Drava ChemiCon

Connecting Chemistry Along the River

BOOK OF ABSTRACTS

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Drava Chemistry Conference – Connecting Chemistry Along the River

Drava ChemiCon

International scientific and professional conference organized by the Croatian Chemical Society - Osijek and Varaždin Branches

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WELCOME WORD

Dear colleagues,

Welcome to **Drava ChemiCon 2026 – Connecting Chemistry Along the River**.

It is our great pleasure to welcome you to the first Drava ChemiCon, jointly organized by the Osijek and Varaždin Branches of the Croatian Chemical Society. This inaugural conference brings together participants from nine countries, providing an international platform for researchers, teachers, students, and industry representatives to exchange ideas, present recent scientific achievements, and establish new collaborations.

Alongside a diverse scientific programme, Drava ChemiCon also features a dedicated chemistry education section and a panel discussion on research funding opportunities, further strengthening the connection between research, education, and practice.

This Book of Abstracts presents the contributions that will be shared during the conference and reflects the diversity and quality of the scientific and educational activities brought together at this inaugural meeting.

We hope you will enjoy an inspiring scientific programme, fruitful discussions, and the opportunity to experience the hospitality of Osijek and the unique atmosphere of the Drava region.

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PLENARY LECTURES

STIMULI-RESPONSIVE POLYMERS FOR SELF-ASSEMBLED THERANOSTICS AND SENSORS

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Self-assembly of macromolecules into polymer micelles, polymersomes, nanogels and microparticles provides a powerful route to biomedical materials whose properties and functions are given not only by their covalent structure, but also by intermolecular reversible noncovalent interactions. When hydrophobicity, charge, coordination state or redox state of a polymer segment changes in response to pH, temperature, reactive oxygen species (ROS), light or ions, the supramolecular equilibrium can be shifted to trigger assembly, disassembly, cargo release or sensing on demand.

Being inspired by biological systems that combine stability with rapid response to local stimuli, this plenary lecture will discuss several classes of stimuli-responsive polymer systems. Microfluidically prepared pH-responsive polymersomes and morphology-changing microparticles will be presented as examples of controlled nanostructuring for anticancer delivery and antibacterial applications. The ferrocene-containing copolymers will be highlighted as redox/photo-responsive platforms for ^{19}F MRI imaging, ROS-responsive drug delivery systems and non-conventional phototherapy.[1-3]

We will also focus on polymer-modified layers and nonbiofouling coatings for real-time in situ electrochemical monitoring of local inflammation and infection around implants, with H^+ (pH), ROS and free calcium as main analytes.[4] Emerging concepts from hypoxia-targeted, self-assembled polymer radiosensitizers will also be introduced, where perfluorinated domains, nitroaromatic targeting motifs and ROS-generating cargo are combined to address the low radiosensitivity of hypoxic tumors.

ACKNOWLEDGEMENTS Financial support from MEYS CR (grants # LUAUS24272) and the project New Technologies for Translational Research in Pharmaceutical Sciences /NETPHARM, project ID CZ.02.01.01/00/22_008/0004607, co-funded by the European Union, is gratefully acknowledged. Support from the Czech Health Research Council (grant # NW24-03-00387) is also gratefully acknowledged.

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WATER–IONIC LIQUID SOLUTIONS AS ECO-FRIENDLY HYDRAULIC FLUIDS: FROM IDEA, THROUGH LABORATORY, TO APPLICATION

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Hydraulic fluids are central to modern industry. They transfer power, dissipate heat, provide lubrication, and ensure reliable operation across systems from heavy construction machinery to highly precise robotic devices. Despite their importance, conventional mineral oil-based hydraulic fluids still face major limitations, including flammability, reliance on complex additive packages, and the risk of environmental contamination from leaks. Because such leaks can easily reach soil and groundwater, developing safer, more sustainable hydraulic fluids has become both a scientific challenge and a practical necessity.

Water–ionic liquid solutions open a new and highly promising avenue in this field. The central idea is to combine the well-known advantages of water, such as very low compressibility, high heat capacity, and efficient heat transfer, with the unique tunability and functional diversity of ionic liquids. This enables the design of hydraulic fluids with controlled viscosity, excellent thermal behavior, reduced fire hazard, and lower environmental risk. In contrast to conventional systems that rely on many additives to balance performance, water–ionic liquid mixtures offer the possibility of achieving desirable properties through molecular design itself. Particular interest is given to protic ionic liquids, which can be prepared in a simple, cost-effective, and scalable manner through acid–base neutralization. Their synthesis does not require elaborate procedures, and in many cases, the final hydraulic mixture can be formed directly in water through in situ preparation. This gives such systems an important practical advantage and makes the transition from laboratory concept to industrial production far more realistic than is often assumed for ionic-liquid-based technologies.

At the same time, the development of such fluids depends strongly on fundamental laboratory research. Detailed physicochemical, thermal, transport, and tribological studies are essential to understanding how molecular structure governs performance under hydraulic conditions. These investigations do more than characterize a new material; they bridge basic chemistry and real-world engineering applications.

Water–ionic liquid hydraulic fluids are more than just an alternative formulation. They signal a broader shift in how hydraulic systems can be designed in the future, with greater attention to safety, sustainability, and environmental compatibility, without sacrificing performance. As a young and largely unexplored area of research, this field offers significant opportunities for innovation, interdisciplinary collaboration, and industrial application, and may contribute to the emergence of a new generation of hydraulic fluids for modern technologies.

ANTIOXIDANTS-METAL COMPLEXES: FROM MOLECULAR INTERACTIONS TO PHARMACEUTICAL POTENTIAL

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Antioxidants are widely recognised for their role in mitigating oxidative stress and are of considerable interest in pharmaceutical and biomedical research. However, their chemical behaviour and biological activity can be significantly influenced by interactions with metal ions, leading to the formation of antioxidant-metal complexes with modified properties. A better understanding of these interactions is important for evaluating their potential applications and functional performance.[1]

In this presentation, the complexation of antioxidants with metal ions, with particular focus on gallic acid as a representative model compound, will be discussed. Due to the presence of three hydroxyl and one carboxyl functional groups, gallic acid exhibits a strong ability to coordinate metal ions, making it suitable for studying the relationship between structure and reactivity in such systems. The formation of metal complexes is investigated using electrochemical and spectroscopic methods to assess changes in redox behaviour and to gain insight into coordination characteristics.[2]

Electrochemical analysis provides information on shifts in redox potentials and changes in electron transfer processes upon complexation, while spectroscopic techniques contribute to the identification of coordination modes and structural features of the formed complexes. The combined approach allows for a comprehensive evaluation of how metal ions influence the chemical properties of gallic acid.[3]

The results indicate that complexation can significantly alter the antioxidant activity, stability, and reactivity of gallic acid. These findings suggest that antioxidant-metal complexes may offer advantages for pharmaceutical applications, particularly in the development of systems with improved functional properties.[4]

ACKNOWLEDGEMENTS The authors thank Josip Juraj Strossmayer University of Osijek and Department of Chemistry, University of Osijek, for financial support.

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INTRINSICALLY MICROPOROUS POLYMERS IN ELECTROCHEMICAL PROCESSES

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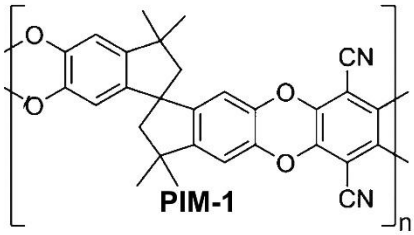
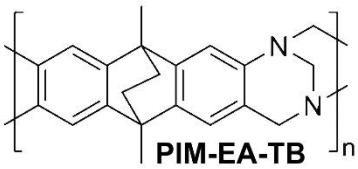
Polymers of intrinsic microporosity (or PIMs) have been developed over the past decade as molecularly rigid and highly processable materials that are readily applied to electrode surfaces or employed as free-standing membranes. Two prototypical PIMs are PIM-1[1] and PIM-EA-TB[2] (see Figure below). Both possess rigid molecular backbones and pack into porous solid/glassy films with high surface area and with typically 1 nm pore size.[3]



PIM-1



PIM-EA-TB

PIMs have been introduced into electrochemical applications in energy storage devices[3] and in sensors.[4] They provide fertile ground for fundamental studies on ion transport and electroosmotic water transport.[5] Intrinsic microporosity leads to binding and transport with size selectivity and chemical selectivity. Binding of gases into nanoparticulate PIM materials is responsible for localised gas activity increases under triphasic conditions (solid|liquid|gas[6]). Localised storage of gases has been reported for example for hydrogen.[7]

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LECTURES – SCIENTIFIC SECTION

CHEMICAL COMPOSITION OF INDOOR AIR IN ZAGREB HOUSEHOLDS: ARE OUR HOMES SAFE?

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Indoor air quality is an important topic because most people spend a large portion of their time indoors. The presence of pollutants in the indoor environments can significantly affect health, comfort, productivity, as well as long-term well-being. However, compared to outdoor air, indoor air remains much less studied, with no clear and unified guidelines and systematic monitoring. This especially applies to households where substantial variability exists in indoor air chemical composition due to differences in lifestyle, occupant activities, building characteristics, outdoor pollution, geographic and climatic differences, seasonality, as well as the measurement methodologies employed. Within the EDIAQI project (Evidence-Driven Indoor Air Quality Improvement), IAQ was investigated in more than 100 Zagreb households, including monitoring of various chemical pollutants such as PM_1 fraction of particulate matter (particles with an equivalent aerodynamic diameter less than 1 µm), polycyclic aromatic hydrocarbons (PAHs) in PM_1, volatile organic compounds (VOCs), radon (^{222}Rn), and PAHs in household dust. Wherever possible, measurements were conducted simultaneously indoors and outdoors.

PM_1 mass concentrations showed greater variability and slightly higher median values indoors and during the cold period; however, a statistically significant difference was observed only between outdoor concentrations in the cold and warm seasons. PM_1-bound PAHs showed a similar pattern, with higher mass concentrations and variability during the cold season. Significant seasonal differences were found both indoors and outdoors, whereas indoor–outdoor differences were not statistically significant. PAH contribution profiles in PM_1 were similar indoors and outdoors, indicating the predominance of six-ring PAHs and some 5-ring PAHs associated with vehicle emissions. In contrast, household dust was dominated by four-ring PAHs, accounting for more than 60% of total PAHs. Among the 19 analyzed VOCs, greater variability was observed during the warm season. Significant indoor–outdoor differences were found, while seasonal differences were not significant. The most abundant compounds were toluene, cyclohexane, and methylene chloride. Radon, measured only indoors, originates from soil and rocks and can enter buildings through the ground or construction materials. Its activity concentration showed a clear dependence on floor level and building age, consistent with previous studies.

The findings highlight the complexity of indoor air quality and the need for systematic monitoring. Future analyses will explore links between pollutant levels, household characteristics, occupants' habits, and health outcomes.

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NEW OPPORTUNITIES FOR A SUSTAINABLE WASTE PLASTICS DEPOLYMERIZATION BY MECHANOCHEMISTRY

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Exponential growth of synthetic polymer production in recent decades has led to one of the most pressing global challenges of our time - sustainable and environmentally-friendly management of waste plastics. One approach is to go back to square one and design new polymers, preferably derived from bio-based sources, with properties engineered to facilitate their breakdown to monomers or harmless products under mild low-energy conditions. While researchers have made progress in this direction, the already present and accumulated plastic waste in the environment still requires efficient strategies that would enable its recycling or upcycling to products with market value.

Alongside energy recovery from plastic by incineration and mechanical recycling technologies for waste plastic bottles and containers, chemical recycling of waste polymers is also gaining momentum over the past few years. By converting the waste into starting monomers or simple low-molecular compounds as feed in industrial processes, chemical recycling aids in closing the loop of circular economy for polymers, circumventing the need for raw material derived from fossil fuel. In this respect, mechanochemistry as an inherently solvent-free methodology, has emerged as a promissing green alternative to conventional depolymerization in bulk solvents.[1] In this lecture, the pioneering contributions from our research group to the field of mechanochemical recycling of post-consumer polymers using ball milling will be presented,[2] with examples of quantitative depolymerization of polyethylene terephthalate to its constituents and upcycling to heterogenous metal-organic framework catalysts for organic transformations.

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INKJET PRINTING IN THE DEVELOPMENT OF FLEXIBLE VOLTAMMETRIC CHEMICAL SENSORS AND BIOSENSORS

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Inkjet printing of conductive materials is a green, scalable, and cost-effective additive technique for fabricating miniaturized, electrical devices. Unlike the more established screen printing, it deposits less functional material, drastically reducing reagent consumption and waste, while enabling high-resolution, contactless patterning on flexible substrates. Due to these advantages, inkjet printing has recently gained traction in the development of electrochemical sensors[1]. However, some challenges persist - formulating stable, jettable functional inks is demanding, and the small amount of deposited conducting material is a particular limitation for voltammetric sensing.

In this talk, the development of flexible low-cost inkjet printed graphene electrodes on polyimide sheets will be presented. A brief intense pulsed light (IPL) treatment is applied after printing to render the deposited films conductive and electrochemically active; following this step, the electrodes match or outperform commercial screen-printed carbon electrodes in electrochemical and electroanalytical performance. As an example of voltammetric chemical sensing, these electrodes were applied to the determination of the antibiotic azithromycin, showing good sensitivity in both batch and flow analysis[2].

The versatility of the inkjet printed platform was further demonstrated for biosensing: the graphene electrodes were modified by inkjet printing of a Prussian Blue nanoparticle suspension. This enabled sensitive amperometric determination of hydrogen peroxide at low potentials. In the last step, lactate oxidase was immobilized, and lactate determined (via determination of the enzymatically produced hydrogen peroxide) in a broad linear range covering sweat lactate concentrations[3]. Together, these examples show how inkjet printing can underpin a variety of low-cost flexible miniature chemical sensors and biosensors, particularly attractive for distributed and wearable sensing.

ACKNOWLEDGEMENTS This research was supported by the Croatian Science Foundation grant UIP-2020-02-9139, and the NextGenerationEU funded Institutional research project ADFABSENS (112103).

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PERSPECTIVES OF SIMPLE PHOTOCATALYSTS FOR LARGE-SCALE WATER AND AIR TREATMENT

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Photocatalysis has long been recognized as a promising technology for environmental remediation. However, despite remarkable progress in developing highly engineered photocatalytic materials, their large-scale implementation remains limited by complex synthesis, high production costs, and challenges associated with long-term operation. In contrast, our research over the past decade has demonstrated that simple, immobilized photocatalysts can provide an effective, robust, and economically viable alternative for practical water and air treatment.

Drawing on our experience in the development and application of immobilized TiO_2-based photocatalytic systems, this lecture will discuss the transition from laboratory-scale research to real environmental applications. Particular emphasis will be placed on the key factors governing successful implementation, including catalyst stability, ease of fabrication, reusability, reactor design, and operation under realistic environmental conditions. Our findings indicate that the future of photocatalysis depends less on maximizing photocatalytic activity under ideal laboratory conditions and more on designing durable, scalable systems that combine satisfactory performance with simplicity, affordability, and sustainability.

The lecture will highlight current and emerging applications of simple photocatalysts for stormwater treatment, tertiary wastewater polishing, passive air purification, and multifunctional infrastructure materials. Future perspectives will also include the integration of photocatalysis with solar irradiation, smart environmental monitoring, predictive modelling, and digital technologies, enabling intelligent and energy-efficient environmental treatment systems.

Rather than pursuing increasingly complex photocatalytic materials, future research should focus on technologies that can be reliably transferred into practice. Such an approach has the potential to accelerate the large-scale adoption of photocatalytic processes and contribute significantly to sustainable water and air quality management in the context of circular economy and climate-resilient infrastructure.

APPLICATION OF CHEMICAL ANALYZES IN THE DAILY AND RESEARCH WORK OF THE INSPECTO LABORATORY

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Inspecto d.o.o. is a specialized inspection company with more than 25 years of experience in laboratory testing and cargo inspection services in Croatia and abroad. The company operates in accordance with international quality standards HRN EN ISO 9001, HRN EN ISO/IEC 17025, and HRN EN ISO/IEC 17020, and is a certified member of the international organizations GAFTA and FOSFA.

The InspectoLab centre consists of five laboratories: a chemical laboratory, microbiological laboratory, water laboratory, soil laboratory, and rheological laboratory. The laboratory performs analyses of food and animal feed, wine and alcoholic beverages, drinking water and wastewater, soil, sludge, and environmental samples, as well as microbiological testing of food, feed, water, and facilities. More than 183,000 analyses are carried out annually using modern analytical techniques such as HPLC, LC-MS/MS, GC-MS/MS, ICP-MS, ELISA, and real-time PCR.

Today, InspectoLab represents the largest laboratory in the region, covering an area of 2,800 m², with more than 1,200 types of laboratory testing, 137 accredited methods, and a team of 50 highly educated experts. Digitalized sample processing and online monitoring systems enables fast and efficient analytical procedures.

An important part of the company's activities relates in research and development projects funded by the European Union. Through the INSPECTOLAB project, a new laboratory centre was built and equipped with modern laboratory instruments, while the INSPECTOIKT project enabled the digitalization of business processes and the implementation of advanced ICT solutions. The INSPECTOKOM project was focused on the commercialization of innovative laboratory methods and increasing the company's international competitiveness.

Currently, one of the company's most important projects is NitroSAFE, aimed at developing innovative methods for the detection of N-nitrosamines in meat products in order to improve food safety and protect consumer health. The PAH SafeGuard project focuses on the development of innovative smoking methods that reduce contamination by polycyclic aromatic hydrocarbons (PAHs) in traditional meat products.

Inspecto d.o.o. collaborates with numerous scientific and professional institutions on projects related to mycotoxins, pesticides, ergot alkaloids and the quality of black Slavonian pig meat. Through such research activities, the laboratory contributes to the advancement of food safety, environmental protection, and the improvement of laboratory service quality not just in Croatia but also in the wider region.

SYNTHESIS AND BIOLOGICAL EVALUATION OF PEPTIDOGLYCAN-DERIVED IMMUNOMODULATORS

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Muramyl dipeptide (MDP) is the minimal peptidoglycan fragment that retains adjuvant activity. The human immune system recognizes MDP as a pathogen-associated molecular pattern, triggering immune responses through activation of the nucleotide-binding oligomerization domain-containing protein 2 (NOD2) receptor. The pharmacological properties of MDP can be enhanced by increasing its lipophilicity and by designing desmuramyl peptide (DMP) derivatives. To date, our research has focused on DMPs bearing lipophilic substituents and their mannosylated analogues. Mannose receptors expressed on immunocompetent cells are pattern-recognition receptors, similar to NOD2, and can therefore modulate immune responses. Herein, we present the design and synthesis of mannosylated desmuramyl peptides containing lipophilic substituents, together with the experimental models used for their biological evaluation and computational studies aimed at elucidating their molecular interactions with receptors.[1-5] This presentation will highlight the structural features governing the in vitro and in vivo immunomodulatory activity of peptidoglycan-derived adjuvants.

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DIASTEREOSELECTIVE CONSTRUCTION OF TERTIARY ALCOHOLS BY THE ADDITION OF DIFFERENT GRIGNARD REAGENTS TO THE SUGAR DERIVED LACTONES

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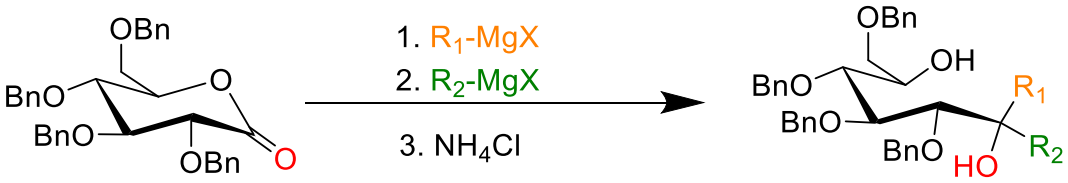
Grignard reagents typically display low selectivity in additions to carbonyl compounds, particularly in reaction with esters, which undergo double addition to form tertiary alcohols due to high reactivity of the ketone intermediate. However, under certain conditions, ketone formation has been reported as the major outcome.[1] To explore the scope of this approach, a sugar-derived lactones were used as a substrate with the goal of developing a diastereoselective method of preparing chiral tertiary alcohols - a strategy recently developed in our group in the course of total synthesis.[2] Reactions between the lactones and different Grignard reagents were performed under different conditions, varying the solvent, temperature, and Grignard reagent concentration to study their effect on reactivity and selectivity (Figure 1). This study explores effective approaches for modulating the selectivity of Grignard reagents and achieving stereochemical control in the diastereoselective synthesis of tertiary alcohols.



