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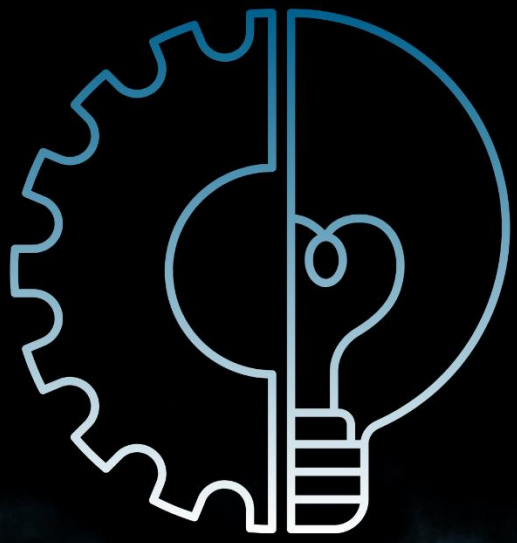

BOOK OF ABSTRACTS

ORLEN FUNDACJA

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Anna Martin

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PLENARY LECTURE

Inventions and Discoveries Don’t Know Their Field

Katarzyna Grochowska[1], **Katarzyna Siuzdak**[1]

[1]Institute of Fluid-Flow Machinery, Polish Academy of Sciences, Fiszera 14, 80-231 Gdańsk, Poland
e-mail: kontakt@sciemce-mission.pl

The lecture explores why the most fascinating discoveries occur at the intersection of different disciplines rather than within the strictly guarded boundaries of a single field. Using examples of accidental discoveries from "super-strong" glue that was actually so weak it was used for sticky notes, to the discovery of sweetener because someone licked an unknown substance in a laboratory (which we do not recommend!), to the power of microwaves discovered when a chocolate bar hidden in a pocket melted, we will show how a lucky break must find fertile ground. We will answer the question of whether inventing an artificial pancreas, a glucose sensor, or an intelligent dressing would be possible if someone drew knowledge from only one field. With humor but without sugarcoating, we will talk about what a scientific career "between" disciplines looks like, why it is worth being interdisciplinary, and show what came out by accident in our laboratory.

ORAL PRESENTATIONS

Acousto-opto-electric effects in hybrid organic-inorganic semiconductor system: bridging materials chemistry and device engineering

Paromita Bhattacharjee[1], Patrick Ganswindt[2], Alexander S. Urban[2], Hubert Krenner[1]

[1]Institute of Physics, University of Münster, Germany
[2]Faculty of Physics, Ludwig-Maximilians-Universität München, Germany
e-mail: paromita.b@uni-muenster.de

Often referred to as "nanoscale earthquakes", surface acoustic waves (SAWs) are elastic waves which propagate on the surface of a solid at the speed of sound. A voltage signal applied to comb-like metal electrodes, termed as interdigital transducer, generates SAW on a piezoelectric substrate. The applications of SAWs are wide spanning from electronics, optics, microfluidics, medical diagnostics or mobile communication and even quantum technologies [1, 2]. While interacting with a semiconductor, the strain and piezoelectric fields of SAW modulate the semiconductor band structure. Strain-induced field imposes an acoustoelectric (AE) drag on the charges in the direction of SAW propagation, and when paired with an optically-active semiconductor, excitons can be ionized by piezoelectric field into separate electrons and holes, captured and transported by the SAW towards an output spot, known as acousto-optoelectric (AOE) effect [3]. Interaction of SAWs with multitude of conventional inorganic semiconductor systems has been studied over the years for AE-driven devices and signal processing components [3, 4]. While the majority of these conventional III-V and 2D semiconductors require high-end cleanroom nanofabrication, emerging new materials, such as organic semiconductors and perovskites, are of low cost, involve spin coated/drop cast deposition and low annealing temperatures to form high-quality thin films. In this field, the influence of SAW has been investigated in first-of-a-kind organic polymer, poly(3-hexylthiophene) (P3HT) and poly[2-methoxy-5-(2-ethylhexyloxy)-1,4-phenylenvinylen] (MEH-PPV) based charge transport devices [5-6] and excitonic transistor [7], opening up the integration of acoustic charge transport with emerging economical solution processable semiconductor systems.

