, surface erosion, and pitting (Fig. 1). Fourier-transform infrared spectroscopy (FTIR) indicated oxidative enzymatic attack, evidenced by the appearance of carbonyl and hydroxyl groups, which suggest polymer backbone breakdown. Additionally, thermogravimetric analysis (TGA) demonstrated a notable decrease in the thermal stability of the treated films, confirming polymer chain scission and reduced molecular weight.

These findings emphasize the gastrointestinal tracts of plastic-exposed aquatic vertebrates as a promising area for discovering biocatalysts and support the development of effective microbial strategies for microplastic bioremediation.

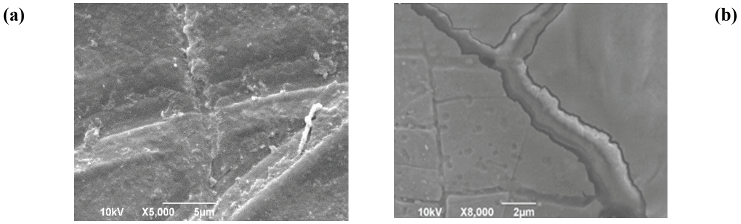

Figure 1. SEM micrographs of the PE (a) and PS (b) surfaces showing ruptures on the polymer surfaces caused by *Hafnia paralvei* MP_29 colonization**.**

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Antioxidant activity and EPR-assessed penetration of liposome-loaded Black Goji berry extract

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Black goji berry (*Lycium ruthenicum*) is a rich source of bioactive compounds, particularly anthocyanins, known for their strong antioxidant properties. In this study, an extract of freeze-dried black goji berries was prepared using 80% methanol (MeOH) in a 1:10 (w/v) ratio with ultrasound-assisted extraction. The obtained extract demonstrated notable antiradical activity, achieving 70.71% scavenging of DPPH radicals and 82.5% inhibition of hydroxyl ($^{\bullet}OH$) radicals.

Despite these promising results, the use of methanol presents limitations for pharmaceutical and dermal applications due to its toxicity. To overcome this issue, a liposomal delivery system was developed to encapsulate the bioactive components following removal of methanol by vacuum volatilization. Liposomes composed of dipalmitoylphosphatidylcholine (DPPC) were prepared using the thin-film hydration method followed by extrusion, yielding vesicles with an average diameter of approximately 200 nm. Encapsulation of the extract into DPPC liposomes resulted in slightly reduced, yet still significant, antiradical activity, with 55.6% DPPH scavenging and 77.5% hydroxyl radical inhibition. This decrease may be attributed to partial shielding of active compounds within the lipid bilayer, potentially affecting their immediate accessibility in radical-scavenging assays. In addition to antioxidant evaluation, the penetration ability of the liposomal formulation was investigated using electron paramagnetic resonance (EPR) imaging. A gelatin-based model was employed as a surrogate for human skin to assess the diffusion of encapsulated compounds. The analysis compared liposomes containing the spin trap 3-carboxy-proxyl (3-CP) with an aqueous solution of the same probe. EPR imaging revealed that the liposomal formulation exhibited a significantly stronger signal in deeper layers of the gelatin matrix, whereas the aqueous solution showed signal localization predominantly at the surface.

These findings indicate that liposomes facilitate enhanced penetration and diffusion of encapsulated molecules through the model matrix. The improved penetration observed for the liposomal system is likely a result of its nanoscale size and lipid composition, which enable better interaction with and passage through structured barriers. This characteristic is particularly relevant for dermal and transdermal delivery applications, where efficient transport of active compounds into deeper skin layers is essential for therapeutic efficacy. This study demonstrates that DPPC liposomes can serve as an effective carrier for bioactive compounds derived from black goji berry extract, enabling safer formulation by eliminating methanol while preserving substantial antioxidant activity. The enhanced penetration capacity of the liposomal system highlights its potential for use in topical and dermatological applications.

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Thermal Behavior of Dried Red Cabbage Waste Pulp and Juice: Correlation with Chemical Composition

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Red cabbage (*Brassica oleracea var. capitata f. rubra*), commonly referred to as purple cabbage, is widely recognized for its significant health-promoting properties. It is rich in nutrients and bioactive compounds, making it a valuable component of a balanced diet [1]. Red cabbage is particularly notable for its high anthocyanin content [2], which contributes to various biological activities, including antioxidant, anti-inflammatory, hepatoprotective effects [3,4], and potential protection against atherosclerosis [1,4]. However, to the best of our knowledge, there is a lack of literature data regarding the overall thermal stability of dried red cabbage pulp remaining after juice extraction. This by-product is rich in dietary fiber, residual anthocyanins, and minerals [1], and therefore represents a potentially valuable nutritionally functional ingredient. Understanding its thermal characteristics is particularly important in food technology, as thermal processing can significantly influence nutritional quality and functional properties.

The aim of this study was to thermally characterize dried red cabbage pulp (obtained after juice extraction) and dried red cabbage juice in order to better understand thermal stability and thermally induced structural changes of the sample.

The red cabbage (*Brassica oleracea L. var. capitata f, rubra*) was purchased from agricultural market known as “Maxi pijaca” in Belgrade. The red cabbage was cut into pieces and subjected to juicing using the “Zepter More Juice Press Frozen” for home use. The pulp obtained after squeezing was subjected to drying. Drying was conducted in the convection way by “Excalibur “food dehydrator, at the 40 °C, for the 12 h. For DSC analysis (DSC, Q1000, TA Instruments, New Castle, DE, USA), dried red cabbage pulp and juice samples were sealed in aluminum pans using a TA Blue Press and scanned from –90 °C to 250 °C, at a heating rate of 5 °C/min.

Chemical composition of dried red cabbage was analyzed in terms of total carbohydrate, diet fibers, fats and proteins, mono and disaccharides (glucose, fructose and sucrose), cellulose, and water content. Total content of carbohydrates as well as the content of glucose, fructose and sucrose, were determined by high performance liquid chromatography on the HPLC Alliance Waters 1515 device (Waters Corporation Milford, MA 01757 USA) with Waters 2414 RI detector carbohydrate analysis column 3.9x300mm. Mobile phase was acetonitrile/water (80/20), f low rate 1.5 ml/min. Total dietary fiber was determined by standard enzymatic-gravimetric AOAC method 985.29. Cellulose content was determined by gravimetry according to standard method SRPS ISO 6541:1997.

The determined proximate compositions of the dried red cabbage pulp and juice were in agreement with literature data [5]. Although the DSC thermograms did not directly represent the complex chemical composition of the samples due to interactions among constituents during heating, the observed differences between the thermograms of dried juice and dried pulp clearly reflected variations in their chemical profiles.

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Thermoanalytical Characterization of Emulsions

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SWOP (Switch Oil Phase) emulsions are metastable o/w emulsions that invert into w/o emulsions upon application of mechanical energy during rubbing it onto the skin. They form a lipophilic layer on the skin much faster than conventional o/w emulsions [1]. The emulsions were prepared using a combination of appropriate emulsifiers, anionic surfactants, and polymeric stabilizers.

To investigate the colloidal structure, with particular emphasis on water distribution within the system, binary systems and emulsions with a simple composition were prepared. Their compositions are presented in Table 1. These systems contain the corresponding emulsifier or a single-component lipid phase that quantitatively and qualitatively correspond to the emulsion.

Table 1. Composition of binary systems, and SWOP emulsion

Composition	% (m/m) binary system S1	SWOP emulsion S2
Polyglyceryl-2 dipolyhydroxystearate	4	4
Liquid Paraffin	/	26
Preservative *	0.5	0.5
Sodium Lauryl Glucoside CarboxylateLauryl Glucoside	1.5	1.5
Water	94	68

* Methylparaben, Butylparaben, Ethylparaben Propylparaben, Isobutylparaben

To gain deeper insight into the differences in structural characteristics and to clarify the mechanism of SWOP emulsion formation and phase inversion, compositionally comparable, binary and emulsion systems were prepared and analyzed using differential scanning calorimetry (DSC; Q1000, TA Instruments, New Castle, DE, USA) and thermogravimetric analysis (TGA; Q500, TA Instruments, New Castle, DE, USA). Each sample was accurately weighed (between 10 and 12 mg) into aluminum pans, sealed, and analyzed using DSC. The samples were heated from 25 to 110 °C at a heating rate of 5 °C/min. The thermogravimetric analysis was performed in the temperature range from 20 to 160 °C with the heating rate of 5 °C/min.

According to the results obtained there was a difference in the thermal behavior of the analyzed emulsions S1 and S2, suggesting that water distribution is strongly dependent on temperature and differs between the binary system and the emulsion. Furthermore, DSC results suggest that the observed difference in the enthalpy (ΔH) of the endothermic transition is mainly a consequence of differences in water content and structure between the binary system and obtained emulsion [2].

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Synthesis and *in silico* evaluation of novel tetralone/benzylpiperidine derivatives

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Alzheimer's disease (AD) is an incurable, progressive neurodegenerative disorder characterized by a loss of cognitive and behavioral functions, such as loss of episodic and semantic memory, speech, and depression. According to the World Health Organization (WHO), approximately 55 million people worldwide are affected by AD [1]. Donepezil, a reversible, selective inhibitor of acetylcholinesterase (AChE) and butyrylcholinesterase (BuChE), is the most commonly used drug in the symptomatic treatment of AD and was approved by the FDA in 1996. Analysis of the crystal structure of AChE in complex with donepezil revealed that the indanone ring binds to the peripheral anionic site (PAS), while the *N*-benzylpiperidine portion of the molecule interacts with the catalytic active site (CAS) of the enzyme [2]. Many donepezil analogues have been synthesized so far, most often by replacing the indanone part of the molecule while retaining the *N*-benzylpiperidine moiety. Tetralone derivatives that contain the *N*-benzylpiperidine and *N*-benzylpyridinium moiety have been reported in the literature and, as such, exhibit inhibitory activity toward AChE and BuChE [3,4]. As a part of our ongoing research on cholinesterase inhibitors (ChEIs), we designed and synthesized donepezil derivatives **1a** and **1b**, in which the *N*-benzylpiperidine fragment was retained, while the indanone moiety was replaced with 2-benzylidene-1-tetralone (Figure 1). Derivative **1a** contains an *N*-benzylpiperidine and tetralone moiety connected via a triazole linker, while in the case of **1b**, the structural motifs are connected by a triazine moiety. Molecular docking and *in silico* ADME analysis of the compounds **1a** and **1b** revealed favorable interactions with target enzymes and pharmacokinetic properties. Therefore, the newly designed donepezil derivatives represent potential lead candidates for comprehensive pharmacological evaluation, including their inhibitory activity against AChE and BuChE, as well as their cytotoxicity.

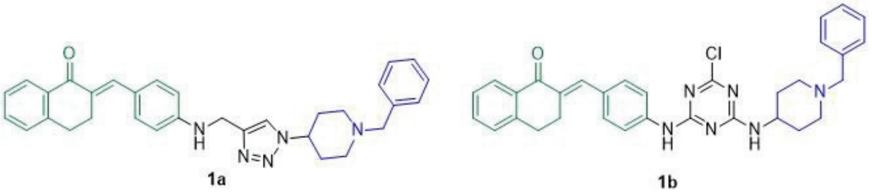

Figure 1. Newly synthesized tetralone/benzylpiperidine derivatives

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Electrochemically cross-linked Zn-alginate films with oregano essential oil: Physicochemical properties, antioxidant and antimicrobial activity

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Alginate is a naturally occurring polysaccharide capable of forming hydrogels through ionic crosslinking with multivalent metal cations, such as Zn^{2+}. Owing to its biocompatibility and film-forming ability, alginate is widely used in biomedical and packaging applications [1,2]. This study aimed to develop Zn–alginate-based films by electrochemical synthesis incorporating oregano essential oil (OR), hyaluronic acid (HA), and propylene glycol (PG), and to evaluate the influence of these additives on their physicochemical and functional properties. Films with varying compositions were prepared and characterized in terms of swelling behavior, morphology (SEM), and molecular structure (FTIR), while antioxidant activity (ABTS and DPPH assays) and antimicrobial activity against selected bacterial and fungal strains were also evaluated. The results demonstrated a strong influence of additives on the film properties. The addition of OR caused significant morphological and structural changes, while FTIR analysis confirmed the presence of all components and indicated interactions between HA and OR within the alginate matrix, consistent with the observed morphology. HA contributed to the formation of a denser network with reduced swelling and slower drying of the film. The antimicrobial activity was evaluated against *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Enterococcus faecalis*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, and *Candida albicans*. The sample containing only OR (ZnAlPGOR) exhibited broader antibacterial activity compared to the one containing both OR and HA (ZnAlPGORHA), likely due to higher release of oregano essential oil from the film matrix. Both formulations showed comparable antifungal activity against *C. albicans*. In agreement with these findings, OR also contributed to enhanced antioxidant activity, highlighting its dual functional role. These results indicate that the combination of OR and HA enables tuning of structural and functional properties of Zn–alginate films, making them promising candidates for biomedical and packaging applications.

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Antioxidant activity of *Ficus carica L.* leaf extract using EPR spectroscopy

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Fig (*Ficus carica L.*) leaves represent a valuable source of bioactive compounds with potential antioxidant activity [1]. To assess the extract's ability to scavenge free radical species (DPPH and hydroxyl radicals), EPR spectroscopy was employed due to its high sensitivity and specificity. Additionally, the spin-trapping technique was utilized to evaluate activity against short-lived hydroxyl radicals. The results indicate that the ethyl acetate extract of *Ficus carica L.* leaves is an effective scavenger of free radicals, exhibiting pronounced selectivity toward hydroxyl radicals. Specifically, the extract showed high scavenging activity against hydroxyl radicals (87.6%), compared to significantly lower activity toward DPPH radicals (5.4%), suggesting a preferential reactivity toward highly reactive oxygen species. The observed antioxidant activity can be attributed to the presence of phenolic compounds and flavonoids in the fig leaf extract. These findings underscore the extract's potential as a natural antioxidant, offering promising applications in the food, pharmaceutical, and cosmetic industries, particularly in formulations aimed at reducing oxidative stress.

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Polyphenol-Based Nanoparticles from *Picea omorika* (Pančić) Purkyně Needles: Synthesis and Biomedical Potential

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Nanoparticles based on bioactive compounds isolated from natural sources offer a promising approach to sustainable nanotechnology with potential applications in biomedicine. Polyphenolic compounds are known for their potent antioxidant and anticarcinogenic properties. We aimed to develop nanoparticles based on polyphenols isolated from *Picea omorika* (Pančić) Purkyně needles, a Balkan endemic conifer known for its rich phytochemical profile [1]. Polyphenols were extracted from the plant's needles through water-based extraction. Nanoparticles were obtained via the hydrothermal synthesis method. Dynamic Light Scattering (DLS) and Transmission Electron Microscopy (TEM) confirmed that the obtained nanoparticles are below 200 nm in size. Nanoparticles demonstrated moderate antioxidant activity against the DPPH radical, determined by the Electron Paramagnetic Resonance (EPR) spectroscopy method. These results highlight the potential of *Picea omorika*-derived polyphenols as a novel basis for the development of bioactive and sustainable nanoformulations with potential biomedical applications.

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From Biochemistry to Cosmetology: Epigenetic Approaches for Safe Anti-Aging Skin Treatments

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Epigenetic regulation includes histone modifications, DNA methylation, and microRNA (miRNA), enabling gene expression control without altering the DNA sequence. These mechanisms are essential for skin homeostasis, while their dysfunction contributes to aging, manifested by loss of elasticity, wrinkle formation, and reduced regenerative capacity. Environmental factors, particularly UV radiation and pollution, induce epigenetic changes that compromise the skin barrier function.

This review is based on an analysis of recent scientific literature and regulatory guidelines, focusing on studies published in the last five years. The effects of bioactive ingredients—retinoids, signaling peptides, polyphenols, and plant extracts – on epigenetic mechanisms in skin cells were examined. Special attention was given to distinguishing the effects of these compounds on DNA methylation and histone-modifying enzymes under controlled conditions versus their action in final cosmetic formulations.

Results indicate that bioactive ingredients can indirectly modulate epigenetic processes through signaling pathways associated with aging biomarkers. Direct effects on epigenetic enzymes in practical application are limited, manifesting as improvements in hydration, elasticity, and reduction of visible signs of aging. The use of the term "epigenetic" in cosmetics requires caution and strict adherence to regulatory frameworks to avoid misleading claims. Integrating epigenetics into cosmetology offers promising prospects for personalized skincare while balancing scientifically proven efficacy and user safety.

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Low light Stress Modulates Redox Metabolism in *Chlamydomonas acidophila* PM01

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Light stress is a key factor in activating the antioxidative system in microalgae. Under intense light conditions, the reactive oxygen species (ROS) formation can lead to impairment of cellular structures [1]. Less is known about stress induced by low light conditions. *Chlamydomonas acidophila* is a microalga that thrives in acidic environments and exhibits unique adaptations in its photosynthetic processes [2]. In this study, we aimed to investigate the effect of reduced light intensity on ROS content and cell viability in the culture of *Chlamydomonas acidophila* strain PM01 during the early stationary growth phase. After 15 days of cultivation under optimal conditions, the culture was exposed to a two-fold lower light intensity for 1 h and 24 h. A slight increase in ROS levels was observed following 1 hour after treatment, followed by more pronounced rise after 24 hours. This did not affect cell culture viability, as the proportion of live cells remained above 90%. Acidophilic strains exhibit an enhanced capacity to regulate electron transport rates, likely reducing electron leakage and ROS formation under stress conditions [3], or accumulate high concentrations of lutein, a carotenoid with antioxidant properties, when exposed to different carbon sources and light conditions [4]. Our results show that short-term exposure to reduced light increases ROS level in *Chlamydomonas acidophila* PM01 without affecting viability, reflecting robust antioxidative regulation. These adaptive mechanisms could be harnessed in biotechnology for production of biomass under suboptimal environmental conditions.

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Cloning and Expression of a Recombinant Monovalent Anti-TNT scFv Antibody

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Recombinant antibody fragments, particularly single-chain variable fragments (scFv), represent a powerful tool in modern biotechnology for the development of selective molecular recognition systems. In this study, cloning and expression of a monovalent anti-TNT scFv antibody were performed with the aim of generating a functional building block for advanced immunodetection platforms targeting nitroaromatic compounds.

The gene encoding the anti-TNT scFv fragment was inserted into an appropriate expression vector and heterologously expressed in *Escherichia coli*. To ensure proper folding and disulfide bond formation, the recombinant protein was directed to the periplasmic space, providing favorable conditions for functional antibody production. Following expression, the scFv antibody was isolated and purified using affinity chromatography. The amplified scFv gene (748 bp) and the expressed protein (~28 kDa) were confirmed by agarose gel electrophoresis and SDS-PAGE/immunoblot analysis, respectively, indicating successful cloning and expression of the recombinant antibody fragment. As the minimal antigen-binding unit, the obtained scFv antibody retains specificity toward TNT-related compounds while offering advantages such as reduced molecular size and ease of recombinant production. Although monovalent fragments typically exhibit lower binding strength compared to bivalent antibodies, their structural simplicity enables greater flexibility for further engineering and functional modification.

Successful cloning and expression of the anti-TNT scFv antibody confirm its suitability as a modular component for the development of next-generation immunoassays and biosensing systems. Such recombinant fragments provide a versatile platform for integration into advanced analytical methods, including engineered detection approaches for environmental and forensic applications.

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Selective Uptake and Biosorption of Rare Earth Elements in *Chlamydomonas acidophila* Strains

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Rare earth elements (REEs) are essential for advanced technologies, including electronics, renewable energy, and catalysis, yet their recovery is challenging due to low natural concentrations and chemical similarity among elements [1]. Selected microalgal strains may serve the purpose selective uptake and separation of REEs from complex aqueous matrices[1]. Acidophilic microalgae are particularly suitable for REE bio-extraction, as they can grow under low pH conditions in which REEs remain soluble and bioavailable. The species *Chlamydomonas acidophila* exhibits high tolerance to acidic environments at pH values as low as 1.5. This study aimed to evaluate the uptake capacity and the ability to preferentially accumulate individual REEs from a mixture in two *C. acidophila* strains (136 and PM01 isolated from two acid mines tailing ponds). Both strains were cultured in MAM medium at pH 3 and treated with a mixture of La, Ce, Pr, Eu, Sm, and Tb (0.2 mM each). After 24 h of treatment, biomass was collected and washed three times with deionized water or 1 mM EDTA (extracellular metal chelator) to distinguish between metals bound to the cell wall and metals accumulated inside the cell. ICP-OES analysis showed that all analyzed metals bind to the cell wall but are also accumulated intracellularly. Both strains preferentially accumulated Ce, Pr, and Eu, demonstrating selective interactions with specific REEs. Discrimination between Eu^{3+} and Sm^{3+} is of particular importance since these show very close ionic radii and are very hard to separate using conventional approaches [2]. These results demonstrate the importance of resolving surface-bound versus intracellular metals, highlighting the dominant role of cell wall interactions in apparent REE accumulation, and support the potential of acidophilic microalgae as efficient and selective biological systems for REE recovery from complex environments.

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Use of Cosmetic and Wellness Treatments Among Young Adults

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Cosmetic and wellness treatments represent an expanding segment of contemporary health and lifestyle practices, particularly among young adults. Cosmetic treatments include non-invasive and minimally invasive procedures aimed at enhancing appearance and improving skin condition, characterized by accessibility, safety, and rapid visible outcomes. Wellness treatments follow a holistic approach grounded in the biopsychosocial model, focusing on health promotion, stress prevention, improvement of musculoskeletal function, and overall quality of life. These interventions, such as massage therapy, spa programs, and relaxation techniques, contribute to both physical and psychological well-being, positioning them as important components of modern preventive strategies. In contemporary society, physical appearance has become a significant determinant of well-being, social interaction, and self-esteem. Aesthetic procedures are more prevalent among women, with literature indicating a positive association between such procedures and psychological well-being, particularly when linked to higher baseline self-esteem. The development of non-invasive techniques, including dermal fillers, botulinum toxin, laser therapy, and microneedling, has further increased their popularity. Additionally, social media plays an important role in shaping attitudes and influencing trends related to cosmetic and wellness practices. The aim of this study was to examine the prevalence, types, and motivations for the use of cosmetic and wellness services among young adults. The research was conducted as a survey-based study on a sample of 184 participants. The majority of respondents (78.8%) were female, with 39.4% aged 18–20 years. Most participants (81.7%) were familiar with the concept of wellness, and 77.9% reported using such services. The most commonly used treatments were massage (31.7%) and facial treatments (36.9%), while 41.3% reported using them several times per year. The main motivations were skin improvement (35.6%) and relaxation (39.4%), with treatments most often performed in specialized salons (44%). Furthermore, 76% of respondents considered these treatments highly beneficial, while 49% obtained information via social media. Notably, 75% would use these services more frequently if they were more affordable, and 86.6% believed they contribute to stress reduction and improved quality of life. The findings indicate a high prevalence of cosmetic and wellness treatment use among young adults, driven primarily by relaxation and aesthetic motives. These results highlight the increasing integration of such practices into modern lifestyles and their perceived value in both physical and psychological domains. They also emphasize the need for improved accessibility, as well as evidence-based guidance and professional support to ensure safe and effective use. A better understanding of these patterns may contribute to optimizing service provision and strengthening preventive health approaches in cosmetology and wellness.

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The use of cosmetic products in massage therapy

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Background: The use of topical cosmetic products represents an integral component of massage therapy practice. Their effectiveness depends not only on formulation characteristics but also on the application protocol, including massage techniques. However, the selection and use of these products are often based on practical experience rather than evidence-based guidelines.

Objective: To investigate the patterns of use, selection criteria, and perceived effects of cosmetic products among massage and wellness professionals.

Methods: A cross-sectional survey was conducted among 155 respondents, primarily physiotherapists and massage therapists. The questionnaire assessed professional background, work environment, types of massage techniques, product selection criteria, and perceptions of cosmetic product effects and skin penetration.

Results: The majority of respondents was physiotherapists (51.8%) and massage therapists (32.1%). Most participants performed treatments in private settings (52.7%) or in cosmetic and wellness salons (38.4%). Therapeutic (medical) (74.1%) and relaxation massages (66.1%) were the most commonly applied techniques. Massage oils were the predominant products used (88.4%), followed by creams (50%). Product selection was primarily influenced by quality and effectiveness (90.2%), while 85.7% of respondents reported choosing products based on the type of massage performed. Dermatologically tested (56.3%) and natural/organic products (47.3%) were most frequently preferred. Although the majority of participants emphasized the therapeutic effect on muscles and tissues (75%) and adequate lubrication (67.9%) as key benefits, 35.7% had not received formal education on the mechanisms of action of these products. Notably, 61.6% of respondents believed that active ingredients exert significant effects through transdermal penetration.

Conclusion: Cosmetic products play a significant role in massage therapy practice, influencing both technical performance and perceived therapeutic outcomes. However, the findings indicate a gap between practical use and formal education, as well as reliance on subjective beliefs regarding transdermal effects. These results highlight the need for improved education and the development of evidence-based guidelines for the use of cosmetic products in massage therapy.

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Synthesis and Characterization of Chitosan/Starch/Gelatin Composite Hydrogels Reinforced with Calcium Hydroxyapatite for Biomedical Applications

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Macroporous composite hydrogels have attracted significant attention in bone tissue engineering due to their structural similarity to natural bone and their ability to combine mechanical support with biological functionality. In this study, hydrogels based on natural polymers-chitosan, starch, and gelatin-were synthesized and optimized for potential biomedical applications. The effects of gelatin content and incorporation of calcium hydroxyapatite (HA) on the hydrogels' structural, mechanical, and physicochemical properties were investigated.

Increasing gelatin content enhanced the polymer network density, resulting in improved mechanical properties, with elastic modulus and fracture energy reaching 9.7 kPa and 9.7 kJ m-^{3}, respectively. SEM analysis revealed that at low gelatin concentrations, the hydrogels exhibited a pronounced gradient structure, with a denser outer layer and a more porous interior, whereas higher gelatin content led to a homogeneous, compact porous network. Morphological analysis confirmed highly porous, interconnected structures with pore sizes of 100–400 µm, favorable for cell infiltration and tissue ingrowth. Swelling behavior initially increased with gelatin content due to partial disruption of chitosan crosslinking, but decreased at the highest gelatin concentration as the denser network limited water uptake. Incorporation of HA further improved mechanical stability, increasing elastic modulus to 32.8 kPa and fracture energy to 23.5 kJ m^{-3}, and ensured uniform distribution of inorganic particles within the polymer matrix. Furthermore, bioactive extracts of *Alchemilla vulgaris* were successfully incorporated into hydrogels to evaluate their potential for controlled release of antioxidant and antimicrobial compounds, and gelatin-rich hydrogels exhibited accelerated release profiles due to increased degradability.

These results demonstrate that the optimized composite hydrogels exhibit improved mechanical strength, a well-defined porous structure, and effective functional properties, including controlled release of bioactive compounds. Such materials are promising candidates for further investigation in bone tissue engineering and biomedical applications.

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Influence of extraction solvent on different parts of Galanthus nivalis L. for antioxidant properties

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Galanthus nivalis L. the snowdrop is the best-known and most widespread of the twenty species in its genus *Galanthus* (*Amaryllidaceae*), important and interesting genus from the aspect of potential therapeutic action and application in order to protect and preserve human health. This study deals with the application of conventional extraction approache for isolating bioactive compounds from the different parts of the plant and investigate antioxidant potential of extracts obtained plant using solvents different polarity, with particular emphasis on their free radical scavenging activity evaluated by DPPH assay. Phenolic compounds were determined by spectrophotometric test, the highest amount of total phenolics was in extract of bulb in methanol (3.82 ± 1.03 mg GAE/g), extract of above-ground part extracted in methanol had a highest amount of flavonoids (1.16 ± 0,25 mg GAE/g). Obtained results indicate methanol is a suitable solvent for efficient extraction phenolics from the bulb and efficient for extraction flavonoids compounds from above-ground parts of *G.nivalis*. The chemical and phenolic profile of extracts was established using HPLC-DAD analysis. Highest amount of polyphenolics compound was in the above-ground part extracted in methanol (85.828 mg/g). Flavonoids such as apigenin, naringenin, quercetin and rutin, phenolic acids as sinapic, ferulic and *p*-coumaric acids were found as a dominant compound. Results of study confirms the effictiveness of methanol as a solvent for the extraction of active phenolic compounds from the plant specie *Galanthus nivalis* L. DPPH test demonstrated significantly higher antioxidant activity in the methanolic extract (69.4 ± 2.4 μg/mL) compared to ethyl-acetate extrats which was confirmed by lower IC_{50} values (29.5 ± 1.5 μg/mL). These results contribute to a better understanding of the relation between extraction solvent polarity and antioxidant efficiency in the pharmacological studies.

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Taxifolin inhibits endovascular differentiation of human trophoblast cells

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Taxifolin (TF) is a bioactive flavonoid with various pharmacological effects including antioxidant, anti-inflammatory, hepatoprotective and anti-cancer activities[1]. It can be extracted from different coniferous trees, and it is present in various plants used in traditional medicine as well as in different commercially available health-promoting products[1]. Also, TF can be found in vegetables, fruits and beverages used in everyday diet [1]. Previously, TF showed cytoprotective, antioxidant and anti-inflammatory activity on trophoblast cells, specialized cells of placenta [2,3], but its effect on function of these cells has not yet been studied. Successful pregnancy largely depends on adequate placentation including remodeling of uterine spiral arteries during which extravillous (EVT) trophoblast cells acquire endothelial-like properties.

The aim of this study was to investigate potential of TF to affect endovascular differentiation of trophoblast cells using human EVT HTR-8/SVneo cell line. We used tube formation assay on Matrigel to assess endothelial-like differentiation and qPCR to evaluate expression of vascular endothelial cadherin (VE-cadherin), adhesion protein important for trophoblast endovascular invasion and spiral artery remodeling [4]. Our results showed that preincubation with 10 or 100 μM TF for 24 h significantly inhibited tube formation of HTR-8/SVneo cells in a concentration-dependent manner decreasing both tube length and number of branching points. Furthermore, TF downregulated expression of *CDH5* (VE-cadherin) indicating a possible mechanism of action.

Although further research is needed, our results indicate that TF could affect endovascular differentiation of trophoblast cells affecting functioning of placenta and consequently pregnancy outcome.