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AZA-OXA SCHIFF BASE MACROCYCLES AS BUILDING BLOCKS FOR COORDINATION POLYMERS AND INCLUSION COMPOUNDS

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Over the last couple of decades, *aza-oxa* macrocycles have been studied as selective separation agents and sensors for toxic metal cations, anions, and neutral species. Several designable structural factors, such as cavity size, donor-atom conformation, system flexibility, and orientation of potential donor atoms, can be used to manipulate the affinity of macrocyclic systems for these species. Although macrocyclic chemistry is traditionally associated with discrete *endo*-coordinated complexes, many of these structural principles can also be exploited to design *exo*-coordinated coordination polymers, particularly when *aza-oxa* Schiff-base macrocycles are employed.[1] The presence of the C=N imine bond imparts rigidity and enhanced stability to the macrocyclic framework. In larger macrocycles, this rigidity promotes the formation of porous solid-state architectures, making them excellent candidates for the sorption of neutral species and for the formation of inclusion compounds.[2]

ACKNOWLEDGEMENTS This paper is supported by the European Union-NextGenerationEU. Project “Advanced Interdisciplinary Approaches to Environmental Chemistry: From Materials to Sustainable Solutions for Pollution” (Grant number: 581-UNIOS-101)

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MECHANOCHEMICAL SYNTHESIS OF *N*-IMINOBORONATES

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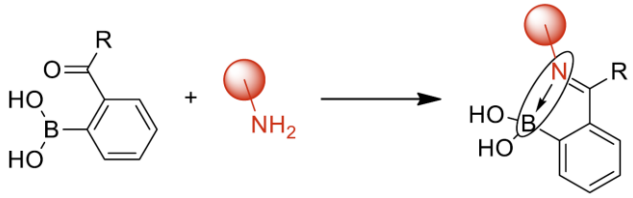
N-iminoboronates[1] are formed by the reaction of carbonylarylboronic acids with amines (Scheme 1). The imine bond, readily formed under mechanochemical conditions,[2] can be stabilized by a boron←nitrogen interaction when the boronate group is in the *ortho* position.[3,4] In this work, the environmentally-friendly mechanochemical preparation[5,6] of *N*-iminoboronates was investigated using aniline derivatives and formylphenylboronic acids. The emphasis was put on determining how the structure of the reactants (position and type of substituents) and the reaction conditions influence the solid-state reaction course and outcome. The reactions were carried out in a vibrational ball mill using solid-state Raman spectroscopy to monitor the reactions *in situ*,[7] as well as nuclear magnetic resonance (NMR), infrared (IR) spectroscopy and powder X-ray diffraction (PXRD) to analyze the obtained products. A fast, high-yield, and reproducible solid-state synthesis of *N*-iminoboronates suitable for further applications was developed.



ACKNOWLEDGEMENTS This work has been financially supported by the NextGenerationEU NPOO project KP1-01-917/1-2025 and the Croatian Science Foundation project HRZZ-IP-2025-02-3843.

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OPTIMIZATION OF UV-ASSISTED DNA IMMOBILIZATION ON NITROCELLULOSE MEMBRANES FOR LATERAL FLOW ASSAYS

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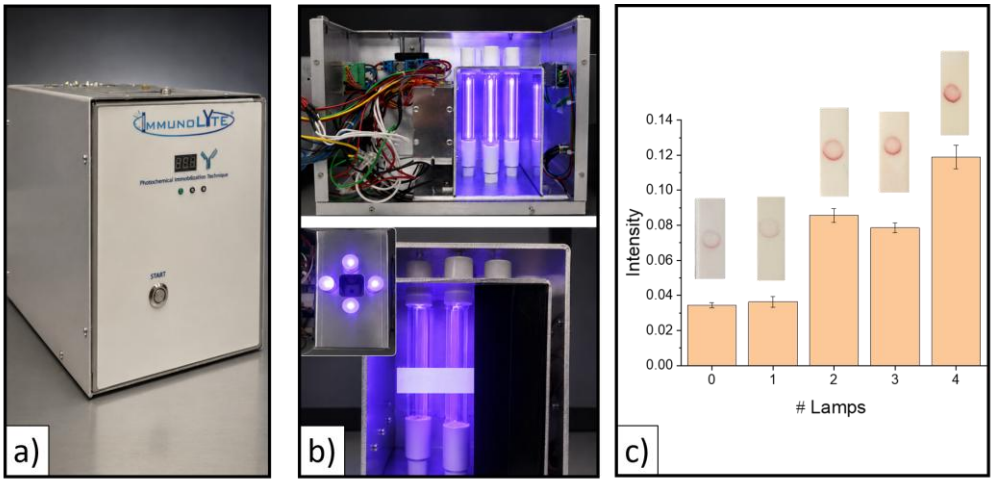
Lateral flow assays (LFAs) are widely used point-of-care diagnostic tools due to their simplicity, rapidity, and low cost.[1] Among the various biorecognition elements employed in LFAs, DNA has attracted increasing interest because of its high specificity, programmability, chemical stability, ease of synthesis, and compatibility with amplification strategies. However, efficient DNA immobilization on nitrocellulose membranes remains a significant challenge. Unlike proteins, DNA shows limited spontaneous adsorption onto nitrocellulose, often leading to poor probe retention and reduced assay sensitivity. Several approaches have been investigated to improve DNA fixation, including chemical crosslinking, biotin–streptavidin interactions, covalent surface modifications, and UV-assisted immobilization.[2] In this work, we developed and optimized a UV-assisted DNA immobilization method using a prototype UV irradiation device originally designed for antibody photoactivation for metallic surfaces (Fig. 1a). The effects of UV exposure time, irradiation power, and DNA concentration were evaluated by exposing DNA-functionalized nitrocellulose strips to UV light using a custom-designed 3D-printed holder integrated into the irradiation system (Fig. 1b). Under optimized conditions, a 3.5-fold increase in signal intensity was achieved in a conventional gold nanoparticle-based lateral flow assay (Fig. 1c). These findings demonstrate a simple, reagent-free strategy for enhancing DNA retention and lateral flow assay performance, with potential applicability across different nitrocellulose membranes and DNA probe formats.



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ANALYTICAL APPROACHES FOR ANALYSIS OF NON-REGULATED MYCOTOXINS IN CROATIA

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Emerging and non-regulated mycotoxins represent an increasing food safety concern due to their frequent co-occurrence in cereals, food, and feed, as well as limited toxicological and occurrence data. The European Food Safety Authority (EFSA) has identified several groups of mycotoxins requiring continuous monitoring, including Alternaria toxins, enniatins, beauvericin, moniliformin, sterigmatocystin, and modified forms of regulated mycotoxins. In Croatia, available occurrence data remain fragmented and are mainly focused on regulated compounds such as aflatoxins, ochratoxin A, citrinin, patulin, ergot alkaloids, alternaria toxins, fumonisins, zearalenone, and trichothecenes[1,2].

Current analytical approaches for mycotoxin determination include immunochemical methods (ELISA, lateral flow assays), chromatographic techniques with fluorescence or UV detection (HPLC-FLD/UV), and advanced mass spectrometric methods (LC-MS/MS and HR-MS). Immunochemical methods are suitable for rapid screening of individual toxins but suffer from limited selectivity and cross-reactivity. Conventional chromatographic methods provide reliable quantification of regulated mycotoxins; however, they usually require extensive sample clean-up and are unsuitable for broad-spectrum analysis of structurally diverse metabolites[3]. Dilute & shoot LC-MS/MS multi-mycotoxin methods have become the preferred analytical strategy for simultaneous determination of regulated and non-regulated mycotoxins[4]. The approach is based on simple extraction followed by dilution of the extract and direct injection into the LC-MS/MS system, significantly reducing sample preparation time, solvent consumption, and analytical cost[1,4].

Recent advances in non-invasive analytical techniques have enabled rapid screening of mycotoxin contamination using hyperspectral imaging (HSI), near-infrared spectroscopy (NIR), Raman spectroscopy, and fluorescence-based approaches. HSI systems integrated with chemometric and machine learning models have shown promising applicability for rapid detection of aflatoxins, fumonisins, deoxynivalenol, and ochratoxin A in cereals, nuts, and other agricultural commodities. Although these approaches currently cannot fully replace confirmatory LC-MS/MS analysis due to limitations in sensitivity, matrix dependence, and indirect toxin detection, they represent valuable high-throughput screening tools for industrial process control and preliminary risk assessment. The combination of non-invasive optical techniques with advanced LC-MS/MS confirmatory methods may significantly improve future monitoring strategies for both regulated and emerging mycotoxins.

ACKNOWLEDGEMENTS This work was supported by NO MICRODRAMA (UNIN-BIOTEH-26-1-2), and MycoSense (IP-UNIN-BIOTEH-2025-2) projects.

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NUCLEIC ACID-BASED COLORIMETRIC BIOSENSORS FOR LIQUID BIOPSY AND ENVIRONMENTAL MONITORING

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Rapid, low-cost, and decentralized diagnostic tools are increasingly needed in both healthcare and environmental monitoring. However, the detection of cancer-derived extracellular vesicles and environmental DNA often relies on laboratory-based methods requiring specialized instrumentation and time-consuming analytical procedures.[1,2] Here, we report the development of two nucleic acid-functionalized gold nanoparticle (AuNP) colorimetric biosensors exploiting localized surface plasmon resonance (LSPR) for rapid detection of clinically and environmentally relevant targets.

The first biosensor was designed for the detection of breast cancer-derived exosomes, which are increasingly recognized as valuable liquid biopsy biomarkers because they preserve the molecular signature of the tumor and are readily accessible in biological fluids. The assay employs AuNPs functionalized with the RNA aptamer Ex.50.T, targeting Gremlin-1 (GREM1), a protein overexpressed on tumor-associated extracellular vesicles. A target-induced disaggregation mechanism generates a visible blue-to-red color transition upon exosome recognition. The biosensor achieved a limit of detection (LOD) of approximately 10^6 exosomes mL^{-1} and successfully discriminated breast cancer patients from healthy donors achieving 84% sensitivity, 90% specificity, and an AUC of 0.92.[3]

The second biosensor targets environmental DNA (eDNA) from *Fusarium oxysporum*, one of the most economically important soil-borne phytopathogens worldwide. Using two batches of complementary ssDNA-functionalized AuNPs, the assay operates through a competitive anti-aggregation mechanism. Freeze-assisted hybridization accelerates target recognition, enabling target detection within 5 min with a LOD of 2 nM (12 pg/µL) and successful identification of target DNA in soil-derived samples.[4]

Together, these findings demonstrate the versatility of nucleic acid-based plasmonic biosensors for biomedical diagnostics and environmental monitoring.

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SANO - SUVREMENA HRANIDBA ŽIVOTINJA D.O.O.

APPLIED CHEMISTRY IN MODERN PIG PRODUCTION – FROM NUTRITION TO BIOSECURITY

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Applied chemistry has become one of the fundamental pillars of modern pig production, providing practical solutions that simultaneously enhance production efficiency, improve animal health, and reduce the environmental impact of livestock farming. Precision feeding based on the use of synthetic amino acids enables a reduction in dietary crude protein content without compromising productive performance. This approach improves nutrient utilization efficiency, lowers feed formulation costs, and significantly decreases nitrogen excretion and ammonia emissions, thereby contributing to more sustainable pig production (Gloaguen et al., 2014; Pomar and Remus, 2019).

The weaning period represents one of the greatest biological challenges in a pig's life due to abrupt changes in diet, environment, and intestinal microbiota. Organic acids exert substantially broader effects than simple acidification of the gastrointestinal tract. Their undissociated molecules penetrate bacterial cells, disrupt intracellular homeostasis, and inhibit the proliferation of pathogenic microorganisms. A carefully formulated combination of different organic acids provides a synergistic effect, promoting microbiota stability, preserving intestinal integrity, and supporting gastrointestinal health (Partanen and Mroz, 1999; Liu et al., 2018).

The third pillar of applied chemistry in pig production is biosecurity. Effective disinfection can only be achieved following thorough cleaning, as organic matter, fats, proteins, and biofilms prevent disinfectants from reaching microorganisms. Proper cleaning and disinfection protocols reduce infectious pressure, decrease the need for antimicrobial treatments, and improve both productive and economic performance at the farm level (Maes et al., 2019). Overall, the integrated application of synthetic amino acids, organic acids, and evidence-based hygiene and biosecurity measures represent a cornerstone of sustainable, competitive, and highly efficient pig production systems.

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NEXE D.D.

NEW CHALLENGES IN THE PRODUCTION OF PORTLAND CEMENT / *NOVI IZAZOVI U PROIZVODNJI PORTLAND CEMENTA*

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The presentation provides insight into the challenges faced by a cement manufacturer in the EU. External challenges stem from EU and national policies, which are prescribed through legal regulations. In addition to legislative requirements, the manufacturer also faces inquiries from customers who want a product compliant with current policies and regulations. Furthermore, challenges also arise from various other manufacturers regarding the possibilities of recovering their by-products and waste. The Portland cement manufacturer must respond to all these demands by producing Portland cement in accordance with the prescribed quality. In doing so, the manufacturer must take into account the physicochemical properties of the offered materials, the available existing technology, as well as new scientific findings in the fields covered by Portland cement production practice, and the emergence of new challenges in the form of supply chain disruptions. To ensure stable operations, the cement manufacturer must integrate several key segments into its policies.

Prezentacija daje uvid o izazovima s kojima se susreće proizvođać cementa u EU. Vanjski izazovi proizlaze iz politika EU i nacionalnih, a propisani su kroz zakonske regulative. Osim zakonodavnih, proizvođać se susreće i sa upitima kupaca, koji žele proizvod u skladu s važećim politikama i regulativom. Također izazovi dolaze i od raznih proizvođaća kroz upite o mogućnostima oporabe njihovih nusproizvoda i otpada. Na sve ove zahtjeve proizvođać portland cementa treba odgovoriti na način da proizvede portland cement u skladu s propisanom kvalitetom. Pri tome mora uzeti u obzir fizikalno-kemijska svojstva ponuđenih materijala, postojeću tehnologiju kojom raspolaže, kao i nove znanstvene spoznaje iz područja koja obuhvaća proizvodna praksa portland cementa, te pojavu novih izazova u obliku poremečaja dobavnih pravaca. Kako bi osigurao stabilno poslovanje, proizvođač cementa mora integrirati nekoliko ključnih segmenata u svoje politike.

LECTURES – EDUCATIONAL SECTION

(FREE) RADICAL CHEMISTRY IN SOLUTION AND IN THE SOLID STATE

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Radicals, chemical species with unpaired electrons, are usually believed to be very unstable; they can be prepared only under special conditions and can be studied only using special, very expensive, instruments. They are also believed to be harmful, and that they should be kept away from school laboratories. However, the radicals have a crucial role in biological reactions. Due to their unpaired electron(s), the radicals have a distinct colour, so their appearance may be easily detected. Some radicals, such as semiquinones, are very stable and are easily isolated, even crystallised.

Semiquinone is an especially important radical, which acts as an electron carrier in the majority of bioenergetic reactions (fermentation, oxidation phosphorilation, photosynthesis). It is formed by reduction of quinones or oxidation of hydroquinones (Figure 1) in the alkaline solution. This radical anion is easily prepared in the alkaline solution. Due to change of colour, it can be easily observed. Even the reaction mechanism can be deduced only by visual observation: the radical may form either by oxidation of the hydroquinone by oxygen from air or by some other oxidant which is present in the solution.

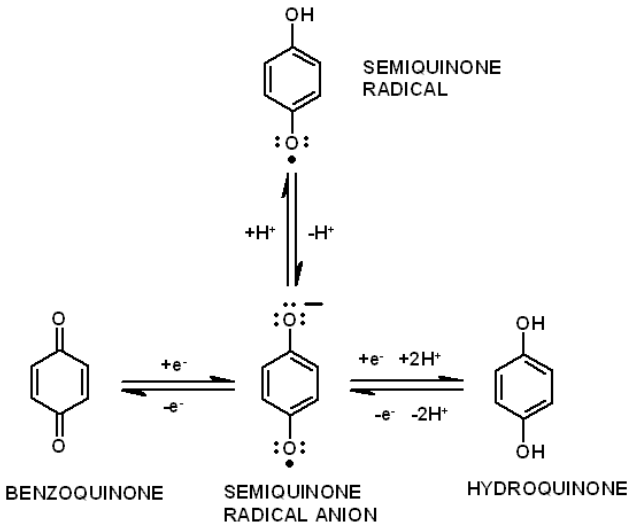

Figure 1 Reactions of semiquinone in aqueous solutions

Several simple experiments involving semiquinone radical are described. They can be easily performed in a school laboratory, using small quantities of cheap, harmless substances. A great deal of radical chemistry can be learned by simple observation of these reactions. Spin pairing and formation of two-electron multicentre bond (*pancake bond*) in the solid state is described.

THINKING LIKE SCIENTIST: THE INVESTIGATIVE SCIENCE LEARNING ENVIRONMENT (ISLE) APPROACH

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The Investigative Science Learning Environment (ISLE) is a research-based instructional approach designed to engage students in processes that mirror the work of scientists[1].
Originally developed and extensively implemented in physics education, the ISLE approach has shown positive effects on students' conceptual understanding, scientific reasoning, and problem-solving abilities[2,3]. In ISLE classrooms, students work collaboratively to investigate carefully selected phenomena, propose explanations and models, design experiments to test their ideas, evaluate the consistency between predictions and evidence, and revise their models when necessary[1]. More recently, the principles of the ISLE approach have also been adapted for chemistry education, opening new opportunities to engage students in authentic scientific practices.
This talk will provide an overview of the theoretical foundations of the ISLE approach and discuss its implementation in science education. Particular emphasis will be placed on fostering students' scientific thinking and helping them understand how scientific knowledge is developed and validated. The talk will also include classroom examples for chemistry that illustrate how ISLE activities can be used to support active learning, authentic scientific practices, and deeper conceptual understanding.

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The author also wishes to thank Eugenia Etkina and Danielle Buggé for sharing the ISLE chemistry resources.

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HOW TO ADOPT EDUCATIONAL OUTCOMES OF CHEMISTRY THROUGH EXTRACURRICULAR ACTIVITIES WITHIN THE SCHOOL ORCHARD

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The adoption of educational outcomes in chemistry takes place through regular classes, but also through extracurricular activities. Based on the curriculum of the chemistry subject for primary schools, four macroconcepts have been identified (substances, changes and processes, energy and the scientific approach)[1].

The aim of the paper is to examine the curriculum of the chemistry subject with reference to the school curriculum based on the provisions of the Act on Education in Primary and Secondary Schools[3], and the goals, purpose and organizational characteristics of extracurricular activities. The school curriculum assumes the development of extracurricular programs and activities that schools are going to implement taking into account student preferences. The paper examines in more detail the experiences in implementing the school curriculum of the extracurricular activity "Fruit Group" as one of the possibilities for adopting both the educational outcomes of the chemistry curriculum and the curriculum of cross-curricular topics. Extracurricular activities are not a mandatory part of the student's workload, but can be recognized by students as fulfilling obligations at school. Through participation in activities, students have the opportunity to evaluate their own work, the work of other students, and the work of their teacher. This develops students' self-criticism and criticality, as well as teachers' openness to the opinions and viewpoints of their students[2]. In accordance with the Rules on Assessment and the parameters that are assessed in chemistry teaching (acquisition of chemical concepts, scientific competences), evaluation options are provided based on the correlation-integration possibilities of interdisciplinary extracurricular activities as the basis of the modern teaching process[4].

By implementing the planned activities, many of the given guidelines of the national curriculum, the curriculum of cross-curricular topics, and the curriculum of the chemistry subject have been achieved. The educational outcomes achieved in students through the aforementioned activities aim to create fundamental competences that they will need in their further education and life.