Here, we present the first study of the SAW-induced charge transport in hybrid organic-inorganic semiconductor system. This system comprises of P3HT and halide perovskite ($CsPbBr_3$ and $CsPb(I_xBr_{1-x})_3$) nanowires (NWs). We observe a pronounced AE effect driven by the SAW. The AE current can be efficiently gated by optical excitation using a focused green laser. Initially, we show that in reference samples with only halide perovskite NWs the total AE current nearly vanishes due to comparable mobilities for electrons and holes in these materials [8]. In strong contrast, in devices with hybrid layers, a weak AE effect is observed for $CsPb(I_xBr_{1-x})_3$ NWs and a hole dominated AE transport for $CsPbBr_3$ NWs. These observations can be explained by the band alignment at the interface between LUMO of the P3HT and the perovskite. While for $CsPb(I_xBr_{1-x})_3$ -P3HT ambipolar electron and hole transport occurs in the perovskite, for $CsPbBr_3$-P3HT, electrons are transferred to the low electron mobility regime in P3HT, inhibiting electron-mediated AE transport. The result accentuates on how the AE and AOE effects reveal the signature of electron and hole mobilities in these systems, and SAW itself acts as a handy tool to measure electrical interfacial characteristics in such heterolayers.

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Inkjet printing of thin film for the fabrication of QD-LED Structures

Adrian Adamski[1], Adam Łuczak[1], Ruslana Udovytska[1], Julia Nowakowska[1], Marta Krencjasz[1], Gabriela Wiosna-Sałyga[1], Jarosław Jung[1], Jacek Ulański[1], Beata Łuszczyńska[1]

[1]Department of Molecular Physics, Faculty of Chemistry, Lodz University of Technology
90-543 Lodz, Zeromskiego 114
e-mail: adrian.adamski@p.lodz.pl

One of the key goals in the development of modern light-emitting diodes (LEDs) is to use of quantum dots (QDs) as electrically driven light sources. Quantum dots are of great interest due to their unique properties, such as very pure colours (narrow photoluminescence spectra) and the ability to easily tune their emission wavelength.

In this presentation, we demonstrate a simple and cost-effective method of fabricating QD-based LEDs using solution-based processes. A significant advantage of this approach is the use of printable layers, which allows precise patterning of the light-emitting areas and facilitate the creation of customized and flexible devices.

This work was carried out in collaboration with the Fraunhofer Institute for Applied Polymer Research, Allresist GmbH, and QWERTY Sp. z o.o. The main goal of the project was to develop a new type of printable electroluminescent light source that could be used in simple displays and signage applications. To achieve this, we studied the properties of green-, red-, and blue-emitting quantum dots, as well as their composites with polymer matrices. These materials were used to prepare thin emissive layers, which were then tested in QD-LED devices with the following structure (Figure).

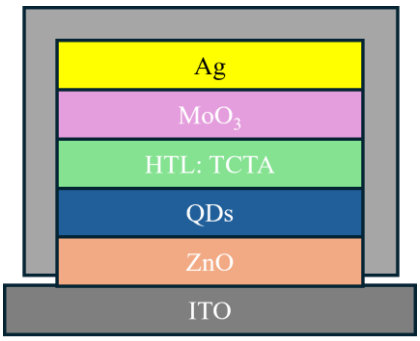

Figure: Structure of QD-LED Device

The work was performed within the framework of the project “New structuring methods for printing of QD-LEDs for signage application” (PrintedQDD), financed by the National Centre for Research and Development under the 5th competition within the framework of the Poland-Berlin/Brandenburg Cooperation (POLBER/5/63/PrintedQDD/2022).

Iron-doped Eutectics for Biomedical Sensing: Optical Properties and Lattice Dynamics of $Y_3Ga_5O_{12}$-Ga_2O_3:Fe^{3+}

Piotr Radomski[1], Karol Bartosiewicz[2], Yevheniia Smortsova[3], Tomasz Runka[1]

[1]Institute of Materials Research and Quantum Engineering, Poznan University of Technology, ul. Piotrowo 3, 61-138 Poznan, Poland
[2]Institute of Physics, Czech Academy of Sciences, Na Slovance 1999/2, Praha 18200, Czechia
[3]Deutsches Elektronen-Synchrotron DESY, Notkestraße 85, Hamburg 22607, Germany
e-mail: piotr.radomski@doctorate.put.poznan.pl

The development of modern biomedical sensing and imaging technologies requires efficient and broadband near-infrared (NIR) light sources. Fe^{3+}-activated oxide hosts are promising candidates due to chemical and thermal stability, moisture and atmospheric resistance, as well as mechanical durability. However, most existing devices operate as phosphor-converted light-emitting diodes excited in the ultraviolet (UV) range (250–320 nm), typically via $O^{2-}\rightarrow Fe^{3+}$ charge-transfer transitions. This hinders the design of high-power systems and increases operational costs.