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Disruption of Monoamine Oxidase Enzymes by SARS-CoV-2 Spike Protein: From Molecular Insights to Potential Health Implications

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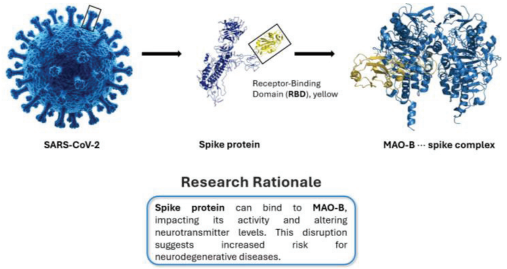
The COVID-19 pandemic, caused by the SARS-CoV-2 virus, has highlighted not only respiratory complications but also a wide range of neurological symptoms observed in patients. Understanding the molecular origins of these effects is essential for developing effective therapeutic strategies and supporting long-term public health.

In this work, we investigate how the viral spike protein may interfere with key human enzymes, monoamine oxidases (MAO A and MAO B), which play a crucial role in regulating neurotransmitters in the brain [1]. Disruption of these enzymes is closely linked to neurological disorders and neurodegenerative diseases, making them highly relevant targets from both biomedical and pharmaceutical perspectives [2].

Using advanced computational modeling techniques, we analyzed how the spike protein interacts with MAO enzymes at the molecular level. Our results indicate strong and stable binding between the viral protein and both MAO isoforms, leading to structural and functional changes in the enzymes. These changes may alter neurotransmitter metabolism, providing a plausible explanation for neurological complications associated with COVID-19 [3].

Beyond fundamental insights, this study demonstrates how computational chemistry can rapidly uncover biologically and medically relevant mechanisms, supporting drug discovery and risk assessment efforts. The identified interactions open new opportunities for designing targeted therapeutic interventions and highlight the importance of integrating computational approaches into industrial research pipelines. By bridging molecular-level understanding with real-world health challenges, this work contributes to ongoing efforts to mitigate the long-term neurological impact of COVID-19 and illustrates the value of interdisciplinary collaboration between academia, healthcare, and industry.



Spike protein can bind to **MAO-B**, impacting its activity and altering neurotransmitter levels. This disruption suggests increased risk for neurodegenerative diseases.

Figure 1. Disruption of the activity of monoamine oxidase enzymes by SARS-CoV-2 spike protein.

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Session 4
Household Chemistry and Materials for Industry

Chemical degradation and mechanical behavior of fabrics intended for medical uniforms under repeated washing cycles with commercial detergents (Warp Direction Analysis)

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Medical textiles used for uniforms in healthcare systems are continuously exposed to intensive maintenance processes involving repeated washing with commercial detergents [1]. These conditions may significantly affect their mechanical performance and service life [2].

This study investigates the influence of repeated washing cycles on the mechanical and structural behavior of woven fabrics intended for medical uniforms. Three fabric samples were analyzed: 100% cotton and two cotton/polyester blends with different twill weave structures. The samples were subjected to up to 60 washing cycles under controlled laboratory conditions simulating real use.

The results showed a significant decrease in tensile strength for cotton fabric (up to 14%), confirming its high susceptibility to chemical degradation under alkaline washing conditions [2]. In contrast, blended fabrics exhibited improved stability due to the presence of polyester fibers. An increase in elongation at break was observed for all samples, indicating structural relaxation and progressive fiber degradation. Additionally, a decrease in the force at the elastic limit suggests a transition from elastic to plastic deformation behavior.

Changes in functional properties, including reduced air permeability and increased water vapor permeability, indicate structural compaction and fiber surface modification. Furthermore, an empirical polynomial model was successfully applied to describe the nonlinear relationship between tensile strength and elongation, providing deeper insight into degradation mechanisms.

The findings highlight the importance of fiber composition and fabric structure in determining the durability of medical textiles under industrial maintenance conditions. Cotton/polyester blends were identified as an optimal solution, offering improved mechanical stability and extended service life, which is of particular relevance for healthcare applications and textile industry optimization [3].

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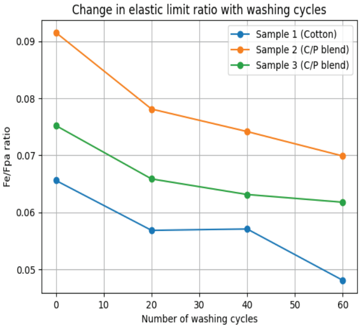

Figure 1. Variation of Fe/Fpa ratio with washing cycles indicating transition from elastic to plastic behavior.

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The effect of different heat treatments on the antioxidant properties of pepper (*Capsicum annuum* L.) during ajvar production

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Ajvar is a speciality of Balkan cuisine and can be consumed as a salad or spread. It is made from red sweet or hot peppers, with or without eggplant. Elephant's ear is a Serbian variety of red sweet pepper that is highly suitable for ajvar production. Due to its bioactive compounds, such as carotenoids, vitamin C, flavonoids, and phenolics, the pepper exhibits remarkable antioxidant activity and provides significant health benefits, particularly in the prevention of cancer, diabetes, cardiovascular diseases, Alzheimer's disease, and oxidative stress on cells. During ajvar production, the skin is removed by roasting the peppers on a stove in smaller facilities, while in larger industrial plants they are boiled or roasted over an open gas flame. This study aimed to heat-treat the pepper using all three methods, then analyse the total phenolic content (TPC), total carotenoid content (TCC), and antioxidant capacity (DPPH and ABTS), using standard spectrophotometric methods, and compare the results with those from a fresh pepper sample. The results obtained for TPC and TCC ranged from 645.71 and 926.03 μg/g dw (boiled pepper) to 1017.39 and 1579.45 μg/g dw (fresh pepper), respectively. Lower values of TPC and TCC were observed in the pepper roasted on the stove compared to the sample treated with an open flame. The $DPPH^{\bullet}$ and $ABTS^{\bullet+}$ radical-scavenging capacities ranged from 52.91 to 94.74 IC_{50} (μmol TE/g dw), and from 5.03 to 5.87 IC_{50} (μmol TE/g dw), respectively. The lowest antioxidant activity was found in the boiled pepper, while the highest, was observed in the fresh pepper, as expected and correlated with TPC and TCC. Based on these results, it can be concluded that roasting on an open flame is the most suitable method for preserving bioactive compounds in ajvar production. Although the temperatures are significantly higher, the treatment period is shorter, which increases the possibility of preserving certain bioactive compounds and antioxidant capacity. However, the technological process of ajvar production involves further steps such as chopping heat-treated pepper, frying, and then pasteurisation as a method of product preservation, which also degrades the bioactive components.

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Stability of carotenoids during long-term freezer storage of heat-treated pumpkin (*Cucurbita maxima*)

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Pumpkin (*Cucurbita maxima*) is widely used in human nutrition, as it can be consumed in both sweet and savoury dishes. This vegetable is rich in nutrients, including carbohydrates, minerals, and vitamins. Additionally, pumpkin seeds are a good source of unsaturated fatty acids and proteins. Due to its chemical composition, pumpkin has a positive effect on human health, particularly on the skin, cardiovascular system, and eyesight. However, when discussing pumpkin, the first association is often with carotenoids (β-carotene, α-carotene, lutein, zeaxanthin, etc), the compounds responsible for the attractive orange colour of this vegetable. Their importance lies in their promising antioxidant activity, which contributes to the prevention of many diseases, as well as their provitamin function (some are precursors for the synthesis of vitamin A). In this experiment, the stability of carotenoids during long-term freezer storage of heat-treated pumpkin was investigated. The samples were processed in three different ways: cooking (100 °C, 20 minutes), baking in a conventional oven (180 °C, 30 minutes), and treatment in a microwave oven (300 W, 10 minutes). To gain better insight into carotenoid stability, a fresh pumpkin sample was also analysed. The samples were extracted using ethanol and petroleum ether, and the total carotenoid content (TCC) was determined in the extracts using a standard spectrophotometric method at a wavelength of 445 nm. The samples were then deep-frozen and stored at -18 °C for 24 months, after which they were analysed using the same methodology. Although this storage period is longer than usually applied, the aim of the study was to determine the extent to which such storage would affect TCC for potential extraction and further valorization. The results showed that the highest reduction occurred in the cooked pumpkin sample (68.50%), followed by the fresh pumpkin sample (65.14%). In the microwave oven, the loss was 52.85%, while the lowest loss of TCC was observed in the conventional oven (45.78%). Based on this research, it can be concluded that although pumpkin is a good source of carotenoids, long-term freezing decreases their content, but still preserves a certain amount of these compounds.

Acknowledgements
This work was supported by the Ministry of Science, Technological Development, and Innovation of the Republic of Serbia (grant numbers 451-03-34/2026-03/200116).

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Impact of key synthesis parameters on zeolite 4A quality

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Despite the progress that has been achieved in zeolite synthesis, the mechanisms of nucleation and growth remain elusive. This is partially due to the large number of chemical reactions, equilibria and solubility variations that take place during the crystallization process. Furthermore, the colloidal nature and complex interactions between various species and zeolite crystals, along with the disparity in length and time scales encountered in zeolite synthesis, render a molecular understanding of growth as difficult. Research activities have been focused on studying zeolite nucleation and growth through the formation of a gel phase and from apparently clear solutions. The aim of work presented was to investigate the impact of some key synthesis parameters on zeolite 4A quality.

The main phase in zeolite synthesis, which is crystallization, is very sensitive to numerous factors affecting crystal regularity and crystal size. Besides the stoichiometry, some important parameters of synthesis process are: (a) the nature of the reactants, (b) the alkalinity, (c) the degree of the reaction mixture homogeneity, (d) the silicon to aluminum ratio, (e) the aging of the gel, (f) possible seeding, (g) the existence of structure directing agents, and (h) the temperature and pressure.

Zeolite crystals are usually synthesized hydrothermally, where an alkaline reaction mixture is prepared from silica and/or alumina sources, and sometimes a structure directing agent. Zeolites then nucleate and grow either directly from an apparently clear solution or through the formation of an amorphous gel phase. The factors mentioned above can affect zeolite synthesis by determining the type of zeolite structure, the growth and nucleation rates, the crystal shape, and the existence of defects (e.g. twinning).

Based on results (one example is shown in Fig. 1) of numerous industrial production trials (about 2,600 in the present work), we establish the relationship between the main synthesis parameters (concentration of Na_2O, SiO_2, Al_2O_3) and their impact on zeolite 4A characteristics (crystal size, residue of crystals greater than 45 μm, yield).

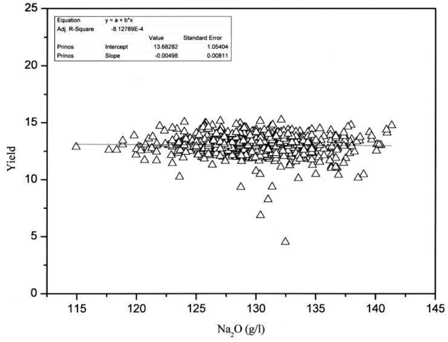

Figure 1. Yield of zeolite as a function of Na_20 concentration in mother solution

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Some of the factors affecting the crystallization are:

(1) Composition: SiO_2/Al_2O_3, [OH-], Cations, Anions (other than [OH-]), [H_2O];

(2) Time;

(3) Temperature;

(4) History – dependent factors (aging, stirring, nature of mixture, order of mixing).

Factors affecting the crystalline zeolite structure:

(i) Composition of the reaction mixture;

(ii) Initial and final pH of the system;

(iii) Temperature of the process and its variation with time (if any);

(iv) Time allowed for the reaction to take place, including the calcination time;

(v) Mixture, whether homogeneous or heterogeneous;

(vi) Seeding.

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Session 5
Sustainable Chemistry & Green Formulations

The Potential of Pharmaceutical Waste-to-Energy Conversion by Incineration

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Pharmaceutical waste management represents a significant aspect of public health and environmental protection, regulated by precise legal frameworks. In the Republic of Serbia, this field is primarily defined by the Law on Waste Management, the Rulebook on Medical Waste Management, and the Rulebook on the Method and Procedure of Pharmaceutical Waste Management, which specify the methods for collection, classification, and treatment of pharmaceutical substances. National regulations are largely aligned with European Union legislation, primarily with the Waste Framework Directive 2008/98/EC, which classifies pharmaceutical waste with hazardous characteristics as hazardous waste [1,2,3,4].

Due to the high reactivity and potential toxicity of these compounds, neutralization methods are legally prescribed to guarantee minimal risk. One of the most effective methods for pharmaceutical waste disposal and its energy recovery is incineration. Incineration is a thermal process that transforms waste into inorganic non-combustible materials, leading to a significant reduction in waste volume and weight [5]. Through successful combustion, pathogens and sharps are completely destroyed and reduced to ash containing no traces of the original material. Thermal treatment, such as pyrolytic incineration, controlled-air incineration, or double-chamber incineration, is a complex and costly process requiring high temperatures, a pyrolytic chamber, and an afterburning chamber for the safe disposal of materials. Incineration takes place under controlled conditions in double-chamber furnaces at temperatures ranging from 800 °C to 1200 °C. This process, in accordance with EU emission standards, enables full gas oxidation and the transformation of waste into inert ash [6].

Beyond the safety aspect, modern regulations and the Waste Management Program in the RS for the period 2022-2031 encourage circular economy principles through energy revalorization [7]. By implementing heat recovery systems, the energy generated by the combustion of pharmaceutical waste can be utilized for the production of electricity or steam, thereby meeting the requirements for energy efficiency and sustainable resource management in the pharmaceutical sector. An efficient incinerator, on the one hand, enables successful waste treatment, while on the other, provides clean hot water, steam, and electricity as sustainable energy sources [8]. This study presents one of the methods for the energy utilization of pharmaceutical waste.

Throughout the life cycle of a pharmaceutical product, a significant amount of waste material is generated. The main components of the waste stream consist of raw materials used in the production of final pharmaceutical products, such as active pharmaceutical ingredients (APIs), various excipients, and pharmaceutical packaging. Modern treatment of heterogeneous medical and pharmaceutical waste primarily relies on double-chamber incinerator technology. Unlike outdated single-chamber systems, which do not meet rigorous environmental standards, double-chamber systems ensure the complete thermal degradation of harmful substances through successive processes of volatilization and oxidation. Initial combustion and volatilization of solid and liquid waste occur in the primary chamber. The generated gaseous products are then transported to the secondary chamber, where complete oxidation takes place with the introduction of excess air. Elevated operating temperatures and adequate residence time in the secondary phase are crucial for preventing the emission of toxic compounds into the atmosphere. Before final evacuation, flue gases pass through a

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droplet separator for dehydration and temperature reduction, thereby achieving safe emission parameters [9].

Although the incineration process requires auxiliary fuels and involves high capital investments, the generated thermal energy offers significant potential for exploitation in the production of steam, electricity, cooling fluids, and similar applications, thereby reducing the load on other energy infrastructure (the power grid, boilers, HVAC systems, etc.) [8].

In conclusion, there is significant potential for the implementation of waste-to-energy conversion systems within the pharmaceutical sector. Substantial amounts of energy can be generated even based on a single case study. Taking into account the volume of pharmaceutical waste generated, the cumulative effect of applying this model would enable considerable economic savings and a reduction in greenhouse gas emissions and carbon footprint. This paves the way for the broader implementation of sustainable plants based on the principles of circular economy and the energy autonomy of industrial systems.

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From Waste Paper to Functional Foams: Chemical-Free Recycling via Laser Deinking

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The laser deinking process is introduced as a novel, chemical-free, and sustainable method for removing inks from printed office paper, providing a clean alternative to conventional wet-chemical deinking. In this study, we report the fabrication of dry cellulose foams from fiber suspensions prepared via three different routes: untreated printed paper, chemically deinked pulp, and laser-deinked pulp. These routes yield suspensions with systematically varied ink-particle contents, allowing a controlled investigation of how residual ink affects suspension rheology, foam formation, and the structural and mechanical characteristics of the resulting foams.
Rheological analysis showed that ink particles significantly influence viscoelastic behavior, flocculation, and shear response. Suspensions derived from laser-deinked paper exhibited lower low-shear viscosity, reduced flocculation, and weaker elastic networks compared to chemically deinked and untreated samples—confirming a higher degree of ink removal. These differences were directly correlated with morphological observations, which revealed that chemically deinked foams had a denser three-dimensional fiber-filler-ink network and smaller, uneven pores, whereas laser-deinked foams displayed uniform porosity and a narrower pore-size distribution.
Furthermore, mechanical testing demonstrated that foams produced from chemically and laser-deinked fibers exhibited improved compressibility and elasticity, with laser-deinked foams showing enhanced softness and tactile quality comparable to foams made from white copy paper. The combined rheological, structural, and mechanical results confirm that laser deinking not only achieves efficient ink removal but also enables the formation of lightweight cellulose foams with controlled microstructure and desirable mechanical properties. This research represents an important advancement toward sustainable recycling of waste office paper into high-value porous materials, supporting circular-economy and eco-design principles in material innovation.

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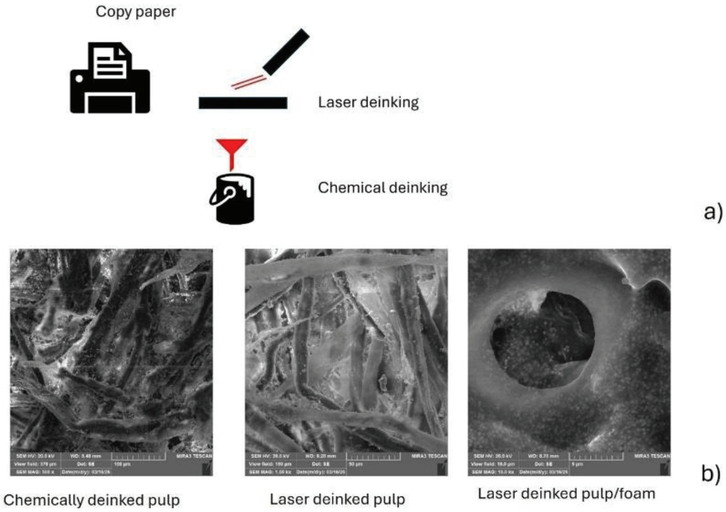

Chemically deinked pulp

Laser deinked pulp

Laser deinked pulp/foam

Figure 1 Production process of cellulose foams from deinked copy paper:(a) schematic illustration of the deinking process;(b) SEM images showing distinct morphological differences between foams produced from chemically and laser-deinked pulps.

Acknowledgments

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Sustainable Surface Flow Calcium Carbonate and Micro- Nanofibrillar Cellulose NO_x Reaction Filter: road vehicle and remote mini-vehicle monitoring for urban NO_x air pollution assessment

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The design of modern air filtration systems for gaseous and particulate pollutants increasingly emphasizes sustainability, repairability, and recyclability, particularly when materials can be repurposed for economically viable secondary uses. Reducing human exposure to nitrogen oxides (NO_x), especially in urban, vehicular, and industrial environments, is a growing global priority for both environmental protection and public health. In this context, recent research introduced a surface-flow filter capable of capturing (NO_x) through surface reactions with calcium carbonate ($CaCO_3$) — a plentiful mineral found in the form of limestone and marble. The filter element construct employed waste-paper-based filter media pixel-coated with fine ground calcium carbonate ($CaCO_3$) and micro- nanofibrillated cellulose (MNFC) derived from recycled newsprint, the latter applied to act as both binder and humectant. The $CaCO_3$ reacts with NO_x under humid conditions to form calcium nitrate [$Ca(NO_3)_2$] with high efficiency. Under prolonged exposure with excess NO_2, complete conversion of $CaCO_3$ to $Ca(NO_3)_2$ can theoretically be achieved.

The developed filter element housing was designed for mounting on a vehicle roof for evaluation under real urban driving conditions. A diesel-powered road vehicle equipped with the filter was compared to a remote electric mini-vehicle operating under similar speeds and trajectories across several locations in Belgrade. Measurements of NO, NO_2, and total NO_x concentrations, along with post-analyses of nitrate and nitrite formation on the filter surface, showed comparable results between the two systems, when scaled for distance travelled, and further compared with internal room exposure, confirming the validity of the proposed configuration for mobile pollution monitoring. Overall, the findings confirm that the $CaCO_3$–MNFC filter system

Katarina Dimić-Mišić - 0000-0002-6397-7711, Nemanja Barać – 0000-0001-5037-9176, Monireh Imani - 0000-0002-0893-8429, Đorđe Janaćković – 0000-0002-8291-4345, Petar Usković – 0000-0001-9543-1732, Ernesto Barcelo - 0000-0001-7251-1836, Patrick Gane7- 0000-0003-4086-7955 effectively captures NO_x and forms stable nitrate compounds, while the remote-vehicle monitoring platform offers a reliable, low-impact, and scalable result.

Mini/robotic vehicle monitoring adopting this uncomplicated material reaction approach, rather than carrying complex power demanding analytical apparatus, is particularly valuable in heavily polluted or hard-to-access areas, also during emergency shutdowns or pandemic health restrictions, for example, when human-driven vehicle movement in urban environments is limited.

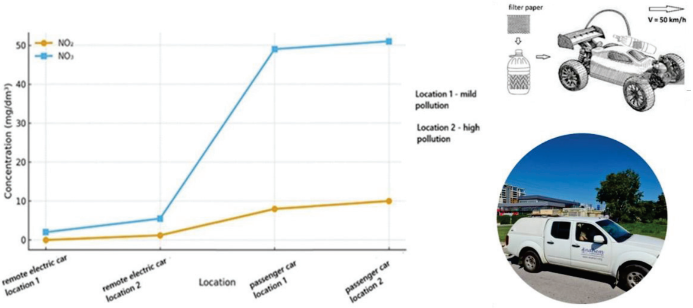

Figure 1. Amount of nitrite and nitrate obtained from Ion chromatography measurements from the filter mounted on the passenger car, and from the remote car, compared at the same urban area.

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Sustainable Cosmetic Formulations: Self-Preserving Cleansers and Toners Based on Agro-Waste-Derived Ingredients

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The growing demand for sustainable cosmetic products has driven the development of innovative formulations based on waterless systems and upcycled raw materials[1]. This study aimed to evaluate the physicochemical properties, stability, and performance of two complementary sustainable cosmetic approaches: natural waterless facial cleansers and water-based toners containing ethanol extracts from agricultural waste materials (sunflower, wheat, and corn), designed as self-preserving systems without the addition of conventional preservatives.

Waterless cleansers were formulated using combinations of emollients, humectants, surfactants, thickeners, and antioxidants, with optional pH adjustment using lactic acid. Their physicochemical properties were assessed through pH, conductivity, rheological behavior, spreadability, and water washability.

All formulations exhibited shear-thinning behavior, facilitating application. Increased thickener content enhanced viscosity but reduced spreadability, while lower surfactant content negatively affected cleansing performance (Figure 1A). The addition of lactic acid enabled skin-compatible pH values (4.41–4.80), whereas its absence resulted in less suitable alkaline systems[2]. In parallel, an extended set of waterless cleansers incorporating lipid extracts from wheat and sunflower agro-waste was developed and evaluated. These formulations also showed pH values within the skin-compatible range (4.73–5.70), shear-thinning behavior, and washability ranging from 45–83%. The type of extract and thickener content significantly influenced formulation performance. Systems containing a combination of wheat and sunflower extracts demonstrated improved washability (Figure 1B) and a more balanced relationship between viscosity, spreadability, and cleansing efficiency, indicating synergistic effects of the lipid components[3,4]. Additionally, 36 formulations of water-based toners containing 0.1% and 1.0% mixed ethanol extracts from agro-waste materials were developed as self-preserving formulations. Physicochemical characterization included pH, conductivity, transmittance, and stability over six months, alongside organoleptic assessment. Optimized formulations (T33–T36) remained stable, transparent, and microbiologically acceptable during six months without added preservatives, indicating effective self-preserving capacity. Biological evaluation using HaCaT keratinocytes showed no cytotoxicity and revealed a dose-dependent increase in cell proliferation (94.4–145.3%), with higher extract concentrations exhibiting enhanced activity (Figure 2), suggesting potential skin-rejuvenating effects. Overall, both formulation strategies demonstrated strong potential for sustainable cosmetic development. Waterless cleansers contribute to water conservation while maintaining functional performance, whereas agro-waste-derived self-preserving toners and extract-enriched cleansers support circular economy principles, reducing reliance on synthetic preservatives while ensuring product stability, safety, and efficacy.

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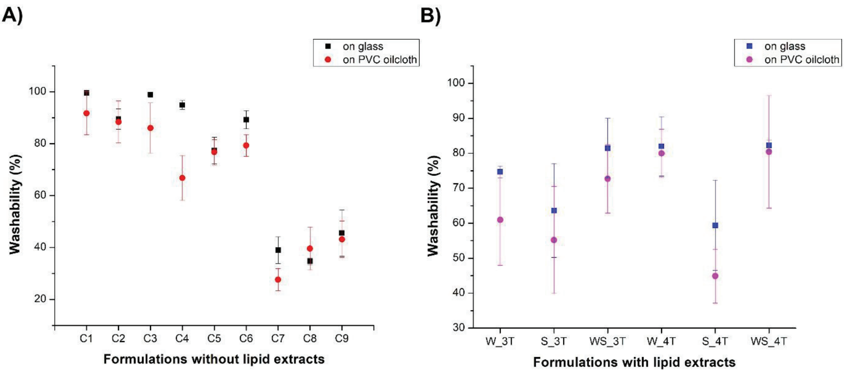

Figure 1. Washability of waterless cleansers without (A) and with (B) agro-waste lipid extracts on glass and PVC.

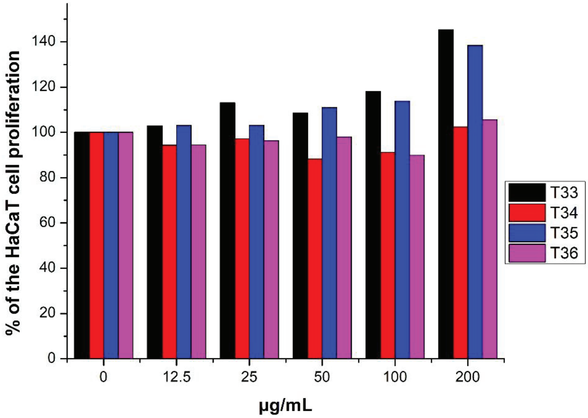

Figure 2. Effect of optimized water-based toners (T33–T36) on the metabolic activity of HaCaT cells.

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Ultrasound-assisted extraction of bioactive components from apricot kernels using a natural deep eutectic solvent

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The food industry generates significant quantities of agro-industrial by-products, such as fruit stones, which represent a valuable yet underutilized source of bioactive compounds. Apricot (*Prunus armeniaca* L) processing produces substantial amounts of stones that are commonly discarded or burned. However, the apricot kernels represent a promising source of compounds with nutritional, pharmaceutical, and cosmetic importance [1]. Notably, amygdalin (D-mandelonitrile-β-D-gentiobioside, D-mandelonitrile-β-D-glucoside-6-β-glucoside) has attracted considerable attention due to its potential therapeutic applications in the treatment of asthma, bronchitis, diabetes, emphysema and others [2]. Efficient recovery of such bioactive compounds from alternative sources is of increasing interest. This study investigates a green and efficient approach for the simultaneous recovery of amygdalin, phenols, and flavonoids from apricot kernels using natural deep eutectic solvents (NADESs) in combination with ultrasound-assisted extraction. The extraction performance of various solvents was evaluated, including water, ethanol, lactic acid (LA), and two NADES systems: choline chloride:LA (ChCl:LA, 1:2 mol/mol) and menthol:LA (M:LA, 1:1 mol/mol). The extraction was conducted at kernel-to-solvent ratio of 1:10 w/v, temperature of 40 °C, and an ultrasound power of 180 W (40 kHz), and extraction for 30 min. The contents of amygdalin, total phenols, and flavonoids in the obtained extracts were determined by a high-performance liquid chromatography (HPLC) method, Folin-Ciocalteu method, and spectrophotometric method, respectively.

The results showed that amygdalin content in the extracts varied significantly (0.6–17.8%), with the extraction efficiency following the order: ethanol < water < M:LA < LA < ChCl:LA. While the highest total phenolic content was achieved using LA (16.5 mg GAE/g) and ChCl:LA (14.9 mg GAE/g), the recovery of total flavonoids was highest with ChCl:LA (4.7 mg QE/g) and markedly lower with water and LA (0.5 and 0.8 mg QE/g, respectively). Overall, the ChCl:LA NADES demonstrated superior performance as an efficient solvent for the simultaneous extraction of diverse bioactive compounds from apricot kernels, offering a sustainable alternative to conventional solvents.

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Extraction of amygdalin from plum kernel waste using choline chloride-based deep eutectic solvents

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Plum (*Prunus domestica* L.) kernels are nutrient-dense by-products rich in oils, proteins, and bioactive compounds, making them a promising raw material for the cosmetic, pharmaceutical, and food industries [1]. However, their direct application in nutrition is hindered by a high concentration of amygdalin, a cyanogenic glycoside that can release toxic hydrogen cyanide upon hydrolysis in digestive tract. Nevertheless, amygdalin has gained significant interest due to its diverse biological activities, including anticancer, antioxidant, and anti-inflammatory effects [2]. Therefore, the efficient isolation of amygdalin from plum kernels is important to ensure its controlled and safe applications. This study investigates, for the first time, the extraction of amygdalin from plum kernels using various deep eutectic solvents (DESs). The extraction efficiency of choline chloride-based DES, combined with lactic acid (ChCl:LA, 1:2), acetic acid (ChCl:AA, 1:2), glycerol (ChCl:G, 1:2), and propylene glycol (ChCl:PG, 1:2), was evaluated and compared with conventional solvents (water, methanol, and ethanol) The extraction was performed at a kernel-to-solvent ratio of 1:15 w/v and 30 °C under magnetic stirring (500 rpm) for 2 h. Amygdalin content in obtained extracts was quantified by high-performance liquid chromatography (HPLC). While conventional solvents yielded low amygdalin contents (1.0% for water, 1.2% for methanol, and 0.5% for ethanol), DES performance was markedly superior. Extracts obtained with ChCl:G and ChCl:PG reached 3.1% and 2.7%, respectively, while organic acid-based DES, ChCl:LA and ChCl:AA, yielded significantly higher values of 18.9% and 13.6%. These findings demonstrate that DES, particularly those based on organic acids, significantly enhance amygdalin recovery, representing a promising alternative to conventional solvents.

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Eco-Engineered Biochar Carbons for Next-Gen Microsupercapacitors

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The continued development of wearable electronics, smart systems, and miniaturized sensors has significantly increased the demand for compact, portable, and sustainable energy storage devices. Microsupercapacitors (MSCs) have emerged as promising candidates owing to their high-power density, long cycle life, mechanical flexibility, and compatibility with on-chip integration. Still, their broader implementation in next-generation portable and flexible electronic systems is critically dependent on the development of alternative, sustainable materials.