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MODERN CHEMISTRY EDUCATION – INTEGRATING INQUIRY-BASED LEARNING, EXPERIMENTAL WORK, AND DIGITAL TECHNOLOGIES FOR THE DEVELOPMENT OF SCIENTIFIC COMPETENCIES

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Modern chemistry education aims to foster scientific literacy, conceptual understanding of chemical processes, and the development of students' inquiry, digital, and problem-solving competencies. The implementation of inquiry-based learning, experimental work, and digital technologies enables students to connect theoretical chemical concepts with real-life phenomena while promoting critical thinking, analytical reasoning, and evidence-based scientific thinking. This presentation showcases examples of innovative chemistry teaching practices that integrate inquiry-based learning, laboratory activities, and digital educational technologies to enhance the quality of chemistry instruction. Particular emphasis is placed on the educational implementation of an original physical–digital periodic table of elements, developed by the author, which combines the traditional periodic table with QR technology, microcontroller-based systems, and interactive multimedia content. This teaching tool enables students to explore the structure, properties, and applications of chemical elements through interactive learning while connecting macroscopic observations with submicroscopic and symbolic representations of chemistry. As an example of inquiry-oriented instruction, the topic of radioactivity is presented through the use of a Geiger–Müller counter to measure natural background radiation and through the investigation of the natural radioactivity of potassium-40 in bananas. Students analyze experimental data using quantitative calculations and interpretation of measurement results while discussing the role of radioactive isotopes in medicine, industry, environmental monitoring, and energy production. The presented examples highlight the importance of integrating experimental work, digital technologies, and interdisciplinary approaches in the development of students' scientific competencies. Such teaching practices promote deeper conceptual understanding of chemistry, increase student engagement and motivation, and support the development of competencies required for lifelong learning and STEM education in the 21st century.

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APPLICATION OF RESEARCH AND PROJECT BASED LEARNING IN CHEMISTRY TEACHING THROUGH INTERNATIONAL AND INTERDISCIPLINARY ACTIVITIES / *PRIMJENA ISTRAŽIVAČKOG I PROJEKTNOG UČENJA U NASTAVI KEMIJE KROZ MEĐUNARODNE I INTERDISCIPLINARNE AKTIVNOSTI*

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The presentation discusses the application of research and project based learning in chemistry teaching through international and interdisciplinary activities.
The emphasis is on the active involvement of students in the learning process through experimental work, field research and projects that connect cross-curricular theoretical knowledge with practical experiences. Examples of good practice include participation in Erasmus+ projects, activities within the GLOBE program with an emphasis on hydrology, while also including pedology, phenology, atmosphere and biometrics, the “Saving Water” project, and the “Cosmetics of Our Grandmothers” project. These activities enable students to understand chemical concepts such as pH, the composition of solutions, and the impact of substances on the environment.
The results show increased student motivation, the development of research and analytical skills, and the ability to connect chemistry to everyday life. In addition, students develop communication and social competences through teamwork and international cooperation.
In conclusion, the integration of research and project-based learning in chemistry teaching contributes to a deeper understanding of the teaching content and the development of key competences for lifelong learning.

Izlaganje prikazuje primjenu istraživačkog i projektnog učenja u nastavi kemije kroz međunarodne i interdisciplinarne aktivnosti.
Naglasak je na aktivnom uključivanju učenika u proces učenja putem eksperimentalnog rada, terenskih istraživanja i projekata koji povezuju međupredmetna teorijska znanja s praktičnim iskustvima. Primjeri dobre prakse uključuju sudjelovanje u Erasmus+ projektima, aktivnosti u okviru GLOBE programa s naglaskom na hidrologiju, ne isključujući pedologiju, fenologiju, atmosferu i biometriju, projekt „Štedimo vodu” te projekt „Kozmetika naših baka”. Ove aktivnosti omogućuju učenicima razumijevanje kemijskih koncepata poput pH-vrijednosti, sastava otopina i utjecaja tvari na okoliš.
Rezultati pokazuju povećanu motivaciju učenika, razvoj istraživačkih i analitičkih vještina te sposobnost povezivanja kemije sa svakodnevnim životom. Osim toga, učenici razvijaju komunikacijske i socijalne kompetencije kroz timski rad i međunarodnu suradnju.
Zaključno, integracija istraživačkog i projektnog učenja u nastavi kemije pridonosi dubljem razumijevanju nastavnih sadržaja i razvoju ključnih kompetencija za cjeloživotno učenje.

DOSE MAKES THE POISON: CHEMICAL LITERACY IN EVERYDAY LIFE

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Chemical literacy is essential for making informed decisions about health and safety and is a key component of contemporary science education. Developing students' understanding of the relationship between chemical composition, dosage, and the effects of substances is particularly important in the context of over-the-counter (OTC) medicines and dietary supplements. Their widespread availability often creates a false sense of safety despite the potential risks associated with improper use.

The project "Lijek ili otrov?" ("Medicine or Poison?") was implemented during the 2024/2025 school year at Gymnasium M. A. Reljković, Vinkovci with the aim of developing the students' chemical and health literacy and encouraging critical thinking about the use of OTC medicines and dietary supplements. The project involved 158 second-year grammar school students. An initial anonymous survey provided insight into the students' habits and served as the basis for designing educational activities.

Based on the survey results, a series of workshops addressed the proper use of OTC medicines, dietary supplements, self-medication, stress management, and correct dosing. The activities included analysing product labels and instructions, calculating doses, discussing adverse effects and interactions, and evaluating information from media and social networks. Through these activities, students connected chemistry concepts with real-life situations and further developed their critical evaluation skills.

The students' feedback indicated a strong interest in the topics and recognition of their practical value. The project improved the awareness of proper dosing, responsible use of medicines and dietary supplements, and the importance of evidence-based decision-making. The implemented activities represent an example of good teaching practices that can be readily adapted and applied in other schools, contributing to the development of chemical literacy and responsible health-related behaviour.

ACKNOWLEDGEMENTS The project *"Lijek ili otrov?"* was funded by the Ministry of Science, Education and Youth of the Republic of Croatia.

SUSTAINABLE DEVELOPMENT THROUGH LOCAL GREEN INITIATIVES – PLANTING FRUIT TREES, FLOWERS AND BUILDING INSECT HOTELS

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As part of the growing need to protect the environment and promote sustainable development, numerous local initiatives have been implemented with the aim of increasing biodiversity, strengthening environmental awareness, and creating a healthier living environment. In this project, special emphasis was placed on planting native fruit trees and a variety of flowers, as well as constructing insect hotels, as key steps toward preserving pollinators and maintaining natural balance.

The planting of fruit trees contributes to the restoration of local flora, improves air quality, and provides natural shade, while flowering plants attract numerous beneficial insects and birds, thereby supporting ecosystem stability. Insect hotels provide shelter for beneficial species such as solitary bees and ladybugs, which play an important role in pollination and pest control. These activities represent a concrete contribution to the fight against climate change, the education of the local community, and the strengthening of the relationship between people and nature.

The project is based on the principles of sustainability, community involvement, and the application of nature-friendly solutions, with the goal of achieving long-term environmental and social impact.

ACKNOWLEDGEMENTS We would like to thank the Wienerberger factory for their cooperation and making the workshop possible.

SIMILAR, YET DIFFERENT: INQUIRY-BASED LEARNING USING EVERYDAY CHEMICALS

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Nowadays, it is increasingly difficult to motivate students for classes, therefore inquiry-based learning is one of the key approaches because it places students at the center of the learning process. In modern STEM education, this approach encourages students to observe, ask questions, formulate hypotheses, gather evidence, and draw conclusions. Chemicals and processes that students encounter in their everyday lives hold special motivational value in these activities.

In this paper, a workshop based on two inquiry-based tasks with different content focus, but a shared methodological approach to inquiry-based learning will be presented.

As their first task, students receive three unlabelled colourless solutions: magnesium chloride, potassium hydrogen carbonate, and sodium carbonate (washing soda), which they need to identify by conducting experiments. By combining samples, observing changes, and analysing their observations, students develop an understanding of chemical reactions as well as scientific reasoning skills.

The second task is focused on investigating the effects of potassium sorbate as a preservative. Students compare fermentation in a sugar-yeast system with fermentation in the presence of potassium sorbate, and based on the observed differences, they explore the effect of the preservative on microorganism activity. Solving this task enables connecting chemical and biological processes with applications in the food industry.

In addition, students are given an inquiry-based problem: under what conditions can potassium sorbate inhibit the activity of catalase in the decomposition of hydrogen peroxide? By analysing the composition and structure of potassium sorbate, students conclude that it is a salt formed from a strong base and a weak acid, and they examine how acidic conditions, achieved by the addition of citric acid, affect its inhibitory effect.

This workshop demonstrates how simple experiments and easily accessible chemicals can be used to achieve the goals of inquiry-based learning and develop critical thinking, experimental skills, and an understanding of the connection between STEM fields and everyday life. The presented examples may serve as a model for designing similar activities in chemistry classes and interdisciplinary STEM education.

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PROTEINS – CROSS-CURRICULAR INTEGRATION OF CONTENT THROUGH AN ESCAPE GAME

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The workshop *Proteins – Cross-curricular Integration of Content through an Escape Game* (***Proteini – međupredmetno povezivanje gradiva kroz escape igru***) represents an example of good practice in education. It is conducted in the 4th grade of grammar school as a correlation between the subjects Biology and Chemistry.
The aim of the workshop is to encourage students, through an interactive game, to actively participate in the revision process of 4th-grade biology and chemistry content, with a special emphasis on understanding the physical and chemical properties of proteins and their key role in the organism. This workshop enables students to deepen their knowledge of proteins by solving puzzles and engaging in practical activities, while simultaneously connecting concepts from chemistry and molecular biology.
The learning outcomes that guide students toward the above goal are:
– to analyse the physical and chemical properties of proteins and their role in the organism;
– to explain the processes of transcription and translation and the role of different molecules (DNA, RNA) and cellular organelles (ribosomes) in these processes;
– to distinguish between essential and non-essential amino acids and explain their role in nutrition and health;
– to explain the role of amino acids in the structure of enzymes and the importance of enzymes for biochemical processes in the organism;
– to explain how amino acids are linked by peptide bonds and to describe the levels of protein structure (primary, secondary, tertiary, quaternary).
Various activities carried out by students during the workshop encourage the development of intellectual abilities such as connecting, comparing, analysing, and logical reasoning. Through collaborative learning, students further develop communication and social skills that will be useful in their further education and professional development.
The effectiveness of the workshop is monitored through evaluation sheets and final test results.

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CONNECTING CITIZEN SCIENCE AND INQUIRY-BASED LEARNING: A PATH TO SCIENTIFIC LITERACY / *POVEZIVANJE GRAĐANSKE ZNANOSTI I ISTRAŽIVAČKOG UČENJA: PUT PREMA PRIRODOSLOVNOJ PISMENOSTI*

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Prirodoslovna pismenost predstavlja jedan od temeljnih ciljeva suvremenoga prirodoslovnog obrazovanja te obuhvaća sposobnost istraživanja prirodnih pojava, interpretiranja rezultata, razumijevanja prirodoznanstvenoga pogleda na svijet i uočavanja međusobne povezanosti znanosti i društva. Razvoj prirodoslovne pismenosti u nastavi biologije i prirode ostvaruje se kroz ishode usmjerene na istraživanje, argumentirano zaključivanje, kritičko vrednovanje informacija i primjenu znanstvenih spoznaja u svakodnevnom životu. U predavanju će se najprije prikazati sastavnice prirodoslovne pismenosti te njihova povezanost s odgojno-obrazovnim ishodima kurikuluma nastavnih predmeta Priroda i Biologija. Poseban naglasak bit će stavljen na istraživačko učenje kao jedan od ključnih pristupa razvoju prirodoslovne pismenosti. Polazeći od pretpostavke da većina učenika nije spremna samostalno provoditi cjeloviti istraživački proces, prikazat će se važnost postupnog osamostaljivanja učenika kroz pažljivo osmišljene aktivnosti i podršku učitelja. U nastavku će biti predstavljene osnovne značajke građanske znanosti te primjer nastavne prakse u kojem su aktivnosti građanske znanosti integrirane s istraživačkim učenjem u online okružju. Na primjeru će se pokazati kako sudjelovanje učenika u autentičnim istraživačkim aktivnostima može pridonijeti razvoju prirodoslovne pismenosti, istraživačkih vještina i razumijevanja znanstvenih procesa. Predavanje će također razmotriti povezanost opisanoga pristupa s kurikulom međupredmetne teme Učiti kako učiti, s naglaskom na razvoj samostalnosti, metakognitivnih strategija i odgovornosti za vlastito učenje. Posebna će se pozornost posvetiti ulozi vrednovanja u procesu istraživačkog učenja te načinima na koje vrednovanje za učenje i kao učenje može poduprijeti razvoj prirodoslovne pismenosti i kompetencije učiti kako učiti.

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ADVANCED METHODS OF EDUCATION IN WORKING WITH ADVANCED PUPILS AND STUDENTS - WORKSHOP / *NAPREDNE METODE EDUKACIJE U RADU S NAPREDNIM UČENICIMA I STUDENTIMA - RADIONICA*

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The workshop will present and analyze various teaching methods used with advanced mathematics and programming students—particularly when solving algorithmic problems. The aim of employing these methods was to enhance classroom engagement and focus on finding solutions—specifically, guiding students toward a state of deep concentration on the task at hand. These methods have been applied in work with advanced students at the primary, secondary, and university levels. The use of puzzles requiring logical reasoning led to a significant increase in motivation, attention, and focus. Research findings highlight the importance of selecting puzzles appropriate for the students' age and needs.

U radionici će biti navedene i analizirane različite nastavne metode korištene u nastavi s naprednim matematičarima i programerima, ponajviše pri rješavanju algoritamskih zadataka. Cilj primjene tih metoda bio je povećanje pažnje na nastavi, povećanje fokusiranosti na pronalaženje rješenja, tj. vođenje učenika i studenata u stanje što veće fokusiranosti na rješavanje zadatka. Navedene metode su korištene u radu s naprednim matematičarima i programerima osnovnih škola, srednjih škola i fakulteta. Primjenom zagonetki koje zahtijevaju logičko razmišljanje, postignuto je značajno povećanje motivacije, pažnje i fokusiranosti. Rezultati istraživanja pokazuju važnost odabira odgovarajuće zagonetke u skladu s dobi i potrebama učenika.

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HOW TO ENCOURAGE ACTIVE LEARNING IN STEM EDUCATION

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Active learning represents a central approach in contemporary STEM education, aiming to increase student engagement, deepen conceptual understanding, and foster the development of higher-order thinking skills. A growing body of research demonstrates that student-centered instructional strategies significantly improve learning outcomes compared to traditional lecture-based teaching.[1,2]

This workshop focuses on exploring a range of pedagogical strategies that promote active student participation, including problem-based learning, inquiry-based approaches, collaborative learning, and formative assessment techniques. Emphasis will be placed on designing learning environments that encourage questioning, experimentation, and peer interaction, thereby supporting the development of critical thinking and scientific reasoning skills.

In addition, the workshop will address the increasingly important role of digital tools and artificial intelligence in shaping modern teaching practices. Particular attention will be given to how AI can support personalized learning, provide immediate feedback, and facilitate the creation of adaptive and interactive learning experiences.[3] At the same time, participants will be encouraged to critically reflect on the pedagogical implications, benefits, and limitations of integrating AI into STEM education.

Participants will have the opportunity to exchange experiences, discuss practical challenges, and reflect on opportunities for implementing active learning strategies in their own teaching contexts. The workshop aims to support educators in developing innovative, inclusive, and effective approaches to STEM teaching that align with the demands of 21st-century education.

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LECTURES – STUDENT SECTION

SYNTHESIS OF CATIONIC IMIDAZOLE-BASED AMPHIPHILES WITH POTENTIAL ANTIMICROBIAL ACTIVITY

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In this study novel cationic amphiphiles based on quaternary ammonium compounds with potential antimicrobial properties were synthesized. Quaternary ammonium salts have found many applications across different fields such as greener solvents in synthesis and extraction procedures, lubricants, additives (in shampoos, fabric softeners, detergents etc.) and as antimicrobial agents. Quaternary ammonium salts interact with cell membranes of different microorganisms, they disrupt the structure of the cell membrane and ultimately lead to cell lysis. The structure of the quaternary ammonium slats dictates its antimicrobial properties. In this work different imidazolium-based quaternary ammonium salts were tried to be synthesized using a greener synthetic approach so called the “neat synthesis”. The reactions were conducted at room temperature without the use of the solvent which is in agreement with the principles of green chemistry. Also, antibacterial and antifungal properties of some of the synthesized compounds were evaluated.[1,2]

The obtained products were characterized using nuclear magnetic resonance (NMR) spectroscopy, infrared (IR) spectroscopy and mass spectrometry (MS). Changing the structure of quaternary ammonium salts impacts its physical and chemical properties. The tunable nature of quaternary ammonium slats allows the synthesis of compounds with virtually any desired characteristics.

The results demonstrate that “neat synthesis” can be successfully used to produce amphiphilic cationic compounds which can later be used in many different fields according to their properties.

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FULLY PRINTED SODIUM-SELECTIVE ELECTRODES: FABRICATION OPTIMIZATION AND ELECTROCHEMICAL EVALUATION

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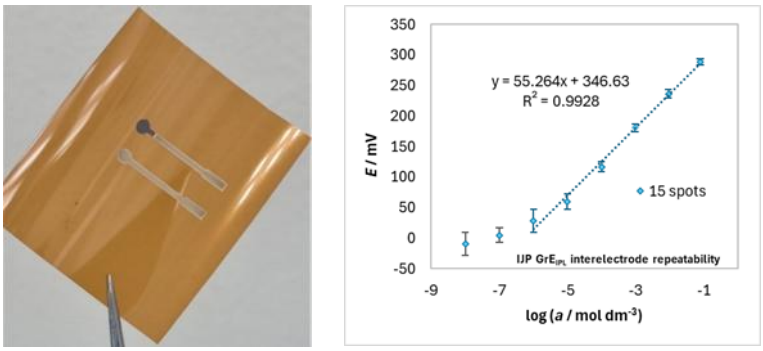
The main focus of this study was to fabricate solid-state potentiometric sensing platforms for on-site sodium ion detection using various printing techniques. Fabrication steps were optimized for achieving repeatability on a flexible surface. Automatically deposited silver ink and inkjet printed graphene ink were examined as working electrode materials. Additionally, intense pulse light (IPL) was investigated as means of achieving greater electrode capacitance to ensure a fast and reversible potentiometric signal transduction [1]. Electrochemical characterization of fabricated graphene electrodes was conducted before and after IPL treatment using cyclic voltammetry (CV) and electrochemical impedance spectroscopy (EIS). The effect of automatically deposited ion-selective membrane thickness on the potentiometric signal was analyzed on both electrode materials. Results show that IPL treatment considerably increases the capacitance of the graphene electrodes, which then results in greater stability of the potentiometric signal. The electrode capacitance before and after IPL treatment determined form the CV-s shows a 5 times greater value after IPL treatment. The optimized ion-selective electrode showed a near-Nernstian sensitivity of 55.3 ± 1.5 mV/log a_{Na}.



a) **b)**

Figure 1. a) DIW printed silver electrode and IJP graphene electrode, **b)** calibration analysis

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VOLTAMMETRIC DETERMINATION OF VANCOMYCIN ON CARBON BASED PRINTED ELECTRODES

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Vancomycin is an important glycopeptide antibiotic commonly administered in the treatment of serious Gram-positive bacterial infections, particularly methicillin-resistant *Staphylococcus aureus* (MRSA). Because of its narrow therapeutic range, reliable and accurate monitoring of vancomycin levels is necessary to reduce the risk of adverse effects such as nephrotoxicity, treatment failure and antibiotic resistance. Although conventional analytical methods, liquid chromatography and immunoassays, provide accurate measurements, they are often associated with high costs, lengthy analysis times and complex instrumentation requirements. Electrochemical sensing approaches could offer a cost-effective, sensitive and potentially faster alternative for vancomycin determination[1].

This study investigates the voltammetric determination of vancomycin using carbon based printed working electrodes. Differential pulse voltammetry (DPV) and square-wave voltammetry (SWV) were used for screening and optimization of experimental parameters in 50 µM vancomycin solutions in phosphate buffer (pH 7) containing 0.1 M KCl. The optimized DPV parameters consist of a scan rate of 20 mV/s, pulse duration of 0.01 s and pulse amplitude of 0.1 V. The influence of pH was evaluated in 50 µM vancomycin in phosphate buffer solutions ranging from pH 5 to 8, while repeatability was assessed at pH 7. Calibration was conducted at pH 7 over a concentration range of 1 µM to 10 mM to assess linearity of the response. Lastly, the applicability of the method for analysis of pharmaceutical formulations was tested using real samples of vancomycin infusions containing 3.365 mM vancomycin prepared with 0.9% NaCl and 5% glucose.