To address these limitations, Fe^{3+}-doped $Y_3Ga_5O_{12}$–β-Ga_2O_3 eutectics were developed using the micro-pulling-down method. In this system, efficient excitation in the blue spectral region (400–425 nm) is achieved, enabling broadband NIR emission spanning 750–1000 nm. The latter lies well within the therapeutic window, and is assigned to the $^4T_1(^4G)\rightarrow{}^6A_1(^6S)$ transition of tetrahedrally coordinated Fe^{3+} ions, as confirmed by synchrotron-based experiment. This compatibility with commercially available cheap and efficient blue light sources represents a significant advantage for practical applications.

The electronic structure and lattice dynamics were investigated using density functional theory (DFT) within the generalized gradient approximation with on-site Hubbard correction (GGA+U). The selected calculations were further refined using hybrid approaches. These results provide insight into crystal field strength, formation energies across different coordination environments, and the thermodynamic properties of the studied systems.

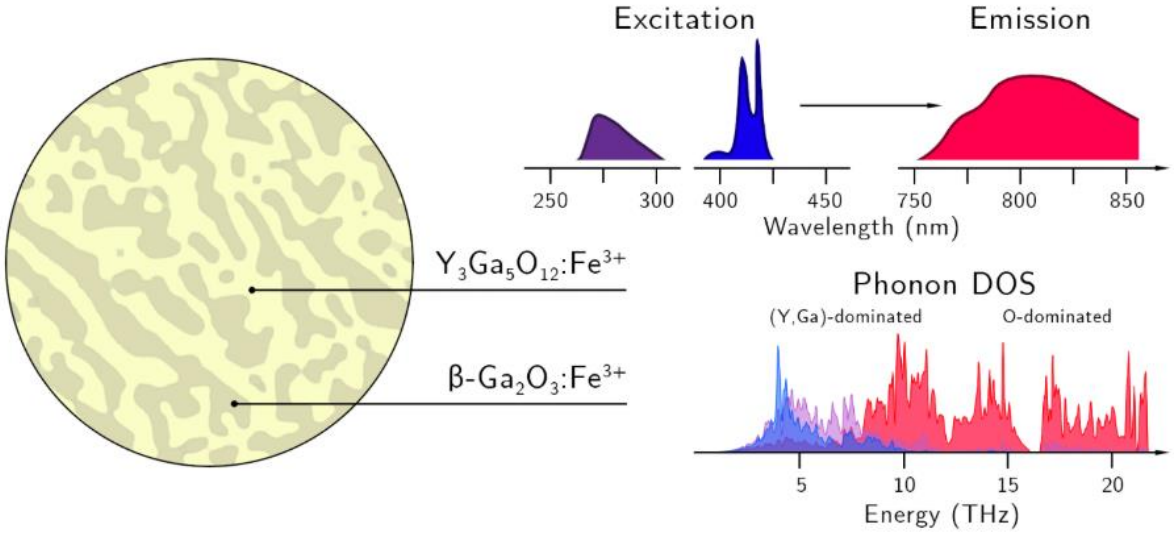

Figure 1. Schematic representation of $Y_3Ga_5O_{12}$–β-Ga_2O_3 lamellar structure, excitation-emission properties, and phonon density of states (DOS, $Y_3Ga_5O_{12}$ phase).

Binder-Dependent Electrochemical Performance and Charge Storage Mechanism in MoCo-Doped Prussian Blue Analogue Cathodes for Sodium-Ion Batteries

Matylda Rybacka[1], Ewelina Rudnicka[1], Karol Rytel[2]

[1] Institute of Chemistry and Technical Electrochemistry, Faculty of Chemical Technology, Berdychowo 4, PL61131 Poznan
[2] Institute of Physics, Faculty of Materials Engineering and Technical Physics, Piotrowo 3, PL61131 Poznan
e-mail: matylda.rybacka@student.put.poznan.pl

INTRODUCTION: Recently, the development of eco-friendly and efficient electrochemical energy storage systems has become a key research area. Since lithium-ion cells face resource, cost, and safety limitations, sodium is an attractive alternative. Consequently, Prussian blue analogues (PBAs) have gained attention as promising cathode materials for sodium-ion batteries; their structure allows for rapid, reversible ion diffusion and high storage capacity [1].