In this study, carbonaceous materials derived from hemp stalk waste were investigated as potential electrode materials for microsupercapacitors. The use of plant waste provides a sustainable and environmentally friendly source of carbon and, at the same time, contributes to the development of green materials for energy storage. Prepared carbon aerogel was doped with nitrogen at different nitrogen-to-material ratios to investigate its effect on the material's electrochemical properties and overall performance.

The cyclic voltammetry was used to determine the charge-storage capacity of all tested materials. Nitrogen-doped carbon aerogel with a nitrogen to CA ratio of 15:1 showed the best electrochemical performance with high capacity and good stability in all electrolytes. The obtained capacitance values are 25.78 mF/cm^2 in KOH, 25.94 mF/cm^2 in H_2SO_4, and 27.69 mF/cm^2 in Na_2SO_4, indicating stable charge storage behavior under different pH conditions. The results highlight the potential of N-doped carbon aerogel as an efficient, universal material for flexible, portable MSC devices. Further research will focus on detailed physicochemical and electrochemical characterization, as well as on the production of flexible MSC devices, to evaluate the practical performance of the tested materials.

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Strawberry and Raspberry Pomaces as Potential Sources of Bioactive Compounds: Phytochemical Characterisation, Antioxidative Activity, and Biopotential Validation

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Agri-food industries generate substantial amounts of by-products that are often discarded despite their high potential for valorization. Strawberry pomace is a notable source of antioxidants such as ellagic acid, quercetin, anthocyanins, and ellagitannins with antimicrobial properties [1]. Similarly, raspberry pomace, a major by-product of fruit processing, retains significant levels of bioactive compounds, making it a promising source of natural colorants and antioxidants [2].

In this study, strawberry and raspberry pomaces obtained from Rauch Serbia (Šeste Ličke Divizije 2, Koceljeva 15220, Serbia) were extracted using 50% ethanol. The objective was to compare the extracts in terms of total phenolic content (TPC), total flavonoid content (TFC), total anthocyanin content (TAC), antioxidant activity (DPPH and FRAP assays), and enzyme inhibitory potential (α-amylase and α-glucosidase).

Strawberry pomace extract showed higher TPC (126.08 ± 3.51 mg GAE/g) and TFC (15.64 ± 4.85 mg CE/g) compared to the raspberry extract (88.04 ± 3.48 mg GAE/g and 8.38 ± 0.36 mg CE/g), while the raspberry pomace extract exhibited higher TAC (21.01 ± 4.31 mg cyanidin-3-glucoside) than the strawberry pomace extract (12.63 ± 3.64). DPPH IC_{50} values were similar (0.2718 mg/mL for strawberry and 0.2597 mg/mL for raspberry), indicating comparable antioxidant activity. FRAP results showed a slightly higher reducing power for the strawberry pomace extract (124.80 mg AAE/g) compared to the raspberry pomace extract (106.79 ± 5.15 mg AAE/g). Raspberry pomace extract demonstrated stronger enzyme inhibitory activity, with lower IC_{50} values for α-amylase (1.70 mg/mL) and α-glucosidase (0.0976 mg/mL) compared to the strawberry pomace extract (2.60 mg/mL and 0.1314 mg/mL, respectively).

These findings highlight both strawberry and raspberry pomaces as valuable sources of bioactive compounds with significant antioxidant and enzyme inhibitory potential, supporting their sustainable utilization. Upcoming research will include HPLC-DAD analysis to further characterize their phytochemical profiles.

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DoE-based optimization of extraction conditions for a selected raspberry variety using natural deep eutectic solvents.

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Raspberries are considered nutrient-dense fruits due to their high content of vitamins, minerals, and other bioactive compounds. They are particularly rich in vitamin C, dietary fiber, and polyphenols, including anthocyanins and ellagitannins, which contribute to their strong antioxidant capacity. These compounds can reduce oxidative stress and support overall human health [1,2].

Design of experiments (DoE) represents a robust statistical approach for the systematic optimization of complex processes by enabling the simultaneous evaluation of multiple variables and their interactions, among other things, when using new solvents. In the context of green extraction technologies, natural deep eutectic solvents (NADES) have emerged as promising alternatives to conventional solvents due to their tunable physicochemical properties and environmental compatibility [3].

In this study, DoE was applied as a strategic tool for the optimization of extraction conditions of bioactive compounds from a selected raspberry variety (*Tula magic*) using NADES. Fruits were harvested from the experimental field Zeleni Hit (Batajnica, Belgrade). After harvesting, the fruits were transported to the laboratory and freeze-dried and subsequently stored again at −20 °C until further investigation. A central composite design (CCD) was employed to investigate the influence of key process parameters, including water content, extraction temperature, extraction time, and solid-to-liquid ratio. Extraction efficiency was assessed using spectrophotometric assays, including antioxidant activity (DPPH) and total anthocyanin content (pH differential method) as response variables.

This methodological framework enables the identification of critical factors, their individual and interactive effects, and development of predictive models describing the extraction system. Such an approach contributes to a deeper understanding of NADES-based extraction mechanisms and supports the rational design of efficient and sustainable extraction processes.

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Identification of potential anti-aging markers in urban forest waste from the Košutnjak forest via HPTLC profiling and targeted enzyme inhibition

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Urban forest management generates substantial amounts of woody biomass; in the Košutnjak Forest (Belgrade, Serbia), residues account for approximately 20% of the total harvesting volume, with twigs representing the dominant fraction (70%). Despite being a sustainable and readily available resource, twig biomass remains globally understudied, with its specific potential for cosmetic applications and anti-aging activity previously unexplored [1,2]. This research focuses on the bioactive valorization of twig extracts from 19 species sourced from the Košutnjak urban forest, evaluating their potential for cosmetic applications for the first time. Chemical profiling was performed within a multidisciplinary framework using High-Performance Thin-Layer Chromatography (HPTLC) derivatized with natural product (NP/PEG) reagent to characterize phenolic fingerprint patterns. Notably, these specific phytochemical profiles were, for the first time, correlated with inhibitory activity against two key skin-aging enzymes, elastase and tyrosinase. Among the tested extracts, *Acer campestre* L. (Sapindaceae) exhibited the strongest elastase inhibition (51.6 ± 9.1%). *Torminalis glaberrima* (Gand.) Sennikov & Kurtto (Rosaceae) was the most potent tyrosinase inhibitor (39.0 ± 3.5%), demonstrated approximately half of the inhibitory activity of the standard inhibitor (kojic acid, 82.0 ± 2.0%). The HPTLC profiling revealed marked diversity in phenolic fingerprints, with certain chromatographic patterns emerging as tentative markers for the observed bioactivities: R_F 0.10, 0.28, and 0.57 for elastase inhibition, and R_F 0.28, 0.57/0.58 for tyrosinase inhibition. These findings provide the first evidence of the enzymatic inhibitory power of previously neglected twig residues from the Košutnjak forest, highlighting their significant potential for valorization into high-value raw materials. Specific species emerge as promising candidates that warrant further investigation through dermatologically relevant assays and cell-based models. Furthermore, the identified chromatographic patterns require detailed structural analysis to confirm the specific compounds responsible for these effects.

This research provides a scientific foundation for transforming underutilized urban green waste into sustainable cosmetic ingredients, supporting the transition toward a circular bioeconomy and reinforcing the multifunctional role of urban forests.

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Sustainable removal of metformin using ZnO nanoparticles synthesized from *Inula Helenium* plant extract

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The increasing presence of pharmaceuticals in aquatic environments has become a significant ecological concern due to their persistence and potential harmful effects on ecosystems and human health. Among these contaminants, metformin (MET), a widely used antidiabetic drug, is frequently detected in water bodies because of high consumption and incomplete removal in conventional wastewater treatments [1]. Therefore, the development of efficient and sustainable methods for its removal is of great importance. Advanced oxidation processes have gained considerable attention for the removal of persistent organic pollutants, with heterogeneous photocatalysis being particularly promising due to its high efficiency, ease of application, and ability to utilize solar energy [2]. This process relies on the activation of a semiconductor material by light irradiation, which generates reactive oxygen species capable of degrading organic pollutants. Accordingly, increasing attention has been directed toward the green synthesis of metal oxide nanoparticles, as it reduces the use of hazardous chemicals and contributes to the development of environmentally friendly photocatalytic materials [3]. The aim of this study was the green synthesis of ZnO nanoparticles using *Inula Helenium* plant extract and the evaluation of their efficiency in the photocatalytic degradation of MET from aqueous suspension under simulated solar irradiation. The overall experimental procedure, from green synthesis of ZnO nanoparticles to MET degradation analysis, is presented in Figure 1. Firstly, a comparison between photolysis and photocatalysis was performed to evaluate their degradation efficiency. The removal efficacy of direct photolysis was 2% of MET after 180 min of irradiation. Additionally, the influence of catalyst loading of the newly synthesized ZnO, ranging from 0.5 to 2.0 mg/cm^3, on MET degradation was also examined. Highest activity was achieved at a catalyst loading of 0.5 mg/cm^3, resulting in 10% of MET removal after 180 min of irradiation. These results point out catalyst loading as one of the critical operational factors in the photocatalytic degradation process and verify the effectiveness of green-synthesized ZnO nanoparticles for the treatment of emerging contaminants in aquatic systems.

Figure 1. Schematic representation of the experimental procedure

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Determination of Total Phenolics and Antioxidant Activity in Berry Fruits Using DPPH and Electrochemical (HPMC) Assays

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Determination of antioxidant activity and total phenolic content in berry fruits is essential for evaluating their nutritional and functional quality. In this study, the aim was to assess the antioxidative potential of strawberry (*Fragaria × ananassa*), raspberry (*Rubus idaeus*) and blackberry (*Rubus fruticosus*) cultivated in Western Serbia using both conventional and electrochemical analytical approaches. Total phenolic content (TPC) was determined by the Folin–Ciocalteu method, while antioxidant activity was evaluated using the widely applied DPPH assay and a direct current polarographic method based on the Hydroxo-Perhydroxyl Mercury(II) Complex (HPMC).

Berry samples were analyzed in different forms (juice, pulp, and whole fruit) to assess the distribution of bioactive compounds. All measurements were performed in triplicate and statistically evaluated. Among the examined samples, blackberry exhibited the highest phenolic content, reaching up to 2044 mg GAE/kg in whole fruit and 2194 mg GAE/kg in pulp, which was consistent with its superior antioxidant activity. The DPPH assay revealed the lowest EC50 value for blackberry (4.05 ± 0.22 μg), followed by raspberry (4.50 ± 0.25 μg) and strawberry (5.92 ± 0.34 μg), indicating stronger radical scavenging capacity. Similarly, electrochemical measurements showed the highest HPMC response for blackberry (0.072 ± 0.007 %/μL), confirming a strong correlation between phenolic content and antioxidant activity. The applied electrochemical method demonstrated high sensitivity and reliability, representing a rapid and cost-effective alternative to conventional spectrophotometric assays. In addition, the results indicate that berry pulp contains higher concentrations of phenolic compounds compared to juice, highlighting the importance of sample form in antioxidant evaluation.

Blackberry cultivated in Western Serbia exhibits superior antioxidant properties compared to raspberry and strawberry, primarily due to its higher phenolic and anthocyanin content. The combination of DPPH and HPMC assays provides a comprehensive and efficient approach for antioxidant characterization, with the electrochemical method showing strong potential for routine analysis of bioactive compounds in food systems.

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Solid-Phase Extraction of Manganese Ions from Natural Lake Waters Using Clinoptilolite Zeolite

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Manganese is widely distributed in the environment and, although essential for human physiology, may cause toxic effects at elevated concentrations [1]. In natural waters, it is typically present at very low levels, often below the detection limit of FAAS, requiring a preconcentration step prior to analysis. Solid-phase extraction (SPE) is widely used for this purpose due to its high sensitivity, low solvent consumption, and cost-effectiveness [2]. The efficiency of SPE depends on the selection of an appropriate sorbent. Although conventional materials such as activated carbon and clays have been widely applied, increasing analytical and regulatory demands have driven the search for more efficient and environmentally friendly alternatives [3]. Natural sorbents, particularly zeolites, have attracted considerable attention due to their high adsorption capacity and availability [4]. The sorbent was characterized using FTIR, XRF, XRD, SEM–EDS, and BET analysis, confirming it as a natural zeolite, clinoptilolite. This study investigates the use of clinoptilolite for the preconcentration of manganese ions from natural lake water samples collected in the Lukavac municipality using a polyethylene SPE column. Key SPE parameters (pH, flow rate, sorbent mass, sample volume, and eluent conditions) were optimized, while tolerance limits for selected ions, adsorption capacity, and sorbent regeneration were also evaluated. The method demonstrated good analytical performance (LOD 0.020 μg/mL, LOQ 0.067 μg/mL, RSD 1.86%, $R^2 = 0.9999$).

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Green NADES-based extraction of bioactive compounds from blackberry pomace: enhanced recovery and biological activity

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Valorization of fruit processing by-products represents a sustainable strategy aligned with circular economy principles. Blackberry (*Rubus fruticosus* L.) processing generates significant amounts of pomace, representing approximately 20–30% of the total fruit mass, which remains an underutilized source of valuable bioactive compounds [1]. However, their instability and the limitations of conventional extraction methods highlight the need for greener and more efficient approaches. Natural deep eutectic solvents (NADES), composed of naturally derived and biocompatible components, have emerged as promising alternatives for the extraction and stabilization of sensitive bioactives [2].

In this study, NADES composed of polyols, betaine, and without/with ascorbic acid were developed and applied in ultrasound-assisted extraction of bioactive compounds from blackberry pomace, using water as a conventional green solvent. The extracts were characterised in terms of total phenolic content and antioxidant capacity, using spectrophotometric assays, and further evaluated for enzyme inhibitory and antimicrobial activities. The results showed that NADES systems significantly outperformed water, yielding up to 378 ± 2 mg GAE/g of total phenolics compared to 15.0 mg GAE/g for water extracts. Among the tested systems, glycerol:xylitol:ascorbic acid demonstrated the highest extraction efficiency among all tested systems. Correspondingly, antioxidant activity reached up to 3237 ± 106 µmol TE/g (DPPH) and 3098 ± 139 µmol TE/g (ABTS), markedly exceeding the activity of water extracts. Extracts obtained with NADES containing ascorbic acid consistently showed higher phenolic recovery and antioxidant capacity compared to non-acidic systems. Additionally, the extracts showed pronounced biological activity, including tyrosinase inhibition up to 100%, lipase inhibition up to 36%, as well as antimicrobial activity against selected foodborne pathogens.

NADES systems containing ascorbic acid demonstrated superior performance in both extraction and stabilization of bioactive compounds, resulting in significantly enhanced biological activity.

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A Comparative Greenness Assessment of Analytical Methods for Synthetic Cathinones Determination Using the AGREE Metric

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Background: Synthetic cathinones are among the most frequently encountered new psychoactive substances and continue to present a significant analytical challenge due to their structural diversity, low concentrations in biological matrices, and the need for reliable confirmatory methods. At the same time, increasing attention is being directed toward the environmental sustainability of analytical procedures, particularly in analytical toxicology where complex workflows and extensive chemical use are often required. In this context, the greenness of analytical methods used for cathinone determination deserves closer consideration.
Aim: The aim of this study was to comparatively evaluate the greenness of selected analytical methods reported for cathinone analysis using the AGREE metric.
Methods: Eight published analytical methods for cathinone determination were selected and assessed using the AGREE software tool. The evaluated methods included electromembrane extraction (EME), molecularly imprinted polymer solid-phase extraction (MIP-SPE), solid–liquid extraction, liquid–liquid extraction (LLE), salting-out assisted liquid–liquid extraction, microextraction by packed sorbent (MEPS), low transition temperature mixture-based dispersive liquid–liquid microextraction (DLLME-LTT), and natural deep eutectic solvent-based DLLME (DLLME-NADES). The methods covered different biological and forensic matrices and were compared according to their overall AGREE scores.
Results: The AGREE scores ranged from 0.42 to 0.72, indicating notable differences in environmental performance. The highest score was obtained for EME (0.72), reflecting the most favorable overall greenness profile. Among the evaluated methods, MEPS (0.61), DLLME-LTT (0.61), and DLLME-NADES (0.62) also showed comparatively high scores, highlighting their favorable environmental performance. In contrast, MIP-SPE showed the lowest score (0.42), while solid–liquid extraction (0.48) and conventional LLE (0.45) were associated with lower greenness. Salting-out assisted LLE (0.55) demonstrated slightly improved performance compared to conventional LLE, but remained less favorable than miniaturized approaches.
Overall, methods characterized by miniaturization, reduced solvent consumption, and simplified workflows consistently achieved higher AGREE scores.
Conclusion: This comparative evaluation demonstrates that the greenness of analytical methods for cathinone analysis is strongly influenced by the overall methodological approach. Techniques based on miniaturization and reduced solvent use, particularly EME, MEPS, and DLLME-based approaches, showed more favorable environmental profiles and represent promising options for the development of more sustainable analytical toxicology workflows.

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Regeneration and reusability of novel magnetic resin for Ni(II) removal: Effect of different desorbing agents

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A newly synthesized magnetic resin was developed to obtain a material with enhanced physicochemical properties and improved efficiency for Ni(II) removal from water [1]. The aim of this study was to evaluate the regeneration and reuse potential of this newly prepared material through successive adsorption–desorption cycles. The desorption process, involving the removal of adsorbed ions using suitable agents, provides insight into the regeneration potential of a sorbent. High desorption efficiency indicates the potential for sorbent reuse, thereby reducing the need for frequent replacement and supporting economically viable and environmentally sustainable applications [2,3]. Regeneration studies extend sorbent lifetime and help optimize desorption conditions (pH, temperature, and regenerant concentration) while preserving the structural integrity of the material and preventing secondary pollution. Overall, regeneration and reuse experiments are essential for improving sorption technologies, ensuring long-term stability during repeated use, and enabling their cost-effective scale-up for practical water treatment applications [4,5]. To evaluate the regeneration and reuse potential of the novel magnetic resin, different regenerating agents (0.1 mol/L NaOH, 0.1 mol/L HCl, and 0.1 mol/L H_2SO_4) [5] were investigated, while nickel adsorption and desorption were monitored over five successive adsorption–desorption cycles (Sn/Dn) (Figure 1).

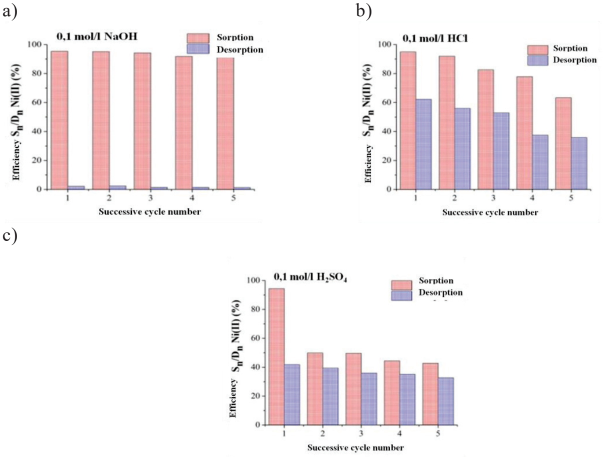

Figure 1. Graphical representation of Ni(II) sorption (%Sn) and desorption (%Dn) on magnetic resin during five successive adsorption–desorption cycles; adsorption conditions (C_0(Ni) = 1 mg/L; sorbent dose = 0.4 g/L; pH = 7 ± 0.2); desorption conditions (volume of regenerating solution = 500 mL): (a) 0.1 mol/L NaOH, (b) 0.1 mol/L HCl, and (c) 0.1 mol/L H_2SO_4

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For the magnetic resin, the Ni(II) sorption efficiency over five cycles ranged from 91.3–95.4%, while the desorption efficiency remained very low (1.3–2.1%) when 0.1 mol/L NaOH was used as the regenerating agent (Figure 1a).

This result indicates that the mechanism of nickel binding to magnetic resin is largely irreversible under alkaline conditions, probably due to strong coordination interactions with the resin functional groups and possible Ni(II) precipitation. NaOH, acting as a weak eluent for breaking such interactions, fails to effectively remove the already sorbed Ni(II), although the sorbent still retains a high capacity for metal re-binding. In contrast, the desorption efficiencies obtained for magnetic resin over five cycles ranged from 35.8–62.2% and 32.7–41.8% for 0.1 mol/L HCl and 0.1 mol/L H_2SO_4, respectively, accompanied by the following Ni(II) sorption efficiencies: 63.3–94.9% and 42.7–94.3% (Figure 1b,c). When HCl was used as the eluent, Ni(II) removal remained above 80% during the first three cycles; however, a decrease was observed after the fourth cycle, with an overall reduction of 17.1% (Figure 1b). A different behavior was observed in the system using 0.1 mol/L H_2SO_4, where the Ni(II) removal efficiency sharply decreased after the first cycle (from 94.3% to 49.8%). By the fifth cycle, sorption efficiency decreased by 6.9%, while desorption efficiency declined by 9.2%. Compared to the first cycle, the overall Ni(II) removal efficiency decreased by 31.6% and 51.6% after the fifth cycle for HCl and H_2SO_4, respectively.

Based on these results, it can be assumed that repeated regeneration in acidic media leads to degradation of active sites, which is reflected in the decreasing sorption efficiency across cycles. This behavior can be attributed to the stronger ability of acids to desorb Ni(II), while simultaneously causing partial damage to the functional groups responsible for adsorption.

Overall, the results indicate that the novel magnetic resin exhibits good reusability, particularly when regenerated with HCl. These findings demonstrate that the selection of an appropriate regenerating agent is crucial for maintaining sorbent stability and performance, and confirm the potential applicability of the synthesized magnetic resin for repeated use in Ni(II) removal from aqueous systems.

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Elderberry as a Natural Source for Antioxidant and UV-Protective Agents

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The skin is the largest organ of the human body and plays a crucial role in protecting the organism and maintaining homeostasis. Ultraviolet radiation, has significant adverse effects on the skin, including the induction of oxidative stress, DNA damage, inflammatory responses, premature skin aging, and the development of skin cancer. UVA radiation promotes the formation of reactive oxygen species, while UVB radiation directly damages DNA, contributing to mutations and carcinogenesis. Due to the limitations of synthetic organic UV filters, such as photoinstability, allergic reactions, and potential systemic absorption, increasing attention is being directed toward natural substances as safer photoprotective alternatives. In this study, extracts of dried fruits of *Sambucus nigra* L. (elderberry) were prepared using ultrasound-assisted extraction with 50% ethanol and water as solvents. Antioxidant activity was evaluated using DPPH and FRAP assays, while UV-absorbing capacity was determined using the Mansur spectrophotometric method. All activities were expressed relative to the weight of the dried extract (DW). The results showed that both elderberry extracts exhibited comparable and pronounced antioxidant activity, characterized by low IC_{50} values (0.49 and 0.47 mg/mL) and high FRAP values (1.44 and 1.46 mmol Fe^{2+}/g DW). Differences in photoprotective efficacy were observed between the extracts, with the ethanol extract showing a higher sun protection factor (SPF = 5.88 ± 0.9) compared to the aqueous extract (SPF = 4.95 ± 1.12). These findings suggest that *Sambucus nigra* fruit extracts represent promising natural candidates with photoprotective potential for application in dermocosmetic formulations.

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Implementation and analysis of different heat exchanger types for utilizing alkaline electrolysis waste heat

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The paper presents the most used electrolysis processes applied in industry and everyday life. Among these processes, special attention is devoted to alkaline electrolysis, and for this purpose an alkaline electrolyser has been developed using SS304 cathode material with an appropriate nickel coating. By using this type of electrolysis, a large quantity of hydrogen is obtained at an optimal current density. The produced hydrogen is then introduced into a PEM fuel cell, where the only by-product is water. During the process, the outlet water temperatures are measured, and it is determined that the maximum water temperature reaches amplitudes of approximately 360 K [1]. Given that this temperature the possibilities of using the waste heat from the water are analyzed in detail. In this context, estimations are performed regarding the heating of hydrogen for its treatment in the PEM fuel cell. In addition to the possibilities of hydrogen heating, the use of the obtained waste heat for the heating of residential buildings is also analyzed. For these purposes, detailed estimations are carried out using brazed-plate heat exchangers, gasketed-plate heat exchangers, while special attention is devoted to heat exchangers with concentric helical tube coils and shell-and-tube heat exchangers with parallel helical tube coils [2]. The results of these analyses show that heat exchangers with helical tube coils have an advantage in long-term service, considering that the cleaning of the heat transfer surfaces is accessible and that the replacement of the tube bundle is very easy to perform. Furthermore, the paper provides directions and recommendations for the analysis of this concept, including aspects of its potential application with appropriate regulators for DC/EC systems and solutions for hydrogen production to meet the needs of fuel cell vehicles.

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Operational Challenges of Agropellet Combustion in Domestic Heating Systems

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Pellet combustion is gaining popularity as an inexpensive domestic heating option with relatively low emissions, contributing to efforts to improve air quality in Serbia. However, commercial wood pellets have reached high market prices in recent years and are associated with deforestation concerns, prompting interest in agricultural residues as an alternative feedstock for pellet production. Nevertheless, the combustion of agropellets in domestic appliances is often accompanied by operational challenges such as fouling and flame extinction. Proximate analysis of pellet fuel properties, together with ash behavior and elemental ash composition, can provide insight into the causes of their different performance compared to wood pellets. Agropellets are produced from a diverse range of biomass feedstocks and differ in fuel quality. In Serbia, the most common raw materials for agropellet production include wheat straw, rapeseed straw, soybean straw, and sunflower husks, the latter of which generally exhibits the best performance. A major issue in small-scale combustion of agropellets is their high ash content, which leads to fouling and clogging of combustion systems. In addition, the elemental composition of ash significantly affects its behavior during combustion. A low content of Ca and Mg combined with a high content of Si results in low ash melting temperatures, leading to ash sintering. Modern automatic domestic pellet appliances are typically designed for fuels that produce fine, non-sintering ash. Therefore, ash agglomeration in agropellet combustion can cause clogging of the burner pot and eventual flame extinction. Furthermore, combustion emissions from agropellets are generally higher than those from wood pellets. Increased emissions of particulate matter (PM), CO, SO_2, NO_x, and organic pollutants can deteriorate indoor air quality and pose health risks. Elevated pollutant emissions, particularly CO and organic compounds, result from lower flame temperatures and incomplete combustion under suboptimal conditions in domestic stoves. High particulate emissions are primarily associated with the high ash content of agropellets, while SO_2 emissions originate from the higher sulfur content in the feedstock compared to wood. NO_x emissions are often attributed to nitrogen content in the fuel, which may be linked to the use of nitrogen-based fertilizers in crop production. Various approaches have been explored to mitigate these issues, including the use of additives to reduce sintering, blending with wood pellets, and modifications to appliance design. However, no solution has yet achieved widespread commercial adoption as a viable alternative to wood pellets. The conclusions and findings regarding the main obstacles associated with domestic agropellet combustion, as well as approaches to overcoming these challenges, are based on literature and experimental results. Fuel quality is a key factor for enabling informed consumer choices, guiding pellet combustion system design, and supporting the development of effective legislation.

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Blockchain in Advancing Handling of Sustainable Electronic Waste

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Electronic waste (e-waste) is among the fastest-growing waste streams globally, yet fewer than 20% of discarded devices are formally collected and recycled. Fragmented documentation, opaque supply chains, fraudulent recycling claims, and illegal cross-border shipments pose serious risks to both ecosystems and human health, while vast quantities of recoverable critical materials are lost each year. This paper presents a comprehensive review of blockchain technology as a systemic response to these challenges, covering its developmental milestones in the electronics industry, sustainability implications, and role in enabling end-to-end e-waste traceability. We examine how distributed ledger architectures, combining on-chain identity models and lifecycle event records with off-chain evidence storage, create tamper-resistant and auditable chains of custody across manufacturers, recyclers, regulators, and consumers. Smart contracts are evaluated as instruments for verifying extended producer responsibility, automating compliance enforcement, and implementing circular economy incentives such as tokenized recycling rewards. By differentiating between energy-intensive public chains and enterprise-grade permissioned networks appropriate for electronics traceability, the review also tackles scalability and cost through hybrid storage architectures, blockchain scaling solutions, consortium governance models, and interoperability frameworks. As tangible implementation benchmarks, real-world deployments by major electronic devices producers and the Circular Electronics Partnership are analyzed and proposed model for effective electronic waste circularity. This investigation concludes that blockchain has the potential to significantly improve e-waste governance, but only if standardized data models, strong governance, and assessment against measurable outcomes like verified material recovery rates, audit-time reduction, and traceability completeness are in effect.

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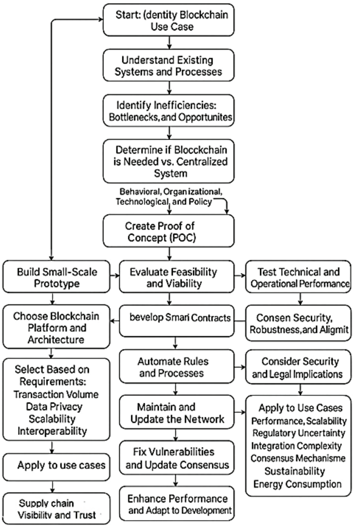

Figure 1. Description of the code proposed for e-waste collection, logistics, and reuse within the blockchain

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Recent Advances in Phosphate Removal and Recovery from Wastewater

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Phosphate removal from wastewater has become a major priority in environmental engineering because excessive phosphorus discharge is one of the principal drivers of eutrophication, which leads to algal blooms, oxygen depletion, deterioration of water quality, and loss of aquatic biodiversity. At the same time, phosphorus is a finite and strategically important resource for agriculture, which has shifted the focus of wastewater treatment from simple removal toward integrated removal and recovery [1].

Conventional phosphate removal methods, including chemical precipitation, biological phosphorus removal, sedimentation-assisted separation, and adsorption, remain fundamental in wastewater treatment practice, but they have numerous disadvantages. These limitations have motivated the development of more advanced systems capable of simultaneously improving selectivity, lowering energy demand, and recovering phosphorus in marketable forms [1].

Recent advances indicate that electrochemical and hybrid recovery systems are among the most promising directions in this field. Dual-electrode electrochemically induced crystallization has demonstrated phosphorus removal above 95%, while enabling the formation of recoverable vivianite and calcium-phosphate phases at relatively low energy demand and lower operating cost than conventional chemical precipitation [2]. Similarly, alternating pulse-current electrocrystallization has improved struvite recovery from high-strength waste streams, reducing electrode passivation and maintaining high removal efficiencies over repeated cycles [3]. Migration-electric-field assisted electrocoagulation with capacitive selective electrodes has also shown strong potential, particularly when modified biochar materials are used to enhance selectivity, lower energy consumption, and achieve very low residual phosphorus concentrations in the treated effluent [4]. Together, these systems represent a shift from simple pollutant removal toward integrated resource recovery with improved operational performance.