ACKNOWLEDGEMENTS This research was supported by the NextGenerationEU funded Institutional research project ADFABSENS (112103).

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SYNTHESIS OF SILVER(I) AND GOLD(III) COMPLEX COMPOUNDS WITH BIS-QUINAZOLINE DERIVATIVES

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This study focuses on the synthesis and characterization of silver(I) and gold(III) complexes with bis-quinazoline derivatives and will evaluate their potential biological activity. Bis-quinazoline complexes reported in the literature are known for their wide range of biological activities, making them relevant for further analysis. In addition, silver(I) and gold(III) complexes are also considered promising candidates for the development of biologically active compounds.

The synthesized silver(I) complex was characterized by TG/DSC and FT-IR spectroscopy, while the gold(III) complex was characterized by single-crystal X-ray diffraction analysis, TG/DSC and FT-IR spectroscopy. Method considered for the determination of biological properties of complexes is DNA nicking assay. Structural analysis revealed the coordination and geometry of the gold(III) complex and proposed structure of the silver(I) complex. The synthesized complexes exhibit high stability, high purity and good solubility in DMSO.

The results are a foundation for further investigation of the biological properties of the complexes.

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COFFEE-RING BASED FINGERPRINTING OF PHARMACEUTICAL FORMULATIONS

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The coffee ring effect, formed during evaporation-driven drying of sessile droplets, produces characteristic deposition patterns that reflect the physicochemical properties of dissolved substances. In this study, the phenomenon was investigated as a non-destructive approach for characterization and screening of pharmaceutical formulations containing pantoprazole as the Active Pharmaceutical Ingredient (API). Formulations were prepared using pure pantoprazole and mixtures containing sodium chloride (NaCl), sodium carbonate (Na_2CO_3) and boric acid (H_3BO_3) as excipients. The influence of excipient composition on drying behavior, particle redistribution, and final deposit morphology was systematically evaluated. Droplets were deposited onto glass substrates and dried under controlled environmental conditions to minimize external variability. The obtained drying patterns were digitized using automated microscopy and analyzed through image preprocessing, contour detection, radial profiling, and extraction of morphometric descriptors related to texture, symmetry, and spatial particle distribution. Computational analysis and machine learning approaches were applied to identify formulation-dependent morphological signatures. Distinct differences in evaporation-induced morphologies were observed between formulations, demonstrating that excipients strongly influence self-assembly processes during droplet drying. The results highlight the potential of coffee ring pattern analysis as a scalable, high-throughput, and non-destructive strategy for rapid pharmaceutical formulation screening and characterization.

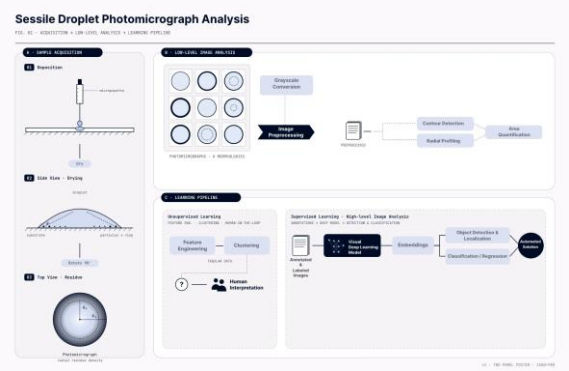

Figure 1. Workflow for acquisition, processing, and analysis of sessile droplet residues.

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NOVEL BISINDOLE SYSTEMS – SYNTHESIS AND ANTIMICROBIAL ACTIVITY

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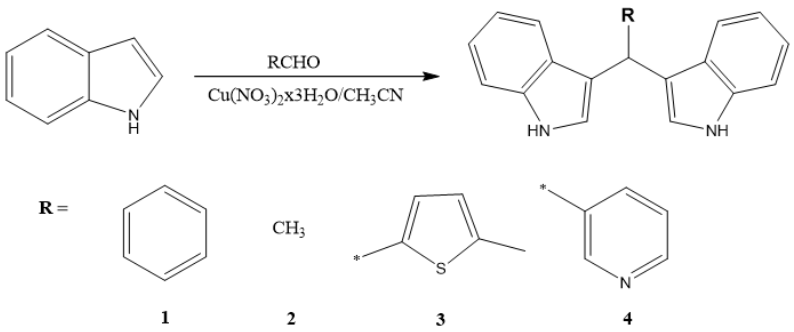
Indole, an important bioactive heterocycle, is present in numerous natural products, including the plant growth hormone, serotonin, tryptophan, and melatonin. Owing to the widespread occurrence of indole derivatives in nature, these compounds have attracted considerable attention in both organic and medicinal chemistry. A large number of indole-based drugs are being investigated for the treatment of pathological conditions such as bacterial, fungal, viral, tubercular, and HIV infections, as well as malaria.[1] Based on previous studies and their significant outcomes, this research is focused on the synthesis of novel bisindole derivatives and the evaluation of their biological activity. A practical and innovative approach for the synthesis of indole derivatives was applied using $Cu(NO_3)_2 \cdot 3H_2O$ as a catalyst. The applied protocol[2] provides several benefits, including the use of an easily available and inexpensive catalyst, mild reaction conditions at room temperature, good yields, high selectivity, and simple experimental procedures. The synthesized indole derivatives were evaluated in vitro for antibacterial activity against *Aspergillus niger*, *Bacillus subtilis*, *Candida albicans* and *Pseudomonas aeruginosa*, by the agar diffusion method. In addition, the possible inhibitory mechanism through which these compounds may act as antibacterial and antifungal drug candidates was investigated using *in silico* molecular docking studies.



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ELECTROSPINNING OF NATURAL POLYMERS IN THE DEVELOPMENT OF ADVANCED MATERIALS

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The increasing demand for sustainable and biologically safe manufacturing processes has intensified the search for environmentally friendly alternatives in nanomaterials engineering.[1] Electrospinning, despite its widespread use in the fabrication of nanofibrous membranes for tissue engineering, advanced coatings, and organ-on-a-chip systems, still predominantly relies on hazardous organic solvents.[2] Therefore, the development of green solvent systems for electrospinning of both natural and synthetic biocompatible polymers represents an important step toward safer, more sustainable, and application-ready biomaterial production. Polymer solutions containing synthetic polymers, as well as combinations of natural and synthetic polymers, were prepared in environmentally benign solvent mixtures. In parallel, fully natural polymer systems dissolved in green solvents were also investigated. To efficiently optimize electrospinning process, a Design of Experiment (DoE) methodology was implemented using Central Composite Design (CCD) for synthetic polymer and combination of polymers, Box Behnken method was used for natural polymer. The effects and interactions of applied voltage, flow rate and tip-to-collector distance and in case of natural polymer mass percentage of polymer were statistically modelled to achieve stable jet formation and reproducible micro- and nanofiber production. The resulting models were optimized using the response surface method. Membrane width, length and surface area were selected as critical variables during optimization in order to obtain most compact fiber mat. Scanning electron microscopy confirmed the formation of continuous and morphologically uniform fibers. Additionally, SEM micrographs reveal that the use of green solvents results in fewer fiber deformations and a smaller fiber diameter in comparison to fibers obtained in conventionally used solvents, which represents a significant advantage of this system. FTIR spectroscopy verified material identity and structural integrity, while confirming that there was no residual solvent. The obtained results demonstrate that acid-based green solvent systems enable the sustainable production of mechanically robust and structurally reproducible nanofibrous membranes.

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SYNTHESIS AND PHYSICOCHEMICAL CHARACTERIZATION OF A COPPER(II) COMPLEX WITH AN OXYGEN-DONOR LIGAND

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Hydroxypyranone-based ligands represent an important class of oxygen-donor compounds due to their strong coordination ability and broad relevance in coordination and bioinorganic chemistry. Maltol, as a representative member of this group, is capable of binding transition metal ions through its hydroxyl and carbonyl oxygen atoms, leading to the formation of stable chelate complexes.

In this study, a copper(II) coordination compound was prepared by reacting a Cu(II) salt with maltol under mild conditions in an aqueous medium. The isolated product was investigated using Fourier-transform infrared spectroscopy (FTIR), ultraviolet–visible spectroscopy (UV–Vis), powder X-ray diffraction (PXRD), and thermogravimetric/differential scanning calorimetry (TGA/DSC).

The spectroscopic results verified the coordination of maltol to the copper(II) center through oxygen donor atoms. Changes observed in characteristic vibrational bands indicated the participation of both hydroxyl and carbonyl groups in the coordination process. Thermal analysis revealed enhanced stability of the synthesized complex relative to the free ligand, while PXRD measurements confirmed the formation of a crystalline phase consistent with Cu(II) chelate compounds. Furthermore, UV–Vis data supported the presence of a coordination environment characteristic of copper(II) complexes containing oxygen-donor ligands.

Overall, the findings highlight the strong binding affinity of maltol toward copper(II) ions and provide additional insight into the structural and physicochemical features of Cu(II) coordination compounds.

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SYNTHESIS AND ANTIMICROBIAL ACTIVITY OF SCHIFF BASES

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Indole represents an important bioactive aromatic scaffold present in numerous natural products and drugs, including the amino acid tryptophan, the neurotransmitters serotonin and melatonin, as well as various alkaloids and anti-inflammatory agents. Owing to the wide range of documented biological activities of indole derivatives, such as antimicrobial, antitumour, anti-inflammatory and antifungal effects, the indole core is often used as a key pharmacophore in the design of new potential drugs.[1] Schiff bases constitute an important class of organic compounds formed by condensation of carbonyl compounds with primary amines, resulting in the characteristic azomethine C=N bond. Due to their straightforward synthesis, structural diversity and ability to form stable metal complexes, Schiff bases and their complexes exhibit a broad spectrum of biological activities, in particular antibacterial, antifungal, antitumour and antioxidant effects.[2] Based on these findings, the aim of this work is the synthesis of new indole-based Schiff bases and the evaluation of their antimicrobial activity. For this purpose, an indole aldehyde will be condensed with selected aromatic amines under mild reaction conditions, and the obtained products will be characterized by spectroscopic methods and tested *in vitro* against selected bacterial and fungal strains. It is expected that the synthesized indole derivatives of Schiff bases will display improved antimicrobial properties and serve as a starting point for the further development of new antimicrobial agents.

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ROUND TABLE

FINANCING SCIENTIFIC PROJECTS: FROM IDEA TO SUCCESSFUL IMPLEMENTATION

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Securing adequate and timely funding remains one of the most decisive factors shaping the quality, continuity and impact of scientific research. The round table "Financing Scientific Projects: From Idea to Successful Implementation" brings together researchers, research managers and representatives of funding bodies to examine the full life cycle of a scientific project — from the initial idea, through the competitive application process, to successful implementation and reporting.

The central focus of the discussion is the way in which available funds are allocated across the research system. Participants will consider the criteria and mechanisms currently used to distribute national and European funding, the transparency of evaluation procedures, and the balance between supporting excellence-driven basic research and thematically targeted programmes. Particular attention will be devoted to the dynamics and predictability of calls for proposals: irregular or infrequent calls, short submission deadlines and long evaluation periods significantly affect researchers' ability to plan their work, retain young scientists and maintain research group continuity.

A further key theme is the competitive position of scientists working at public research institutes compared with those employed at universities. Although both communities compete for the same funding sources, they operate under different institutional conditions — differing teaching obligations, overhead structures, administrative support and access to co-financing. The round table will explore whether the current competitive framework treats these two groups equitably, how institutional context influences success rates, and what forms of cooperation between institutes and universities could strengthen, rather than fragment, the national research base.

The discussion aims to formulate concrete recommendations for funders and policymakers: more predictable and regular funding cycles, clearer and more transparent allocation criteria, and support instruments tailored to the realities of both institute-based and university-based researchers, thereby improving the pathway from promising ideas to successfully completed projects.

POSTERS

DIFFERENTIATED APPROACH AS A KEY TO THE DEVELOPMENT OF GIFTED STUDENTS / *DIFERENCIRANI PRISTUP KAO KLJUČ RAZVOJA DAROVITIH UČENIKA*

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Gifted students represent a special group characterized by above-average abilities, high levels of creativity, and strong motivation for learning and achievement. Traditional teaching methods often fall short in fully meeting their educational needs, making differentiation in instruction essential. A differentiated approach allows educators to adapt content, teaching methods, learning pace, and assessment strategies to individual abilities and interests. This approach fosters the development of critical thinking, creativity, independence, and excellence across various competencies. This paper aims to highlight the importance of differentiated instruction as a key factor in supporting the intellectual, emotional, and social development of gifted students and creating a stimulating and inclusive learning environment. Differentiation involves enriching content, increasing complexity, and individualizing learning tempo through acceleration and independent projects. An interdisciplinary approach and the use of diverse resources, including advanced technologies, further enhance their educational experience. These strategies promote creativity, critical thinking, and autonomy, enabling gifted students to reach their full potential while contributing to societal progress.

Daroviti učenici predstavljaju posebnu skupinu učenika s iznadprosječnim sposobnostima, visokim stupnjem kreativnosti i izraženom motivacijom za učenjem i postignućima. Tradicionalni oblici nastave često ne mogu u potpunosti zadovoljiti njihove obrazovne potrebe, zbog čega je diferencijacija nastave od iznimne važnosti. Diferencirani pristup omogućava nastavnicima prilagodbu sadržaja, metoda rada, tempa učenja i načina vrednovanja individualnim sposobnostima i interesima učenika. Takav pristup potiče razvoj kritičkog mišljenja, kreativnosti, samostalnosti i izvrsnosti u različitim područjima kompetencija. Cilj ovog rada je istaknuti važnost diferencirane nastave kao ključnog čimbenika u podršci intelektualnom, emocionalnom i socijalnom razvoju darovitih učenika te stvaranju poticajnog i uključivog okruženja za učenje. Diferencijacija uključuje obogaćivanje sadržaja, povećanje složenosti i prilagodbu tempa učenja putem akceleracije i samostalnih projekata. Interdisciplinarni pristup i korištenje raznovrsnih izvora, uključujući napredne tehnologije, dodatno obogaćuju njihov obrazovni put. Ove strategije doprinose razvoju kreativnosti, kritičkog mišljenja i samostalnosti, omogućujući darovitim učenicima da ostvare svoj puni potencijal i pridonose napretku društva.

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USING THE SAME EXPERIMENT TO ACHIEVE DIFFERENT LEVELS OF LEARNING OUTCOMES

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This study presents an approach to chemistry teaching in which the same experimental activities are adapted to different educational levels in order to achieve age-appropriate learning outcomes. Three experiments were implemented in both primary and secondary school settings: conservation of mass demonstrated by popcorn popping, density and concentration concepts illustrated through a rainbow density column, and the reaction of eggshells with acids.

In primary school, students focused on observation, description of changes, and qualitative interpretation of experimental results. In secondary school, the same experiments were extended with quantitative measurements, calculations, and deeper chemical interpretation. During the popcorn experiment, students investigated the law of conservation of mass and additionally calculated the amount of water released during popping. In the density column experiment, primary school students prepared solutions using teaspoons as a measure, while secondary school students measured masses, determined densities, constructed the density column, and calculated the amount of dissolved substances. In the eggshell experiment, primary school students observed the reaction between eggshells and acetic acid, whereas secondary school students compared reactions with acetic, citric, and tartaric acids and interpreted the results using balanced chemical equations and stoichiometric relationships.

The results indicate that the use of the same experimental framework at different educational levels enables a gradual development of scientific understanding, experimental skills, and chemical reasoning. While younger students develop observation and inquiry skills, older students engage in quantitative analysis, data interpretation, and application of chemical concepts. Such an approach supports curriculum continuity and demonstrates how experimental work can be differentiated to achieve progressively more complex learning outcomes.

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TOXICITY OF CHEMICAL COMPOUNDS IN DEODORANTS AND ANTIPERSPIRANTS

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Personal hygiene is very important in the life of a modern person. Preventing sweating, unpleasant odors, and the unsightly appearance of sweaty clothing have become standard practices in maintaining personal hygiene. Deodorants are used to counteract the odour caused by the bacterial decomposition of skin secretions, while antiperspirants reduce sweat secretion by creating a barrier on the skin surface.[1]
However, how safe are the products offered on the market for our health? Do we read the labels on deodorants and antiperspirants? Do we understand the meaning of terms parabens, triclosan, phthalates, and propylene glycol that could be part of the cosmetic products? Should we choose a product based on its smell, composition or price?
This study aimed to investigate the chemical content of 10 spray deodorants, 10 stick deodorants, and 10 antiperspirants, as shown in the declaration of the cosmetic product. The data were collected at the local perfumeries. The 2D structures of the listed compounds and SMILES notations were found at the PubChem database (https://pubchem.ncbi.nlm.nih.gov/). Toxicity was predicted by aim of the ADMETlab 3.0 online platform (http://admet.scbdd.com). ADMET evaluation of chemicals is based on quantitative structure-activity relationship (QSAR) predictive model. In this study, we have calculated: cardiotoxicity; neurotoxicity; respiratory toxicity; nephrotoxity; toxicity to eye; skin corrosion and irritation; mutagenicity; ototoxicity; hematotoxicity; genotoxicity; and cytotoxicity.
The study has showed that some of the deodorants and antiperspirants contain potentially toxic substances that can cause the skin and eye irritation, as well as neurotoxicity. Particular attention should be paid to zinc salts and aluminium-based compounds, especially in stick deodorants. The majority of fragrance agents are terpenes, such as linalool, hexyl cinnamal, citronellol, limonene, geraniol, higher alcohols, and esters that also can induce skin sensitization and eye irritation, respiratory toxicity, and lung cytotoxicity.
In conclusion, deodorants and antiperspirants should not be avoided, but it is important to read the product declaration. Some applications on mobile phones (such as INCI Beauty) can also help us in this, by scanning the bar code, they read the most important ingredients and warn of their toxic effects.

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CHEMISTRY MEETS THE FUTURE: INTEGRATING INFORMATICS AND ARTIFICIAL INTELLIGENCE INTO CHEMISTRY EDUCATION THROUGH PROJECT-BASED LEARNING / *KEMIJA SUSREĆE BUDUĆNOST: INTEGRACIJA INFORMATIKE I UMJETNE INTELIGENCIJE U NASTAVU KEMIJE KROZ PROJEKTNU NASTAVU*

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Suvremena nastava kemije u osnovnoj školi mora učenicima ponuditi više od memoriranja formula — mora razvijati istraživački duh i digitalnu pismenost. U OŠ Vladimir Nazor u Čepinu razvijen je integrativni model u kojemu su učiteljica kemije Monika Pavić, učiteljica informatike Maja Jurić Babaja i školska knjižničarka Ivana Pavlin zajednički planirali aktivnosti, pratili napredak učenika i dokumentirali rad. Materijalnu osnovu projekta čini novoopremljeni kabinet biologije i kemije, obnovljen u sklopu projekta „Pametni laboratorij – STEM integracija za budućnost" koji financira Ministarstvo znanosti, obrazovanja i mladih RH. Učenici su izrađivali zbirke kemijskih pokusa, sustavno ih dokumentirali i objavljivali putem školskih profila na društvenim mrežama, a knjižničarka je pratila i bilježila napredak darovitih učenika.

Središnji dio projekta bila je primjena alata strojnog učenja: koristeći Google-ov alat Teachable Machine, učenici su prikupljali uzorke, trenirali AI model za prepoznavanje kiselih i lužnatih tvari i testirali njegovu točnost, spajajući kemijske pojmove s konceptima umjetne inteligencije na način primjeren osnovnoj školi. Paralelno, projekt BrAIn učenicima je omogućio upoznavanje s primjenama UI – od prepoznavanja deep fake videosadrtžaja do korištenja AI alata u kemijskim istraživanjima. Kroz eTwinning i Erasmus+ učenici su rezultate predstavljali vršnjacima iz Europe na engleskom jeziku, a projekt je kulminirao učeničkim radionicama kemijskih pokusa na STEAM festu 2026. i terenskom nastavom u Parku prirode Kopački rit.

Rezultati pokazuju značajan porast motivacije učenika za prirodne znanosti, razvoj digitalnih i istraživačkih kompetencija te pozitivan transfer znanja između predmeta. Izrađena zbirka pokusa, obogaćena AI modelima treniranim alatom Teachable Machine, trajni je nastavni materijal za buduće generacije. Ključan čimbenik uspjeha bila je međupredmetna suradnja triju učiteljica uz potporu EU projekata i MZO-a, što dokazuje da je održiva STEM integracija moguća i prenosiva na druge osnovne škole u Republici Hrvatskoj.