EXPERIMENTAL PART: This study investigates the effect of binders Locust Bean Gum (LBG), Carboxymethyl Cellulose (LBG), Cellulose Acetate (CA), and Polyvinylidene Fluoride (PVdF) on the performance of transition metal-doped Prussian blue analogue (PBA) cathodic material synthesized via co-precipitation. The electrolyte was 1 M $\boldsymbol{NaClO_4}$ dissolved in a mixture of ethylene carbonate (EC) and dimethyl carbonate (DMC) (1:1 v/v). In order to evaluate electrode stability, and reaction resistance electrochemical tests included cyclic voltammetry (CV), electrochemical impedance spectroscopy (EIS), and galvanostatic charge-discharge tests (GCD) at a current of 10, 20, and 30 $\boldsymbol{mA\ g^{-1}}$.

RESULTS: A novel electrode material based on a molybdenum- and cobalt-doped PBA was successfully synthesized. Uniform element distribution within the material structure was confirmed with the results of EDX analysis (Fig. 1a). The results of CV analysis confirmed the reversible character of $\boldsymbol{Fe^{2+}/Fe^{3+}}$ redox reactions. The superior electrochemical response was observed for the CMC binder, which displayed distinct anodic and cathodic peaks even at high current densities. GCD tests (Fig. 1b) revealed that LBG exhibited the highest initial capacity (152 $\boldsymbol{mAh\ g^{-1}}$), though it significantly decreased in subsequent cycles. EIS measurements proved that while all binders share similar ohmic resistance, CMC emerged as the most effective due to the lowest charge transfer resistance, indicating superior ion transport and a stable electrode-electrolyte interphase.

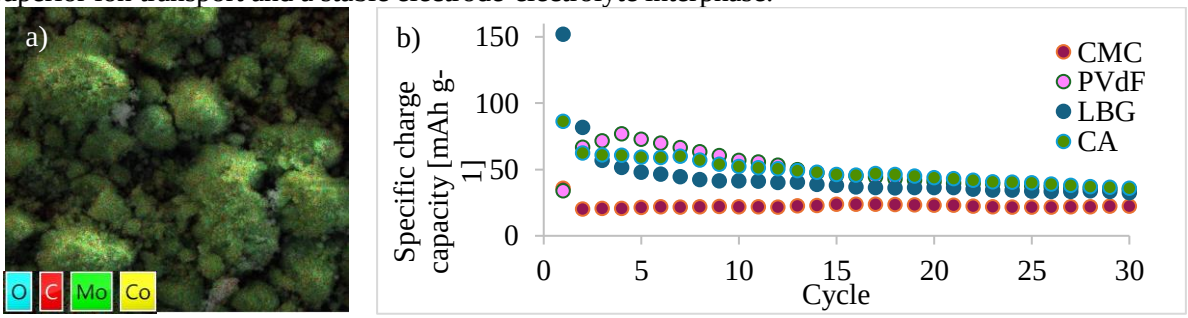

Figure 1. (a) EDX mapping showing the distribution of O, C, Mo, and Co; (b) Galvanostatic cycling performance at 20 $\boldsymbol{mA\ g^{-1}}$ of PBA half-cell using various binders: CMC, PVdF, LBG, and CA.

CONCLUSION: Polysaccharide binders significantly influence PBA-based cathode performance. While LBG provides high initial capacity, CA offers better capacity retention and Coulombic efficiency over 30 cycles. These findings suggest that optimizing binder composition is crucial for enhancing the stability and viability of sodium-ion battery components.