In parallel, substantial progress has been made in the design of selective adsorbent materials. Modified biochars, doped layered double hydroxides, hybrid anion exchangers, magnetic carbon nanofibers, and calcareous waste-based materials such as modified oyster shells have all shown promising results [4,6–9]. Their significance lies not only in adsorption capacity, but also in selectivity in the presence of competing ions, regenerability, magnetic separability, and the ability to promote crystallization of recoverable phosphorus minerals. These materials expand the range of available treatment options by enabling system design for effluent polishing, enhanced phosphorus recovery, and reduced chemical demand through the use of waste-derived feedstocks.

Another important trend is the development of combined concentration–crystallization processes for dilute waste streams, especially secondary effluents where phosphorus concentrations are too low for efficient direct recovery. Approaches such as Donnan dialysis followed by vivianite crystallization, as well as circulating fluidized bed systems coupled with calcium-based materials, have shown that it is possible to convert dilute phosphorus into concentrated, transportable, and reusable mineral products [5, 9]. These integrated process trains are particularly relevant for future wastewater treatment systems because they improve the feasibility of phosphorus recovery from streams that would otherwise remain economically unattractive. Table 1 summarizes recent advances in this field.

Table 1. Recent advances in phosphate removal and recovery methods

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Material	Mechanism	Key performance
N-doped Fe-La modified biochar (LFNB) as capacitive electrode	Selective electro-adsorption within MEAEC	Achieved effluent 0.1 mg P/L and improved removal from 74%→95% with lower energy use and good durability [4]
Mn/Zn/Fe-doped Mg-Al LDH composite	Adsorption via complexation, anion exchange, precipitation	High phosphate capacity ≈82.3 mg/g; effective near neutral pH; limited recovery (~51% recovered in second cycle) [6]
Hybrid anion exchanger (HEX)	Polymer resin + hydrated ferric oxide combining electrostatic and Lewis acid interactions	Demonstrated selective removal in presence of competing anions, robust mechanical durability in column/field trials [7]
Magnetic carbon nanofibers (Fe_3O_4-CNF)	Electrostatic attraction and surface precipitation with magnetic regeneration	Uptake ≈7.26 mg P/g; reduced effluent from 0.95→0.05 mg/L in secondary effluent at 0.5 g/L; >80% capacity retained after five regenerations [8]
Modified oyster shell (MOS-800) releasing Ca^{2+}/OH^{-}	Heterogeneous crystallization to form hydroxyapatite in CFB	Enabled continuous-flow phosphorus elimination up to 98.2% and produced hydroxyapatite as recoverable product [9]

Despite these advances, important barriers remain. Economic feasibility, especially at smaller scales, is still insufficiently characterized. Many emerging systems also face operational challenges related to maintenance, fouling, long-term stability, or material regeneration. In addition, increasingly strict regulatory requirements demand technologies that are not only efficient today, but adaptable to future discharge standards. Environmental performance must also be assessed beyond removal efficiency alone, including energy demand, life-cycle impacts, and the agronomic and ecological implications of applying recovered phosphorus products to soils. For this reason, future research should prioritize techno-economic assessment, long-term field validation, life-cycle analysis, and interdisciplinary integration of materials science, process engineering, policy, and digital optimization tools.

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Sustainable synthesis of ZnO nanoparticles using grape pomace extract for photocatalytic degradation of metformin and glyphosate

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The increasing presence of pharmaceuticals and herbicides in aquatic environment has raised significant ecological concerns due to their persistence and potential toxicity. Metformin (MET), a first-line drug in the treatment of type 2 diabetes, and glyphosate (GLY), a widely applied herbicide, are increasingly detected in surface waters, as they are not efficiently removed by conventional wastewater treatment methods [1,2]. Advanced oxidation processes, particularly heterogeneous photocatalysis employing semiconductor materials, have emerged as efficient strategies for the removal of persistent pollutants. Recent studies highlight the use of green photocatalysts synthesized using plant extracts, which reduce the use of hazardous chemicals and support the principles of green chemistry and circular economy, especially when derived from agricultural waste [3]. The aim of this study was the green synthesis of ZnO nanoparticles using grape pomace extract and their application in the photocatalytic degradation of MET and GLY under simulated solar irradiation. In addition, a comparison between efficiency of photolytic and photocatalytic processes was performed. The removal efficiency of direct photolysis was 12.9% for GLY and 1.8% for MET. Besides, the effect of loading of the newly synthesized photocatalyst was investigated in the range of 0.5–2.0 mg/cm^3. After 180 min of irradiation, the system containing 1.0 mg/cm^3 of the newly synthesized photocatalyst exhibited the highest efficiency, achieving 9.4% removal of MET. In the case of GLY, the maximum efficiency was observed at a catalyst loading of 0.5 mg/cm^3, resulting in 36.7% removal after 60 min of irradiation. Besides, the obtained results indicate that photocatalysis is a more effective process than photolysis. Finaly, these results highlight the importance of catalyst loading as a key operational parameter in the photocatalytic degradation process and confirm that green-synthesized ZnO nanoparticles are effective photocatalysts for removing emerging contaminants from water systems.

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Towards advanced water purification: graphene-based adsorbents for cadmium removal

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Heavy metal pollution in aquatic environments, including wastewater streams and natural water resources, has become a growing concern over recent decades due to its potential risks to both ecosystems and human health. During the past decade, significant progress has been made in the development of novel materials for adsorption processes, with carbon-based nanomaterials emerging as particularly promising [1,2]. In this study, graphene oxide (GO) and magnetic graphene oxide (MGO) were synthesized and evaluated for the removal of cadmium (Cd(II)) from water under batch conditions. The adsorption kinetics of Cd(II) on both adsorbents were well described by the pseudo-second-order model (GO: $R^2 = 0.989$; MGO: $R^2 = 0.959$), indicating a chemisorption-controlled rate-limiting step. Equilibrium data for Cd(II) removal on GO were best described by the Langmuir isotherm ($R^2 = 0.981$), indicating a maximum monolayer adsorption capacity of 78.6 mg g^{-1}. In the case of MGO, both the Freundlich and Langmuir models provided very similar fits ($R^2 = 0.990$ and 0.989, respectively), with the Langmuir model indicating a maximum monolayer adsorption capacity of 27.7 mg g^{-1}. FTIR analysis revealed that oxygen-containing functional groups, along with magnetic oxide sites, play a key role in Cd(II) adsorption. Mechanistic interpretation, supported by the integration of spectroscopic insights with kinetic and isotherm modeling, indicated that the adsorption process is primarily governed by surface complexation between Cd^{2+} ions and oxygen-containing functional groups on both adsorbents, consistent with the dominant Cd species under the experimental conditions (pH 5.0 ± 0.2). In addition, surface precipitation (deposition) may contribute as a secondary removal mechanism for Cd(II) on GO and MGO. Although MGO exhibits a lower adsorption capacity than GO, its magnetic properties enable facile separation and recovery, addressing a critical limitation of nanomaterial-based adsorbents in practical applications. This trade-off between adsorption capacity and processability highlights MGO as a more viable candidate for scalable, continuous, and sustainable water treatment systems.

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Adsorption performance of rosehip seed-derived biochar for the removal of methylene blue

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Synthetic dyes represent a significant class of pollutants in industrial effluents, particularly from the textile, paper, and pharmaceutical sectors. Their removal from wastewater streams is essential to mitigate their impact on the aquatic environment due to their toxicity and resistance to biodegradation. Among various water treatment methods, adsorption is widely regarded as an effective approach owing to its operational simplicity, cost-effectiveness, and minimal generation of secondary pollutants. Consequently, the development and identification of low-cost, sustainable adsorbents are crucial for enhancing the environmental and economic feasibility of wastewater treatment processes. In this study, the removal of methylene blue from aqueous solution was investigated using biochar derived from waste rosehip seeds via slow and incomplete combustion. The aim of the study was to evaluate the adsorption capacity of biochar and to elucidate the adsorption mechanism. Batch adsorption experiments were conducted at ambient temperature with an adsorbent dosage of 1 g/L and initial dye concentration ranging from 1 to 7 mg/L. The experimental data were analyzed using Langmuir and Freundlich isotherm models. Based on the coefficient of determination (R^2), Langmuir model provided a better fit, suggesting monolayer adsorption on a homogeneous surface with negligible interactions between adsorbed molecules. The Langmuir isotherm analysis revealed a maximum adsorption capacity of q_{max}= 2.8 mg/g and a high Langmuir constant (K_L=142.2 L/mg), indicating a strong affinity between methylene blue and the biochar surface at low concentrations, despite the relatively limited adsorption capacity. The low maximum adsorption capacity may be attributed to the limited number of active adsorption sites on the biochar surface. Furthermore, the calculated separation factor (R_L) values were in the range from 0.001 to 0.007, indicating highly favorable adsorption of methylene blue onto the surface of biochar. The observed decrease in R_L values with increasing initial methylene blue concentration suggested increasingly favorable adsorption, approaching irreversible behavior. Based on these findings, further modification or activation of rosehip seeds-derived biochar is necessary to enhance its adsorption capacity and expand its potential application in wastewater treatment.

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Mineral carbonation of phosphogypsum using carbon dioxide

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Phosphoric acid is one of the most important inorganic acids in chemical industry. The production of phosphoric acid generates large quantities of phosphogypsum (PG), which is commonly disposed of despite its high calcium sulfate content. Mineral carbonation represents a promising approach for PG valorization, involving the reaction of CO_2 with alkaline earth metals, such as Ca and Mg, to form stable solid carbonates, enabling permanent CO_2 sequestration. In this study, the mineral carbonation of PG using CO_2 in the presence of a 25% aqueous solution of NH_4OH was investigated at ambient temperature and atmospheric pressure. The effect of CO_2 flow rate (0.1-0.6 L/min) on the $CaCO_3$ content in the final solid product and PG conversion degree was evaluated at constant liquid-to-solid ratio (L/S=5), molar ratio of $NH_3/CaSO_4$ (N/S=2), and carbonation time of 20 min. Increasing the CO_2 flow rate enhanced both the $CaCO_3$ content in the solid product and the PG conversion degree. At CO_2 flow rates between 0.3 and 0.6 L/min, $CaCO_3$ contents above 70% and PG conversion exceeding 90% were achieved. The improved carbonation performance is attributed to the increased availability of dissolved CO_2 in the reaction medium, which promotes the formation carbonate ions and consequently enhances the carbonation of PG. The obtained results demonstrate that mineral carbonation enables efficient PG valorization and the production of valuable $CaCO_3$ under mild reaction conditions while simultaneously contributing to CO_2 sequestration.

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The effect of pretreatment of lavender flowers with deep eutectic solvents on the essential oil yield

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Conventional methods for essential oil recovery, such as hydrodistillation, steam distillation, and solvent extraction, often face limitations including low extraction yields and prolonged process times. To overcome these drawbacks, research has shifted toward innovative techniques, including ultrasound-, supercritical fluid-, and microwave-assisted extractions, as well as the application of deep eutectic solvents (DES). These modern approaches offer significant improvements in extraction efficiency, time reduction, and oil quality. DES, in particular, have emerged as promising green solvents due to their ease of preparation, biodegradability, and low toxicity. Furthermore, their unique ability to solubilize a wide range of plant constituents makes them particularly well-suited for enhancing the recovery of essential oils through biomass pretreatment [1].

In this work, the influence of lavender flower (LF) pretreatment with various DES types on the lavender essential oil (LEO) yield obtained by hydrodistillation was evaluated and compared to conventional hydrodistillation (CHD). The solvents investigated included choline chloride:lactic acid (ChCl:LA, 1:2), choline chloride: propylene glycol (ChCl:PG, 1:2), and triethanolamine:lactic acid (TEOA:LA, 1:2). Pretreatment of LF was conducted under the following conditions: temperature of 60 °C, agitation speed of 1000 rpm, DES:LF ratio of 5:1 mL/g, pretreatment time of 1 h, and 20% (v/v) water, relative to the DES. LEO hydrodistillation was performed at the water:LF ratio of 14:1 mL/g and hydrodistillation time of 120 min. Results demonstrated that DES pretreatment significantly enhanced LEO yield. The highest yield was obtained using TEOA:LA (5.0 mL/100 g), followed by ChCl:LA (4.8 mL/100 g) and ChCl:PG (4.7 mL/100 g), all of which outperformed CHD (4.2 mL/100 g). The superior performance of TEOA:LA can be attributed to its enhanced ability to disrupt the lignocellulosic matrix of the lavender flowers, thereby facilitating a more efficient release of the essential oil [2]. Future research will focus on analyzing the chemical composition of the obtained oils and evaluating the recyclability of the DES to further improve the sustainability of the process.

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Statistical optimization of the sunflower oil methanolysis catalyzed by wood ash

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Fatty acid methyl esters (FAME), derived from vegetable oils, represent an important class of alternative fuels, commonly referred to as biodiesel. Homogeneous catalysts (both base and acid) are the most widely employed for FAME production due to their high catalytic activity and rapid oil conversion into FAME. However, their use presents several challenges, including equipment corrosion, the formation of stable emulsions during water washing of biodiesel, and difficulties associated with catalyst separation and waste disposal. To address these challenges, increasing attention has been directed toward heterogeneous catalysts, owing to their ease of separation, reusability, and potential for more sustainable biodiesel production. In particular, growing interest has been focused on alkaline waste-derived solid materials that can be valorized as heterogeneous catalysts for FAME production. One such material is wood ash, a byproduct of heat and electricity generation from biomass, which disposal represents an environmental challenge. Although wood ash has been successfully tested for FAME production [1,2], the optimization study on reaction conditions using statistical modeling approach remains limited. Therefore, this study investigates the statistical optimization of sunflower oil methanolysis catalyzed by wood ash under batch conditions at atmospheric pressure and 60 °C. The effects of catalyst loading (5-15%), methanol:oil molar ratio (9:1-15:1, mol/mol) and reaction time (10-30 min) on FAME content were evaluated using 3^3 full factorial design with two replications. The experimental data were modeled using a quadratic regression equation. Analysis of variance (ANOVA) confirmed the statistical significance of the model and revealed that the catalyst loading had the most significant effect on the FAME content, followed by reaction time and methanol-to-oil molar ratio. All three factors showed a positive influence on the FAME content within the investigated range. The model exhibited good predictive reliability as confirmed by a low mean relative percentage deviation between predicted and experimental values (±6.45%, based on 54 data). The optimal reaction conditions were identified as catalyst loading of 14% (based on the oil mass), a methanol:oil molar ratio of 13:1 mol/mol, and a reaction time of 24 min, resulting in predicted FAME content of 99.1%. This value was in good agreement with the experimentally obtained FAME content of 98.3%. The obtained results provide a reliable foundation for further process development, including scale-up studies.

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Fostering sustainability in Serbia through innovation and collaborative business models in greener and sustainable chemistry

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Research in sustainable chemistry in Serbia is principally oriented around green solvents and safer analytical methodologies, bio-based materials and natural product extraction, green synthesis, and chemical management models aligned with circular economy (CE) principles [1–4]. Sustainable chemistry is functionally embedded within national imperatives for cleaner industrial transformation, pollution prevention, and chemical substitution.

Several converging trends are projected to shape Serbia's green chemistry pathway, such as waste-to-chemicals approaches and alternative feedstocks developed for the industrial and agricultural waste streams as secondary raw material inputs. Concurrently, the integration of digitalization with green chemistry enables real-time process monitoring, data-driven management of material flows, optimization of energy and raw material utilization.

A concrete and well-documented case study of such collaborative models in Serbia includes chemical leasing implementation involving three partners: a beverage producer, a chemical producer, and a facilitating organization. Chemical leasing is a service-oriented business model in which the producer sells the function performed by the chemical with payment indexed to a functional unit rather than volume or quantity sold [1].

Serbia has established foundational capacity through collaborative ecosystems of academia and industry involving the Center for Cleaner Production, University of Belgrade, Vinča Institute of Nuclear Sciences, University of Novi Sad, and the Chamber of Commerce of Serbia, among others. Funding from the Science Fund of the Republic of Serbia, UNDP-supported programs, alongside with the Ministry of Environmental Protection, supported the development of Circular Economy Platform for Sustainable Development in Serbia, the Green Program of Cooperation between Science and Industry, and the GreenUp Accelerator, collectively advancing sustainable innovation through multi-stakeholder collaboration. Sustainable chemistry in Serbia is also operationalized indirectly through cross-sectoral instruments, e.g. the Roadmap for Circular Economy, the Circular Economy Development Program, and the Green Agenda for the Western Balkans, rather than through a designated green chemistry policy framework. While green and sustainable chemistry represents a strategic nexus of scientific innovation, environmental protection, and economic competitiveness, structural barriers persist. It includes slow EU regulatory alignment, limited financing for scaling innovations to industrial level, market fragmentation, and low industry uptake due to cost concerns. Extended development cycles, cross-disciplinary requirements, and insufficient pathways to commercialization remain the principal constraints on broader adoption.

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Bio-based formulation ingredients from agri-food by-product valorization: a circular chemistry approach

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The practical potential of agricultural and food processing by-products is well proven, such as the utilization of fruit and vegetable pomaces, berry seeds, and botanical processing residues as renewable secondary feedstocks for bio-based formulation ingredients. It is applicable to cosmetic, pharmaceutical, and food product development. It demonstrates a sustainable, circular chemistry approach, integrating green extraction principles with value-chain development of agri-food waste, providing scientifically validated and industrially relevant pathways for the substitution of fossil-derived or synthetically produced formulation ingredients [2,3].

Published experimental data encompasses various green extraction technologies. By-product matrices included grape pomace, pumpkin processing residues, raspberry seeds, and botanical processing waste. Functional applicability of recovered fractions as cosmetic actives and food formulation ingredients was assessed against established quality and safety benchmarks [1,4].

Scientifically proven results include the optimized green extraction of grape pomace under three-stage ethanol extraction, with gallic acid, caffeic acid, syringic acid, and chlorogenic acid identified as dominant phenolic constituents [1]. Deep eutectic solvents formulated with L-proline/betaine and lactic acid achieved comparable polyphenol recovery from grape pomace with substantially reduced environmental burden relative to conventional organic solvents [4]. Microbial valorization pathways demonstrated the simultaneous production of antioxidant, antimicrobial, and skin-protective bioactive fractions from grape pomace, advancing its applicability as a circular, multi-functional cosmetic ingredient. Accelerated solvent extraction from pumpkin by-products yielded carotenoid- and polyphenol-enriched extracts exhibiting strong and statistically correlated antioxidant activity. Across all matrices, bio-based actives presented functional equivalence or superiority over synthetic counterparts in antioxidant, photoprotective, and antimicrobial properties [2].

Agri-food by-product valorization through green extraction chemistry represents a scientifically robust and strategically significant pathway for producing bio-based cosmetic and functional formulation ingredients, directly advancing the circular chemistry agenda, supporting sustainability and the transition away from fossil-derived excipients [3]. The convergence of sustainable solvent systems, process optimization methodologies, and multi-sector formulation applications underscores the translational readiness of this approach. From a Serbian perspective, established research capacity in green extraction chemistry, combined with a substantial agri-food processing sector, positions the country to develop commercially viable, sustainability-compliant bio-based ingredients aligned with EU Green Chemistry and Circular Economy frameworks.

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Methyl Salicylate-Based NADES with Terpenoids and Capric Acid: Antioxidant and Antimicrobial Potential

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Natural deep eutectic solvents (NADES) represent a new generation of sustainable solvents with the framework of green chemistry. They are formed through hydrogen-bond interactions between two or more natural components that create stable liquid systems with low toxicity and high biodegradability. What makes NADES potent systems is their dual role, as eco-friendly alternative to conventional organic solvents, but they also exhibit a wide spectrum of biological activities. Our research includes newly synthetized formulations based on methyl salicylate combined with terpenoids (menthol, thymol and camphor) and fatty acid capric acid. Methyl salicylate, a bioactive component derived from wintergreen oil, is well known for its anti-inflammatory and analgesic properties. Terpenoids contribute potent antioxidant, anti-inflammatory and antimicrobial activity, while capric acid adds antiviral and antifungal activity alongside its antioxidant and anti-inflammatory potential.

The aim of this study was to investigate the potential of an innovative NADES formulation, utilizing methyl salicylate as hydrogen bond donor (HBD) and menthol, thymol, camphor and capric acid as hydrogen bond acceptors (HBAs). Physicochemical properties were evaluated by measuring density, and structural confirmation was obtained through FT-IR spectroscopy. The bioactivity of the formulations was assessed through antioxidant and antimicrobial assays. Antioxidant capacity was determined using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging method, whereas antimicrobial activity was evaluated via Minimal Inhibitory Concentration (MIC) testing four bacterial strains, one Gram-positive (*Staphylococcus aureus*, ATCC 25923) and three Gram-negative strains (*Escherichia coli*, ATCC 25922, *Salmonella enterica* serotype Enteritidis, ATCC 13076, and *Pseudomonas aeruginosa*, ATCC 27853).

The results revealed that solvent density was closely linked to the structural features of the HBD, while FT-IR results confirmed that H-bonds, occurring between two components in NADES, were the main force leading to the eutectic formation. The DPPH assay demonstrated that only the methyl salicylate:thymol formulation exhibited potent antioxidant activity with an IC_{50} value of 0.25 mg/mL. In the MIC assay, the most potent antimicrobial formulations were methyl salicylate:menthol and methyl salicylate:menthol where ranging from 0.0625 to 0.3125%. On the other hand, methyl salicylate:camphor and methyl salicylate:capric acid displayed lower activity, with MIC values in the range of 0.625-1.25%.

These findings highlight that these innovative hydrophobic NADES formulations display significant antioxidant and antimicrobial properties. Our future research will include *in vitro* experiments and expand antimicrobial testing to additional bacterial strains, with focus on dermal applications.

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Green chemistry of antimicrobial agents: application of medicinal and aromatic plant by-products for enhancing food safety

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The modern food industry faces a dual challenge: the need to extend product shelf life and the increasing pressure from regulatory authorities to reduce the use of synthetic preservatives (such as nitrites and parabens), which are classified as potentially hazardous chemical substances. At the same time, the processing of medicinal and aromatic plants generates significant amounts of solid by-products rich in bioactive compounds, which are often underutilized. The aim of this review study is to systematize current knowledge on the chemical and phytochemical profiles of by-products derived from selected plant species (such as sage, rosemary, and thyme) and to analyze their potential as sources of natural antimicrobial and antioxidant agents in accordance with the principles of green chemistry. The study discusses the major classes of plant-derived bioactive compounds (polyphenols, terpenes, and alkaloids), with particular emphasis on their role in stabilizing food systems through the inhibition of oxidative processes and the improvement of food quality. Special attention is given to the synergistic effects of phytochemical components, as well as their impact on sensory and functional properties of food, particularly lipid oxidative stability. Although plant-derived extracts are often perceived as safe, they may contain antinutrients or natural toxic compounds, such as thujone and pyrrolizidine alkaloids. Therefore the aim of this study is to propose a framework for controlling the concentrations of these compounds to ensure the safe application of plant-based bioactive agents in food systems, in compliance with relevant regulatory frameworks (EFSA and REACH). The utilization of plant processing by-products contributes to the principles of circular economy and reduces the chemical footprint of the industry. Special emphasis is placed on the substitution of synthetic additives with plant-derived bioactive agents, including plant extracts, isolated compounds, and their formulations, using hazard analysis and critical control points (HACCP) and chemical risk management approaches. This study demonstrates that the valorization of plant materials through green chemistry principles represents a sustainable approach to improving food safety and functionality.

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Tartrazine Adsorption on Biochar Obtained from European hake collected from Adriatic Montenegrin coast

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Tartrazine (E102) is a synthetic azo dye widely used in all industrial brunches [1]. Due to its potential harmful effect on flora and fauna, as well as on human beings, its removal from water solution has high priority in a pollution treatment. Biochar from different origins, is used as an adsorbent in water pollution control because of its high surface area and pore volumes. In this work adsorption of tartrazine dye on biochar obtained by annealing fish European hake *(lat. Merluccius merluccius)*, collected from Adriatic Sea (Montenegro, Bar) was examined.

Fish ash of European hake was obtained by annealing the lyophilized fish samples. The temperature 450 °C in a muffle furnace was used, after which sample was crushed, sieved through a stainless-steel sieve sized 250 μm and homogenized. Samples were gold-coated for conductivity and analyzed using a JEOL JSM-6610LV SEM with EDS mapping. The adsorption of tartrazine (0,0040 g tartrazine in 100 ml flack) was monitored by UV/Vis method on 0,05 g fish ash sample throughout time. FTIR spectra of tartrazine, fish ash before and after adsorption, are recorded on Perkin Elmer equipment, ATR technique.

EDS mapping via SEM confirmed a mineral composition primarily consisting of hydroxyapatite [2] and trace $CaCO_3$, indicated by the presence of elements such as Ca, P, and O. During a 24-hour adsorption study using 0.05 g of fish ash, the solution pH increased from 7.1 to 8.9 due to the dissolution of alkaline oxides and carbonates, which also caused a hyperchromic UV/Vis shift. Despite this shift to a more basic environment, tartrazine remained chemically stable as it resists decomposition up to pH 11. The slightly decrease in tartrazine concentration regarding to starting, make fish ash sample as a promising adsorbent. Additionally, the FTIR spectra of tartrazine, fish ash before and after adsorption, are recorded and compared.

EDS and FTIR analysis confirmed that the adsorption of tartrazine on fish ash has occurred in an aqueous solution of tartrazine. This study is attempting to prepare a low-cost adsorbent from fish collected from Adriatic Sea.

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Thermal Behavior and Stability of Berry Fruits Cultivated in Western Serbia

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Understanding the thermal behavior of berry fruits is essential for optimizing their processing, storage, and stability. In this study, thermal properties of strawberry (*Fragaria × ananassa*), raspberry (*Rubus idaeus*), and blackberry (*Rubus fruticosus*) cultivated in Western Serbia were investigated using differential scanning calorimetry (DSC) and thermogravimetric analysis (TGA).

Thermal transitions of fresh berry samples were analyzed over a temperature range from −90 to 200 °C using DSC, while TGA measurements were performed up to 700 °C to evaluate weight loss and thermal stability. Key parameters, including glass transition temperatures (Tg), melting behavior, evaporation temperatures, and enthalpy changes, were determined. All measurements were conducted under controlled nitrogen atmosphere and analyzed in relation to the chemical composition and water content of the samples.

All examined berry fruits exhibited similar thermal profiles, characterized by glass transition in the range of approximately −60 °C, followed by ice melting near 0 °C and water evaporation in the temperature range of 100–120 °C. Slight variations were observed in evaporation enthalpy and weight loss behavior, which can be attributed to differences in moisture content, sugar composition, and pectin content. TGA analysis confirmed high total weight loss (approximately 93–97%), reflecting the high water content typical of fresh berry fruits.

Despite differences in chemical composition and antioxidant properties, the thermal behavior of the analyzed samples showed a high degree of similarity, indicating that water content is the dominant factor governing thermal transitions in these systems. These findings suggest that thermal stability of berry fruits is less influenced by phenolic composition and more by physicochemical parameters such as water activity and solid content.

In conclusion, DSC and TGA analyses provide valuable insight into the thermal characteristics of berry fruits, which is crucial for their industrial processing and storage. The observed thermal uniformity among different berry types highlights the importance of water-related properties in determining their behavior under thermal conditions, supporting the development of optimized food processing strategies.

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pH-Dependent Adsorption of Emerging Contaminants Using Waste-Wood Hydrochar: Comparison of Hydrochars Produced With and Without Process-Water Recirculation

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Contaminants of emerging concern (CECs), including pharmaceutically active compounds and pesticides, are often found in aquatic environments and may pose risks to ecosystems and human health. Since conventional wastewater treatment is not designed to remove these micropollutants, advanced (quaternary) methods such as adsorption on activated carbon are increasingly being developed [1]. Hydrochar (HC), produced from waste biomass via hydrothermal carbonization (HTC), is a promising adsorbent due to its carbon structure and surface functional groups [2]. The HTC process yields solid HC, a liquid by-product (process water) rich in organic compounds, and gases. Recirculating process water within the HTC cycle can reduce waste while enhancing HC surface properties and performance [3].

In this study, the efficiency of removal of selected CECs from water was assessed using two HC produced from waste wood biomass, across a pH range 4–9. The removal efficiency was evaluated by comparing two HC produced from waste wood biomass with and without HTC process water recirculation (HC-1); HTC was conducted at 300 °C for 30 min with a solid-to-liquid ratio of 1:15 under autogenic pressure. HC produced with process-water recycling (HC-R2) was obtained in the second cycle under the same HTC conditions. Batch adsorption experiments were conducted using a model solution containing 30 CECs (15 pesticides and 15 pharmaceuticals) at an initial concentration of 20 µg/L in deionized water. Treatment was performed for 1 h with an adsorbent dose of 2.0 g/L.

Total CEC removal efficiency from the model water in the pH range 4-9 using HC-1 was from 15% to 48%, whereas HC-R2 achieved 13% to 58%. For both adsorbents, the highest overall efficiencies occurred at pH 5-6, indicating mildly acidic conditions as the optimal pH window for adsorption of the investigated pollutants. The highest individual removals were obtained for tebuconazole, trichlorfon and propiconazole (70-79%); imazalil and diltiazem (80-89%); and furosemide, propranolol, famotidine and bezafibrate (>90%).

Process-water recycling during HTC improved HC performance, with HC-R2 reaching higher overall CEC removal (up to 58%) compared to HC-1 (up to 48%). Solution pH strongly affected adsorption efficiency, and the best results were consistently obtained under weakly acidic conditions (pH 5-6).