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BIOSTIMULANTS MODULATE THE ANTIOXIDANT ACTIVITY AND POLYPHENOLIC CONTENT OF BASIL (*OCIMUM BASILICUM* L.) HYDROETHANOLIC EXTRACTS

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There is an increasing need to adapt current plant production systems by reducing reliance on fertilizers and plant protection products, while implementing alternative strategies that are environmentally friendly and safe for human health. Biostimulants represent a promising solution, as their application enhances plant tolerance to abiotic stress and improves both yield and quality parameters[1]. Basil (*Ocimum basilicum* L.), an aromatic herb widely used for its flavor and fragrance, is also valued for its diverse range of bioactive compounds, which contribute to its potential health-promoting properties[2]. This study investigates the effects of foliar application of the biostimulant Bombardier (BT1), root drenching with the biostimulant Ryzo (BT2), and their combined application (BT3) on the antioxidant activity and polyphenol content of hydroethanolic basil extracts. The strongest antioxidant activity, assessed using the DPPH assay, was recorded in treatments BT2 and BT3, with IC_{50} values of 28.6 and 28.2 µg/mL, respectively. Treatment BT1 showed slightly reduced activity (IC_{50} = 29.6 µg/mL), whereas the control group (untreated plants) exhibited the lowest antioxidant activity (IC_{50} = 33.3 µg/mL). Biostimulants application also modulate polyphenol content. Compared to the control (11.8 µg GAE/mL), treatments BT2 and BT3 increased polyphenol content to 12.4 and 12.6 µg GAE/mL, respectively, while a lower value was observed in BT1 (10.6 µg GAE/mL). The results indicate that biostimulant treatments enhance the functional quality of basil hydroethanolic extracts by promoting the accumulation of bioactive compounds associated with the evaluated parameters. Root application and combined treatments proved more effective than foliar application alone, demonstrating their suitability as strategies for optimizing basil production. Such optimization aims to increase the content of bioactive compounds while reducing reliance on conventional practices.

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DIFFERENT POLARITY SOLVENTS EFFECT ON THE FLUORESCENT PROPERTIES OF SELECTED XANTHEN-3-ONE DERIVATIVES

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Numerous naturally occurring xanthenes and their derivatives have been shown to have important pharmacological and biological characteristics, including anticancer, antifungal, and antibacterial effects. Because of their favourable spectroscopic characteristics, xanthenes are well-known for their application as leuco-dyes, pH-sensitive fluorescent materials for biomolecule visualization, and in laser technologies. The UV/Vis and fluorescence spectra of the dye molecule demonstrate its interaction with a solvent at the molecular level. Knowledge of the pH and solvent effects on the spectra and the quantum yields of fluorescence is necessary for the utilization of these fluorescence materials to their maximum potential. The aim of this study was to investigate fluorescence properties of nine selected xanthene-3-one derivatives in four solvents of different polarity and three pH values. All tested substances fluoresce in each solvent, except the nitro derivative. Fluorescence characteristics of the compounds under test were noted in relation to substituent type, concentration, solvent polarity, and solvent acidity. Substances with an electron-donating substituent on the phenyl ring do not show a significant shift in the position of the emission maximum and fluorescence intensity compared to the unsubstituted derivative. In acidic media, the fluorescence intensity decreases compared to neutral media, except in ethyl acetate. In basic media, the emission maximum shifts to longer wavelengths and the fluorescence intensity decreases for most of the tested substances. The limits of detection and quantification were determined due to very strong correlation between fluorescence intensity and concentration in all four solvents and different pH. Based on the linearity, LD values were calculated, ranging from 0.1017 to 2.000 $\mu moldm^{-3}$, while LQ values range from 0.1175 to 6.6693 $\mu moldm^{-3}$. Since quenching of fluorescence occurred as concentration increased, the spectrofluorimetric assessment of concentration requires determining the concentration range in which this correlation is linear.

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INFLUENCE OF PRASEODYMIUM CONCENTRATION ON THE STRUCTURAL EVOLUTION OF DOPED CERIA-BASED HIGH-ENTROPY OXIDES

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High-entropy oxides (HEOs) represent a class of materials with significant potential for diverse applications due to their distinctive compositions and crystal structures. These single-phase solid solutions, typically composed of five or more principal metal cations in near-equiatomic ratios, exhibit remarkable structural stability arising from the random distribution of cations within the crystal lattice[1]. In this study, Ce–Zr–Pr–Sm–Eu-based high-entropy oxides with varying Pr concentrations were synthesized using a modified sol–gel citrate method to examine the effect of Pr incorporation on crystal structure, defect chemistry, and photocatalytic activity[2]. All synthesized samples retained a single-phase cubic fluorite structure, while progressive lattice expansion and increased microstrain were observed with increasing Pr content due to the substitution of smaller cations by larger Pr^{3+} ions. Morphological and surface analyses indicated the development of porous nanostructures at moderate Pr concentrations, whereas higher Pr levels promoted particle densification and reduced surface accessibility. Spectroscopic investigations confirmed the coexistence of Pr^{3+}/Pr^{4+} and Ce^{3+}/Ce^{4+} redox couples, significant 4f–2p orbital hybridization, and the generation of defect-related electronic states that contributed to bandgap narrowing. Under UV-light irradiation, the optimized Pr-containing composition achieved nearly complete degradation of methylene blue within 30 minutes. The enhanced photocatalytic performance is attributed to improved charge carrier separation, facilitated by the narrowed bandgap, together with efficient redox cycling between Ce and Pr species.

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SKELETAL MUSCLE LIPID FEATURES ANALYSIS IN AGED C57BL/6 MICE EXPOSED TO KETOGENIC DIET USING MALDI-TOF IMS

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Skeletal muscle is important for whole-body energy metabolism, but its lipid-related response to prolonged ketogenic diet (KD) exposure during aging remains insufficiently understood. The aim of this study was to investigate sex- and diet-specific lipid-related changes in the skeletal muscle metabolic profile of aged C57BL/6 mice exposed to KD using MALDI-TOF imaging mass spectrometry. Twelve-month-old C57BL/6 mice were divided into four experimental groups: standard diet (SDM) and ketogenic diet male (KDM), standard diet (SDF) and ketogenic diet females (KDF) for 12 weeks. MALDI-TOF imaging mass spectrometry (IMS) was performed in positive ion mode on skeletal muscle tissue sections within the m/z 300–700 range. Partial least squares discriminant analysis (PLS-DA) was used to assess group separation based on the overall m/z profile. Pairwise statistical comparisons were performed using the Mann–Whitney U test followed by false discovery rate correction to identify statistically significant m/z signals. Significant signals were further explored using METASPACE for tentative metabolite annotation. PLS-DA showed separation between groups, indicating that both sex and diet may contribute to differences in the skeletal muscle metabolic profile. Tentative annotation of significant m/z features suggested that KD exposure might be associated with changes in lipid-related molecular classes, including acylcarnitine-, glycerolipid-, lysophospholipid-, phospholipid-, fatty acid-related features. Diet-specific comparisons showed more pronounced lipid-related changes, which may indicate that KD induced a detectable shift in the skeletal muscle lipidomic profile, while sex-specific comparisons suggested distinct male and female responses to diet intervention. Overall, prolonged KD exposure in aged C57BL/6 mice may be associated with diet- and sex-specific changes in the skeletal muscle metabolic profile. These results might suggest alterations in fatty acid transport, glycerolipid metabolism and membrane phospholipid remodeling.

SYNTHESIS AND STRUCTURAL CHARACTERIZATION OF A COPPER(II) COMPLEX WITH AN OXYGEN-DONOR LIGAND

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Hydroxypyranone derivatives are well known oxygen-donor ligands with pronounced metal-binding ability and significant importance in coordination and bioinorganic chemistry. Among them, maltol readily coordinates transition metal ions through hydroxyl and carbonyl oxygen atoms, forming stable chelate complexes [1–3]. In this work, a copper(II) coordination compound was synthesized using a Cu(II) salt and maltol under mild reaction conditions in an aqueous medium. The obtained product was isolated and characterized by Fourier-transform infrared spectroscopy (FTIR), ultraviolet–visible spectroscopy (UV–Vis), powder X-ray diffraction (PXRD), and thermogravimetric/differential scanning calorimetry (TGA/DSC). Spectroscopic analyses confirmed successful coordination of the ligand to the Cu(II) center through oxygen donor atoms, while shifts in characteristic vibrational bands indicated the involvement of hydroxyl and carbonyl functional groups in complex formation. Thermal measurements demonstrated improved stability of the coordination compound compared to the free ligand, and PXRD data suggested the formation of a crystalline phase characteristic of Cu(II) chelate systems. UV–Vis spectra additionally supported the formation of a Cu(II) coordination environment typical for oxygen-donor ligands. The obtained results demonstrate the strong affinity of maltol toward copper(II) ions and contribute to a better understanding of the structural and physicochemical properties of Cu(II) coordination compounds.

ACKNOWLEDGEMENTS This research was funded by the European Union – NextGenerationEU, project "Advanced Interdisciplinary Approaches to Environmental Chemistry: From Materials to Sustainable Solutions for Pollution" (Grant number: 581-UNIOS-101).

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CHARACTERIZATION OF A POTENTIOMETRIC SENSOR BASED ON A MOLECULARLY IMPRINTED POLYMER MODIFIED WITH NANOPARTICLES FOR THE DETERMINATION OF THIABENDAZOLE

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Thiabendazole (THIA) is a benzimidazole fungicide widely used in agriculture to protect fruits and vegetables from fungal infections during storage and transport[1]. THIA residues frequently appear in various food products due to its widespread use. Although it exhibits relatively low acute toxicity, concerns remain about its long-term effects, as high levels of exposure are associated with potential carcinogenicity and thyroid dysfunction[2]. For this reason, it is crucial to monitor its concentration to reduce the potential risk to human health.

Traditional analytical techniques used for the determination of THIA, such as chromatographic methods, are the most commonly used and are known for their high sensitivity but involve complex sample preparation, expensive instrumentation, and significant solvent consumption[3]. These limitations have prompted the development of simpler and more cost-effective alternatives such as potentiometric ion-selective electrodes. They have attracted attention due to their ease of operation, fast response, and satisfactory analytical performance. The new potentiometric THIA-selective sensor is an ion-selective electrode with a liquid membrane. Its membrane contains a molecularly imprinted polymer (MIP) modified with nanoparticles as sensor material. Dibutyl phthalate was used as the plasticizer. The analytical performance of the THIA-selective sensor was characterized using direct potentiometry. Response characteristics, signal drift, dynamic response, influence of pH, and selectivity were evaluated. The new THIA-selective sensor shows very promising results for use in real samples.

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IMPACT OF THE PREPARATION METHOD ON THE SOLID–LIQUID EQUILIBRIUM DIAGRAM OF A HYDROPHOBIC EUTECTIC SOLVENT SYSTEM AS DETERMINED BY THE DIFFERENTIAL SCANNING CALORIMETRY

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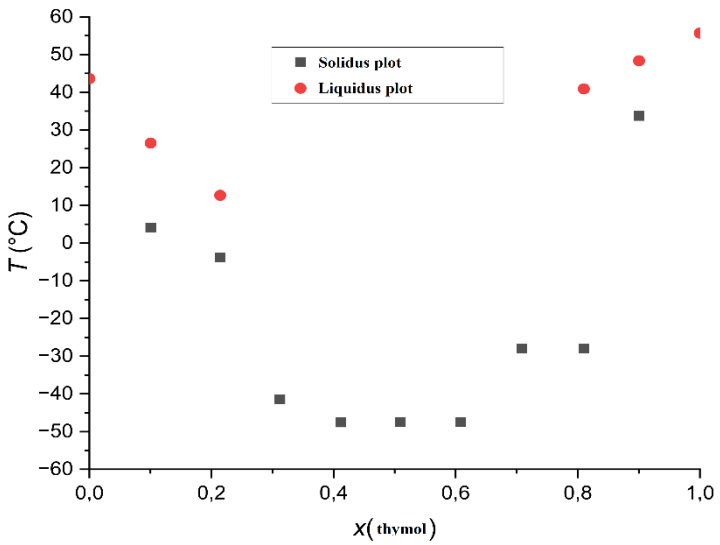
Commonly investigated nonaqueous deep eutectic solvents (DES) are hydrophilic which directs them to applications in analytical, medical and biochemical fields. They are easy to prepare and environmentally friendly. However, in this study a hydrophobic system consisting of thymol and L-menthol was studied. The usual starting point for physical chemical investigations in DES research is construction of the solid-liquid equilibrium phase diagram. In many systems, due to the structure of the molecules and the characteristics of the newly formed solution, new stable or metastable crystal structures may form from the components of the DES, which will cause changes in the appearance of the phase diagram. Such a system can no longer be considered truly binary. In this investigation, the hydrophobic DES was prepared in two ways: by mixing the components directly and by dissolving them in a common solvent, followed by the solvent evaporation. The prepared mixtures were analyzed by the differential scanning calorimetry method, and the differences in the obtained phase diagrams between the two preparation methods were noticed. The results are compared with the literature data[1-3].



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MICROWAVE-ASSISTED SYNTHESIS OF ADAMANTYL IMIDAZOLE DERIVATIVES

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Compounds classified within the imidazole (1,3-diaza-2,4-cyclopentadiene) group are characterized by a five-membered heterocyclic ring containing two nitrogen atoms. Owing to these structural features, imidazole derivatives possess significant importance in various scientific areas, especially in the pharmaceutical and medical fields. Due to their diverse biological activities, imidazole derivatives have attracted considerable interest as potential acetylcholinesterase (AChE) inhibitors. Besides pharmaceutical applications, AChE inhibitors are also widely recognized as active agents in insecticidal plant protection products[1]. In addition, butyrylcholinesterase (BuChE), a related cholinesterase enzyme with broader substrate specificity, is often evaluated alongside AChE to assess the inhibitory profile, selectivity, and potential safety of newly synthesized compounds in agrochemical and medicinal research[2]. In this study, the structural modification of imidazole derivatives is described, in which the adamantyl moiety was selected as the subunit for structural modification. Imidazole derivatives containing hydroxyl or amino groups were selected as starting materials for the synthesis, while adamantanecarbonyl chloride was used as the adamantane source. The compounds were prepared using both conventional synthetic methods and microwave-assisted synthesis by reacting the selected imidazole derivative with adamantanecarbonyl chloride in the presence of triethylamine. All synthesized compounds were characterized by melting points, ^{1}H, ^{13}C NMR spectroscopy, and mass spectrometry (MS). Target derivatives were synthesized with the aim of evaluating their potential application as AChE and BuChE inhibitors.

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DETERMINATION OF AMOXICILLIN IN PHARMACEUTICAL FORMULATIONS

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Antibiotics are widely used for the treatment and prevention of bacterial infections in both humans and animals, resulting in their extensive consumption and widespread presence[1]. Amoxicillin is β-lactam antimicrobial agent that is effective against a broad range of Gram-positive bacteria and provides additional activity against certain Gram-negative organisms[2]. Due to its extensive therapeutic application, the accurate determination of amoxicillin at low concentration levels is of considerable importance for quality control, stability studies, and the monitoring of pharmaceutical formulations. Various analytical techniques for amoxicillin determination have been reported, including capillary electrophoresis, UV spectrophotometry, high-performance liquid chromatography (HPLC), and liquid chromatography–mass spectrometry (LC–MS). Among these, HPLC is the most commonly employed technique because of its high sensitivity, reliability, and reproducibility. Despite its effectiveness, HPLC typically requires the use of relatively large volumes of organic solvents, creating challenges related to solvent consumption and waste management[3]. Therefore, the development of an HPLC method capable of accurately determining low concentrations of amoxicillin in pharmaceutical formulations while reducing organic solvent usage is of significant scientific and practical importance.

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SYNTHESIS AND CHARACTERIZATION OF GOLD NANOPARTICLES FOR PLASMONIC SENSORS

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Gold nanoparticles (AuNPs) exhibit unique optical properties due to localized surface plasmon resonance (LSPR), making them highly important for applications in plasmonic sensors, biosensors, and nanophotonics.[1] In this study, AuNPs were synthesized using the classical and modified Turkevich methods with different sodium citrate ratios ($Na_3Ct/HAuCl_4$ = 6.2, 1.25, and 0.89), while all other synthesis parameters were kept constant. The nanoparticles were characterized by UV–Vis spectroscopy, dynamic light scattering (DLS) and scanning electron microscopy (SEM).

The results show that decreasing the citrate concentration leads to an increase in nanoparticle size, a red shift of the plasmon resonance maximum toward longer wavelengths and broadening of the absorption peak. DLS analysis further confirmed the increase in the hydrodynamic particle diameter.

The obtained results demonstrate that citrate concentration significantly influences the optical properties of AuNPs and enables their tunability for applications in plasmonic sensing systems.

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KINETICS OF THE ANTIRADICAL ACTIVITY OF PHENOLIC COMPOUNDS FROM ARONIA AFTER DIGESTION

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Phenolic compounds exhibited antiradical activity in the gastrointestinal tract, which can be beneficial for health. The aim was to study the kinetics of the antiradical activity of phenolic compounds from aronia (*Aronia melanocarpa*) after their release during gastric and small intestinal digestion. Gastrointestinal digestion was conducted *in vitro*, antiradical activity was measured using the DPPH method, and results were analyzed with non-linear regression using modified first- and second-order reaction equations. The amount and recovery of phenolic acids, flavonols, anthocyanins, and total polyphenols significantly decreased from the gastric phase to the end of small intestinal digestion ($P<0.05$). Released phenolic compounds showed antiradical activity after digestion in the stomach (EC_{50} 7.29±0.56 µg of phenolic compounds) and small intestine (EC_{50} 2.43±0.05 µg of phenolic compounds), with stronger antiradical activity in the small intestine. The scavenging of 50% of DPPH radicals in the stomach was theoretically reached in up to 6.7 and 10 minutes, and in the small intestine in up to 3.8 and 4.3 minutes, according to first- and second-order kinetics, respectively. It can be suggested that, due to lower standard error, second-order kinetics better described free radical scavenging in the stomach and small intestine.

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A NEW FORMULATION OF POLYPHENOLS IN PCL NANOFIBERS FOR ENCAPSULATION AND POTENTIAL CONTROLLED RELEASE

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The growing demand for sustainable pharmaceutical manufacturing has intensified interest in replacing conventional toxic organic solvents with greener alternatives in electrospinning processes. In this study, poly(ε-caprolactone) (PCL) nanofibers were fabricated using acetic acid and formic acid as environmentally benign solvent systems for the encapsulation of structurally diverse polyphenolic phytopharmaceuticals - flavonoids (morin, quercetin), phenolic acids (ferulic, rosmarinic and gallic acid), and coumarin. These compounds share common formulation challenges, including poor aqueous solubility, oxidative instability, and low bioavailability, which electrospun nanofibers are well-positioned to address.[1] Acetic and formic acid were selected as green solvent alternatives due to their favorable toxicological profiles, biodegradability, and demonstrated ability to dissolve PCL and support stable fiber formation, in accordance with the principles of green chemistry.[2] Fiber morphology was examined by SEM, while FTIR, XRPD, and DSC were used to confirm the successful incorporation and physicochemical state of the entrapped polyphenols within the fiber matrix. SEM analysis revealed generally smooth and continuous fibers; however, the presence of beads along the fiber structure was also observed, indicating that further optimization of the electrospinning process is needed. Despite this, the physicochemical characterization confirmed successful loading of polyphenols into the fiber matrix, with the compounds retained in an amorphous state. The DPPH free radical scavenging assay demonstrated that the antioxidant activity of the encapsulated polyphenols was well preserved, indicating that neither the processing conditions nor the encapsulation within the fiber matrix compromised the bioactive properties of the polyphenols. Overall, the results confirm that green solvent-based electrospinning yields well-defined nanofibers with preserved chemical integrity and retained biological activity of the incorporated phytopharmaceuticals. These findings establish acetic and formic acid as viable and sustainable alternatives for the development of polyphenol-loaded PCL nanofiber systems with potential for controlled release applications.