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Choline Salts as Green Liquid Electrolytes for Supercapacitors

Joanna Fijałkowska[1], Julianna Czerniawska[1], Beata Sikora[1], Adam Borwin[1], Xymena Gross[1], Jakub Tomasz[1], Julia Marecka[1], Amelia Miller[1], Piotr Gajewski[1], Katarzyna Szcześniak[1], Agnieszka Marcinkowska[1]

[1] Wydział Technologii Chemicznej, Politechnika Poznańska, Berdychowo 4, 60-965 Poznań
e-mail: joanna.fijalkowska@student.put.poznan.pl

Conventional aqueous systems used in electrochemical devices have provided energy for many years; however, their toxicity and multiple properties negatively impact their usage in numerous applications. Water based electrolytes with conventional salts such as lithium or sodium sulphates are non-toxic but often, have freezing point slightly below 0°C. With the increase in ecological impact, the choline cation has been chosen for the synthesis of promising electrolytes. Its role in ionic liquids has been extensively investigated, and the compound has been demonstrated to be non-toxic [1,2]. Anions of the salts were also carefully chosen as organic acids which are entirely biodegradable and derived from renewable, naturally sourced materials found in nature.

In this work, the following acids were chosen: maleic, malic, tartaric, oxalic, lactic and glycolic. For consistency and comparative purposes, salts in which all carboxyl groups were substituted with the choline cation were investigated, as these exhibited the most promising properties.

All salts were synthesized via a straightforward neutralization reaction of the appropriate organic acid with choline hydroxide in a ratio of 1:1 or 1:2. Water formed as a by-product, was removed through a three-step evaporation process. To further enhance purity, selected salts were subjected to recrystallization using appropriately chosen solvents tailored to each compound. Due to hygroscopic nature of certain salts, the samples were stored in a vacuum desiccator containing phosphorous pentoxide as a desiccant.

Following synthesis, the products were subjected to comprehensive analytical characterization. Structural confirmation of the salts was carried out using ^{1}H NMR and ^{13}C NMR spectroscopy. Thermal properties were evaluated by Differential Scanning Calorimetry (DSC) and Thermogravimetric Analysis (TGA). Subsequently, aqueous electrolytes were prepared and their ionic conductivity was investigated using Electrochemical Impedance Spectroscopy (EIS). The conductivity of each salt was measured as a function of concentration and temperature, allowing for the determination of the molar concentration with the highest conductivity, as well as the crystallization temperature of the electrolytes. Finally, selected electrolytes were applied in electrochemical capacitors to evaluate their electrochemical performance.

The study has been financed by the Minister of Science and Higher Education, Republic of Poland, under the Programme „Studenckie koła naukowe tworzą innowacje”.

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Silicon-MXene Nanocomposites for Photoelectrochemical Water Splitting

Artur Krukowski[1], Andrii Lys[2], Igor Iatsunskyi[2]

[1] Adam Mickiewicz University, Faculty of Physics and Astronomy, Poznań, Poland
[2] NanoBioMedical Centre, Adam Mickiewicz University, Poznań, Poland
e-mail: artkru1@st.amu.edu.pl

This study investigates a composite of silicon nanowires (SiNWs) and Ti_3C_2 MXenes to develop efficient, low-cost electrodes for photoelectrochemical water splitting. It was hypothesized that the high conductivity and catalytic properties of MXenes would mitigate the electron-hole recombination and low stability typical of pure silicon electrodes. SiNWs were synthesized via the MACE procedure, and Ti_3C_2 MXenes via MILD etching of Ti_3AlC_2. Photoelectrochemical properties and electron transport were evaluated using CV, LSV, and EIS in Na_2SO_4, KOH, and $K_3Fe(CN)_6$ electrolytes. Unexpectedly, the composite electrode exhibited strong surface oxidation to SiO_2, reduced electrical double-layer (EDL) capacitance, and significantly increased charge transfer resistance (R_{ct}) compared to pure SiNWs. SEM and EDS analyses identified the cause of these adverse effects: a high concentration of insulating AlF_3 salt crystals and the presence of -F functional groups. Nevertheless, despite these structural challenges, the addition of MXenes successfully improved hydrogen evolution reaction (HER) kinetics in alkaline KOH.

This work was supported financially by the National Science Centre of Poland under the SONATA BIS grant (202/38/E/ST5/00176), and the authors express their sincere gratitude

One-step activation of bio-based carbon materials using zinc chloride

Xymena Gross[1], Beata Kurc[2]

[1] Faculty of Chemical Technology, Poznan University of Technology, Berdychowo 4, PL-60965 Poznan, Poland
[2] Institute of Chemistry and Electrochemistry, Faculty of Chemical Technology, Poznan University of Technology, Berdychowo 4, PL-60965 Poznan, Poland
e-mail: xymena.gross@student.put.poznan.pl

INTRODUCTION

Activated carbons are the primary electrode materials in supercapacitors due to their high specific surface area and hierarchical porosity. Single-step activation with zinc chloride enables effective modification of the pore structure of carbon precursors through chemical etching and dehydrogenation [1], leading to the optimisation of sorption and electrochemical properties.