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Sunflower Protein in the Development of Sustainable Biodegradable Films: Innovative Solutions for Eco-friendly Materials

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This study investigates the development of biodegradable films based on sunflower protein isolate (SFP) and polyvinyl alcohol (PVA), with particular emphasis on the effect of glycerol as a plasticiser on the structural, thermal, mechanical, and biodegradability properties of the films. Advanced characterisation techniques, including FTIR, XRD, SEM, DSC, and TGA, were used to analyse molecular interactions, crystallinity, surface morphology, thermal stability, and mechanical properties. FTIR analysis indicated a decrease in crystallinity and an increase in amorphous regions in films containing SFP, resulting in improved flexibility. The addition of glycerol promoted hydrogen bond formation and further reduced crystallinity, enhancing flexibility while reducing mechanical strength. DSC and TGA analyses showed a reduction in glass transition temperature (Tg) and melting temperature (188°C → 172°C), as well as decreased thermal stability, attributable to reduced crystallinity and earlier degradation. XRD analysis revealed a shift in the crystallographic peak (19.32° → 19.74°) with increasing SFP content and glycerol concentration, indicating reduced crystallinity and increased amorphous character. Mechanical testing demonstrated a decrease in tensile strength and stiffness with increasing glycerol concentration. Films with 50% glycerol showed significantly reduced stiffness (below 10 MPa) and tensile strength (below 2 MPa), indicating enhanced flexibility but diminished mechanical integrity. Biodegradability testing showed up to 80% degradation in soil within 30 days, highlighting the potential of these films to reduce plastic waste and address environmental pollution. This research demonstrates the potential of combining natural biopolymers such as SFP with synthetic polymers like PVA to create sustainable biodegradable materials. These films offer promising applications in the packaging and pharmaceutical industries, providing a sustainable solution to the global plastic waste problem. Further optimisation of composition, plasticisers, and additives could significantly improve material properties, enabling widespread commercial applications in industries seeking to reduce their environmental footprint.

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Comparative performance of biochars from raspberry stalk and exhausted chestnut wood for total iron removal from synthetic and real water samples

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During the last few decades, scientists have been actively researching cheap, natural, and easily available materials known as biosorbents, which can be effectively applied for the adsorption of pollutants from water and can largely replace commercial activated carbon [1]. Biochar, a specific type of carbon obtained by pyrolysis under oxygen-limited conditions, is often tested as an adsorbent. The cost of producing biochar is six times lower than the cost of preparing activated carbon, as its production requires less energy and utilizes chemical-free processes, making it a potentially good material for adsorption [2].

In this work, the use of biochar from exhausted chestnut wood after tannin extraction (ECW) and raspberry stalk (RS) for removing iron ions from synthetic solutions and real samples was investigated. Adsorption was carried out in model water with an initial concentration of iron ions 10 mg/l, at pH 5. The kinetics of the process and the adsorption capacity were examined over a time period of 5-1440 min. For RS, it was determined that contact time needed to establish adsorption equilibrium is 30 minutes, while for ECW it was 6 hours. With longer contact time between adsorbate and adsorbent, the efficiency of iron ion removal increased. Significantly better results were achieved using RS, where the maximum efficiency was 99.7%, after 24 hours, compared to 76.5% for ECW. The maximum adsorption capacities of biochar from RS and ECW were 12.87 mg/g and 9 mg/g, respectively. The results were compared with the removal efficiency of iron ions using commercial activated carbon powder (67.7%), which demonstrated that biochar adsorbs iron ions more effectively than the commercial adsorbent. In order to test the effectiveness of biosorbents on real samples, groundwater from a 12 meters deep well in Stara Pazova was used, where the iron concentration before treatment was 7.6 mg/l. After adsorption, the residual concentration of total iron in the water was 1.81 mg/l, 0.93 mg/l, 0.13 mg/l for activated carbon, ECW and RS, respectively. As in the synthetic solution, RS exhibited the highest efficiency (98.3%), while commercial activated carbon was the least efficient (76.3%). Based on the obtained results, it can be concluded that raspberry stalk and ECW can be successfully used as adsorbents for iron ion removal from synthetic solutions and real water samples. The highest efficiency in all experiments was shown by RS, with which further experiments will be conducted to optimize the adsorption process and modify the adsorbent itself.

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Influence of transition metals and carbon supports on Pd-based catalysts for the hydrogen evolution reaction in acidic media

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The hydrogen evolution reaction (HER) is a key process in water electrolysis for hydrogen production. Its efficiency depends on the use of effective electrocatalysts that minimize energy losses. In this study, six transition metal–palladium (M–Pd) alloy-based catalysts with M = nickel (Ni), cobalt (Co), or copper (Cu), were tested in acidic media to evaluate their performance for HER. These catalysts contain a small fraction of Pd, a noble metal, combined with earth-abundant metals (Ni, Co, or Cu) to reduce overall catalyst cost. Two different support materials were used, mpgC_3N_4-KetjenBlack and mpgC_3N_4-rGO.

Catalyst inks were deposited on glassy carbon electrodes via drop-casting and characterized using linear sweep voltammetry (LSV) and electrochemical impedance spectroscopy (EIS). Tafel analysis and EIS fitting were used to quantify HER kinetics and charge-transfer properties.

Among all catalysts tested, Co–Pd supported on mpgC_3N_4-KetjenBlack yielded the best performance. This catalyst exhibited a current density of 80.5 mA cm^{-2} at an overpotential of 400 mV, an onset potential of −196 mV vs. RHE, a high exchange current density, and low charge-transfer resistance. Across the catalyst series, Ni–Pd consistently outperformed Cu–Pd counterparts, independent of the support material.

Since Co–Pd was the best-performing catalyst, it was then compared with the commercial Pt/C catalyst. While Co–Pd showed higher exchange current density and current density at 400 mV, as well as lower charge-transfer resistance, it exhibited a more negative onset potential and a higher Tafel slope than Pt/C, indicating comparatively slower kinetics at low overpotentials.

Furthermore, catalysts supported on mpgC_3N_4-KetjenBlack systematically exhibited lower onset potentials and charge-transfer resistance than those supported on mpgC_3N_4-rGO.

Overall, these results highlight the importance of the support material in governing HER electrocatalytic performance. The findings of this study also suggest that Pd-based catalysts coupled with transition metals are promising candidates for improving the cost-efficiency of green hydrogen production.

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Sustainable valorization of pepper seed residues as a rich source of polyphenols

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Substantial amounts of agricultural and food waste are generated globally, representing both an environmental burden and an underutilized resource. Their valorization into high-value bioactive compounds, particularly polyphenols, contributes to environmental sustainability, circular economy strategies, efficient waste management, and improved human health outcomes (Yadav et al., 2024). One such underexplored and underutilized material is pepper seed residue, a by-product generated during industrial food processing. Seeds and stalks are removed to obtain pepper halves, which are subsequently subjected to cutting and freezing operations. Pepper seed residues account for approximately 20-25% of the processed material, representing a significant amount of underutilized biomass.

The primary aim of this study was to evaluate the potential of dried pepper seed residues as a sustainable source of polyphenols using conventional solid-liquid extraction with different ethanol concentrations (20%, 40%, 60%, 80%, and 96%). The obtained extracts were analyzed for total polyphenol content, and their antioxidant activity was evaluated using DPPH, FRAP, and ABTS assays. The total polyphenol content ranged from 2.43 to 6.78 mg GAE/g DW (Figure 1). Antioxidant activity values ranged from 0.76 to 2.56 mg TE/g DW, 1.03 to 2.26 mg Fe^{2+}/g DW, and 3.98 to 8.02 mg TE/g DW for DPPH, FRAP, and ABTS assays, respectively. The obtained results indicate that pepper seed residues are rich in polyphenols, highlighting that a substantial amount of bioactive compounds are currently discarded as waste and remain underutilized. As potent natural antioxidants, polyphenols have promising applications in the pharmaceutical, cosmetic, and food industries. Moreover, their recovery from food waste provides additional environmental benefits through waste reduction and resource valorization.

Future research will focus on the application of advanced green extraction techniques to optimize the recovery process, enhance polyphenol yield, and further improve antioxidant potential. Such an approach would contribute to promoting the sustainable utilization of underexploited agri-food waste within the framework of the circular economy.

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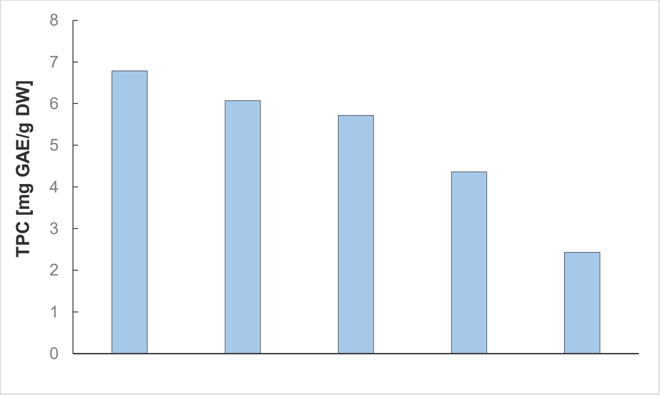

Figure 1. TPC values of pepper seed waste extracts using different concentrations of ethanol

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Development of innovative solutions in the production of sustainable biodegradable polymers

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Biopolymers are biodegradable and biocompatible sustainable materials that can be an adequate replacement for conventional petroleum-based plastics. They include a wide range of materials such as polysaccharides, proteins, polyesters with unique properties, derived from natural sources. The use of environmentally friendly materials leads to a reduction in the accumulation of non-degradable plastics in the environment, introducing more innovative industrial solutions [1]. Polyhydroxyalkanoates (PHA) are biodegradable polymers belonging to polyesters. They are produced by various Gram-positive and Gram-negative bacteria in conditions of excess carbon and lack of nutrients (N, P, K). Microorganisms store PHA in the form of granules as a source of carbon and energy in starvation conditions. The PHA molecule consists of monomeric units (R)- hidroxy fatty acids, interconnected by an ester bond [2]. Thanks to their physical and chemical properties, such as thermal stability, elasticity, low porosity, they are recognized as promising materials for various purposes such as agriculture, packing industry, construction materials, etc. PHAs can be isolated from various waste streams such as agricultural waste and wastewater, making them additional sustainable and cost-effective materials.

In our study, we compared the efficiency of PHA extraction from sewage sludge, using chloroform, a commercially used PHA solvent, and alkaline pretreatment with sodium carbonate. Sludge is an organic substrat for a diverse bacterial consortium, which makes it suitable source of PHA. In the experiment we varied different parameters such as biomass:solvent ratio, biomass:surfactant ratio, as well as the time and temperature of homogenization. The nonionic surfactant Tween 80 (polyethylene sorbitol ester) was used in order to remove all non-PHA cells. After extraction, the samples were dried and subjected to FT-IR analysis. The results of FT-IR analysis showed that the sample with chloroform show a sharp peak at 1733.93 cm^{-1}, which represents the ester carbonyl band (C=O), and the strong absorption C–O bands at 1348.78 cm^{-1}-1247.63 cm^{-1} in the fingerprint region, which is actually an indication of the presence of PHA. The spectrum shows a strectching from 2991.19 cm^{-1}-2855.42 cm^{-1}of $–CH_2$, $–CH_3$ bands, which is conformation of the presence of long aliphatic chains. Also, the use of sodium carbonate as a alkaline pretreatment showed results similar to the use of chloroform. A sharp peak at 1734.56 cm^{-1} indicates C=O band, C–O bands at 1348.69 cm^{-1}-1247.79 cm^{-1} in the fingerprint region, the spectrum showed the presence of $–CH_2$, $–CH_3$ bands at 2920.64 cm^{-1}-2853.77 cm^{-1}.

The above indicates that less harmful methods such as alkaline pretreatment can replace the use of harmful chemicals, contributing to the development of the producing of biodegradable plastics.

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Session 6
Forensic & Analytical Chemistry

Electrochemical Study of a Novel Rhodium(III) Schiff Base Complex in Relation to Human Serum Albumin Binding

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The electrochemical behavior of a Schiff base ligand, bis(phenylacetylaceton)ethylenediimine, and its Rh(III) complex was examined in both aqueous media (PBS pH 7.4) and aprotic organic solvents (acetonitrile and dimethylformamide). The results revealed a clear solvent-dependent response, with non-aqueous media enabling better-defined and more stable electrochemical signals. For the evaluation of protein binding, phosphate-buffered saline solution containing 10 mM NaCl was chosen as a suitable media to investigate the interaction between the Rh(III) complex and human serum albumin (HSA). These interactions were investigated by cyclic voltammetry, while the calculated binding constants (10^4–10^5 M^{-1}) pointed to a moderate to favorable affinity toward HAS [1]. Overall, the observed behavior supports the potential of this Rh(III) complex as a promising candidate for further biomedical or drug-delivery related studies.

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Electrochemical behavior and determination of cefradine at a pencil graphite electrode

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Cephalosporins are a group of β-lactam antibiotics derived from 7-aminocephalosporanic acid (7-ACA). They have a broad spectrum of antibacterial activity and are widely used to treat various bacterial infections in both human and veterinary medicine (1). Cephradine, a first-generation cephalosporin, acts by inhibiting bacterial cell wall synthesis.

Cephalosporins are susceptible to hydrolysis in surface water systems, especially under alkaline conditions. They tend to form complexes with cations and accumulate in wastewater sediments. They enter aquatic systems primarily from industrial and manufacturing facilities, which are their main source. Other sources are more difficult to identify because antibiotics undergo structural and compositional changes over time after entering the environment. Intensive use of β-lactam antibiotics in livestock and aquaculture often leads to low concentrations of antibiotic residues in food products and by-products. First-generation cephalosporins, such as cephradine and cefadroxil, can reach high concentrations in urine after ingestion of contaminated food.

Antibiotic residues pose a potential risk to human health and contribute to environmental imbalance when released into ecosystems. Such contamination may negatively affect aquatic organisms and promote the spread of resistant bacterial strains.

Given these challenges, accurate and sensitive detection of β-lactam antibiotics in complex environmental and food samples is essential. Such detection is necessary to ensure food safety, monitor environmental pollution, and implement regulatory standards.

Traditional analytical and optical methods, such as high-performance liquid chromatography (HPLC), liquid chromatography–mass spectrometry (LC-MS), and UV-Vis spectrophotometry, offer high accuracy in antibiotic determination. However, these methods are expensive, require laboratory conditions, and involve complex, time-consuming sample preparation procedures, limiting their use for rapid on-site analysis. They also often require organic solvents that may harm the environment. Due to these limitations, electrochemical techniques and sensors are increasingly used. Electrochemical methods are faster, more efficient, more sensitive, simpler, and more cost-effective. They allow the detection of low concentrations of antibiotics in small sample volumes. These techniques measure electrical parameters such as current or potential and correlate them with the presence of specific chemical species in the sample. The main electrochemical methods for antibiotic detection include amperometry/potentiometry, voltammetry, and electrochemical impedance spectroscopy.

Various electrochemical sensors have been used to detect cephalosporins, employing different electrolytes and buffer solutions depending on the analyte and method. The choice of electrode significantly affects the sensitivity and selectivity of the method. Commonly used electrodes include mercury electrodes, glassy carbon electrodes, and electrodes modified with nanomaterials, while Britton-Robinson and phosphate buffers are frequently used as supporting media. These methods have been successfully applied to the analysis of real samples, including serum and other clinical specimens. The choice of medium influences the shape, intensity, and position of the voltammetric peak. The electrochemical behavior of cephalosporins is often studied in buffers of different pH values, as acidity or alkalinity can affect the reaction mechanism and electrochemical activity of the analyte. Britton-Robinson buffer is used over a wide pH range, while phosphate buffer (PBS) is

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suitable for certain cephalosporins, such as cefotaxime. In some cases, acidic or alkaline media are used to induce degradation of cephalosporins and form electroactive products, enabling indirect detection of compounds that do not exhibit a significant electrochemical signal (3).

In this study, the electrochemical detection of cephradine was investigated using differential pulse voltammetry (DPV). The effects of concentration and electrolyte pH were examined. A Pencil graphite electrode served as the working electrode, a saturated calomel electrode (SCE) as the reference electrode, and a platinum electrode as the counter electrode. The pH 7.5 solution was prepared by mixing BR buffer with 0.1 M NaOH.

The effect of concentration was studied in Britton-Robinson (BR) buffer at pH 2, using concentrations of 2×10^{-5}, 5×10^{-5}, and 6×10^{-5} mol/L (Figure 1.). The results showed that increasing concentration led to higher peak currents, with the highest peak observed at 6×10^{-5} mol/L. All voltammograms displayed a well-defined peak at approximately E ≈ 1.0–1.1 V. As the concentration decreased, the peak current also decreased, while the peak potential remained nearly unchanged. These results indicate a concentration-dependent oxidation process without changes in the reaction mechanism.

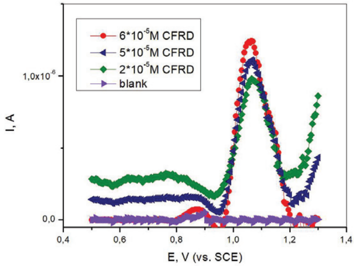

Figure 1. The effect of concentration on the peak intensity of cephradine.

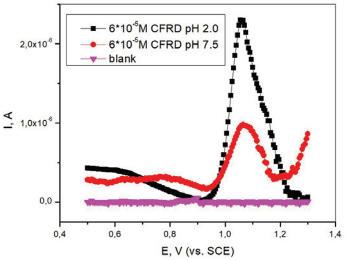

Figure 2. The effect of pH on the peak intensity of cephradine.

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From Research to Results: 15 Years of Clinical Mass Spectrometry Assay Development at a Canadian Academic Hospital

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This work describes the systematic development, validation, and clinical implementation of a broad liquid chromatography–mass spectrometry (LC-MS/MS) diagnostic portfolio at a major Canadian academic health network over a 15-year period. The aim was to expand high-complexity diagnostic capabilities, overcome the analytical limitations of immunoassay-based methods, and translate emerging biomarker science into actionable clinical and investigational tools - directly bridging scientific discovery and improved patient outcomes. Over 20 multiplex assays were developed and validated using LC-MS/MS across a wide range of analyte classes and biological matrices. LC-MS/MS was selected as the platform of choice for its unmatched specificity, ability to resolve structurally similar compounds, and capacity for simultaneous multi-analyte quantification. These are capabilities that immunoassays frequently cannot provide, particularly for low-abundance endogenous molecules or structurally related metabolite families.

Several assays addressed well-recognized limitations of immunoassay cross-reactivity and matrix interference. Catecholamines (epinephrine, norepinephrine, dopamine) and their O-methylated metabolites metanephrines and 3-methoxytyramine are critical biomarkers for the diagnosis of pheochromocytoma and paraganglioma, rare but life-threatening neuroendocrine tumours. Their quantification in plasma at sub-nanomolar concentrations demands exceptional sensitivity and the ability to distinguish structurally similar species, requirements uniquely met by LC-MS/MS. Similarly, vitamin D metabolites 25(OH)D2, 25(OH)D3, and the catabolite 24,25(OH)2D3 required chromatographic separation to avoid epimer interference and cross-reactivity that compromise immunoassay accuracy, with direct implications for diagnosis and monitoring of metabolic bone disease including osteoporosis.

Developing assays for low-abundance endogenous molecules presented particular analytical challenges. Pentosidine, a fluorescent advanced glycation end-product and biomarker of oxidative stress and bone quality in osteoporosis and chronic kidney disease, required acid hydrolysis of protein-bound adducts prior to LC-MS/MS quantification, with careful attention to matrix effects in complex plasma. Adenosine, a purine nucleoside with an essential role in renal hemodynamic regulation needed carefully optimized pre-analytical protocols and sensitive detection. Estradiol at the low levels encountered in postmenopausal women and men highlighted the inadequacy of direct immunoassays, requiring extraction and concentration steps to achieve clinically meaningful sensitivity. The portfolio (Fig.1) also encompassed tissue-based MS applications, including amyloid subtyping and confirmation of fibrillary glomerulonephritis from formalin-fixed paraffin-embedded (FFPE) biopsy material, analyses that complement or replace immunohistochemistry with definitive proteomic identification, enabling precise diagnosis and guiding targeted therapy. Drug quantification assays (metformin, salsalate, voriconazole, oseltamivir, plerixafor, testosterone in gels and creams) supported clinical pharmacology research and patient safety monitoring, with LC-MS/MS providing the specificity needed to distinguish parent compounds from metabolites and endogenous interferences. Omega-3 index in whole blood and dried blood spots extended the portfolio into nutritional biochemistry, relevant to cardiovascular risk assessment and population-level screening. All assays were developed following established clinical laboratory validation frameworks incorporating linearity, precision, accuracy, matrix effect, and interference assessments, alongside rigorous quality control and external proficiency testing. A laboratory-wide quality management system (QMS) was developed in parallel to standardize workflows, ensure regulatory compliance, and sustain analytical performance at scale.

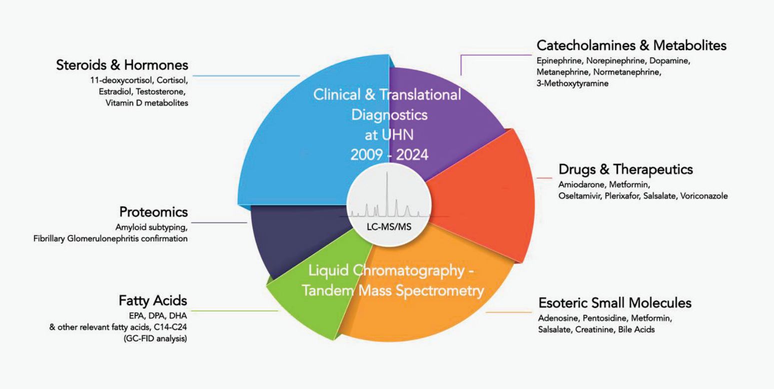

Figure 1. Overview of the LC-MS/MS assay portfolio developed at UHN (2009–2024), organized by clinical domain

The clinical implementation of this LC-MS/MS portfolio had direct and measurable impact on patient care. Improved specificity in catecholamine and metanephrine testing reduced diagnostic uncertainty in neuroendocrine tumour workup. Accurate vitamin D metabolite profiling informed treatment decisions in bone disease and renal patients. Amyloid subtyping by MS redirected patients toward appropriate systemic therapies. Drug monitoring assays supported dosing decisions and pharmaceutical stability assessments with direct patient safety implications. Research assays contributed to peer-reviewed studies advancing the understanding of renal hemodynamics, polycystic kidney disease, diabetes, and bone metabolism, several of which informed changes in investigational treatment strategies [1-5]. This 15-year experience demonstrates that a rigorous, quality-driven approach to MS-based assay development rooted in deep analytical expertise and sustained cross-disciplinary partnership is a reproducible and transferable model for academic–industry collaboration in the implementation of high-complexity diagnostics.

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Chemical Profiling of Bioactive Metabolites in Medicinal Fungi: Environmental Determinants and Application Potential

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Medicinal fungi are increasingly recognised as a significant source of structurally diverse bioactive compounds with considerable potential for pharmaceutical and biotechnological applications. This study investigates the chemical profile of two selected fungal species, *Fomes fomentarius (L.)* and *Schizophyllum commune (Fr.)*. The focus is placed on key groups of metabolites relevant to antioxidant and immunomodulatory activity, with particular emphasis on elucidating the influence of environmental factors on the distribution and concentration of these compounds. Fungi samples were collected from 16 geographically distinct locations across Serbia, enabling the assessment of spatial variability in chemical composition. The dried and homogenised material was subjected to ethanol extraction, followed by spectrophotometric analysis. Total phenolic content was determined using the Folin-Ciocalteu method, flavonoids were quantified via complex formation with aluminium, while total carbohydrate content was assessed using the phenol–sulphuric acid method [1]. These standardised analytical procedures allow for a reliable estimation of the major classes of secondary metabolites. The obtained results indicate pronounced variability in metabolite content both between species and across different locations, confirming the significant influence of ecological factors such as altitude, substrate composition, and climatic conditions. Samples with higher phenolic and flavonoid content exhibit enhanced antioxidant potential, whereas elevated carbohydrate levels suggest the presence of biologically active polysaccharides associated with immunomodulatory effects. These findings are consistent with contemporary research on medicinal fungi, which highlights a complementary distribution of antioxidant and polysaccharide components among different species [2]. From the perspective of analytical chemistry, this study confirms the applicability of rapid spectrophotometric methods for the comparative screening of natural bioresources. Furthermore, the observed chemical diversity points to the potential application of fungal-derived metabolites in the development of functional materials, dietary supplements, and biologically based formulations. In conclusion, the integration of analytical techniques with an ecology-driven sampling approach provides a robust framework for evaluating natural sources of bioactive compounds. Future research should incorporate advanced chromatographic and spectrometric methods for detailed molecular characterisation, as well as the correlation of chemical composition with biological activity, in order to more precisely define their applications in modern chemical and pharmaceutical technologies.

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Au-Functionalized MOF-808 for Electrochemical Arsenic Sensing: Optimization and Application in Real Water Samples

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Arsenic contamination of drinking water is a widespread environmental concern affecting millions of people worldwide. Long-term exposure to inorganic arsenic species, particularly As^{3+}, which is 60–70 times more toxic than As^{5+}, poses serious health risks, including damage to the nervous, respiratory, and cardiovascular systems and an increased risk of cancer [1,2]. Conventional analytical methods, such as atomic fluorescence spectroscopy and inductively coupled plasma-mass spectrometry, provide high sensitivity but require expensive, laboratory-based instrumentation, which limits their practical use for in-situ monitoring. Electrochemical sensors offer a promising alternative, providing portability, rapid analysis, and low-cost operation, while enabling detection at low concentrations necessary to comply with safety regulations [3,4]. In this work, we report the development of an electrochemical sensor based on Au-functionalized MOF-808, specifically amine-modified MOF-808 (Au@NH_2-MOF-808), for sensitive arsenic detection. The deposition potential, deposition time, and scan rate of cyclic voltammetry were systematically optimized to achieve the lowest possible detection limit. The optimized sensor demonstrated high sensitivity and reproducibility, as well as reliable arsenic detection in the presence of potential interferences (e.g., in the presence of copper ions occurring at a potential close to that of arsenic). Its practical applicability was confirmed in real water samples from Zrenjanin, a region known for arsenic contamination of drinking water. These results highlight Au@NH_2-MOF-808 as a cost-effective, portable, and efficient platform for monitoring trace arsenic in the environment.

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Enhanced solubility and photostability of Furosemide through complexation with Ethylenediamine-modified β-cyclodextrin

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Cyclic oligomers with seven glucose units, β-cyclodextrins (β-CD), are used as excipients in pharmaceutical formulations, providing protection against oxidation, photodegradation, and chemical degradation, and increasing the solubility of active compounds in biorelevant media. One of the biggest problems in β-CD behavior is their low water solubility, low complexation constants, and their low binding selectivity towards target molecules [1]. Furosemide, a well-known diuretic used for treating high blood pressure, swelling, and edema, with low water solubility and high photosensitivity, was used as a molecule of interest in this study. Synthesized 1,2-ethylenediamine-modified β-CD (EDA-β-CD) [2], was used to improve the solubility and photostability of Furosemide. Solubility of Furosemide was determined in two separate series from 0.5 to 5.0 mM solutions of unmodified β-CD and EDA-β-CD in 0.10 M Acetic buffer, pH 5.0, and in pure Acetic buffer. A solubility experiment was performed using the shake-flask method, by adding solid Furosemide in excess at 25 °C. After mixing and sedimentation, Furosemide concentration in supernatants was determined using an optimized method on a C18 reversed-phase (RP) HPLC system with PDA detection. Furosemide solubility in the 4.0 mM EDA-β-CD was $1.54 \pm 0.04 \times 10^{-3}$ mol/L, almost three times higher than in unmodified 4.0 mM β-CD, which was 5.89×10^{-4} mol/L. Furosemide complexation constant using the Higuchi-Connors method for modified EDA-β-CD was 1023 ± 18 L/mol, for unmodified β-CD was 151 L/mol, indicating that EDA-β-CD had almost seven times higher Furosemide binding affinity than unmodified β-CD. After irradiation with a mercury (Hg) lamp at 254 nm, the Furosemide concentration in solutions containing EDA-β-CD, unmodified β-CD, and Acetic buffer (pH 5.0) was determined using the above-mentioned RP-HPLC method. According to first-order kinetics, the lowest Furosemide photodegradation constant was 0.0169 ± 0.0013 min^{-1} in the presence of 5.0 mmol/L EDA-β-CD and 0.0240 ± 0.0021 min^{-1} in acetic buffer. The highest was observed in the presence of 5.0 mmol/L unmodified β-CD (0.0292 ± 0.0003 min^{-1}), indicating that EDA-β-CD has the greatest photoprotective effect and the largest contribution in photo protection of Furosemide. Interestingly, in the presence of unmodified β-CD, photostability was lower than in the Acetic buffer pH 5.0. The Furosemide photodegradation half-time in the presence of modified EDA-β-CD, 41.0 ± 3.3 min, was almost twice as high as in the presence of unmodified β-CD, 23.7 ± 0.2 min, and in Acetic buffer was 28.9 ± 2.6 min.

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Enhanced solubility of Haloperidol in highly concentrated Tartaric acid solutions, mechanistic insights into acid-base supersolubilization

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The solubility of weakly basic active pharmaceutical ingredients is shown to rise in highly concentrated weak acid solutions. This method is known as "Acid-base supersolubilization" (ABS), and it involves the formation of amorphous dispersions of poorly soluble compounds, such as Haloperidol (HAL) [1]. Haloperidol is an antipsychotic, weakly basic, and low-soluble drug (in aqueous media) used to treat acute psychosis, schizophrenia, and other behavioral disorders. ABS phenomena have been shown to work across different systems, but the main interactions that lead to supersolubilization have not been sufficiently investigated so far [2]. In this study, we investigated the high solubility of HAL in highly concentrated Tartaric acid (TA) solutions. HAL solubility in D_2O at different TA concentrations was determined using the miniaturized shake-flask method, at 25 ± 1 °C. All samples were equilibrated during six-hour stirring, followed by 18 h sedimentation (pH measurement done six times during mixing, and after sedimentation). Phases were separated by centrifugation, and the HAL concentration in the solutions was determined using an optimized method on a C18 RP-HPLC with PDA detection. ^{1}H NMR spectra were recorded in all studied solutions, and the solution density was also measured. FT-IR spectra of solid phases were recorded, and in the dissolved solid phases, the contents of HAL and TA were determined by HPLC. The HAL solubility in 5.0 mol/L TA and D_2O was 343.58 mg/mL, which is in accordance with the results reported by Singh et al. (2013) for HAL solubility in TA and H_2O. The pD profile shows an unexpected increase in pD from 1.63 at 3.0 mol/L TA to 2.04 at 5.0 mol/L TA. Solution density increases with concentration and is higher for solutions with dissolved HAL than for the starting solution with TA in D_2O. Overlaid ^{1}H NMR spectra show a shift towards lower ppm values for all HAL protons as TA concentration increases. The shift is particularly pronounced for all HAL aromatic protons, suggesting that dimerization and aggregation occur as TA concentration increases, along with an increase in solution density. FT-IR of the formed solid phases showed that, with an increase in HAL solubility, TA content in the solid phases increases. HPLC analysis of solid phases supports FT-IR, suggesting that the molar ratio of HAL to TA in the solid phase reduces from 2/1 to in 0.25 mol/L TA to 1/1 in 4.00 mol/L TA. From FT-IR, it was not possible to determine in which form TA is present in the solid phase. For further characterization of the solid phases, PXRD, TGA, and DSC, together with molecular modeling analyses, are necessary.