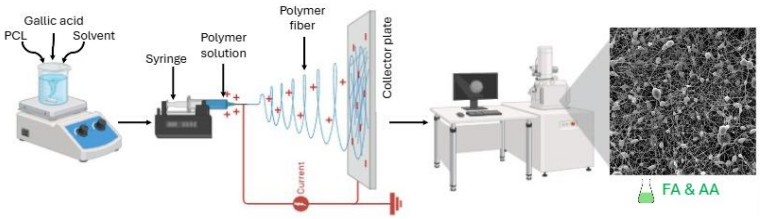

Figure 1. Electrospinning process of PCL/gallic acid nanofibers using green solvents

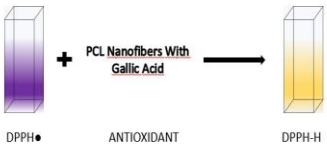

Figure 2. DPPH assay

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RELEASE OF ACTIVE SUBSTANCES FROM POTENTIAL TRANSDERMAL FORMULATIONS

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To overcome the limitations of traditional topical formulations, such as rapid removal from the skin and uneven drug absorption, this study develops an advanced multilayered transdermal system merging electrospun poly(ε-caprolactone) (PCL) nanofibers and 3D bioprinted chitosan/alginate hydrogels. While electrospun scaffolds typically mimic the natural extracellular matrix to support tissue regeneration, loading them with poorly soluble, Biopharmaceutics Classification System (BCS) Class II drugs like indometacin often yields a problematic, rapid burst release.[1,2]

In this work, indometacin was successfully encapsulated at a high 50% drug-to-polymer ratio within a uniform PCL matrix fabricated via electrospinning. This membrane was subsequently layered with a precisely engineered, 3D bioprinted polyelectrolyte hydrogel blend of chitosan and sodium alginate. The multi-layered composite was then ionically cross-linked with $CaCl_2$ to establish a diffusion barrier and prevent premature matrix swelling.

FTIR and optical microscopy confirmed excellent structural homogeneity, stable molecular physical dispersion, and strong electrostatic interactions between the biopolymers without any chemical degradation. Remarkably, *in vitro* dissolution testing under simulated physiological skin conditions pH = 5.6 demonstrated continuous, zero-order release kinetics (R^2 = 0.998) over a 24-hour period. The hydrogel barrier completely suppressed the typical initial burst effect, achieving a highly controlled drug release. This innovative hybrid platform unlocks outstanding potential for highly predictable, sustained localized therapy in managing chronic inflammatory and chronic skin conditions.

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ANTIDIABETIC POTENTIAL OF AQUEOUS SKIN EXTRACTS OF SELECTED RED GRAPE VARIETIES

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Red grape is one of the most widely cultivated fruits in the world. It is mostly grown for winemaking, but nowadays also wanted for fresh consumption due to being a rich source of phytonutrients. Polyphenols in grapes are mainly localized in the skin and seeds. With rich polyphenolic profile, grape skin extracts are considered excellent candidates for the development of nutraceuticals.[1] It has been shown that red grape skin is able to act against mammalian intestinal α-glucosidase and pancreatic α-amylase, emphasizing its antidiabetic potential.[2] We aimed to evaluate this potential for several red grape varieties grown in the Slavonia and Croatian Danube region, mainly used for fresh consumption. Experiments were conducted with five red grape varieties (Venus, Heike, Cardinal, Muscat Bleu and Kodrianka), collected from the Mandićevac experimental vineyard. The red grape skin extracts (RGSEs) were prepared via microwave-assisted extraction using water as solvent in 1:5 ratio (1 g of fresh skin weight to 5 mL of water). Inhibition of both enzymes was observed at low concentrations of all RGSEs, with α-amylase inhibition ranging from 56% to 81% and α-glucosidase inhibition from 72% to 94%. Notably, α-glucosidase was almost completely inhibited by an amount of extract corresponding to only 0.1 mg of fresh grape skin weight. Due to their stronger inhibitory effect on α-glucosidase, RGSEs could therefore moderate glucose release in the intestine without completely suppressing starch digestion. Among the tested varieties, Venus and Muscat Bleu exhibited the strongest antidiabetic potential, which was consistent with their higher total phenolic content. Although much of the antidiabetic activity of RGSEs can be attributed to polyphenols, further research is needed to characterize their polyphenolic profile through detailed qualitative and quantitative analyses.

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STRUCTURAL CHARACTERIZATION OF OLIGONUCLEOTIDES ON FUNCTIONALIZED GOLD NANOPARTICLES USING SERS SPECTROSCOPY

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Surface-enhanced Raman scattering (SERS) spectroscopy is a vibrational technique that enables the structural characterization of molecules located in close proximity to metal nanostructures.[1] SERS-active substrates are most commonly silver or gold nanoparticles stabilized by adsorbed ionic species, which often facilitate the adsorption of oppositely charged analytes and enhance their Raman signals. However, negatively charged biomolecules such as nucleic acids are difficult to investigate by SERS because they are electrostatically repelled by the negatively charged citrate ions commonly used to stabilize colloidal nanoparticles. One approach to overcome this limitation is the chemical attachment of oligonucleotides to metal nanoparticles, which positions the nucleotide chains near the metal surface and enables their structural characterization.[2]

In this study, spherical gold nanoparticles were synthesized and functionalized with selected thiol-modified oligonucleotides. Two oligonucleotide sequences differing in length and base composition were investigated: a 12-base oligonucleotide, d[CGCATTCAGGAT] (Oligo12), and a 24-base telomeric sequence, d[$(TTAGGG)_4$] (Tel24). The latter is particularly interesting because its guanine-rich sequence can adopt G-quadruplex conformations capable of inhibiting telomerase, an enzyme overexpressed in many cancer types.[3]

Following functionalization using a previously described procedure,[4] SERS spectra of the resulting nanoparticle suspensions were recorded with 785 nm excitation. Detailed spectral analysis enabled the proposal of oligonucleotide binding modes and orientations on the gold nanoparticle surface. The results demonstrate that nanoparticle functionalization provides a promising strategy for the structural characterization of negatively charged nucleic acids by SERS spectroscopy.

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THERMODYNAMICS OF NAPROXEN BINDING BY β–CYCLODEXTRIN

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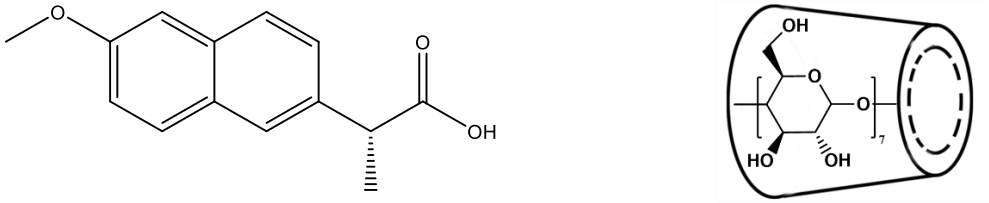
Naproxen (NPX) is a nonsteroidal anti-inflammatory drug (NSAID) widely used to treat pain and inflammatory conditions. Due to its relatively high lipophilicity (log P ≈ 3.2) and poor aqueous solubility, naproxen belongs to a class of drugs whose dissolution rate can limit absorption. Although it exists predominantly in its anionic form at physiological pH (pK_a ≈ 4.2), its solubility remains low in the acidic environment of the stomach. To address this limitation, cyclodextrins have been extensively studied as solubility-enhancing excipients. Cyclodextrins are cyclic oligosaccharides composed of α-(1→4)-linked glucopyranose units, characterized by a hydrophilic outer surface and a hydrophobic central cavity. This unique structure enables them to form non-covalent inclusion complexes with poorly soluble drugs such as naproxen, thereby improving their apparent aqueous solubility, dissolution rate, and bioavailability.
In this study, the complexation of naproxen with native β–cyclodextrin (β–CD) was investigated by isothermal titration calorimetry (ITC) in simulated intestinal medium (0.20 M phosphate buffer, pH 6.8). The results showed that NPX forms 1:1 inclusion complex with β–CD characterized by moderate affinity (log K =2.92 M^{-1} at 298 K). Thermodynamic analysis indicated that formation of the inclusion complex was both enthalpically and entropically favorable. Investigations over a temperature range (293–313 K) revealed a significant dependence of $\Delta_r H°(T)$ and $\Delta_r S°(T)$, resulting in almost complete enthalpy-entropy compensation.



NPX β–CD

Figure 1. Chemical structure of naproxen and β–CD.

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SYNTHETIC APPROACHES TO SURFACE-MOUNTED METAL-ORGANIC FRAMEWORKS USING VAPOR-PHASE PROCESSING

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Metal–organic frameworks (MOFs) are porous materials composed of metal ion clusters interconnected by organic linkers, forming crystallline or amorphous networks with high surface areas, tunable pore structures and chemical functionalities. These characteristics have made MOFs attractive candidates for gas storage and separation, catalysis, sensing, and energy-related applications.[1] While MOFs are traditionally synthesized as powders, their immobilization on solid substrates has become a key step toward applications. Surface-mounted MOFs (SURMOFs) combine the advantages of porous frameworks with improved stability and handling, in devices such as membranes, electrodes, sensors, and catalytic reactors etc.[2] Among the numerous MOF families, zinc- and iron-based MOFs (Zn- and Fe-SURMOFs) have attracted particular attention owing to their low cost and large potential in applications, such as CO_2 capture and utilization.[3]

In recent years, vapor-phase processing techniques, including chemical vapor deposition (CVD), atomic and molecular layer deposition (ALD/MLD), and related solvent-free methods, have emerged as alternative scalable and sustainable fabrication routes to conventional solution-based synthesis, such as solvothermal growth methods. The approaches that utilize precursors from the vapor phase provide superior control over film uniformity and conformality, and facilitate the integration of MOF thin films in advanced devices.[4]

Based on our previous results in the synthesis of photocatalytic metal oxide thin films by ALD and stepwise building of organic monolayers with free carboxylic groups on metal oxide substrates by MLD,[5] we aim to develop reliable synthetic routes to obtain stable Zn- and Fe-SURMOFs using ALD/MLD vapor-phase processes or combination between vapor- and solution-phase methods.

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BIOAVAILABILITY AND GASTROINTESTINAL STABILITY OF ERINACINE A FROM THE MUSHROOM *HERICIUM ERINACEUS*

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Erinacine A is a bioactive diterpenoid isolated from the mycelium of the mushroom *Hericium erinaceus* that exhibits significant neuroprotective and neurotrophic potential. Available preclinical studies suggest that erinacine A partially retains its chemical stability during gastrointestinal digestion and can be absorbed from the gastrointestinal tract following oral administration. Pharmacokinetic studies in animal models have demonstrated moderate oral bioavailability, with the compound being distributed to various tissues after absorption, including the brain and cerebrospinal fluid, confirming its ability to cross the blood-brain barrier. The highest concentrations were detected in the gastrointestinal tract and liver, indicating pronounced first-pass metabolism and possible biotransformation into active metabolites. Although current findings suggest that erinacine A possesses favourable pharmacokinetic properties for the development of functional preparations and neuroprotective strategies, data regarding its stability during human digestion, interactions with the gut microbiota and actual bioavailability in humans remain limited. Further clinical studies are required to more precisely determine its absorption, metabolism, and biological activity in the human body.

ACKNOWLEDGEMENTS This study was supported by the project “Studies of Bioactive Food Components with New Possibilities of Use for Healthy Nutrition and Nutritional Supplements” (BioActFood, NPOO 581-UNIOS-93), funded by the European Union-NextGenerationEU through the Recovery and Resilience Mechanism.

ATR-FTIR SPECTROSCOPY IN TRACKING LIPOREGULATORY AND ANTIOXIDATIVE EFFECTS OF (−)-EPICATECHIN IN A MASLD MODEL

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Metabolic dysfunction-associated steatotic liver disease (MASLD) is characterized by excessive lipid accumulation and oxidative stress. This study evaluated the preventive and therapeutic effects of (−)-epicatechin (EPI) on lipid peroxidation in an oleic acid (OA)-induced *in vitro* MASLD model using attenuated total reflectance–Fourier-transform infrared (ATR-FTIR) spectroscopy. HepG2 cells were exposed to 1.5 mM OA to induce steatosis and treated with EPI (10, 30, and 50 µM) as a pretreatment (preventive) or post-treatment (therapeutic). Extracted lipids were analyzed in the spectral range of 4000–650 cm^{-1}. Relative lipid peroxidation was evaluated using ester carbonyl (C=O) stretching (~1740 cm^{-1}) and unsaturated lipid (=C−H) stretching (~3010 cm^{-1}) intensities, normalized to total aliphatic lipid content (CH_2 stretching at 2922–2925 cm^{-1}) [1]. OA-treated cells showed dominant lipid bands at 2923, 2852, and 1740 cm^{-1}, indicating neutral lipid accumulation and enhanced peroxidation. In both models, EPI treatment induced concentration dependent decreases in CH_2 stretching and lower relative C=O intensities, while protein-associated amide I and II bands remained stable, indicating reduced lipid content without cytotoxicity. These changes strongly correlated with reduced triacylglycerol levels and LOOH/CD ratios. Overall, ATR-FTIR spectroscopy successfully identified molecular alterations in steatotic HepG2 cells, demonstrating that EPI effectively attenuates OA-induced lipid accumulation and oxidative modifications.

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IMPROVED STABILITY AND HYDROPHOBICITY OF SOLID-CONTACT POTASSIUM-SELECTIVE ELECTRODES USING PYROLYSED C_{60}@ZIF-67

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State-of-the-art potentiometric sensors are fabricated as electrically conductive layered structures consisting of a receptor that selectively interacts with an analyte, a transducer (solid contact, SC) that converts this interaction into a measurable signal, and electrical connection to a voltmeter. Their miniaturisable design makes them highly suitable for wearable and portable on-site devices. While receptor composition and structure are well established, increasing attention has been directed toward SC materials, as their chemical nature and deposition strategy critically influence potential stability, signal reproducibility, and long-term sensor performance[1].

Herein, fullerene C_{60} molecules were successfully entrapped within a cobalt-based zeolitic imidazolate framework (ZIF-67) using a rapid and environmentally friendly mechanochemical approach. The obtained composite, C_{60}@ZIF-67, was characterized by FTIR, PXRD and TGA analyses. To improve electrical conductivity and hydrophobicity, both ZIF-67 and C_{60}@ZIF-67 were pyrolysed at 520 °C. Morphological characterization showed that fullerene incorporation improves the structural integrity of ZIF-67 during pyrolysis. The performance of pristine ZIF-67 and C_{60}@ZIF-67 as SC materials was systematically evaluated in screen-printed potassium-selective electrodes (K-ISEs) before and after pyrolysis. Fullerene encapsulation significantly enhanced surface hydrophobicity, increasing the water contact angle from 82.8° for pristine ZIF-67 to 135.0° for C_{60}@ZIF-67. After pyrolysis, the contact angles further increased to 144.0° and 148.5° for ZIF-67 and C_{60}@ZIF-67, respectively.

The influence of fullerene encapsulation and pyrolysis on electrochemical properties was evaluated using electrochemical impedance spectroscopy (EIS) and potentiometric measurements. Low-frequency capacitance increased from 9.1 ± 1.3 µF for ZIF-67 to 14.1 ± 2.0 µF after C_{60} incorporation, with a further increase after pyrolysis (27.2 ± 0.6 µF). The combined effects of thermal treatment and fullerene encapsulation broadened the linear response range by one order of magnitude, improved the standard deviation of the standard electrode potential (< 1 mV), and lowered the detection limit of the fabricated K-ISEs.

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SOLID-STATE REACTION CALORIMETRY OF THE "GOLDEN RAIN" EXPERIMENT AND ITS HALIDE ANALOGUES

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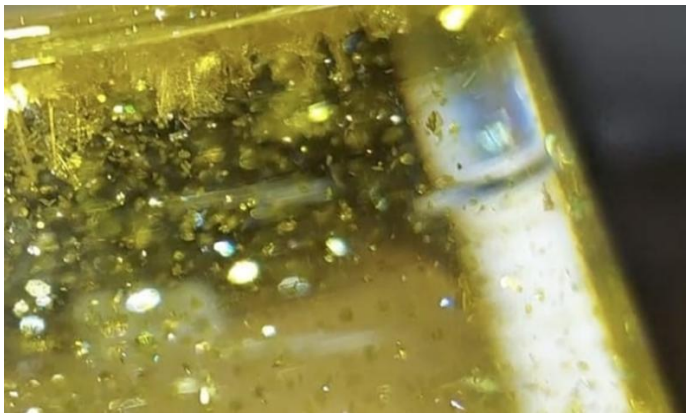
Compared with solution-based methods, solid-state syntheses can reduce solvent use, simplify work-up, give high reaction yields, and provide efficient access to crystalline products.[1] Although mechanochemistry has become an established field,[2] the thermodynamic characterization of solid-state reactions remains limited. A major obstacle is that conventional milling introduces additional heat,[3] which complicates direct interpretation of calorimetric measurements. As a result, solid-state reaction enthalpies are still commonly estimated indirectly through thermodynamic cycles,[4] with only a few examples of direct isothermal calorimetric measurements at room temperature.[5]

In this work, solid-state salt metathesis reactions between lead(II) nitrate and potassium halides, K**X** (**X** = Cl, Br, I), were studied by isothermal calorimetry at 25 °C under gentle mechanical agitation. The solid-state equivalent of the "golden rain" experiment was extended to chloride and bromide analogues, allowing the effects of halide identity, reactant ratio, and added liquid amount to be examined. Experiments with different reactant ratios and liquid amounts showed that even small changes can strongly affect reaction progress and the measured heat. Despite practical difficulties caused by a mixing system originally designed for solutions, the determined reaction enthalpies are in good agreement with literature data.[6] These results support further development of isothermal calorimetry as a faster and greener approach to studying solid-state reaction thermodynamics.



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WEARLYZE - RESEARCH AND DEVELOPMENT OF RFID-BASED SMART TEXTILE SYSTEMS FOR PREDICTIVE WORKWEAR LIFECYCLE MANAGEMENT

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This project focuses on developing two innovative solutions for smart lifecycle management of workwear and protective clothing: SmartStitch and PredictTex. SmartStitch addresses the challenge of detecting physical wear in safety-critical garments by integrating passive RFID components into textile structures, where changes in RF response can serve as indicators of material degradation, without the need for batteries, active sensors, or additional equipment for the user. PredictTex is being developed as a digital platform for predicting the optimal replacement time of workwear based on contextual data, including usage conditions, material characteristics, procurement history, maintenance cycles, and environmental factors.
Together, these solutions enable a shift from reactive and interval-based replacement practices toward data-driven, context-aware, and proactive management of textile equipment. In current industrial practice, decisions on garment replacement are often based on visual inspection, fixed usage periods, or washing cycles, while the actual condition of the textile material remains unknown. Wearlyze addresses this gap by combining passive RFID-based monitoring with predictive models derived from research data, allowing organizations to make more accurate decisions about safety, maintenance, procurement, and replacement planning. The project contributes to improved occupational safety by supporting earlier identification of potentially compromised protective clothing, particularly in sectors where garment functionality directly affects user protection, such as firefighting, energy, chemical, mining, industrial, and public service environments. At the same time, the project supports operational efficiency by reducing unnecessary replacement of functional garments, improving inventory planning, and enabling better integration with existing enterprise systems such as ERP, PIM, and asset management platforms.
Wearlyze also promotes sustainability and circular economy principles by extending the useful life of textile products, and creating a more transparent basis for planned collection, replacement, reuse, or recycling of worn-out workwear.

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REGENAIR – RESEARCH AND DEVELOPMENT OF REGENERATIVE AIR FILTRATION SYSTEMS FOR VOC REMOVAL AND CRITICAL INFRASTRUCTURE PROTECTION

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This project focuses on developing two innovative air filtration solutions, VOClean and AirFort, designed to enhance the sustainability, efficiency, and safety of industrial and infrastructure air treatment systems. VOClean addresses the removal of volatile organic compounds (VOCs) from emissions in industrial processes, particularly in the wood-processing and coating/painting sector through regenerative filtration technologies that reduce waste generation and operational costs. AirFort is being developed to provide advanced air purification and monitoring in protective shelters and critical infrastructure facilities, ensuring reliable protection against harmful airborne contaminants.

Both systems integrate smart sensors and digital monitoring platforms that enable continuous tracking of filtration performance, early detection of system failures, and optimization of maintenance activities. This approach improves energy efficiency, extends filter lifespan, and supports compliance with increasingly stringent environmental regulations.