EXPERIMENTAL AND RESULTS

The process of obtaining the material is shown in Figure 1. Cellulose was used as the precursor in the study due to its high chemical purity and structural homogeneity, which allows for reproducible activation results. Its linear polysaccharide structure with numerous hydroxyl groups promotes the formation of complex porous structures during thermal treatment [2]. Furthermore, as the most abundant biopolymer, cellulose is inexpensive, renewable and consistent with the principles of sustainable development.

Figure 1. Schematic representation of the research conducted

Activation occurs due to the dehydrating properties of $ZnCl_2$ and the formation of pores resulting from the leaching of Zn–O–C complexes [1]. The CV curves exhibit a classic rectangular shape, typical of EDLC electrochemical capacitors. The repeatability of the signal across successive cycles demonstrates high electrochemical stability and the reliability of the charge–discharge processes.

The presented systems were subjected to cyclic voltammetry using the G 1000 Potentiostat/Galvanostat/ZRA (Gamry Instruments, USA) measuring apparatus. CV analysis of the electrochemical capacitors was carried out at scan rates of 5mV s^{-1}. On the basis of the results, presented as voltammograms, the reversibility of the reactions occurring during cell operation and the cyclic performance of the capacitors were determined.

This work was supported by the Polish Ministry of Education and Science, grant 911/SBAD/2602.

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Influence of electropolishing process on corrosion resistance of stainless steel

Monika Derkowska[1], Jarosław Wojciechowski[1], Grzegorz Lota[1,2]

[1]Institute of Chemistry and Technical Electrochemistry, Poznan University of Technology, Berdychowo 4, 60-965 Poznan, Poland
[2] Łukasiewicz Research Network – Institute of Non-Ferrous Metals Division in Poznan, Central Laboratory of Batteries and Cells, Forteczna 12, 61-362 Poznan, Poland
e-mail: monika.derkowska@doctorate.put.poznan.pl

Stainless steels are widely used in food, pharmaceutical, bioprocessing and personal care products industry, due to their favourable properties such as strength, durability, temperature resistance, recyclability, easy formability and most importantly – high corrosion resistance. Enhanced anti-corrosion properties are achieved by introducing alloy additives such as chromium, nickel and molybdenum [1,2]. The addition of those elements allows the formation of passive oxide layer after exposure to air, which inhibits further corrosion process. However, it is important to remember that stainless steels aren't corrosion resistant, only the rate of it is roughly 25 times slower comparing to carbon steels [3].

Slowing down the corrosion process isn't sufficient in some more specific applications, such as energy storage devices or delivery systems for high-purity electronic special gases used for fabrication and processing of semiconductors, microelectronics and integrated circuits [3]. In those specific applications, stainless steels remain in contact with highly corrosive and aggressive media, which causes the corrosion of the material and its degradation, further leading to deterioration of device performance and failure [3].

One of the possible solutions for improving corrosion resistance of stainless steels is the electropolishing process [1-3]. As a result of the anodic dissolution, microscale defects and embedded contaminants removed. Moreover, electropolishing generates a passive oxide layer containing higher percentage of chromium than in the air-formed passive layer. Such composition of the obtained protective film results in better corrosion resistance. As a result of electropolishing process a mirror-finish of the piece is obtained, which additionally prevents moisture accumulation and accelerated corrosion [1]. Figure 1 presents a pieces of 316L stainless steel before and after electropolishing.

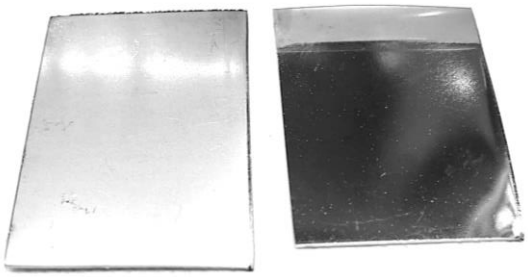

Figure 1. 316L stainless steel before and after electropolishing.

In this work, the electropolishing process of stainless steel was optimized in order to achieve enhanced corrosion resistance. Obtained results imply that electropolished stainless steel presents potential for application in aforementioned highly corrosive and aggressive environments.