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Many thanks to Shimadzu (Japan) for providing the HPLC LC2050C 3D PDA for use.

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Method development for BTEX determination using headspace GC/MS

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The BTEX (benzene, toluene, ethylbenzene, and xylene isomers) are commonly found in mineral oils widely applied in different industrial processes. They are also constituents of petroleum derivates, and commonly used as solvents. Therefore, they are usually detected in soil and groundwater in the closest areas to the petroleum production and storage sites after leaking from old underground storage fuel tanks and piping. These compounds finally reach the groundwater and become major issue for public health and for the environment. Generally, benzene and its derivatives represent a suitable mixture for quality monitoring of surface and underground water. This is the primary reason for necessity for analytical method for determining them qualitatively and quantitatively.

To limit the effects of BTEX on the environment, it is necessary to develop accurate, sensitive, and reliable analytical methods to detect their presence. Analyzed samples are often a complex mixture of different compounds and pollutants other than BTEX. Therefore, these compounds can interfere with the analysis and contaminate the gas chromatographic system. Headspace coupled with gas chromatography is one of the most popular analytical techniques for analyzing volatile compounds in a variety of matrices, as it eliminates tedious sample preparation steps and prevents contamination problems.

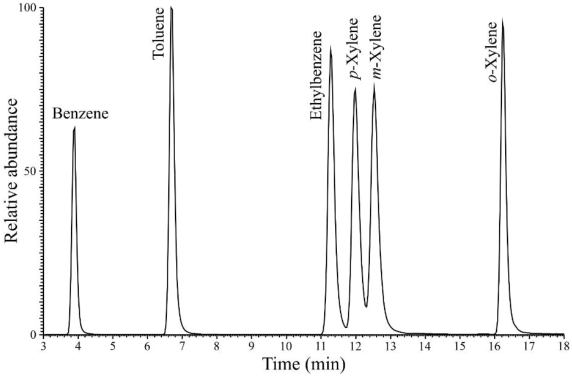

Figure 1. Chromatogram of the standard BTEX mixture in concentration 1.0 μg/mL

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It this case, headspace coupled with gas chromatograph and mass spectrometer (TriPlus HS Autosampler with Focus GC and Polaris Q MS) has been used for method development. A polar TR-WaxMS (30 m × 0.25 mm, 0.25 μm) capillary column was used for analysis. The standard mixture of BTEX was analyzed in full scan mode to determine the retention time of the compounds and for selection of proper *m/z* values for single ion monitoring (SIM) method development. The chromatogram of standard mixture is shown in Figure 1. Next step was to create the calibration curve for each compound and performed the validation and verification of the developed method. Obtained results indicated that this method is suitable for determination of the BTEX in waters and solid samples.

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Molecular docking analysis of fentanyl, methylenedioxynitazene, and selected metabolites at the µ-opioid receptor

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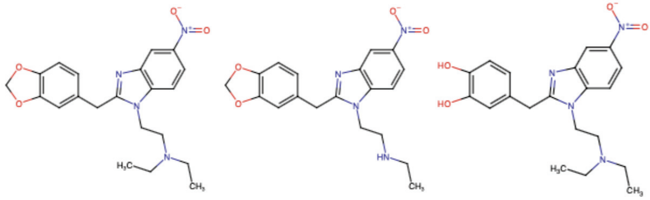
Metabolic transformations influence how synthetic opioids engage the µ-opioid receptor and may modulate their binding behavior. In this study, fentanyl was used as a reference ligand and compared with methylenedioxynitazene and five human liver microsome metabolites (M1A1, M1A2, M2A, M4A1, and M4A2), previously characterized by high-resolution mass spectrometry (Figure 1). Molecular docking and protein–ligand interaction profiling were performed to assess how biotransformations affect binding geometry and interaction patterns.



methylenedioxynitazene
Chemical Formula: $C_{21}H_{24}N_4O_4$
Molecular Weight: 396.4 g/mol

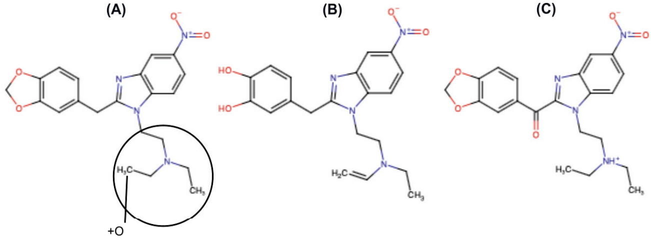
(A)

M1A1
Chemical Formula: $C_{19}H_{24}N_4O_4$
Molecular Weight: 369.2 g/mol

(B)

M1A2
Chemical Formula: $C_{20}H_{24}N_4O_4$
Molecular Weight: 385.2 g/mol

(C)



M2A
Chemical Formula: $C_{21}H_{22}N_4O_5$
Molecular Weight: 413.2 g/mol

(D)

M4A1
Chemical Formula: $C_{20}H_{22}N_4O_4$
Molecular Weight: 383.2 g/mol

(E)

M4A2
Chemical Formula: $C_{20}H_{22}N_4O_5$
Molecular Weight: 399.2 g/mol

(F)

Figure 1. Structures of methylenedioxynitazene and its five metabolite derivatives.

Fentanyl exhibits a canonical binding mode characterized by a hydrophobic core and a conserved ionic interaction between the protonated amine and an aspartate residue in transmembrane helix 3, which serves as a primary anchoring point. Methylenedioxynitazene retains this interaction framework while introducing additional aromatic and polar contacts, slightly expanding its interaction network. Fentanyl showed a docking score of −35.88 kJ/mol, while methylenedioxynitazene exhibited a slightly more favorable binding energy of −36.81 kJ/mol. Across the metabolite series, PLIP analysis reveals a stepwise modification of this anchoring

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interaction and a redistribution of contact types. N-dealkylation (M1A1) and O-dealkylation (M1A2) alter amine positioning and show docking scores of −36.80 and −35.09 kJ/mol, respectively. Hydroxylation (M2A) introduces additional hydrogen-bonding capacity, yielding a score of −35.81 kJ/mol. More extensively modified derivatives M4A1 and M4A2 display reduced dependence on the conserved aspartate interaction and instead rely on hydrophobic, aromatic, and hydrogen-bonding networks, with docking scores of −37.86 and −35.37 kJ/mol, respectively. M1A2 is highlighted as a representative intermediate, showing partial preservation of the canonical anchoring interaction, along with additional polar and aromatic contacts (Figure 2).

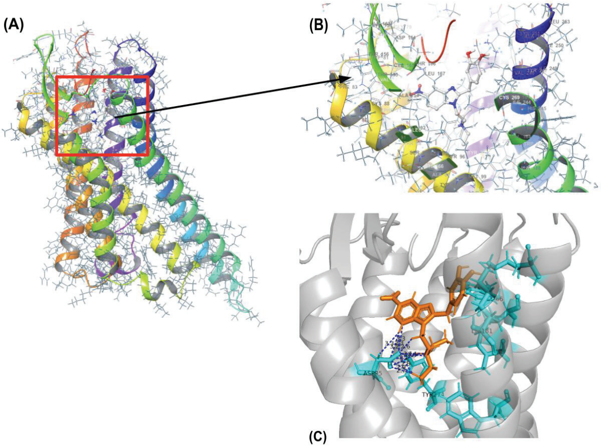

Figure 2. Binding pose of M1A2, highlighting preserved anchoring interactions and redistributed ligand–receptor contacts at the μ-opioid receptor.

Based on these results, it can be concluded that metabolic modifications shift binding from a predominantly Asp-anchored mode toward a more distributed, multi-point interaction landscape driven by hydrophobic and aromatic complementarity. The observed docking scores do not show a strictly linear trend across metabolites, indicating that structural modifications primarily affect binding mode and interaction distribution rather than binding affinity alone.

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Non-destructive ATR–FTIR and portable Raman spectroscopy for the forensic analysis of lipstick traces in combination with Principal Component Analysis

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Lipstick traces are an important type of evidence in forensic investigations. Chromatographic methods for analyzing them are often costly, time-consuming, destructive, and require trained personnel. As a result, there is growing interest in green, non-destructive techniques such as attenuated total reflectance–Fourier transform infrared spectroscopy (ATR–FTIR) and portable Raman spectroscopy [1,2]. Analysis of lipstick residues on different substrates can provide valuable chemical information relevant for forensic discrimination. ATR–FTIR spectroscopy reveals characteristic fingerprints of organic components in lipstick formulations, including waxes and oils. Stretching vibrations of aliphatic C–H groups at 2917 and 2847 cm^{-1} indicate the presence of long–chain hydrocarbons, while the band at 1730–1749 cm^{-1} (C=O stretching vibration) confirms esterified lipids and oils. The –CH_2 bending vibration at 1465 cm^{-1} further highlights the predominance of long aliphatic chains. Bands near 800 cm^{-1} suggest the presence of pigments and fillers. Portable Raman spectroscopy complements FTIR by providing enhanced sensitivity to pigments and chromophores, with characteristic bands of titanium dioxide and iron oxide pigments (518 and 639 cm^{-1}, respectively), as well as aromatic structures in dyes (1491 cm^{-1}). Raman signals 1130–1364 cm^{-1} confirm the presence of lipid components such as castor oil and beeswax, supporting FTIR findings and allowing discrimination of variations in binder composition. Principal Component Analysis (PCA) was applied to ATR–FTIR and Raman spectral data to evaluate substrate effects and similarities among lipstick traces. PCA of ATR–FTIR spectral data revealed separation of samples primarily according to lipstick type but also reveals grouping tendencies associated with specific substrate. Several samples forming separated clusters and others showing partial overlap due to similar spectral profiles. Additionally, the sample distribution indicated separation based on substrate type, distinguishing absorbent and fibrous materials from non–absorbent surfaces, reflecting the influence of lipstick-substrate interactions on spectral variance. The separation of samples is primarily driven by bands in the regions 2920–2850 cm^{-1} and 1740–1020 cm^{-1}. PCA of Raman spectral data enabled discrimination of lipsticks based on both pigment composition and the organic matrix across different formulations. The strongest contribution to sample separation originated from Raman bands in the low-wavenumber region ~600–700 cm^{-1} associated with inorganic and organic pigments, and from the 1300–1600 cm^{-1} region, corresponding to vibrational modes of aliphatic chains in waxes and oils. These results demonstrate that ATR–FTIR and Raman spectroscopy combined with PCA provide a reliable approach for forensic analysis of lipstick traces.

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Application of Advanced LC-MS Techniques for Polyphenolic Profiling

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Polyphenols are important bioactive compounds in honey and other bee products, with profiles depending on the plant species from which bees collect nectar and pollen. This makes them increasingly valuable as specific chemical markers.

In this context, analysis has been extended from honey to the corresponding plant, pollen, and nectar. To study polyphenolic compounds in buckwheat plant, pollen, nectar, and honey, the UHPLC-LTQ-Orbitrap MS/MS technique was used, combining ultra-efficient liquid chromatography with a high-resolution hybrid mass spectrometer [1]. Polyphenols transmitted through nectar and pollen become key components of honey, confirming their potential as markers for buckwheat honey. Comparative analysis revealed significant similarities between honey and nectar, even in samples with varying pollen content. This is particularly important because, in some cases [1], the polyphenolic profile provides a more reliable indicator of botanical origin than melissopalynology. Further confirmation was obtained by quantitative analysis using UHPLC-QqQ-MS/MS, a triple quadrupole system that allows precise determination of target compounds. Buckwheat honey analyzed by this method showed consistent qualitative and quantitative results, reinforcing the role of polyphenols in authenticity assessment. Analyses also demonstrated the potential to differentiate honey samples not only by botanical, but also by seasonal origin [2]. Progress was further achieved with UHPLC-QToF MS, which enables simultaneous targeted and untargeted analysis. Both known and novel markers were identified in beebread samples from diverse geographical and botanical origins [3]. Targeted analysis quantifies predefined compounds, while non-targeted analysis can reveal previously unknown polyphenols, further improving authentication of bee products.

Overall, modern chromatographic techniques enable the discovery of new markers for assessing origin and verifying the authenticity of bee products, while providing effective solutions to mislabeling and adulteration, thereby supporting quality control and enhancing consumer protection.

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Spectrofluorimetric Study of Interactions between Transport Proteins and Triphenyltin(IV) Compounds with N-Functionalized 2-Quinolones

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In this study, the interactions of (3-(4-methyl-2-oxoquinolin-1(2H)-yl)propanoato)triphenyltin(IV) (hereafter B1) and (3-(4-methyl-2-oxoquinolin-1(2H)-yl)ethanoato)triphenyltin(IV) (hereafter B2) with transport proteins (human serum albumin (HSA) and bovine serum albumin (BSA)) were investigated. The ligands used in the synthesis, 3-(4-methyl-2-oxoquinolin-1(2H)-yl)propanoic acid (HL1) and 3-(4-methyl-2-oxoquinolin-1(2H)-yl)ethanoic acid (HL2), were also included. The binding mechanism and the influence of ligand structure on the stability and nature of the resulting interactions were analyzed using a combination of spectrofluorimetric methods and *in silico* approaches. The results of spectrofluorimetric analysis and the calculated thermodynamic parameters indicate that the interactions are spontaneous and exothermic at all studied temperatures, with more favorable binding at lower temperatures. The change in Gibbs free energy values for B1 ranged from −21 to −35 kJ mol^{-1} in interaction with HSA and from −23 to −29 kJ mol^{-1} with BSA. For B2, the change in Gibbs free energy values ranged from −19 to −26.5 kJ mol^{-1} for HSA and from −14 to −23 kJ mol^{-1} for BSA. The experimental data were analyzed using the double-log Stern–Volmer equation, yielding high correlation coefficients, which indicate good linearity and reliability of the applied model. It was observed that organotin compounds form more stable complexes with BSA, which can be attributed to a greater number of available interaction sites, while the changes observed for HSA were less pronounced. The binding mechanism to HSA was further elucidated by molecular docking, which identified potential binding sites and stable ligand conformations. The ligands HL1 and HL2 were localized to the FA8 binding site, in close proximity to Trp214, consistent with the experimentally observed fluorescence quenching. The calculated binding free energy values indicate greater stability of the organotin(IV) complexes than that of the free ligands. The dominant interactions include π–cation, π–σ, and π–alkyl interactions, along with additional stabilizing contributions from hydrogen bonding and other weak intermolecular interactions. The obtained results provide valuable insight into the nature and strength of interactions between organotin(IV) compounds and transport proteins, highlighting the important role of ligand structure in the formation of stable complexes.

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The effect of food supplementation on the concentration of heavy metals in the blood of cows

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Brown algae are known to be used as a supplement to the diet of cows. They are a good source of protein and minerals and help cows strengthen their immunity. In recent studies, they are also used in studies to reduce methane production [1].

Tannins are also used as supplements in cow nutrition. They are also a good source of protein, but they also allow food to be better digested in the cow's rumen, making minerals and other food components more available to the body [2].

In this study, the concentration of several heavy metals was monitored: Cr, Ni, Co, Cd, As and Pb. We tested whether food supplementation had an effect on the increase or decrease of these metals in the blood of cows.

Metal analysis was performed on an ICP MS instrument. Blood samples from cows were taken immediately before the start of supplementation of certain cows and after 30 days of supplementation. The cows were divided into three groups: control group, tannin group and brown algae group. Cows in the tannin group received 80g of tannin daily through their diet, while the brown algae group received 100ml of a 10% algae solution daily.

After the test was performed in the control group, there was no trend of either increasing or decreasing concentrations of the tested elements. In the tannin group, Cr, Ni, Co and Cd decreased on average by about 70%, As by 13% and Pb by about 80%. In the brown algae group, Cr, Ni, Co and Cd also decreased by about 70%, As increased by 10% and Pb decreased by 65%.

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Nanocomposite Electrodes for Trace Arsenic Detection: From Method Optimization to Real Sample Analysis

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Arsenic (As) is a highly toxic metalloid widely distributed in the Earth's crust and represents a significant environmental and public health concern due to its occurrence in water, soil, and food. Chronic exposure, particularly to the more toxic As(III) species, has been associated with severe health effects, including carcinogenic, pulmonary, hepatic, and neurological disorders[1,2]. Historically, arsenic has also been recognized for its use as a poisoning agent, largely due to the difficulty of its detection. Although intentional poisoning has declined, arsenic remains relevant in the context of environmental contamination, food safety, and industrial exposure [3].

In this work, a CoAu/CNT nanocomposite electrode was investigated for the electrochemical detection of As(III) in acidic media using anodic stripping voltammetry. The key experimental parameters of the ASV procedure, including deposition potential and deposition time, were systematically optimized to achieve enhanced sensitivity and well-defined stripping signals. Under optimized conditions, the electrode exhibited a clear and sharp anodic peak corresponding to arsenic oxidation.

The applicability of the developed sensor was further evaluated in real water samples without pretreatment. The CoAu/CNT electrode demonstrated reliable performance, yielding well-defined anodic peaks for As(III) even in complex matrices. The results confirm that the proposed nanocomposite electrode is a promising platform for sensitive and practical detection of trace arsenic in aqueous environments.

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Optimization of a $Y(acac)_3$-Modified Carbon Paste Electrode for the Determination of Trace Sulfamethoxazole

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A carbon paste electrode (CPE) sensor modified with a yttrium acetylacetonate ($Y(acac)_3$) complex [1] was developed for the simple, cost-effective, and sensitive determination of sulfamethoxazole (SMX). SMX is a widely used sulfonamide antibiotic employed in human and veterinary medicine, and is frequently detected in environmental matrices such as surface water and wastewater. Its persistence and contribution to antimicrobial resistance make it an important target analyte in environmental and pharmaceutical analysis [2].

Method optimization included variation of the modifier content in the carbon paste, supporting electrolyte and pH, as well as square-wave voltammetry (SWV) parameters (pretreatment, scan rate, amplitude, and frequency). The electrochemical process was further characterized by cyclic voltammetry (CV), revealing that the oxidation of SMX is diffusion-controlled and involves the transfer of two electrons, as determined using the Laviron equation. Under optimized conditions, the sensor exhibited a linear response in the concentration range of 50–100 nM ($I = 87.68x - 3.87$, $R^2 = 0.995$). The limit of detection ($3\sigma/s$) was 5.8 nM, while the limit of quantification ($10\sigma/s$) was 17.7 nM.

The developed sensor shows potential for application in environmental monitoring and quality control of pharmaceutical formulations.

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Comprehensive HPTLC-based profiling of tree and shrub seed extracts: Integrating bioautography, chemometrics, and greenness assessment

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Rapid and efficient screening of natural bioactive compounds is key to identifying ingredients with potential cosmetic applications [1]. In this study, methanolic extracts of seeds from 17 tree and shrub species were evaluated using high-performance thin-layer chromatography (HPTLC) as a versatile single-platform approach for simultaneous chemical and biological assessment (Figure 1). HPTLC allows fast, simple, and environmentally friendly analysis of complex matrices, providing opportunities for both chemical and biological derivatization. Non-targeted chromatographic profiling, combined with chemometric analysis, offered a comprehensive evaluation without requiring identification of individual peaks [2]. On-plate bioassays enabled assessment of total phenolic content (TPC), antioxidant activity *via* DPPH assay, and antimicrobial activity against *Staphylococcus aureus* and *Pseudomonas aeruginosa*. The chemical profiles revealed patterns rich in phenolic compounds, while bioautographic assays demonstrated that the separated phytochemicals possess strong antioxidant potential and moderate antimicrobial activity against skin-related bacteria. Furthermore, principal component analysis (PCA) suggested that the samples tend to cluster according to their botanical families. In addition, greenness assessment of the analytical workflow was performed using the Analytical GREEnness (AGREE) tool, yielding a score of 0.68, which confirms the sustainability of the proposed high-throughput approach.

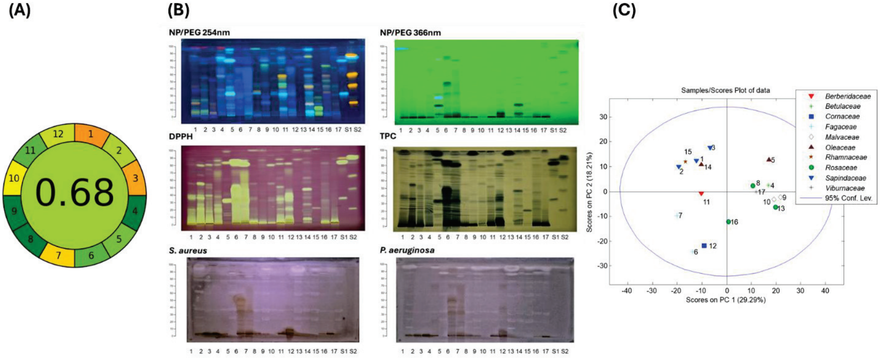

Figure 1. The integrated analytical workflow for seed extracts evaluation: (A) greenness assessment using AGREE; (B) HPTLC-based chemical and biological profiling; (C) principal component analysis.

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Laser-Induced Breakdown Spectroscopy of Bone: Elemental Analysis and Plasma Diagnostics

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Laser-induced breakdown spectroscopy (LIBS) was applied for elemental characterization and plasma diagnostics of pig shoulder bone as a model biological material. The spectra were dominated by emission lines of calcium and phosphorus, with additional contributions from Mg, Na, K, Zn, C, H, and O. Broader lines of H, O, and N were attributed to strong Stark broadening and emission from hotter plasma regions. The spectral features were consistent with the typical mineral composition of bone and confirmed the suitability of LIBS for rapid multi-elemental analysis of biological hard tissues.

Quantitative analysis using selected spectral lines enabled the estimation of limits of detection (LOD), yielding values in the range of approximately 2–20 ppm for Na, K, Mg, and Zn, and around 0.1% for carbon. Although some overestimation occurred due to self-absorption in strong resonance lines, the results demonstrate the sensitivity of LIBS for trace element detection in bone. Elemental ratios such as Mg/Ca, Ca/P, and C/P showed potential for discriminating between different bone samples. These ratios may be particularly useful in comparative studies, including forensic and biomaterials applications.

Plasma diagnostics were performed using Stark-broadened spectral lines. The electron number density was determined from the C I 247.86 nm line and independently from the Hα line, yielding values in the range of approximately $(1–5)\times10^{17}$ cm^{-3}, showing good agreement between the methods. Plasma temperature was estimated from Mg I/Mg II line intensity ratios, giving values in the range of approximately 10000–12000 K, while higher temperatures of about 17000–19000 K obtained from C II/C I ratios indicate emission from hotter plasma regions. These findings reflect the spatial and temporal inhomogeneity of laser-induced plasma.

Overall, LIBS proves to be a powerful technique for simultaneous elemental analysis and plasma diagnostics of bone, providing insight into both composition and plasma physicochemical properties.

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Spectrochemical characterization and structure optimization of a novel Ru(II) complex bearing pyren-1-carboxaldehyde hydrazone ligand

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A new ruthenium(II) half-sandwich complex, containing an η^6-*p*-cymene and (*E*)-1-(pyren-1-ylmethylidene)hydrazine ligand, was synthesized and structurally characterized using FTIR, NMR spectroscopy, elemental analysis, and DFT calculations. The structure of the complex was optimized using the B3LYP functional with the 6-311++G(d,p) basis set for H, C, N, and Cl atoms, and the LanL2DZ basis set for Ru(II) ions. The strong agreement between the experimental and theoretical FTIR spectra was confirmed. In the high-wavenumber region (>3000 cm^{-1}), the spectrum is dominated by N–H stretching vibrations, with an intense asymmetric mode at 3546 cm^{-1} and a symmetric mode at 3390 cm^{-1}, confirming the hydrazone functionality. The Ru–N stretching vibration appears at 559 cm^{-1} in the theoretical spectrum, but it is weak and unresolved experimentally. NMR spectra showed excellent agreement with theoretical simulations. In the ^{1}H NMR spectrum, isopropyl CH_3 protons appear at 1.24 ppm (1.26 calc.), while *p*-cymene CH_3 resonates at 2.23 ppm (2.65 calc.), and the isopropyl CH gives a septet at 3.00 ppm (3.03 calc.). Aromatic *p*-cymene protons occur around 5.38 ppm (5.21 calc.), whereas hydrazone ligand signals span 8.1–9.5 ppm (8.4–9.8 calc.).

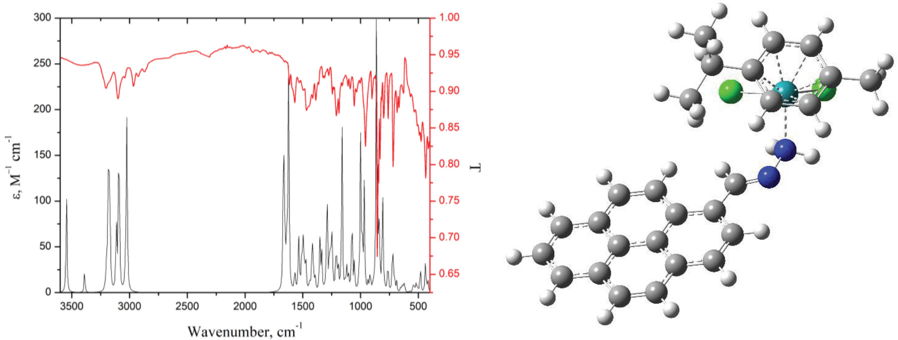

Figure 1. Experimental (red line) and theoretical (black line) FTIR spectra of [RuCl$_2$(η^6-*p*-cymene)(1-pcah-κ*N*)] (left); Optimized structure of the complex at the B3LYP/6-311++G(d,p)(H,C,N,Cl)/LanL2DZ(Ru) level of theory (right)

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An open-source pipeline for multivariate evaluation of ternary solvent system composition on HPTLC chromatograms

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Fungi of the genus *Ganoderma* have been in the zeitgeist of medicinal fungi research and natural product chemistry for more than 20 years [1], yet this model system still presents challenges in obtaining the highest product yield while preserving good quality. A lot of work has gone into learning the relationships between solvent systems used for extraction and large spectra of compounds within this genus of fungi. The High-Performance Thin Layer Chromatography is a cheap and reliable method for qualitative and quantitative studies in mushrooms using chemometrics [2]. When using HPTLC, preprocessing of chromatograms, such as spectral warping, can give variable results based on the algorithm used and its parameters [3]. Here, we present an open-source pipeline for optimizing chromatogram warping algorithms and building multivariate models using Orange Data Mining [4] software as well as R and Python programming languages. Orange Data Mining is used as a quick and visual way to inspect how changes in the dataset impact the models, while R and Python fill the void of using more specialized tools, not yet implemented in software. Using this pipeline, it is possible to pinpoint pre-processing methods in order to obtain the best supervised and unsupervised models, as well as to elucidate the most important factors and their impacts on composition within Box-Behnken design. Open-source models also allow better verifiability and reproducibility of methods across the scientific community.

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Biotin-Linked Antigen Sandwich ELISA (BLA-S-ELISA) for Sensitive Detection of TNT Derivatives

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Detection of TNT and its derivatives remains a significant challenge in environmental monitoring and forensic analysis due to their persistence and toxicity. In this study, a novel immunodetection approach based on biotin-linked-antigen-sandwich ELISA (BLA-S-ELISA) was developed and evaluated for sensitive detection of TNT-like compounds. The previously cloned and expressed anti-TNT scFv antibody was used as an immobilized component in the assay.

The method relies on the formation of a stable tri-component system consisting of a monovalent scFv antibody, a biotinylated antigen (TNP-biotin), and a streptavidin–horseradish peroxidase conjugate. The assay was performed in a 96-well plate format using immobilized antibody (2 µg/mL), followed by incubation with serial dilutions of TNP-biotin (0.5–20 ng/mL). Signal generation was achieved using ABTS substrate, with absorbance measured at 405 nm. The developed assay achieved a detection limit of 4 ng/mL (≈ 0.42 pmol, corresponding to 8.4 nM), confirming high sensitivity of the system. The strong biotin–streptavidin interaction enabled efficient signal amplification, resulting in enhanced signal stability and reduced background noise. According to current knowledge, this represents one of the first applications of a biotin-linked antigen sandwich ELISA format for detection of small model antigens.

Compared to conventional immunoassays, the BLA-S-ELISA approach provides improved sensitivity and simplified assay design by integrating antigen capture and signal amplification through a single interaction system. In addition, the method demonstrated good selectivity toward structurally related nitroaromatic compounds, supporting its applicability in complex analytical matrices.

The developed BLA-S-ELISA represents a sensitive and robust analytical platform for TNT derivative detection. Its performance and operational simplicity make it particularly suitable for forensic applications and environmental monitoring, including trace detection of explosive residues in water and soil samples.

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Green forensic approach for discrimination of white automotive paints using portable Raman and ATR-FTIR spectroscopy coupled with principal component analysis

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White automotive paints, despite appearing visually identical, possess unique chemical compositions that can serve as critical forensic evidence in criminal investigations. These samples are particularly challenging to differentiate because white formulations are typically dominated by titanium dioxide pigments with relatively low spectral diversity [1,2]. In this study, twenty-five automotive paint samples from various vehicle manufacturers including Fiat, Ford, Yugo, Volkswagen and Mercedes were analyzed using portable Raman (MIRA XTR) and ATR-FTIR spectroscopy combined with Principal component analysis (PCA) to assess their forensic discriminative potential. The greenness of both methods was assessed using AGREE software, indicating that Raman is the greener technique (0.93) compared to FTIR (0.85). The FTIR and Raman spectra of all analyzed samples showed characteristic bands corresponding to aliphatic C–H stretching (~2938 cm^{-1}), carbonyl C=O stretching (1735 cm^{-1}), and C–O/C–C vibrations in the 1050–1310 cm^{-1} region, indicating the presence of acrylic and urethane-based components. Additionally, Raman bands at ~1000–1033 cm^{-1} and 1540–1605 cm^{-1} confirm aromatic (styrene) structures, while signals at 444–446 and 609 cm^{-1} are indicative of Ti–O vibrations (rutile filler), highlighting the contribution of inorganic additives. PCA applied on FTIR spectral data indicates clustering tendencies (particularly for Fiat, Ford, and Mercedes) with greater dispersion observed for Volkswagen and Yugo samples, along with partial overlap between clusters, while PCA applied on Raman data shows that Mercedes and Fiat samples form tight clusters, whereas Yugo and Volkswagen are more dispersed. PCA results demonstrate that variability in FTIR spectra is primarily associated with binder chemistry, particularly carbonyl (1750 cm^{-1}) and C–O (1000–1300 cm^{-1}) vibrations, whereas Raman–PCA highlights the dominant role of inorganic pigments, especially TiO_2 bands at ~446 and 609 cm^{-1} and aromatic features around 1000–1033 cm^{-1}. Together, these complementary techniques provide a comprehensive chemical fingerprint of automotive paints, where FTIR emphasizes the organic matrix and Raman captures pigment-related variability, significantly enhancing discrimination power in forensic applications.