The project promotes the transition toward circular and low-emission industrial processes by enabling filter regeneration and reuse, thereby reducing hazardous waste and resource consumption. In addition to environmental benefits, the developed technologies enhance the resilience of critical infrastructure and contribute to healthier indoor and outdoor air quality.

Through close cooperation between industry and research institutions, the project creates the technical and validation basis for commercialization of advanced filtration technologies, strengthens innovation capacity, and supports European objectives related to environmental protection, digitalization, industrial competitiveness, and climate neutrality.

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APPLICATION OF DIFFERENT SOFTWARE TOOLS FOR ASSESSING THE GREENNESS OF FOUR NOVEL ANALYTICAL METHODS

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This research was conducted with the goal to assess the greenness of the four analytical methods and procedures: a High Performance Liquid Chromatography with Diode Array Detection, a Microchip electrophoresis with capacitively coupled contactless conductivity detection, a Capillary electrophoresis with UV-VIS detection and a Capillary electrophoresis – nanoElectrospray ionization – mass spectrometry method. To do that, AGREE and GAPI software have been used which are based on the well-known and widely accepted twelve principles of green (analytical) chemistry.

A method assessment was done by the analysis of available data on the assessed methods. After that, pictograms for the abovementioned methods were made in order to visualise the results.

The final results show that such evaluations can help to compare different methods, to point out their advantages and disadvantages and to give some guidance in which direction methods should be further developed to achieve better greenness results.

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BIOCHEMICAL CHARACTERISATION OF THE DPP III–KEAP1 INTERACTION AND ITS ROLE IN NRF2 PATHWAY REGULATION

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Dipeptidyl peptidase III (DPP III) is a zinc-dependent exopeptidase involved in peptide degradation and various physiological processes, including the regulation of oxidative stress. Following its identification as a component of the Keap1 (Kelch-like ECH-associated protein 1) interactome, DPP III was shown to modulate the Keap1–Nrf2 signalling pathway through competitive binding to the Kelch domain of Keap1 via its ETGE motif [1,2]. By disrupting the Keap1–Nrf2 interaction, DPP III promotes Nrf2 activation, thereby enhancing the cellular antioxidant response. While this mechanism is protective under physiological conditions, elevated DPP III expression and sustained Nrf2 activation have been associated with tumor progression and resistance to therapy in several cancers, including breast, lung, and colorectal cancer [1,3].

To data, the catalytic and moonlighting functions of DPP III have largely been investigated independently. In this study, we employed an integrated experimental and computational approach to determine whether catalytic inactivation of DPP III influences its interaction with the Kelch domain of Keap1. Our aim was to elucidate the interplay between the enzymatic and moonlighting functions of DPP III and assess their potential impact on the Keap1–Nrf2 signaling pathway. To achieve this, we combined recombinant protein expression and purification, site-directed mutagenesis, isothermal titration calorimetry (ITC), molecular dynamics (MD) simulations, and binding free-energy calculations. Using wild-type DPP III and catalytically inactive DPP III variant, both in ligand-free and peptide-bound state, we investigated how catalytic inactivation affects the structural and thermodynamic determinants of DPP III–Kelch recognition and complex stability. Our findings indicate that both catalytic inactivation and ligand binding alter the conformational dynamics of the ETGE-containing loop responsible for Keap1 recognition, providing new insights into the relationship between the enzymatic and moonlighting functions of DPP III. Furthermore, these results advance our understanding of DPP III–Keap1 interactions and may support the development of novel strategies for modulating the Keap1–Nrf2 signalling axis.

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APPLICATION OF ADSORPTION PROCESSES IN THE INVESTIGATION OF POLYPHENOL–DIETARY FIBER INTERACTIONS IN GASTROINTESTINAL TRACT

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Polyphenols and dietary fibers are important food components whose interactions may influence the stability, bioaccessibility, and potential biological activity of polyphenolic compounds. Polyphenols have been associated with numerous beneficial effects on human health. However, due to their chemical degradation in the upper gastrointestinal tract, interactions with dietary fibers may improve their stability and enable their delivery to the colon. Polyphenol–dietary fiber interactions can be investigated as colon-targeted delivery systems for bioactive compounds and potential therapeutic agents. Adsorption processes can be used to study these interactions, while different adsorption models can be applied to describe the binding behavior. In this study, adsorption was applied to study interactions between polyphenols and dietary fiber. Since factors such as pH and temperature may affect adsorption, the interactions were studied under different pH and temperature conditions. Experimental data were fitted using adsorption models, including Langmuir, Freundlich, and Dubinin–Radushkevich models. The results showed that the adsorption process was dependent on both pH and temperature. The chemical structure of polyphenols and the dietary fibers influenced their binding affinity. These findings provide insight into adsorption mechanisms of polyphenol and dietary fiber interactions and may contribute to a better understanding of the behavior of polyphenols in gastrointestinal tract.

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NITROXOLINE AS A MODULATOR OF BACTERIAL ADHESION ON URINARY CATHETER SURFACES: PRELIMINARY INSIGHTS INTO SURFACE-DEPENDENT ANTIBIOFILM ACTIVITY

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The increasing prevalence of antimicrobial resistance has renewed interest in repurposing older antimicrobial agents with unique mechanisms of action. Nitroxoline (5-nitro-8-hydroxyquinoline, NTX), a small heterocyclic molecule historically used for the treatment of urinary tract infections (UTIs), has recently attracted considerable attention due to its broad antimicrobial spectrum and low resistance rates.[1] Unlike conventional antibiotics that target specific cellular processes, NTX primarily acts through metal-ion chelation, depriving microorganisms of essential divalent cations involved in numerous metabolic and regulatory pathways. Beyond its antimicrobial activity, NTX has been reported to interfere with bacterial adhesion and biofilm formation, making it a promising candidate for controlling biomaterial-associated infections.[2]

In the present study, the anti-adhesion and antibiofilm activity of NTX was investigated using *E. faecalis*, one of the major pathogens causing catheter-associated UTIs. Four bacterial strains were used, including two vancomycin-resistant isolates. Biofilm formation was evaluated on uncoated and silicone-coated latex urinary catheters in the presence of subinhibitory concentrations of NTX (16 μg/mL and 32 μg/mL) after 24 h and 72 h of incubation.

The results demonstrated marked strain-dependent differences in biofilm formation and response to NTX treatment. Significant variations were observed between uncoated and silicone-coated catheter surfaces for several strain/treatment combinations, indicating that the anti-adhesion activity of NTX is influenced not only by bacterial characteristics but also by the physicochemical properties of the underlying material. These findings suggest a complex interplay between the chelation-driven biological effects of NTX and surface-mediated adhesion phenomena.

To gain mechanistic insight into these observations, ongoing work focuses on the physicochemical characterization of catheter surfaces through surface free energy determination and atomic force microscopy. The correlation of these parameters with microbiological data is expected to clarify how surface chemistry and topography modulate the anti-adhesion performance of NTX and contribute to the development of antibiofilm strategies for urinary catheter materials.

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EVALUATED TOXICITY OF NOVEL SERIES OF IMIDAZOLES

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The derivatives of imidazoles show wide range of biological activities such as antibacterial, antimycobacterial, anti-inflammatory, antitumor. Many drugs contain an imidazole ring, such as certain antifungal drugs, the nitroimidazole series of antibiotics, and the sedative midazolam. Toxicity evaluation is essential for minimising failures and reducing time consumption in the drug discovery process. We have performed toxicity evaluation on a series of 31 newly synthesized. Toxicity was predicted by aim of the ADMETlab 3.0 online platform that is freely accessible (http://admet.scbdd .com). ADMET evaluation of chemicals is based on a comprehensively collected database, while for the developing quantitative structure-activity relationship (QSAR) predictive model, six different modelling algorithms were used.[1] In this study, we have calculated: cardiotoxicity; neurotoxicity; respiratory toxicity; nephrotoxity; toxicity to eye; skin corrosion and irritation; mutagenicity; ototoxicity; hematotoxicity; genotoxicity; and cytotoxicity. Lowest toxicity was predicted for the *N*-hexyl (**29c**) derivatives of 2-(1*H*-imidazol-1-yl)acetamide. For compound **29c**, a high probability was predicted only for skin sensitisation and eye irritation. The two most toxic derivatives, with high predicted probabilities of hepatotoxicity, carcinogenicity, nephrotoxicity, ototoxicity, genotoxicity, and cytotoxicity, are the propyl and ethyl derivatives of imidazolyl adamantane (**2** and **13**). According Free ADME-Tox Filtering (FAF-Drugs4) role for identifying potential protein-protein interaction (PPI) inhibitors, compound **29c** has one alert structural fragment (1-methyl-1*H*-imidazole), (Figure 1a), while compound **2**, along with that alerting structural feature has adamantane core (Figure 1b). Although the adamantane core, an important structural fragment implicated in toxicity, is present, adamantane derivatives have proven to be very potent compounds in a wide range of pharmaceutical applications. However, compound **29c**, which stood out as the safest compound, is a promising candidate for further drug development.

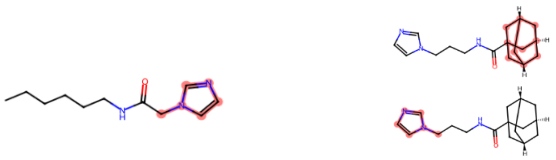

Figure 1. An important structural fragment implicated in toxicity for **29c** (left) and **2** (right).

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OPTIMIZATION OF ENZYMATIC GREEN SYNTHESIS OF ZnO NANOPARTICLES BY DESIGN OF EXPERIMENT

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Enzyme-assisted green synthesis of zinc oxide nanoparticles (ZnO NPs), performed under mild conditions using environmentally benign reagents, represents a sustainable alternative to conventional synthetic routes for water treatment applications. In this study, a systematic Design of Experiments (DoE) strategy was employed to optimize the principal synthesis variables, including precursor concentration, plant extract/bioreductant ratio, pH, temperature, and reaction time, with the objective of controlling nanoparticle size to maximize photocatalytic performance, antimicrobial activity, and colloidal stability while minimizing ZnO leaching and environmental impact. A fractional factorial design was used to identify the most influential parameters, followed by response surface methodology based on a central composite design to determine their optimal levels and predict parameter combinations required to obtain nanoparticles with targeted dimensions. This data-driven approach established a robust and scalable green synthesis protocol for ZnO nanoparticles with high treatment efficiency and reduced ecological risk, providing a foundation for sustainable and field-deployable ZnO-based water treatment technologies.

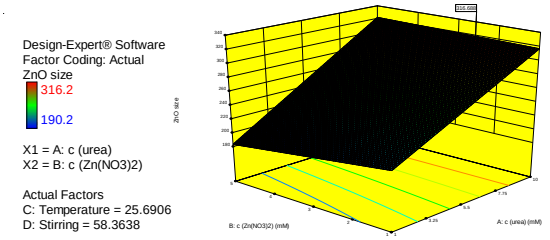

Figure 1. Impact of process parameters (temperature and stirring) on the size of ZnO nanoparticles

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OPTIMIZATION OF THE MEMBRANE COMPOSITION OF A MOLECULARLY IMPRINTED POLYMER-BASED POTENTIOMETRIC SENSOR FOR FLUCONAZOLE DETERMINATION

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Fluconazole or 2-(2,4-difluorophenyl)-1,3-di(1*H*-1,2,4-triazol-1-yl)-2-propanol, is a widely used triazole antifungal compound, mostly active against *Candida* species[1]. Considering its persistence, mobility, and resistance to conventional wastewater treatment processes, it can be found in natural waters worldwide[2]. Therefore, its determination in pharmaceutical formulations and environmental samples is crucial. Various analytical methods can be used for this purpose, but they often require expensive instrumentation, complex and time-consuming procedures, and toxic solvents. Potentiometric sensors can be a good alternative due to their simplicity, accuracy, and selectivity. In order to obtain a sensor with enhanced performance, its membrane, which is the key component responsible for its analytical properties, can be modified using a molecularly imprinted polymer.

The new potentiometric sensor for fluconazole determination based on a molecularly imprinted polymer was developed. Its membrane was optimized by varying the type of plasticizer and the content of the sensing material. Direct potentiometry was used for its characterization. Based on the results, the sensor with the optimal analytical performance was selected.

ACKNOWLEDGEMENTS The project is funded by the European Union − Next Generation EU under the number 581-UNIOS-105.

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OPTIMIZATION OF $FAPbI_3$ PEROVSKITE SOLAR CELLS WITH A $BaTiO_3$ LAYER

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In the past decade, perovskite organometal halides have become the leading thin film material for the development of next-generation solar cells. In this study[1] we added a layer of $BaTiO_3$ between the TiO_2 electron transport layer and the perovskite absorber using spin coating method. This layer should affect the local electric field, enhance the extraction of electrons from the perovskite layer, and thus increase the current and performance of the perovskite solar cell (PSC). We produced a device which had an FTO/TiO_2/$BaTiO_3$/$FAPbI_3$/spiro-OMeTAD/Au architecture (Figure 1) with an experimental power conversion efficiency (PCE) of 11%. Theoretical simulations were performed using SCAPS-1D software[2]. Firstly, SCAPS was used to fit the experimental curve, and then to optimize the PSC parameters that can affect its performance (thickness of the BaTiO3 and absorber layers, doping, and defect concentration). The results indicated that after the optimization the PCE could reach a value of 14.71%. If we further assumed an ideal structure of the PSC with a low impact of interlayer resistivity, our device could theoretically reach over 20% in efficiency. This verifies that the $BaTiO_3$ layer can drastically improve the PSC performance and can be used in future research as a promising material for optoelectronic devices.

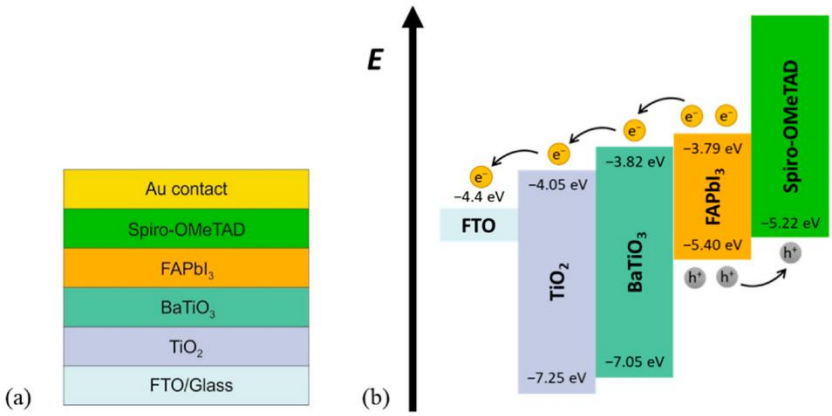

Figure 1. (a) Solar cell structure and (b) band diagram.

ACKNOWLEDGEMENTS This work has been supported by Croatian Science Foundation, HRZZ-IP-2018-01-5246.

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EFFECTS OF WATER SOURCE AND CO-FORMULANTS ON SPIROTETRAMAT AGAINST GREEN PEACH APHID

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The green peach aphid, *Myzus persicae* (Sulzer), is a globally distributed pest with high reproductive capacity and a broad host range, making its control challenging. Spirotetramat, a systemic insecticide from the spirocyclic tetramic acid group, is widely used against aphids and other sucking pests. Because spirotetramat is susceptible to alkaline hydrolysis in aqueous solutions, its efficacy may be influenced by water quality and formulation components. This study evaluated the effects of different water sources and co-formulants on spirotetramat degradation and efficacy against *M. persicae*.

Sprays were prepared using analytical-grade spirotetramat and the commercial formulation Movento with ultrapure water, tap water, rainwater, and river water (Drava). Samples were stored in the dark at room temperature for 7 days and analyzed at 9 time points up to 168 h after preparation. Efficacy against *M. persicae* was assessed using the IRAC Susceptibility Test Method 019 with peach leaves.

Water source significantly affected spirotetramat persistence and aphid control. Degradation rates increased in the order: ultrapure water < tap water < rainwater < river water. Co-formulants reduced degradation but did not significantly affect efficacy. Among sprays containing analytical-grade spirotetramat, the lowest efficacy was observed with tap water, whereas rainwater yielded the lowest efficacy in Movento sprays. These findings highlight the importance of water quality in pesticide spray preparation and performance.

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IN VITRO BIOLOGICAL ACTIVITY OF NOVEL SERIES OF IMIDAZOLES

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Imidazoles are compounds well known for their diverse biological activities. Their mode of action is primarily associated with the disruption of insect hormonal systems through the inhibition of juvenile hormone and ecdysone biosynthesis, leading to developmental abnormalities, premature metamorphosis, and mortality. In addition to their insecticidal properties, many commercially available imidazoles are widely used as fungicides due to their pronounced antifungal activity. Their selectivity, relatively low toxicity, and potential for synergistic interactions with other pesticides make imidazoles promising candidates for the development of new pesticidal agents.[1] Cholinesterase inhibitors have important applications in both medicinal chemistry and agriculture. In medicine, they are widely used in the treatment of Alzheimer's disease, while in agriculture they serve as active ingredients in plant protection products designed to control insect pests.[2]

In this study, eighteen newly synthesized imidazole derivatives were evaluated as potential acetylcholinesterase (EC 3.1.1.7) and butyrylcholinesterase (EC 3.1.1.8) inhibitors using a modified Ellman's method.[3]

The highest inhibitory activity against butyrylcholinesterase was exhibited by compound **1a** (87.13 %), with an IC_{50} value lower than that of the standard inhibitor galantamine.

ACKNOWLEDGEMENTS This work was supported by the Croatian Science Foundation under the project number HRZZ-IP-2024-05-6164 "Innovative Approaches in the Development of Imidazoles for Plant Protection".

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RECENT ADVANCES IN ELECTROCHEMICAL LAB-ON-CHIP BIOSENSORS FOR BISPHENOL A MONITORING IN THE ENVIRONMENT

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The increasing presence of endocrine-disrupting compounds (EDCs) in the environment is a major concern for ecosystem stability, water quality, and human health [1]. Among these contaminants, Bisphenol A (BPA) is one of the most extensively studied pollutants due to its widespread use in various products and industries. Although conventional analytical techniques provide reliable and accurate BPA detection, they often require complex laboratory infrastructure, trained personnel, time-consuming sample preparation, and expensive instrumentation. These limitations restrict their use for rapid, on-site, and continuous environmental monitoring.

In response, electrochemical biosensors integrated with lab-on-chip (LOC) technologies have emerged as promising analytical platforms for sensitive, selective, and portable real-time detection of BPA in environmental samples. Electrochemical biosensors offer several advantages, including low detection limits, rapid response, cost-effective analysis, and compatibility with miniaturised sensing systems. LOC platforms further enhance these benefits by enabling reduced sample and reagent consumption, automation, microfluidic control, and integration of multiple analytical steps into compact devices. The aim of this work is to describe recent developments in electrochemical lab-on-chip biosensors for Bisphenol A detection in environmental systems, with particular emphasis on analytical performance, sensor design, portability, and suitability for rapid field-based monitoring.

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INFLUENCE OF GIBBERELLIN TREATMENTS ON PHENOLIC AND ANTHOCYANIN CONTENT IN MUSCAT HAMBURG GRAPE SKINS

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Muscat Hamburg (Black Muscat) is a red grape cultivar widely appreciated for fresh consumption due to its favorable storage potential and moderate transportability.[1] Gibberellins (GAs) are naturally occurring plant hormones that promote cell division and elongation, thereby influencing fruit development and potentially modulating plant stress-response mechanisms. In grapevine cultivation, GA application has been associated with increased berry size, enhanced seedlessness, reduced cluster compactness, and improved overall fruit quality.[2] In the present study, a GA*4+7* formulation (a mixture of gibberellins GA_4 and GA_7) was applied to Muscat Hamburg grapevines at two developmental stages: pre-bloom (treatment 1) and fruit set (treatment 2). Untreated vines served as the control (treatment 0). Following harvest, berries were stored in a cooling chamber at 3 °C for 0, 14, or 28 days. Aqueous extracts of berry skins were prepared from all treatments and analyzed for total phenolic content (PC) and total anthocyanin content (AC). Berries from the pre-bloom treatment exhibited the highest PC and AC values, which were maintained even after 28 days of cold storage. In contrast, GA application at the fruit-set stage resulted in lower PC and AC levels compared with the untreated control. These findings indicate that pre-bloom application of a GA*4+7* mixture may be an effective strategy for enhancing the phenolic and anthocyanin composition of Muscat Hamburg grape skins.

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Part of the research was conducted within the Wine Analytics Research Group at Julius Kühn-Institute - Federal Research Center for Cultivated Plants, Institute for Grapevine Breeding, Siebeldingen, Germany.

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JOINT INFLUENCE OF MEDIUM COMPOSITION AND PHENOL OXIDASE INDUCTION ON FUNGAL NANOPARTICLE BIOSYNTHESIS

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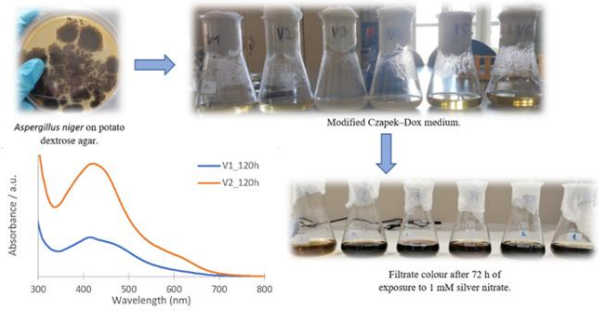
Green synthesis has attracted growing interest as an environmentally sustainable alternative to conventional chemical approaches for nanoparticle production[1]. Within biological systems, fungal-mediated biosynthesis of silver nanoparticles (AgNPs) is particularly appealing due to its high efficiency in reducing metal ions and its inherent capacity to secrete biomolecules that stabilize the resulting nanoparticles[2]. This study examined whether enhancing phenol oxidase activity in the growth medium could improve the rate and yield of AgNP biosynthesis by the filamentous fungus *Aspergillus niger*. Six variants of Czapek–Dox medium were formulated using sucrose, starch, or glucose as carbon sources. Phenol oxidase induction was introduced in variants 2, 4, and 6 through supplementation with copper(II) sulfate, oak sawdust, and hydrogen peroxide. *A.niger* was cultivated in each medium for 72 hours, after which the biomass was transferred to ultrapure water to promote the release of extracellular metabolites. Following an additional 72-hour incubation period, the biomass was removed and 1 mM silver nitrate was added to the resulting cell-free filtrates. AgNP formation was monitored over 120 hours using UV–Vis spectroscopy. Functional groups associated with nanoparticle synthesis were characterized by FTIR, while XRD analysis confirmed the crystalline structure. A characteristic surface plasmon resonance peak of AgNPs was observed at approximately 420 nm across all variants. Media supplemented with phenol oxidase inducers exhibited higher absorbance values and faster nanoparticle formation kinetics. FTIR results indicated the presence of protein-, enzyme-, and carbohydrate-related functional groups involved in nanoparticle capping, whereas XRD confirmed the crystalline nature of AgNPs in all samples. Overall, phenol oxidase induction enhanced the rate of AgNP biosynthesis without altering nanoparticle structure. These findings suggest that optimization of culture conditions is a key factor for scalable production and industrial applications.



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BREAKING RESISTANCE BARRIERS: NISIN'S ANTIMICROBIAL AND ANTI-BIOFILM POTENTIAL AGAINST KEY PATHOGENS

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Nisin, easily the most studied lantibiotic, is a 37-amino-acid peptide produced by *Lactococcus lactis*. It is used as a food preservative, and it has high bactericidal activity against a wide range of Gram-positive bacteria. Nisin inhibits bacterial replication by binding to the pyrophosphate moiety of lipid II, an important precursor in bacterial cell wall synthesis. Biofilm formation was assayed in 96-well polystyrene microtiter plates by slight modification of method described by Stepanović et al.[1] Clinically relevant bacteria, represented by adequate ATCC strains, were inoculated in Mueller-Hinton broth. Nisin was added to the wells in serial dilution from 256 to 0.5 µg/ml for Gram-positive and from 2048 to 4 µg/ml for Gram-negative strains and yeasts. After incubation, the wells were observed to evaluate MIC (minimum inhibitory concentration) and washed three times with PBS (phosphate-buffered saline). The biofilm was then stained with 0.2% CV (crystal violet). The plates were rinsed thrice with PBS and then dried. After drying, 96% ethanol was added to the wells to dissolve the dye. OD (optical density) at 550 nm was measured with a microtiter plate reader. MIC was detected for all tested strains. For Gram-positive bacteria it was in range from 4 to 16 µg/ml, while for Gram-negative bacteria and yeasts was 1024 µg/ml, except for *A. baumannii*, whose MIC was 32 µg/ml. Significant biofilm reduction was observed for *S. aureus*, *E. faecalis* and *A. baumannii*. On the other hand, *K. pneumoniae*, *P. aeruginosa,* and *C. albicans* showed both reduction and increased production of biofilm depending on nisin concentration. *E. coli* showed no significant difference in biofilm production or reduction. Results indicate that nisin has stronger antimicrobial activity on Gram-positive bacteria than on Gram-negative bacteria. Antibiofilm activity was detected against most of tested strains, but certain sub-MIC concentrations of nisin can increase biofilm production.

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BIOPROSPECTING OF THE ADRIATIC SEA BROWN ALGAE *CYSTOSEIRA BARBATA*

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Marine invertebrates and algae are rich sources of bioactive secondary metabolites. Brown algae of the genus *Cystoseira* have recently gained attention for pharmaceutical exploitation[1,2], but studies on the biological activities of Adriatic Sea *Cystoseira barbata* extracts remain scarce, with most research focusing on its ecology[3] and distribution[4].
We performed bioactivity-guided fractionation of dichloromethane (DCM) and methanolic (MeOH) organic extracts of *C. barbata*. The *in vitro* antiproliferative and cytotoxic effects were evaluated in three human cancer cell lines (A375 melanoma, A549 lung carcinoma, SW620 colon carcinoma) and one normal human cell line (HEK293 embryonic kidney). Qualitative chemical screening identified major compound classes. Fractions were further purified using column chromatography and preparative thin-layer chromatography. The DCM extract showed stronger cytotoxic effects than the MeOH extract across all cell lines. Notably, the DCM extract exhibited a lower IC50 value in SW620 cancer cells compared to HEK293 normal cells, indicating selective activity against colon carcinoma. In contrast, for A375 and A549 cells, the IC50 values of both DCM and MeOH extracts were higher than in HEK293 cells, showing no selectivity for these cancer types. Phytochemical screening revealed terpenoids, alkaloids, and steroids in the DCM extract, while the MeOH extract contained only steroids.
The DCM extract of *C. barbata* demonstrates selective cytotoxicity against SW620 colon cancer cells relative to normal HEK293 cells. Further investigations will focus on assessing the bioactivity of purified fractions, isolating the active metabolites responsible for this selective effect, and testing the extracts against a broader panel of cancer cell lines.

ACKNOWLEDGEMENTS This research was funded by the Croatian Government and the European Union, through the European Regional Development Fund – the Competitiveness and Cohesion Operational Program (KK.01.1.1.01), for funding this research through the project Sustainable Bioprospecting of Organisms from the Adriatic Sea for Innovative Natural Products (KK.1.1.10.0001) - BioProCro, granted to the Center of Research Excellence for Marine Bioprospecting.

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MULTICOMPONENT MECHANOCHEMICAL SYNTHESIS OF 2,3-DIHYDROQUINAZOLIN-4(1*H*)-ONE DERIVATIVES WITH ANTIBACTERIAL EVALUATION

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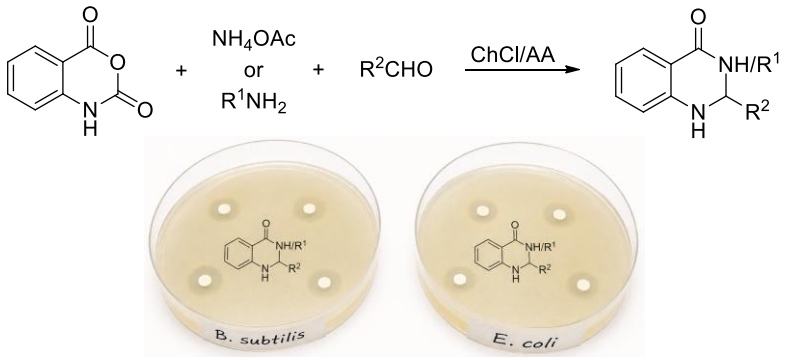
2,3-Dihydroquinazolin-4(1*H*)-ones are an important class of nitrogen-containing heterocycles that have attracted considerable attention due to their structural diversity, synthetic versatility, and broad biological potential.[1,3] In line with current interest in more sustainable synthetic methodologies, this work describes the multicomponent mechanochemical synthesis of several 2,3-dihydroquinazolin-4(1*H*)-one derivatives and their antibacterial evaluation. The target compounds were prepared from isatoic anhydride, selected aromatic aldehydes, and either ammonium acetate or aromatic amines. During the optimisation stage, several catalysts were evaluated, and the reaction was also carried out without a catalyst to determine suitable conditions for efficient product formation. Among the catalytic systems tested, choline chloride: ascorbic acid showed the most favourable effect and was therefore used in the further synthesis of the target compounds. The results obtained further support the usefulness of mechanochemistry as a simple and practical approach to the preparation of quinazolinone derivatives.[2] The synthesised compounds were subjected to antibacterial testing against *Bacillus subtilis* and *Escherichia coli* to assess their antibacterial profile.



ACKNOWLEDGEMENTS This study was supported by the project “Studies of Bioactive Food Components with New Possi-bilities of Use for Healthy Nutrition and Nutritional Supplements” (BioActFood, NPOO 581-UNIOS-93), funded by the European Union -NextGenerationEU through the Recovery and Resilience Mechanism.

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COPPER(II) COMPLEXES WITH MIXED OXYGEN- AND NITROGEN-DONOR LIGANDS: SYNTHESIS AND PHYSICOCHEMICAL CHARACTERIZATION

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Copper(II) complexes containing oxygen- and nitrogen-donor ligands have attracted considerable attention due to their structural diversity and potential biological activity. In this work, copper(II) coordination compounds with chromone and pyridine ligands were synthesized using different copper salts as metal precursors [1,2]. The obtained complexes were characterized by Fourier-transform infrared spectroscopy (FTIR), powder X-ray diffraction (PXRD), ultraviolet–visible spectroscopy (UV–Vis), and thermogravimetric/differential scanning calorimetry (TGA/DSC). Spectroscopic analyses confirmed successful coordination of chromone and pyridine ligands to the Cu(II) center through oxygen and nitrogen donor atoms. Differences observed in the vibrational and electronic spectra suggested that the nature of the copper precursor influences the structural organization and physicochemical properties of the resulting complexes. Thermal analysis demonstrated the formation of stable coordination compounds with characteristic decomposition pathways, while PXRD measurements indicated the presence of crystalline phases in the synthesized materials. The obtained results contribute to a better understanding of the coordination behavior of Cu(II) ions toward mixed oxygen- and nitrogen-donor ligands and provide a basis for further investigation of their structural and potential functional properties.

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STRUCTURAL TRANSFORMATION OF GRAPHENE BASED SCREEN-PRINTED ELECTRODES DURING ELECTROCHEMICAL ACTIVATION

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Screen-printed electrodes (SPEs) and carbon-based electrochemical sensors have been widely studied owing to their affordability, ease of manufacturing, and wide range of applications.[1] However, the electronic properties of carbon materials, including graphene, depend strongly on their surface orientation and defect distribution. Specifically, there are two types of electrochemically active surfaces of graphene – basal and edge planes. Basal planes are characterized by high chemical stability and poor electron transfer, while edge planes are more electrochemically active.

Electrochemical activation is a commonly employed method to improve the analytical performance of carbon-based materials by increasing the number of available edge sites.[2]Electrochemical activation involved cyclic voltammetry (CV) or chronoamperometric treatments of work electrode in electrolyte solutions.[3] As a result, these methods caused partial oxidation and reorientation of graphene, leading to higher heterogeneous electron transfer rates (HETR) and significantly decreased charge transfer resistance (R_{ct}).

The research mainly deals with the electrochemical activation of screen-printed electrodes of graphene-based ink. The idea is that electrochemical activation will promote the realignment of graphene flakes from the basal to the edge plane, thereby improving electron-transfer kinetics. Techniques such as Cyclic Voltammetry (CV) and Electrochemical Impedance Spectroscopy (EIS), along with X-Ray Photoelectron Spectroscopy (XPS), X-ray diffraction, Raman Spectroscopy, SEM, and TEM, have been employed to measure these effects. The results provide some insight into the electrochemistry of graphene-coated electrodes and their use in sensor development.

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ANNUAL TRENDS OF TOTAL VOLATILE ORGANIC COMPOUNDS IN INDOOR AND OUTDOOR AIR IN RURAL AND URBAN AREAS

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Volatile organic compounds (VOCs) are air pollutants of concern due to their health impacts and their role in forming secondary pollutants[1]. Studies have shown that indoor VOC concentrations are often higher than those outdoors, and can also exhibit significant seasonal and spatial variations, with seasonal, spatial, and environmental factors playing an important role in their distribution[2]. This study investigated annual variations in total volatile organic compounds (TVOCs) in both indoor and ambient air in rural and urban households. Sampling was conducted monthly from May 2024 to April 2025. In the urban area, samples were collected at nine locations within the city of Zagreb, whilst in the rural area, samples were collected at eight locations across the Virovitica-Podravina County. The results show that the highest total VOC concentrations were observed in urban indoor air, with a mean of 339.7 μg/m³ and a median of 235.7 μg/m³ in February. In the rural area, the highest concentrations were measured in outdoor air, with a mean of 208.6 μg/m³ in July and a median of 180.2 μg/m³ in September.

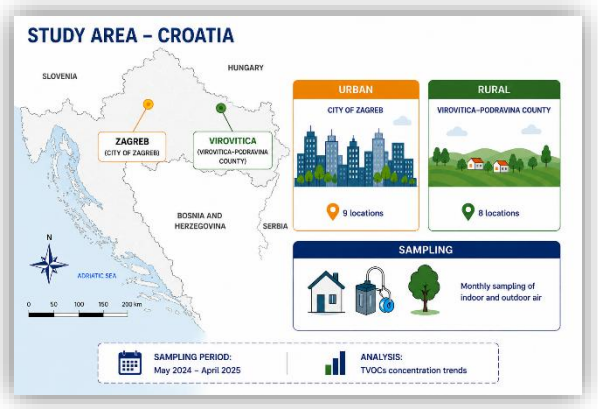

Fig. 1. Study design and sampling overview

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DESIGN AND FABRICATION OF A LUNG-ON-A-CHIP SYSTEM: INTEGRATION OF MEMBRANES, HYDROGEL COMPONENTS AND SENSORS FOR FUNCTIONALITY MONITORING

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There is growing interest in developing alternatives to animal testing due to its high costs, ethical concerns, and limited ability to accurately predict human responses to drugs. In this context, *organ-on-a-chip* systems have emerged as promising microfluidic platforms capable of mimicking human organ physiology and pathology in vitro. One of the first successful examples was the *lung-on-a-chip* (LOC) model, which reproduced complex alveolar functions using alveolar epithelial and endothelial cells separated by a porous membrane. These models enable evaluation of inhaled therapeutic while allowing real-time monitoring.[1] To achieve physiological relevance, a LOC model should replicate essential features of the alveolar-capillary barrier, including controlled fluid flow mimicking blood circulation, realistic breathing frequency of 12-20 breaths/min and cyclic mechanical stretching of lung tissue.[2]
The aim of this research was to develop a functional in-house lung-on-a-chip platform, allowing complete oversight and control of the development process from initial design to final implementation. Using CAD-based design, a compact LOC housing was developed in which the compartments were separated by an electrospun PCL membrane mimicking the alveolar basal membrane. A hydrogel layer simulating connective tissue was deposited via bioprinting, resulting in a porous structure that supported mass transport within the system. Furthermore, cyclic air suction and release in the upper chamber reproduced breathing-associated airflow and membrane deformation. To mimic blood circulation, a controlled flow of Simulated Body Fluid (SBF) was introduced into the lower chamber. In addition, a flexible inkjet-printed pH sensor, enabled real-time monitoring of environmental conditions within the system.[3] This study demonstrated the diffusivity and transport capability of the developed LOC system, while also confirming the compatibility and functionality of the developed sensors under dynamic conditions simulating the respiratory microenvironment.

ACKNOWLEDGEMENTS This paper was funded by the Croatian Science Foundation through the project IP-2024-05-4339 entitled "'Coffee ring' effect in 'Lab on a Chip' environments in the development of new drug formulations" (leader prof. Ernest Meštrović) and by the University of Zagreb Institutional research project "Advanced fabrication technologies of (bio) chemical sensors and lab-on-a-chip devices" (112103).

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DESIGN AND SYNTHESIS OF TAILORED CATIONIC AMPHIPHILES

Aleksandar Čeke Trišler,[a] Nikolina Filipović,[a] Hanna Zhukouskaya,[b,c] Martin Hrubý, [c] Jiří Pánek, [c] Nikola Sakač[d], Brunislav Matasović,[a] Marija Jozanović[a]

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This study focuses on the synthesis of novel cationic amphiphiles based on quaternary ammonium compounds using a mechanochemical approach. Quaternary ammonium salts are well-known for their wide application as surfactants and antimicrobial agents. In this work, cationic amphiphiles were synthesized via a two-step process involving quaternization of imidazole derivatives followed by anion exchange (metathesis) with sodium tetraphenylborate. The reactions were carried out using a planetary ball mill, enabling solvent-free conditions in accordance with the principles of green chemistry. Mechanochemistry offers significant advantages such as reduced solvent use, lower energy consumption, shorter reaction times, and improved atom economy. [1-3]

The obtained products were characterized using nuclear magnetic resonance (NMR) spectroscopy, infrared (IR) spectroscopy, mass spectrometry (MS), and X-ray diffraction (XRD) analysis. The structural design of the synthesized compounds allows modulation of amphiphilic properties, which directly influence their surface activity and potential biological effects.

The results demonstrate that mechanochemical synthesis is an efficient and environmentally friendly method for the preparation of cationic amphiphiles with potential applications in catalysis, electrochemistry, and as antimicrobial or biologically active agents.

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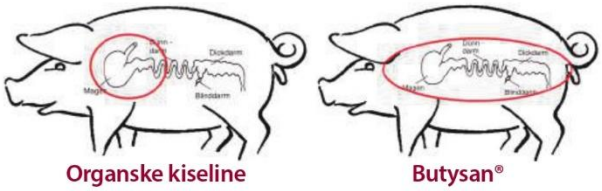

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Masena spektrometrija s induktivno spregnutom plazmom (ICP-MS) je tehnika u kojoj se induktivno spregnuta plazma koristi kao ionizacijski izvor, a detekcija se vrši masenom spektrometrijom.

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Sustavi za tekućinsku kromatografiju (LC) uspješno razdvaja tvari na osnovi razmještanja između čvrste stacionarne faze i tekuće mobilne faze.

Sustavi za plinsku kromatografiju - masenu spektrometriju (GC/MS) omogućuju brzu identifikaciju nepoznatih komponenti i preciznu kvantitativnu analizu, čak i za komponente u tragovima.

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Vanquish Horizon UHPLC system

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Dionex ICS-6000 HPIC sustav

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NeverVent tehnologija omogućuje zamjenu kromatografske kolone u samo 35 minuta bez narušavanja vakuuma, te zamjenu ionskog izvora u svega 5 minuta.

TSQ 9610 Triple Quadrupole GC-MS

KARAKTERIZACIJA ČESTICA

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Dinamička analiza slike (DIA) suvremena je metoda karakterizacije čestica za određivanje raspodjele veličine i parametara oblika. Omogućuje brze analize uz iznimnu točnost i ponovljivost u vrlo širokom mjernom rasponu.
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Camsizer X2+

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Nanotrac Flex

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MASENA SPEKTROMETRIJA S INDUKTIVNO SPREGNUTOM PLAZMOM (ICP-MS)

ICAP TQ ICP-MS

Portfelj Thermo Scientific ICP-MS instrumenata uključuje jednostruke kvadrupole (ICP-MS SQ), trostruke kvadrupole (ICP-MS TQ) te visokorezolucijske masene spektrometre (ICP-MS HR). Fleksibilnost i jednostavnost uporabe, u kombinaciji s visokom osjetljivošću i stabilnošću, čine ih idealnima za rutinske i zahtjevne analize.

OPTIČKA EMISIJSKA SPEKTROSKOPIJA S INDUKTIVNO SPOREGNUTOM PLAZMOM (ICP-OES)

iCAP PRO XPS ICP-OES

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