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Quantification of Cobalt and Chromium in Soda-Lime Glass by TEA CO_2 Laser-Based LIBS

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Glass is a complex silicate material whose properties strongly depend on its elemental composition, and therefore elemental analysis is of essential importance in fields such as industry, archaeology, and forensic science. Conventional analytical techniques often require complex sample preparation or exhibit limited sensitivity toward light elements, whereas LIBS offers a rapid, minimally invasive alternative with little or no sample preparation [1].

In this work, the application of Laser-Induced Breakdown Spectroscopy (LIBS) using a pulsed TEA CO_2 laser (10.6 μm) for the quantification of elements in a soda-lime glass matrix is investigated. The selection of this specific laser wavelength proved to be a critical advantage; the high absorption of the mid-infrared radiation by the silicate matrix ensures stable ablation and plasma formation with minimal mechanical damage, effectively avoiding the sample cracking or shattering typical of standard Nd:YAG lasers [2].

Quantitative analysis was performed using the calibration curve method for cobalt (Co) and chromium (Cr). These elements were chosen as analytes not only because of their strong coloring effect in glass, but also because Co and Cr are commonly present in glass as trace elements. The analyte signal was normalized to the intensity of an internal standard line, using iron emission lines as the internal standard to compensate for intensity fluctuations [3]. The obtained calibration curves exhibited high linearity and fulfilled all criteria necessary for reliable quantitative elemental analysis. The limits of detection (LOD) for several elements in the glass, including cobalt and chromium, ranged from 10 to 30 ppm, demonstrating the high sensitivity of the method for the analyzed elements. Validation was conducted by comparing the LIBS results with X-ray fluorescence spectrometry (XRF), showing excellent agreement. In addition, plasma diagnostics were performed using standard spectroscopic methods. The obtained values of temperature and electron number density were within the range characteristic of the temporal evolution of laser-induced plasma relevant for spectrochemical applications. Surface profilometry showed shallow ablation craters, with depths of only a few micrometers per laser pulse, confirming the method's low-destructive nature. Overall, the results indicate that a LIBS system based on a TEA CO_2 laser can be an efficient tool for quantitative analysis of glass materials, combining high sensitivity with minimal sample damage.

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MOCA-assisted fraction pooling after Sephadex chromatography of *Viola tricolor* extract using UV and FTIR fingerprints

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Viola tricolor represents a significant source of bioactive compounds and has been widely used in traditional medicine due to its anti-inflammatory, diuretic, and antioxidant properties. Among the most notable components are cyclotides, cyclic peptides of remarkable structural stability, known for a broad spectrum of biological activities, including antimicrobial and cytotoxic effects [1]. In addition, flavonoids, and phenolic acids are present, further contributing to the overall biological activity of this plant. The combination of these secondary metabolites makes *V. tricolor* an attractive subject for research in the pharmaceutical, cosmetic, and functional food industries. The aim of this study was the isolation and characterization of potential bioactive compounds from the methanol extract using chromatographic and spectroscopic methods, coupled with multivariate analysis to optimize the fractionation process. Fractionation was performed by Sephadex LH-20 column chromatography, after which the obtained fractions were analyzed using UV and FTIR spectroscopy. The resulting data were further processed using Multiblock Orthogonal Component Analysis (MOCA), a method that allows separation of shared and block-specific variations, enabling the identification of related fractions and their grouping according to chemical composition [2]. The results of the multivariate analysis revealed clear separation of several clusters of fractions with similar spectroscopic profiles, facilitating their efficient grouping and optimization of subsequent isolation steps. Based on the obtained models and the subsequent merging of related fractions, cyclotide-enriched fractions, a highly specific and diverse class of cyclic peptides, were obtained, while phenolic components, as a dominant class of compounds, were successfully separated into distinct fractions. Notably, several fractions achieved a high degree of purity, demonstrating the efficiency of the applied approach. Additional assessment of the purity and homogeneity of the isolated fractions was confirmed through HPLC profiling. These results indicate that the combination of conventional chromatographic techniques and advanced multivariate approaches represents an effective tool for selecting and improving the purity of plant extract fractions, providing a solid foundation for targeted isolation and further structural characterization of biologically active compounds.

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The importance of selecting appropriate analytical methods in the studies of adsorption of pharmaceuticals: example of paracetamol adsorption on biochar

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The pursuit of sustainable solutions in adsorption is accompanied by the proliferation of inappropriate methodological approaches in studies of novel adsorbents [1]. However, less attention is given to the selection of fit-for-purpose analytical methods that provide reliable estimates of adsorbate concentration, which is a prerequisite for trustworthy adsorption modeling. Prior adsorption tests, an investigation of basic performance in terms of matrix effect estimation and linearity range establishment should be performed as an initial step. Therefore, this study aimed to compare UV spectrophotometric and HPLC-UV methods for determining paracetamol concentration used to calculate the mass adsorbed on biochar by evaluating the abovementioned parameters. Biochar was prepared from the leaves of the invasive plant species *Amorpha fruticosa* L. by initial pyrolysis at 500 °C, followed by activation with $ZnCl_2$ (biochar to $ZnCl_2$ mass ratio of 3:1) at 800 °C and thorough washing. The biochar sample was mixed with ultrapure water at a solid-to-liquid ratio of 0.5 g L^{-1}, then divided into two parts: one was filtered (nylon 0.45 µm), and the other was centrifuged to obtain a clear supernatant. Paracetamol stock solution (1 mg mL^{-1}) was prepared in ultrapure water. Standard solutions in the concentration range 1-100 µg mL^{-1} were prepared to establish the linearity range of the methods. The supernatant was spiked with paracetamol at two concentrations, 2 µg mL^{-1} and 20 µg mL^{-1}, to calculate the matrix effect as the ratio of the signal in matrix-containing to matrix-free analyte solutions, multiplied by 100. The absorption maximum at 242 nm was used for analyte detection in both cases, while the HPLC method employed a simple mobile phase-15% acetonitrile and 85% water with the column thermostated at 30 °C. The HPLC method showed a significantly wider linear range (1-100 µg mL^{-1}) compared to the spectrophotometric method (1-25 µg mL^{-1}). Accordingly, HPLC methods may in some cases avoid dilution steps, which introduce additional uncertainty in concentration. Furthermore, with the ability of the HPLC system to inject higher sample volumes, the ability to detect even lower concentrations can be achieved. From the spectra in Fig. 1A, it can be seen that supernatant and filtrate from adsorbent blank have similar non-negligible signals and thus may affect the accuracy of the method. Since the most prominent signal appears below 220 nm, it is important to avoid selecting these wavelengths for analyte detection, but this may be unfeasible with some pharmaceuticals that show absorption only near 210 nm. Matrix effects of 123.77 % and 101.04 % were calculated for 2 µg mL^{-1} and 20 µg mL^{-1} paracetamol solutions, respectively, demonstrating the loss of accuracy at the lower part of the calibration range, despite the apparently insignificant signal contributable to matrix. On the other hand, chromatograms in Fig. 1B show that no peaks from the matrix appeared at the retention time of paracetamol. The results suggest a clear advantage of HPLC over spectrophotometric methods, highlighting the need to reconsider the widespread practice of using spectrophotometric methods and to establish minimum requirements for analytical methods used in adsorption studies.

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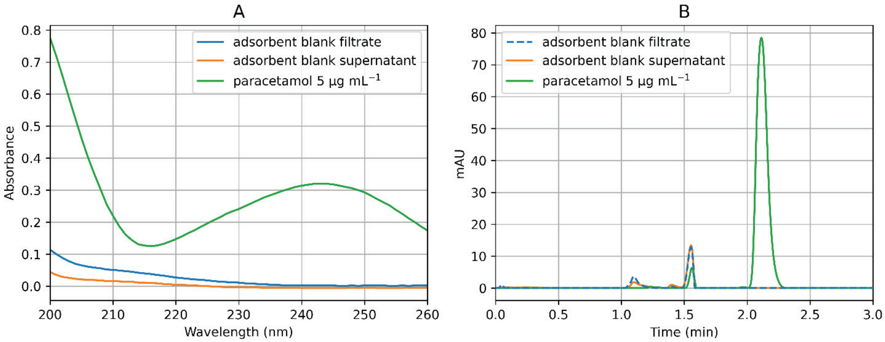

Figure 1. A) UV spectra of adsorbent blank filtrate, supernatant and paracetamol; B) chromatograms of adsorbent blank filtrate, supernatant and paracetamol.

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Determining the concentration of active ingredients in sunscreens

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Sunscreen cosmetics have become an indispensable part of daily care, especially in the era of global warming and increased ultraviolet (UV) radiation. The main purpose of these preparations is to create a barrier between the sensitive epithelium of the skin and the sun's rays, thus preventing immediate damage such as erythema (redness of the skin). Although creams are most often used during the summer months on the beach, dermatologists are increasingly emphasizing the importance of their application throughout the year.

The effectiveness of these products is measured by the sun protection factor (SPF), which indicates how long a person can stay in the sun without redness compared to unprotected skin. There are two main types of filters used in formulations: chemical and physical (mineral) filters. Chemical filters work by absorbing UV radiation and converting it into thermal energy that is released from the skin, while physical filters, such as zinc oxide (ZnO) and titanium dioxide (TiO_2), act as mirrors that physically reflect the rays from the body's surface.

In addition to protecting against skin cancer, sunscreens play a key role in preventing photoaging, a process in which UVA rays destroy collagen and elastin, leading to premature wrinkles and hyperpigmentation. However, excessive and incorrect use can lead to vitamin D deficiency, as sunlight is necessary for its synthesis in the body. Therefore, it is important to find a balance between adequate protection and moderate sun exposure. Understanding the chemical composition and how these products interact with our skin is crucial for maintaining health in modern environmental conditions [1,2].

In Serbia and the European Union, according to the Cosmetic Products Regulation, which is directly aligned with EU Regulation (EC) No. 1223/2009, the permitted levels of zinc oxide and titanium dioxide in the finished product must not exceed 25% [3].

In this study, we will examine the concentrations of these active substances in some of the popular cosmetic products that can be purchased commercially using the ICP-OES analysis. After testing 10 different sunscreen samples, we found that the concentrations of zinc oxide and titanium dioxide ranged up to 7 mg/g, which is well below the permitted values.

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Competitive Immunodetection of TNT Derivatives Using a 3.5-scFv-β-Lactamase Fusion Protein Biosensor

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The detection of nitroaromatic explosives such as TNT and its derivatives requires highly sensitive and reliable analytical methods, particularly for environmental monitoring and forensic investigations. Building upon a previously engineered bifunctional fusion protein system, this study evaluates the analytical performance of a 3.5-scFv-β-lactamase construct as a biosensor for the competitive immunodetection of TNT-like compounds.

A competitive ELISA format was employed using TNP–Tris as a model hapten. The fusion protein integrates antigen recognition and enzymatic signal generation within a single molecular entity, eliminating the need for secondary antibody-based detection. The assay was optimized to evaluate sensitivity and signal inhibition in the presence of increasing concentrations of free antigen. The lowest detectable inhibition signal was achieved at 50 ± 2 fmol (175 ± 6 pg/mL), representing the limit of detection for the system. For comparison, previously reported bivalent antibody-based systems demonstrated higher sensitivity, with detection limits as low as 25 fmol (~87 pg/mL), attributed to enhanced binding affinity and avidity effects. In contrast, the monovalent scFv-based fusion protein exhibits slightly reduced sensitivity, likely due to the absence of multivalent binding interactions. Despite this, the developed fusion protein biosensor offers significant advantages in terms of assay simplicity, reduced number of components, and shorter detection time.

The integration of recognition and signal amplification into a single construct enables a streamlined, one-step detection approach, making it particularly suitable for rapid and portable analytical applications. Such systems are especially promising for on-site screening of explosive residues in environmental water samples and contaminated forensic locations.

In conclusion, while the fusion protein-based system shows a modest decrease in sensitivity compared to traditional bivalent antibody assays, it provides a highly efficient and simplified platform for TNT derivative detection. These findings highlight the trade-off between analytical performance and operational simplicity, emphasizing the potential of fusion protein biosensors in next-generation field-deployable forensic detection systems.

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Session 7
Technological & AI-driven digital innovations

AI - buzzword or disruptive technology for both science and everyday life?

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The AI – either as a buzzword but also did become a part of our everyday life. From performing the simplest tasks, it advanced, rapidly (and even more disruptive than 3D printing), to more and more complex implementations, including scientific research.

Some of the notable scientifically important results include (but not limited to) areas like: Biology, Materials, Robotics/Automotive, and also… to Additive Manufacturing.

In Biology we can note the evolution of AlfaFold and the improvements it brought, e.g. from the first results in 2021 - <<Highly accurate protein structure prediction>> “demonstrating accuracy competitive with experimental structures in a majority of cases and greatly outperforming other methods”[1] to “Accurate structure prediction of biomolecular interactions with AlphaFold 3”[2.] but also other breakthrough ideas like RFdifussion which strives to enable generating *de novo* proteins “with specified structural and/or functional properties”[3].

In Materials design, Materials and Chemistry one can highlight the use of Large GNN to discover millions of candidate crystals, with 736 already experimentally validated; or a method – SME (substructure mask explanation) – that strives to explain the predictions by using “chemically meaningful substructures” and providing improved interpretability and alignment with SAR (structure-activity relationship) intuition[5].

In Robotics, the striving to improve the human-like manipulation for daily tasks by combining vision with tactile advanced sensors (e.g. pressure, temperature, texture, thermal conductivity, slipping) – and managing real world housekeeping tasks[6], evolving into a challenge - ManiSkill-ViTac 2025[7].

For Advanced Manufacturing and Materials, one can mention a proposed framework – and end to end infrastructure problem to address, by proposing an unified AI infrastructure spanning discovery → validation → manufacturing → deployment.[8]

Regarding the last 10 years disruptive technology – AM / 3D printing – the AI involvement couldn’t be left aside nor avoided – and involves using ML across the entire product lifecycle in AM/3D printing – proposing to replace using the existing fragmented tools with end-to-end intelligent design systems.[9] The latter approach seems to be the core idea of what other domains proposes to use with the generic name of “Agentic AI era”.

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Assessing a Machine Learning Interatomic Potential for Efficient DFT Modeling of Refractory High-Entropy Alloys

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Density functional theory (DFT) calculations on refractory high-entropy alloys (RHEAs) are computationally expensive because chemically disordered body-centred cubic (BCC) systems require large supercells and expensive structural relaxations [3]. Here we ask a practical question: can the pretrained MACE machine-learning interatomic potential (MLIP) make this workflow more efficient? We use MACE [1,2] to estimate lattice parameters and pre-relax quaternary BCC RHEAs represented by special quasi-random structures before the final DFT step. For the less explored HfZrNbMo alloy, MACE gave a useful starting lattice parameter, and the pre-relaxed structures converged to the same final DFT geometries as structures relaxed directly with DFT. The energy difference between the two routes stayed below 0.6 meV/atom, while the final lattice parameters and cell shapes were essentially identical. The MACE step also reduced the wall time of the DFT relaxation. In practice, this means pretrained MLIPs can be useful for setting up first-principles calculations on chemically disordered refractory alloys, even though the final structural optimization still has to be done at the DFT level. The benchmark is now being extended to simpler BCC metals and selected binary alloys to see how the model performs as the chemistry becomes less complex.

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Digitalization of food safety control in Serbia – Remote auditing

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Auditing and delivery of official controls in Serbia is carried out mainly in the traditional manner involving onsite visits. During the COVID-19 pandemic, control officials and food industry were obliged to develop ways to ensure continued compliance with food safety requirements that were consistent with the lockdown requirements. The aim of this research was to improve understanding of the use of remote audit/inspection in the food industry and in the delivery of official food controls.

The objectives were to establish the extent to which remote audit/inspection is already in use by food control officials and regulators and to identify barriers and limitations relating to its use in the food industry and for the delivery of official food controls.

Out of 36 answers received the majority was from the official authorities, followed by certification and control bodies, accredited laboratories, Accreditation body of Serbia, FBOs and others. More than 50 % of participants answered that they had experience in using remote auditing. Majority of the positive answers were coming from certification and control bodies (43.7 %), Accreditation body of Serbia (31.2 %) and accredited laboratories (25 %). On the other hand majority of those who answered that they did not have any experience using remote auditing were coming from official authorities (55 %), FBOs (20 %) and certification and control bodies (15 %).

Main reason for starting to use remote auditing as a method of conducting audits was COVID restrictions (75 %). However, saving resources (30 %), limited access due to geography (30 %) and preparatory work to facilitate onsite audit (30 %) were also named as reasons for starting with remote audit practice.

Main reasons for currently not using remote auditing are following:

Remote inspections/audits do not give the same level of control as traditional face to face, on site inspections (50 %), the Competent Authority has not been in favour of the process (22.2 %), Law on Official controls does not permit the use of remote inspection/audit (22.2 %), the legislation related to data protection or data access creates barriers or prohibitions (22.2 %), there are no protocols for remote inspection/audit available (22.2 %), new equipment is required which is not yet available (11.1 %), new electronic and communication systems are required (16.7 %).

The majority of the sample group who had experience of using remote audit/inspection felt that it had a role to play in food safety, especially when targeted according to risk and used as part of a hybrid model. Lack of trust is addressed as the general problem in the area of food safety control. The lack of nationally accepted guidelines was identified as a significant gap in the delivery of remote practices such as remote audit/inspection as well.

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Forecasting GIC Activity in Algeria Using Wavelet-Encoded Geomagnetic Images and Deep Learning

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Geomagnetically induced currents (GICs) pose significant risks to power grid infrastructure during space weather events. This paper presents a novel deep learning framework for GIC event detection using geomagnetic field measurements from INTERMAGNET observatories. The methodology encompasses comprehensive feature extraction including geomagnetic component rates of change (dX/dt, dY/dt, dZ/dt), magnitude variations (dB/dt), and sliding-window statistics over 5-minute and 15-minute intervals. GIC event classes are generated through transformer modeling, where a physics-informed thresholding approach identifies events based on extreme dB/dt values (top 10th percentile), simulating transformer neutral current injections proportional to geomagnetic field variations. To address severe class imbalance (original ratio: 9:1), we implement a hybrid resampling strategy combining random undersampling and Synthetic Minority Oversampling Technique (SMOTE), achieving a balanced 2:1 class distribution. The balanced time- series data is then transformed into 2D wavelet images using Morlet continuous wavelet transform, which are processed by a deep convolutional neural network (ResNet-18) for automated feature learning. Experimental results demonstrate exceptional performance, achieving 98% accuracy, 97% precision, and 100% recall for non-GIC events, with 100% precision and 97% recall for GIC events. The framework provides an effective deep learning-based early warning system, significantly enhancing space weather resilience for power grid operations**.**

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Transforming Clinical Supply Chains through Digital Innovation

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Digital innovation is transforming the clinical supply chain by enabling greater visibility, agility, and data-driven decision-making. This presentation highlights how integrating digital tools with strong process design and governance improves demand planning, inventory management, and turnaround times.

Drawing on practical experience, it outlines key enablers such as standardized data, cross-functional alignment, and scalable platforms, while addressing common pitfalls like technology-first approaches. Attendees will gain actionable insights to enhance operational performance and accelerate patient access to therapies.

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A Hybrid Digital Twin Approach for Enhancing Energy Efficiency and Reducing Emissions in Industrial Steam Systems

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Driven by the need for flexible, energy-efficient industrial processes, Digital Twin (DT) technology is becoming a cornerstone of utility system management. This study introduces a hybrid modeling framework for steam utility systems, specifically applied to an ethylene production plant. By merging first-principles thermodynamics with deep learning, the framework enables real-time monitoring and predictive optimization. The resulting system, which includes a high-pressure boiler, steam turbines for compression units, and a medium-pressure header, demonstrates a significant reduction in operational expenditure.

The hybrid framework employs a deterministic hardware model [1] based on energy balance equations to characterize boiler steam generation under variable loads. This is complemented by Long Short-Term Memory (LSTM) neural networks [2], which capture the nonlinear dynamics of the steam turbines and downstream network. Validated against real-time operational data, the digital twin demonstrates high fidelity in predicting temperatures, pressures and power outputs during both steady-state and transient phases. Simulation results show a 12.4 % reduction in natural gas consumption and a 14.1 % decrease in CO_2 emissions by precisely aligning steam production with demand. Furthermore, sensitivity analysis reveals that fuel price volatility accounts for 87 % of operational cost variance, significantly outweighing the 13 % impact of carbon taxation.

This research highlights the effectiveness of hybrid digital twin modeling as a scalable solution for improving the energy performance of industrial steam systems. By providing a robust decision-support framework, this approach enables operators to navigate real-time control, predictive maintenance and strategic planning within increasingly carbon-constrained regulatory environments.

Acknowledgements
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Visual literacy in chemistry, AI, and the *zeitgeist* of Modernism

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Visual literacy in chemistry as a subject of research, in contemporary contexts, is represented in various ways, most obviously through the evolution of visuality associated with research techniques, from spectroscopic methods during the 1950s, to AFM (Atomic Force Microscopy) and STM (Scanning Tunneling Microscopy) at the end of the century, with the introduction of NMR (Nuclear magnetic resonance) being seen as the turning point of this period, in many ways [1]. At the beginning of the 21st century, there is a mention of *visual chemistry* through the three-dimensional perception of chemical structures [2] which is different from the multidisciplinary *visual image of chemistry*, associated with the history of art and science, where visual *stereotypes about chemistry* are already introduced [3]. In the next decade, the subject of research is also *dynamic visualization* in chemistry education [4] which, in conjunction with art, points to *visual presentations of chemical space* [5]. An important parameter that has shown good theoretical continuity over time in the research of visual literacy in chemistry to this day is the visual idiom [6]. What is missing from the sequence of these thematizations is a more specific place of *chemical visuality* in the overall corpus or universe of knowledge, which is one of the more important questions in the field of developing the application of AI in searching for the topic of visual literacy in chemistry. Our research is therefore oriented towards establishing a research framework for knowledge about visual chemical literacy, bearing in mind that instruments and devices constitute only one side of the visuality of chemistry, which equally belongs to the materials that are the subject of research, i.e. their zeitgeist temporal determinations, in research related to the conservation of archaeological and artistic objects [7]. We therefore focused our methodological focus on comparative analyses of the conceptualization of visual literacy provided by AI in relation to conceptualizations from the pre-Internet era, namely Otlet's (Paul Marie Ghislain Otlet (1868 –1944)) early, analogue system (Mondaneum), the counterpart to today's Internet. This allowed us to approach the visual chemical idiom in accordance with its definition of a document as a "unit of information with its own identity [8] which allows us to add the parameter of *visual identity* to the series of visualities in chemistry. In the second part of the research, we aimed to overcome the multidisciplinary framework and introduce visual chemical identity into a pan-disciplinary framework - towards a holistic synthesis of research. This is in line with Otle's understanding of holistics, which in working with documentation implied the goals of creating opportunities for "new combinations of facts and new relationships of ideas [9], in the context of building a "moving image of the world as its memory [10]. This is a fundamental and qualitative difference from the observation made by AI at this stage of development when it defines visual literacy as "the ability to interpret and create visual media." In relation to the observed difference, in the last phase of the research, we examined the contexts that provide the zeitgeist of modernism and the zeitgeist brought to visuality by the use of AI, on a sample of 17 works by Paul Otle, considering issues of the visual identity of the document in comparison with the "interpretations" provided by AI (as a "hurricane of modernity" according to Rayward). A comparative analysis of the results led to the conclusion that the issue of visual chemical literacy should be moved from the domain of general visuality, which has a high degree of indeterminacy in hyperproduction and conceptualized in a broader conceptual framework (Fig. 1), in which it is located in the domain of intellectual exchange within the

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universe of knowledge (production, accumulation and transmission), as the natural, logical, primary place of chemical visuality.

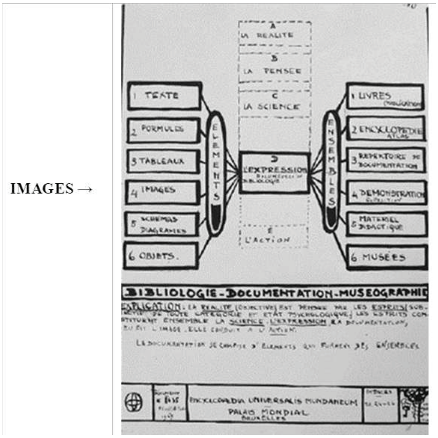

Figure 1. Original drawing by Paul Otle: “Bibliologie – documentation – museographic”, 1937, (Mundaneum Collection, Mons, Belgium), showing the position of Images among the basic elements of documentation, https://mundaneum.org/collections-et-recherches/

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AI and *chimie douce*: exploring the phenomenon of invention

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Progress in chemical research over the past decades has been significantly linked to the application of artificial intelligence, which chemistry relies on various domains, including: process optimization, improving the accuracy and speed of chemical reactions, increasing the speed of scientific discoveries, automating processes and control, as well as increasing production efficiency, while reducing operating costs, [1]. The application of artificial intelligence, at this stage of its development, has visible limitations, related to the insufficient volume of data and the insufficient presence of specific features necessary for its training in order to increase accuracy, [2]. In this regard, there is a noticeable lack of thematization of the issue of invention in chemistry, especially in the way that the French chemist and academician Jacques Livage (1938-2025), a pioneer in the field of *chimie douce* (soft chemistry), [3], posed and affirmed it five decades ago, with the phrase 'imagining materials that did not previously exist', [4]. This is a significant mode of improvement in chemistry based on an innovative approach inspired by biological mineralization processes in the synthesis of materials at low temperatures, where the invention in the design of functional materials is based on the idea of natural mineralization processes present in diatoms, [5]. The observed interconnection of the aforementioned limitations and the absence of thematization represented the leitmotif for our research on the possibility of conceptual analytical extension in the temporal and conceptual domain, through the study of *invention*, which, as Livage's syntagm shows, is most closely related to the phenomenon of imagination. The first phase of the research covered the issue of conceptual categorizations in constituting a research framework appropriate for artificial intelligence, where in the domain of time extension it was shown that the ideal basis is provided theory of objects by Alexius Meiningen (1853-1920), "Über Gegenstandstheorie", [6], which allows us to treat *'material that did not previously exist'*, in its '*imagination*' phase, as an entity (in the sense of a logical subject), whose fundamental objectivity is based on the broadest ontology of matter. This enabled us to formulate a paradigmatic environment for artificial intelligence in the next methodological step, in the so-called pre-existential phase of the material that still exists as an 'idea', i.e. an intangible value, whose determinism and limitation of purposefulness we syntagmatically articulate as *'production of material for targeted application'*. This temporal extension also enabled its conceptual counterpart: from the ancient by Parmenides of Elea (c. late 6th century BC) view of 'absent things', through the Renaissance work *Perspectiva Corporum Regularium* by the German author Wenzel Jamnitzer (1508 –1585), whose geometric bodies correspond to the shapes of diatoms, [7], to the contemporary research of the 'open imagination' of the French philosopher Gaston Bachelard (1884–1962), especially in his work *L'Eau et les Rêves: Essai sur l'imagination de la matière*, [8] which, by the thematizing water, provides an opportunity to examine possible correspondences with water as the environment in which the mineralization processes present in diatoms take place. The mode of this methodological approach, with the perspective of studying other schools of thought and conceptual structures, gave the final result: Livage's initial interdisciplinary field (connecting chemistry, biology, physics, materials science and engineering), was temporally and conceptually extended into a multidisciplinary field in which, in addition to the aforementioned sciences, philosophy and heritology also exist, thus expanding the possibilities for new research on the potential of artificial intelligence applications in inspiring to inventions in chemistry.

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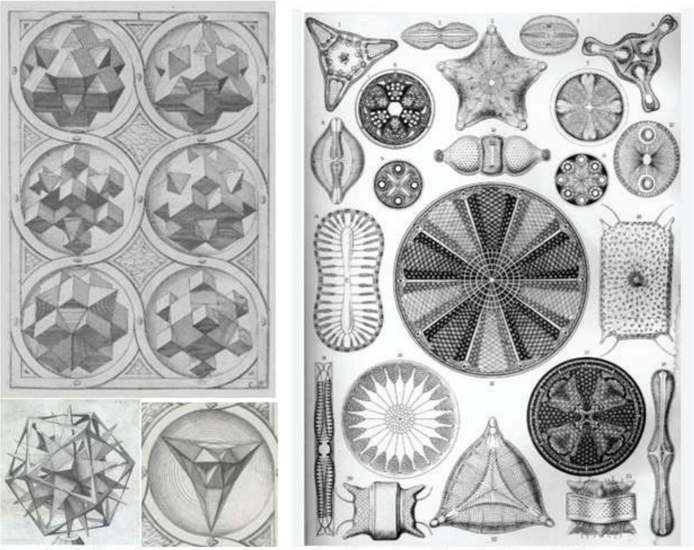

Figure 1. a) Wenzel Jamnitzer, *Perspectiva Corporum Regularium*, 1568.
[https://www.si.edu/object/perspectiva-corporum-regularium%3Achndm_1957-192-3-18]
b) Diatoms by Ernst Haeckel in 'Kunstformen der Natur' 1904.
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AI and Interpretations in Chemical Writings: A Contribution to the Research of Dmitri Ivanovich Mendeleev's Writings

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Recent studies of European scientific writings from the 18th and 19th centuries address the phenomenon of simplification in the understanding of science and technology, due to the existence of language barriers, especially in cases of indirect (or relay) translations, [1]. Also, comparative research on Dmitri Mendeleev's elementary ontology and its interpretations in English and German warn of distortions of Mendeleev's concepts (through bifurcation or distillation of the text, as well as the loss of simplicity and clarity), which is why it is believed that Mendeleev's elementary ontology was not immediately understood outside of Russia at the time of its publication. On a higher semantic level, the aforementioned research also leads to a discussion about the distinctions in defining Mendeleev's scientific profile, as a chemist-philosopher or philosopher-chemist or philosopher of chemistry, [2]. Recognizing that these distinctions have a direct impact on shaping the process of knowledge transfer about Mendeleev's chemical writings, especially when data search on this topic is performed by artificial intelligence, we opted for comparative research, with the aim of generating new suggestions in AI training. The focus of our research was two texts. The first is Mendeleev's original preface to the seventh edition of his work *Основы химии*, [3], published in St. Petersburg in 1903, printed in the Russian language of the pre-revolutionary orthography, (Fig. 1), i.e. before the Russian language reform carried out in 1918. The second text is the English translation, made from the original by George Kamensky, in the edition of the same Mendeleev work (Osnovy khimii) published in New York in 1903, [4], under the title The Principles of Chemistry. Kamensky himself writes about this translation:" There are special difficulties in rendering the Russian language into good English, and we are conscious that these have not been entirely overcome." Our research, however, is not linguistic in nature, but takes into account on the opinion of the eminent American linguist Noam Chomsky, that "AI programs cannot explain the rules of English syntax", [5]. Therefore, in the first phase of the work, we compared the Russian original with the English translation exclusively in the context of searching for topos that, in the domain of thematization of subject distinctions, could be obstacles to the precision of artificial intelligence. In the second part of the research, we addressed the possibilities of logical abductions, [6] which would, when searching chemical repositories, lead AI into the trap of syllogismus imperfectus (incomplete syllogism). Due to the insufficient number of studies dedicated to this topic, in the third phase of the research we formulated the necessary broader research framework, by examining possible analogies (in connecting logical, semantic, technological, historical and etymological aspects), such as those modeled in Cesare Brandi's work, *La Teoria del restauro*, [7]. This led to the possibility of determining the representation of subject distinctions (chemist-philosopher, philosopher-chemist or philosopher of chemistry) in defining Mendeleev's scientific profile, which, according to our research results on the selected research sample, is manifested in all three domains. It turned out that the translation into English, in accordance with the translator's own statement, gave a blurred picture, while the required distinctions are clearly visible in the original Russian text: Mendeleev is a philosopher-chemist, who derives his postulates from the philosophy of nature, presenting personal views on the world of chemical elements, taking into account the views of other researchers, with an awareness of the influences of the subjectivity of authorship, the influence of time and place. He is

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also a chemist-philosopher, in his observations on the chemical worldview, which is different from chemical contemplation, as the same term is translated into English. Mendeleev is also a philosopher of chemistry, when he speaks about the philosophical principles of science and the harmony of scientific knowledge. With this in mind, we summarize the results of our research in the conclusion that Mendeleev's chemical writings should be reinterpreted comparatively in each of the above-mentioned contexts of the relationship between chemistry and philosophy, in accordance with new interpretations of European scientific writings from the 18th and 19th centuries. We also see the benefit of the results of our research, in terms of deepening the understanding of the issue of interpreting Mendeleev's writings in a way that will advance the use of artificial intelligence, in the demonstrated potential for forming a specific type of chemical repository of interpretations, based on revised translations of Mendeleev's writings.

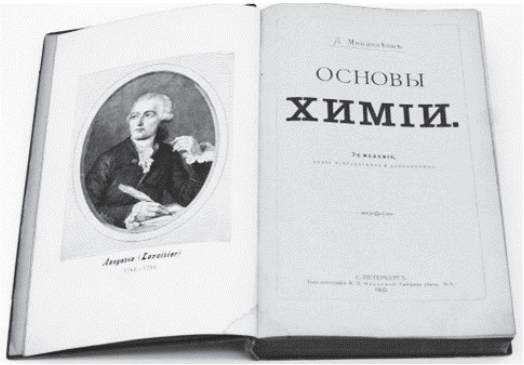

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Figure 1. Менделѣевъ, Д., *Основы химиiи, 1903.*

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Machine Learning-Based Predictive Modeling of Chemical Dosing in Drinking Water Treatment: Comparison with Operational Practice

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Aim

The integration of artificial intelligence (AI), particularly machine learning (ML) models, into chemical dosing in drinking water treatment plants (DWTPs) offers a practical tool to address the limitations of conventional empirical approaches [1]. Data-driven models based on historical plant laboratory data have been recognized as effective tools for chemical dosage prediction under dynamic water conditions [2]. This study aims to develop and compare machine learning models for predicting operational doses of aluminum-sulfate $Al_2(SO_4)_3$ (hereafter referred to as Al-S) and polyacrylamide (PAA) based on influent water quality, evaluating the capacity of data-driven models to replicate full-scale chemical dosing patterns.

Methods

A four-year dataset (2021 – 2024) from DWTP Makiš was preprocessed and modeled using the Python programming environment. Stratified seasonal sampling is used to allocate 10% of the observations [3]. Two predictive approaches were evaluated: Multiple Linear Regression (MLR), representing a conventional statistical method, and the Random Forest (RF) algorithm, an ensemble machine learning technique capable of modeling complex non-linear relationships between variables. Model performance was assessed using the coefficient of determination (R^2), root mean square error (RMSE), and mean absolute error (MAE) [4].

Results

As illustrated in Figure 1, the RF model more closely follows the applied dose trajectory across the test set compared to MLR for both chemicals, capturing dosing trends under varying conditions.

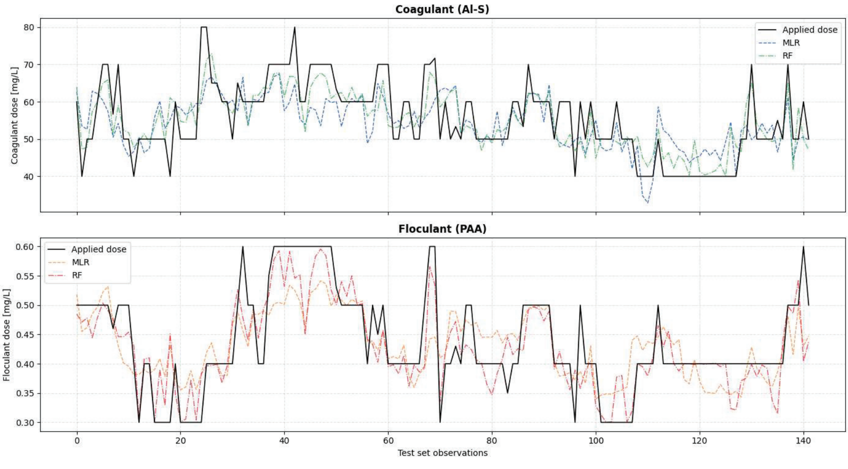

Figure 1. Predicted versus applied doses for Al-S and PAA across the stratified seasonal test set.

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The RF model achieved $R^2 = 0.631$ and MAE = 4.66 mg/L for Al-S, and $R^2 = 0.674$ and MAE = 0.034 mg/L for PAA, outperforming MLR by approximately 0.22 and 0.18 in R^2, respectively. The evaluation metrics confirm that operational dosing reflects nonlinear process dynamics that are not adequately captured by linear model. These results are consistent with comparable RF-based approaches reported in literature [5], while the higher R^2 reported by [3] likely results from the inclusion of effluent turbidity as an additional model input.

The continuous nature of regression outputs limits RF model ability to resolve discrete dose transitions suggests that classification-based approaches represent a promising direction for future work. Furthermore, the temporal structure of operational dosing decisions motivates the exploration of Long Short-Term Memory (LSTM) networks, to capture dynamic process behavior and support predictive process control.

Acknowledgements

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DM1 Guardian: A Mobile Application for Supporting Diabetes Self-Management

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In modern society, managing chronic diseases such as diabetes presents a significant challenge due to the fast-paced lifestyle and the need for continuous monitoring. Type 1 diabetes, in particular, requires lifelong insulin therapy and daily tracking of blood glucose levels, making self-management complex and demanding.

The aim of this study is to develop a mobile application for Android devices that facilitates efficient monitoring and management of insulin therapy. The application is designed to provide users with a simple, organized, and reliable way to record insulin intake, track daily parameters, and support therapy-related decision-making.

The methodology includes the design and implementation of the application using Android Studio and the Kotlin programming language. Firebase services were integrated to enable secure user authentication and real-time data storage. The application consists of several functional modules, including carbohydrate intake calculation using an external API, insulin dose calculation based on user-specific parameters, BMI calculation, and a calendar-based system for tracking daily therapy data.

The results indicate that the developed application provides a practical and effective solution for diabetes self-management. The implemented algorithm for insulin dose calculation contributes to more accurate dosing, thereby helping to reduce the risk of hypoglycemia and hyperglycemia. By guiding users in determining appropriate insulin doses based on carbohydrate intake and current glycemic levels, the system enhances decision-making and promotes better glycemic control. Additionally, the application improves the organization and consistency of daily therapy by centralizing all relevant data in one place.

In conclusion, the application represents a cost-effective alternative to advanced medical devices such as insulin pumps, particularly for users with limited access to such technologies. It contributes to improved self-control, better disease management, and enhanced quality of life. Future improvements include advanced graphical visualization of health data, integration with continuous glucose monitoring systems, and the ability to share results with healthcare professionals, enabling more personalized and data-driven medical support.

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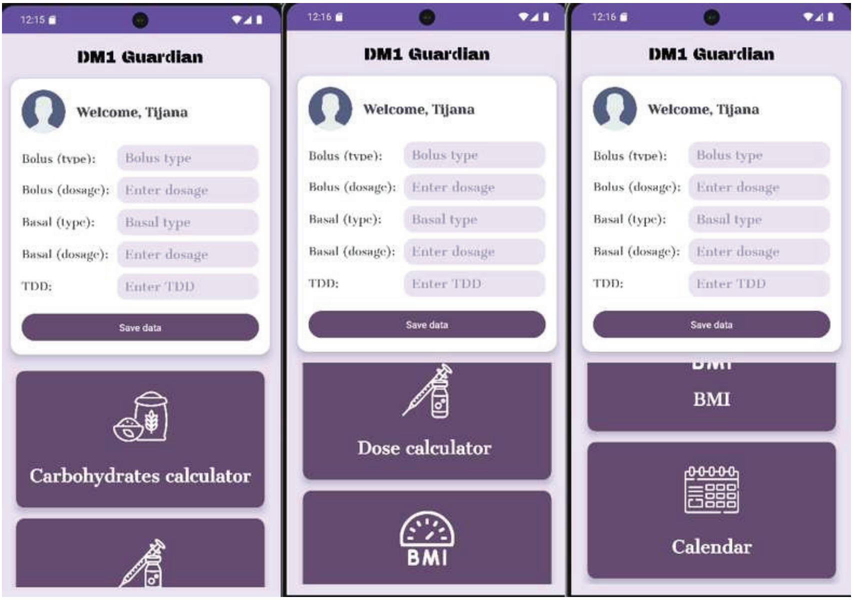

Figure 1. Main Page

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Session 8

Chemical Safety, Regulation, Standards& Knowledge Transfer

From Poison Control to Chemical Safety: Historical Legal Frameworks and Knowledge

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The development of legal regulations governing medicines and poisonous substances in Serbia from the mid-19th to the early 20th century represents an early framework for chemical safety and control of hazardous substances, illustrating an early example of knowledge transfer from chemical science into regulatory practice. Although ensuring the availability of poisons for agricultural, industrial, and commercial purposes was necessary, the primary challenge for policymakers lay in defining which substances should be classified as poisonous and in organizing their regulated distribution through pharmacies and retail shops. This study analyzes key legislative acts and their role in incorporating contemporary chemical knowledge into legal and regulatory frameworks. The first significant step was taken in 1850 with the enactment of the Regulations on the Possession and Sale of Poisons and Poisonous Substances, while amendments in 1852 strengthened oversight by district authorities and the administration of Belgrade. The Law for Pharmacies and Pharmacists on Keeping and Selling Medicines and Poisons, enacted in 1865, introduced integrated measures for quality control and chemical safety. The 1881 Sanitary Law, along with accompanying regulations, further codified categories of medicinal and poisonous substances, as well as the conditions for their import and distribution. The introduction of lists of permitted and prohibited substances during 1881–1882 marked a major step in formalizing this knowledge transfer into a structured regulatory framework, while standards for storage, packaging, labeling, and the qualifications of individuals handling poisons gradually strengthened over the following decades. In the early 20th century, the enactment of laws regulating the trade and control of narcotic drugs and poisons in 1929 and 1930, and particularly the 1932 Regulation on the Trade and Control of Poisons, completed the consolidation of these regulatory measures, creating a comprehensive system that balanced public access to useful substances with the protection of public health. This historical evolution demonstrates how scientific knowledge in chemistry was systematically transferred into legal norms and practical regulatory measures, reconciling industrial, agricultural, and commercial needs with public health protection.

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Manipulation of Health Claims in Magnesium Bisglycinate Supplements: Market Analysis and Regulatory Compliance in Serbia

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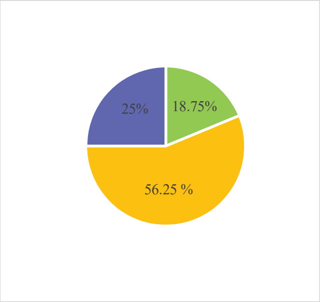
Manipulation of health claims in the field of dietary supplements represents a significant public health and regulatory challenge. In addition to product labeling, promotional content available on online platforms plays an important role in shaping consumer perception, often further extending and intensifying health-related claims. The aim of this study was to assess the compliance of health claims used in the marketing of magnesium bisglycinate-based supplements with the applicable regulations in the Republic of Serbia, as well as to examine the role of online platforms in potential consumer manipulation. The analysis was conducted in accordance with the Rulebook on Nutrition and Health Claims on Food Declarations, as well as with the authorized health claims defined by the European Food Safety Authority.

The methodology included a qualitative analysis of 16 dietary supplements available on the Serbian market, along with a review of promotional content on official and unofficial websites. Identified claims were classified as compliant, partially compliant, or non-compliant, based on regulatory criteria.



Fifure 1. Distribution of Compliant, Partially Compliant, and Non-compliant Health Claims (%)

The results showed that only 18.75% of the analyzed products used exclusively authorized health claims, referring to the contribution to normal nervous system function, muscle function, and reduction of fatigue. The majority of products (56.25%) contained claims within a regulatory “grey zone”, such as those related to stress reduction, relaxation, and mood improvement, which are not explicitly authorized. The remaining 25% of products included clearly non-compliant claims implying the treatment or prevention of diseases, including anxiety, insomnia, and other health conditions. The most prominent example is represented by products of the one brand, which include indications such as treatment of anxiety, depression, and insomnia, as well as prevention and management of chronic diseases such as hypertension and diabetes.

Additionally, the analysis of online content revealed that digital platforms often use even more pronounced manipulative claims, including statements related to sleep improvement, anxiety reduction, and superior absorption, despite the lack of sufficient scientific evidence or regulatory approval.

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It can be concluded that manipulation of health claims is not limited to product labeling but is further amplified through online marketing, significantly increasing the risk of consumer misinformation. These findings highlight the need for stricter control of digital marketing of dietary supplements and more consistent enforcement of regulatory frameworks in order to protect public health.

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Bioactive Peptides in the “Grey Zone”: The Impact of Digital Platforms, Safety Risks, and Regulatory Challenges

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Bioactive peptides represent a rapidly evolving class of molecules with significant potential in modern medicine, including applications in diabetes, oncology, metabolic disorders, and targeted therapies. Recent research indicates that peptides exhibit high specificity toward biological targets and a favorable safety profile under controlled conditions; however, they are simultaneously limited by issues related to stability, bioavailability, and the need for parenteral administration [1,2].

The most relevant therapeutic peptides include insulin and its analogues, as well as GLP-1 receptor agonists, which are approved for the treatment of type 2 diabetes and obesity. However, their increasing off-label use, particularly for aesthetic weight loss, further blurs the boundary between evidence-based therapy and wellness-oriented practices. In addition to approved drugs, peptides such as BPC-157, TB-500, CJC-1295, and Ipamorelin are frequently used within the so-called “grey zone,” despite lacking adequate clinical validation and regulatory approval [3,4].

Table 1. Some FDA-Approved Peptides With Frequent Off-Label Use

Peptide	Off-Label Use	FDA Indication
GLP-1 peptides (Semaglutide, Tirzepatide)	Addiction, migraine, autoimmune diseases, polycystic ovary syndrome, and others	Diabetes and obesity
Sermorelin	Increase in muscle mass, decrease in fat mass, wound healing, anti-aging	Children with growth hormone deficiency
Tesamorelin	Increase in muscle mass, reduction of abdominal fat, cognitive health	HIV lipodystrophy
Thymosin Alpha-1 (Zadaxin)	Immune system support	Chronic hepatitis B and cancer chemotherapy

Advances in peptide design and delivery systems have significantly expanded their clinical applications. Peptides accounted for more than 11% of newly approved pharmaceutical agents between 2016 and 2024, highlighting their growing importance in drug development [5]. Furthermore, the global peptide therapeutics market is estimated at approximately USD 140 billion, with projections reaching nearly USD 300 billion by 2033, reflecting an annual growth rate of approximately 5–10% [6]. Despite these advances, safety concerns remain significant. One of the key challenges is immunogenicity, where peptides or their impurities may trigger unwanted immune responses, including the formation of anti-drug antibodies [5]. This emphasizes the critical importance of strict quality control and regulatory oversight.

In parallel with scientific progress, an informal peptide market has emerged within the “grey zone,” where these compounds are distributed via online platforms and social media, often labeled as “research chemicals.” Such products bypass regulatory pathways and quality standards, increasing the risk of impurities, incorrect dosing, and unknown long-term effects [4]. A particularly concerning phenomenon is the role of digital platforms and influencers in promoting peptide use. Emerging trends indicate that individuals, influenced by online communities, self-administer injectable peptides and share dosing protocols, effectively creating a decentralized and uncontrolled system of experimentation. Although there is no evidence of deliberately organized clinical trials, this practice

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functionally resembles early-phase clinical studies without ethical oversight, standardization, or risk control [7].

Furthermore, recent literature highlights that most peptides used in the wellness context are not approved for specific indications and lack robust clinical evidence, creating a significant gap between regulated medicine and market-driven practices [6].

In conclusion, while peptides represent one of the most promising areas of pharmaceutical science, their use within the "grey zone" raises important concerns regarding safety, ethics, and regulation. The growing influence of digital platforms may contribute to the emergence of a parallel, uncontrolled system of "experimental medicine," warranting increased attention from both scientific and regulatory communities.

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In vitro models for assessing human exposure to toxic elements from the environment: from lab to application

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In vitro models of the gastrointestinal tract and lungs are increasingly used to assess oral and inhalation exposure to environmental pollutants. In our research, these models were applied as tools for environmental and food safety assessment, with relevance for agricultural management and risk-based decision-making. Agricultural soils from conventional and organic vineyards, grapevine leaves and grapes, as well as soils from the surroundings of agricultural parcels, semi-urban and rural areas, and illegal waste dump sites were investigated to reflect realistic pollution scenarios relevant for primary food production and human safety.

Toxic element (TE) concentrations were determined in pseudo-total digests and in gastric and lung extracts using ICP-OES and ICP-MS. Gastrointestinal bioaccessibility was assessed using the Unified BARGE Method (UBM), while inhalation bioaccessibility was evaluated using simulated lung fluid (SLF) models representing both healthy and inflammatory conditions. The obtained bioaccessible concentrations were further integrated into human health risk assessment for oral and inhalation exposure pathways, enabling more realistic exposure estimates compared to conventional approaches based solely on total concentrations.

Oral ingestion was identified as the dominant exposure pathway for agricultural workers and the rural population (Milićević et al., 2021). Although pseudo-total concentrations indicated Ni, Cr, Co, and Mn as major contributors to the risk, bioaccessibility-based assessment showed no significant non-carcinogenic risk ($THQ < 1$), demonstrating the potential of this approach to prevent overestimation of risk in regulatory and agricultural practice. However, elevated bioaccessibility at specific locations, such as illegal landfills in agricultural areas, and moderately increased carcinogenic risk (Mitić et al., 2025) indicated priority zones for remediation and land-use management. The main contributors to risk for grape consumers were Ni, Cr, Mo, and B, although their bioaccessibility was negligible, suggesting limited transfer into the food chain under the studied conditions.

Overall, the *in vitro* gastrointestinal and pulmonary models represent cost-effective and ethically acceptable tools that can support evidence-based agricultural management, targeted soil remediation strategies, monitoring of the pollution, and the development of risk-informed policies aimed at reducing human exposure and ensuring food safety.

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A Didactic Approach to Hydrocarbon Teaching through Industrial, Environmental, and Legal Perspectives

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This paper argues for a broader and more contextualized approach to hydrocarbon teaching in Serbian chemistry curricula through the integration of industrial, environmental, and legal perspectives. In current school practice, hydrocarbons are taught predominantly through their classification, structure, properties, and reactions, while their technological relevance and broader social implications often remain insufficiently emphasized. Such a reduction of the topic to formal chemical description limits students' ability to connect curricular knowledge with real industrial processes and with contemporary environmental issues.

The proposed didactic approach links the teaching of hydrocarbons with the industrial processing of crude oil, including refining, fractional distillation, and cracking, in order to present these compounds not only as a class of organic substances, but also as materials of considerable industrial, economic, and environmental significance. Within this framework, petroleum pollution is interpreted not as an abstract ecological topic, but as a consequence of specific chemical and technological processes associated with oil extraction, processing, storage, transport, and the use of petroleum-derived products. By relating hydrocarbon chemistry to concrete examples of water, soil, and air contamination, as well as to hazardous waste generation, teaching may become more meaningful, socially relevant, and more effective in fostering students' scientific understanding of environmental problems [1].

The paper further suggests that age-appropriate legal awareness should form part of this educational framework [2]. The intention is not to introduce students to technical legal discourse, but to familiarize them with fundamental principles of environmental responsibility, including pollution prevention, safe waste management, and the regulatory oversight of industrial facilities associated with significant environmental risk. Such an approach may contribute not only to chemical literacy, but also to the development of critical thinking, environmental responsibility, and a broader understanding of the social role of chemistry education. More broadly, it may help students recognize chemistry as a discipline inseparable from technological development, public health, environmental protection, and responsible civic decision-making. In this sense, the educational value of this approach extends beyond the classroom: it supports the formation of scientifically informed and socially responsible future citizens capable of understanding the chemical dimensions of major environmental challenges and of participating more thoughtfully in the sustainable development of society.

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Arsenic in Rice: Occurrence, Analytical Determination and Food Safety Implications

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Arsenic is a toxic element of major public health relevance, and rice is recognized as one of the most important dietary sources of exposure because flooded cultivation increases arsenic mobility and plant uptake [1-3]. Owing to the global importance of rice as a staple food, reliable determination of arsenic content and species remains a priority in food safety assessment [4,5].

The aim of this paper was to review current literature on the occurrence of arsenic in rice, the analytical methods used for its determination, and the implications for human exposure. A narrative review was performed using peer-reviewed publications retrieved from PubMed, Scopus, Web of Science, and Google Scholar. The search included the terms arsenic, rice, inorganic arsenic, arsenic speciation, ICP-MS, AAS, food safety, dietary exposure, and regulatory limits, with emphasis on studies describing validated analytical approaches [4,5].

The reviewed evidence indicates that arsenic levels in rice vary according to geographical origin, irrigation water quality, soil characteristics, and rice genotype [1-3]. Inorganic arsenic is the toxicologically most relevant fraction, which makes speciation analysis essential for accurate risk assessment [4,5]. Among available techniques, ICP-MS, especially when combined with chromatographic separation, is considered the most sensitive approach for arsenic speciation, while AAS remains useful for routine quantification. Standardized sampling, quality control, and harmonized reporting are necessary for reliable and comparable results.

In conclusion, arsenic contamination in rice remains an important issue in environmental chemistry and food safety. Continuous monitoring and robust analytical protocols are needed to support risk assessment, regulatory decision-making, and strategies aimed at reducing human exposure [2,5].

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Hydrogen Beyond Energy: Functional Materials and Detection Strategies for CBRN-Relevant Hydrogen Hazard Management

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The rapid expansion of hydrogen technologies as a cornerstone of the global energy transition introduces not only opportunities for decarbonization but also emerging safety and security challenges. Due to its low ignition energy, wide flammability range (4–75 vol%), high diffusivity, and lack of sensory detectability, hydrogen represents a high-consequence hazard across production, storage, transport, and end-use systems. While these risks have been extensively analyzed within industrial safety and process engineering frameworks, hydrogen has not yet been systematically examined through the lens of **Chemical, Biological, Radiological, and Nuclear (CBRN) risk and preparedness**, where early detection, rapid decision-making, and resilience to both accidental and intentional events are critical.

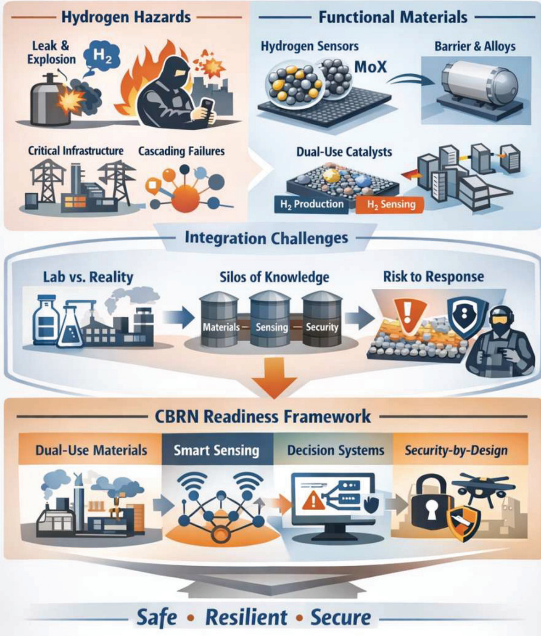

Figure 1. Hydrogen safety and hazard management overview

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Our review critically examines the current state of knowledge at the intersection of hydrogen technologies, functional materials, and hazard detection, with a particular focus on their relevance to CBRN-oriented scenarios. We analyze advanced hydrogen-responsive materials-including metal oxides, noble metal-based systems, and carbon-derived nanostructures-highlighting their sensing mechanisms, performance characteristics, and limitations under realistic environmental conditions such as humidity, mixed gas atmospheres, and long-term operational drift [1][2][3]. Furthermore, we identify a significant gap between material-level performance metrics (e.g., sensitivity, response time) and system-level requirements for reliable hazard detection and decision support in complex, real-world environments [4,5].

A key contribution of this work is the introduction of a **Hydrogen-CBRN readiness framework**, which links material properties to sensor functionality, system integration, and operational response. Within this framework, we emphasize the emerging concept of **dual-use materials**, where electrocatalysts and structural materials developed for hydrogen production and storage may simultaneously serve as sensing or self-monitoring components. The review also addresses underexplored aspects of hydrogen risk, including infrastructure vulnerability, cascading failures, and potential misuse scenarios, which are insufficiently represented in current hydrogen safety literature [6].

Finally, we propose research directions aimed at bridging existing gaps, including the development of standardized testing protocols under field-relevant conditions, integration of sensor networks and data-driven decision systems, and the adoption of **security-by-design principles** in hydrogen infrastructure. By connecting materials science, sensing technologies, and CBRN risk frameworks, this work provides a novel perspective for enabling the safe, resilient, and secure deployment of hydrogen systems in future energy landscapes.

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Zeolite systems for food safety, control, and monitoring of contaminants

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Zeolites are microporous crystalline aluminosilicates with well-defined ion-exchange, adsorption, and size-selective properties. Their tunable framework composition (Si/Al ratio, exchangeable cations, and surface functionalization) enables targeted interactions with heavy metals, mycotoxins, ammonium ions, and volatile organic compounds through ion exchange, selective adsorption, and molecular sieving. This study critically examines the role of zeolites as multifunctional materials for the control and indirect monitoring of chemical contaminants in food systems. It synthesizes existing knowledge on structure–property relationships and identifies key mechanisms governing contaminant binding under processing and storage conditions relevant to food systems. Design principles for tailoring zeolite performance to specific contamination scenarios are outlined. Particular attention is given to the relationship between pore structure and adsorption selectivity, which governs performance under complex matrix conditions. In food matrices, zeolites reduce the bioavailability of mycotoxins and toxic forms of metals. In intelligent packaging, functionalized zeolites remove moisture, ethylene, and volatile compounds, thereby slowing degradation kinetics and extending shelf life during storage and distribution. Their application extends across the food chain, including animal feed, contributing to a reduction in the overall chemical burden of the system. These effects highlight the importance of material stability and regeneration potential under repeated exposure conditions.
In addition, zeolite-based materials are applied for the immobilization of Pb^{2+}, Cd^{2+}, Hg^{2+}, and radionuclides in aqueous and industrial streams, which may be associated with food and environmental systems. This study establishes a unified framework for the application of zeolites in simultaneous contaminant control and semi-quantitative monitoring of chemical load in order to enhance food safety and related industrial systems. The proposed approach supports the rational design of integrated multifunctional systems for chemical safety in food and related industrial environments.

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Standardization of Safe and Sustainable Chemical Applications

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Standardization represents a fundamental instrument for ensuring safety, quality, and environmental protection in contemporary chemical sciences and industrial practice. Technical standards provide clearly defined and structured methodologies for testing chemical substances, evaluating product performance, and maintaining controlled laboratory conditions. In addition to their technical function, standards contribute to the implementation of green chemistry principles by improving resource efficiency and reducing the use of hazardous substances at the source.

As the national standardization body, the Institute for Standardization of Serbia actively participates in the adoption and implementation of European and international standards. This process enables the establishment of harmonized technical requirements that support laboratory activities, industrial production, and compliance with the applicable regulatory framework.

The role of standardization is particularly significant in the field of laboratory safety, through the definition of performance requirements for laboratory equipment such as fume cupboards and biosafety cabinets, thereby ensuring controlled handling of hazardous chemical and biological agents. Furthermore, standardized laboratory equipment and measurement procedures ensure the accuracy, reproducibility, and reliability of analytical results, which is essential for reducing experimental errors and optimizing the use of chemicals.

In the context of sustainability in chemistry, standards provide a basis for the development and evaluation of environmentally acceptable products, including biofuels, detergents, and cosmetic formulations. Particular importance is given to requirements related to biodegradability and composition control of surfactants and detergents, thereby leading to the reduction of environmental impact. In the field of cosmetics, standardization ensures product safety, microbiological quality, and promotes the use of natural and sustainable ingredients.

Standardization also contributes to the enhancement of chemical safety through clearly defined requirements for substance characterization, reagent quality and clear identification and labeling of hazards and risks. By enabling harmonized approaches across laboratories, industry, and regulatory systems, standardization facilitates knowledge transfer, promotes innovation, and supports the development of safer and more sustainable chemical applications.

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