This work was supported by the National Science Centre, grant number 2021/41/B/ST5/04047 and by Ministry of Science and Higher Education, Poland.

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Solvothermal Synthesis and AI-Enhanced Characterization of Bi_2X_3 Nanomaterials for Sustainable Optoelectronics

Mahreen Akhtar[1], Sofiyan Mohammed[2], Eryk Wolarz[1]

[1] Faculty of Materials Engineering and Technical Physics, Poznan University of Technology, Jacka Rychlewskiego 1, 61-131 Poznan, Poland
[2] Faculty of Computing and Telecommunications, Poznan University of Technology,Piotrowo 2, 60-965, Poznan, Poland
e-mail: mahreen.akhtar@doctorate.put.poznan.pl
e-mail: sofiyan.mohammed@student.put.poznan.pl

Bismuth-based compounds (Bi_2X_3, where X = O, S, Se, Te) are promising materials for optoelectronic and solar energy applications, serving as non-toxic alternatives to lead in hybrid perovskites [1–3]. Conventional lead-based perovskites, such as $MAPbI_3$, can release toxic Pb^{2+} ions upon degradation, posing significant risks to human health and the environment. To address this issue, bismuth-based chalcohalides (BiXI, X = O, S, Se, Te, in hybrid perovskites MABiXI2) have been proposed, offering comparable optoelectronic properties with improved stability and lower toxicity. These materials can be synthesized from bismuth chalcogenides. In this study, Bi_2X_3 nanoparticles were synthesized via a simple solvothermal method and characterized using various structural, optical, and electrical techniques. X-ray diffraction confirmed the presence of high-purity nanoparticles with hexagonal, orthorhombic, or tetragonal crystal structures and good crystallinity, with crystallite sizes calculated using the Scherrer equation ranging from 15 to 20 nm. The direct bandgaps for Bi_2O_3 and Bi_2S_3 were measured to be 2.43 eV and 1.19 eV, respectively. Poole–Frenkel analysis provided further insights into charge transport mechanisms and dielectric properties, underscoring their potential for applications in optoelectronic and solar energy devices. Additionally, an innovative approach utilizing XGBoost-based SHAP interaction mapping and meta-model waterfalls was employed [4] to automatically characterize conduction regimes and retrieve permittivity constants of the bismuth chalcogenides (Bi_2X_3) based on their experimental I-V characteristics. These analyses successfully demonstrated that conduction occurs through different transport mechanisms, contingent on the specific compound and temperature regime. The work also identified the conduction-specific Ohmic-to-Poole-Frenkel transition temperatures and illustrated how these macroscopic conduction features modulate temperature-dependent dielectric permittivity constants. Ultimately, this approach shows promise in replacing traditional, manually intensive parameter estimation processes with a more physically meaningful machine-learned model interpretation, enhancing the understanding of these materials' electrical properties.

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Vibrational and Luminescence Spectroscopic Characterization of a Pr^{3+}-Doped $Lu_{1.5}Y_{1.5}Al_4ScO_{12}$ Garnet Single Crystal

Maciej Rzeczkowski[1], Piotr Radomski[1], Tomasz Runka[1], Karol Bartosiewicz[2]

[1] Institute of Material Research and Quantum Engineering, Poznan University of Technology, Piotrowo St. 3, Poznan 60-965, Poland
[2] Institute of Physics, Academy of Sciences of the Czech Republic, Na Slovance 1999/2, 18200, Praha, Czechia
e-mail: maciej.rzeczkowski@student.put.poznan.pl

Garnet crystals with the general formula $RE_3B_5O_{12}$, grown by the Czochralski or micro-pulling down methods, are currently under intensive investigation due to their advantageous stoichiometry and robust crystal structure, which facilitate efficient incorporation of rare-earth dopants [1-3]. These features allow the design of materials with tailored physicochemical properties. Garnets have attracted significant attention owing to their promising applications in high-energy physics, high-sensitivity luminescence thermometry, and as scintillators in nuclear medicine [1-3].

In particular, mixed garnet systems such as $Lu_{1.5}Y_{1.5}Al_{5-x}Sc_xO_{12}$ doped with praseodymium ions (Pr^{3+}) constitute an important class of advanced materials, allowing for the investigation of processes related to crystal lattice engineering and the control of structural defects in real crystals. These aspects are crucial for optimising parameters such as luminescence efficiency and scintillation decay time.

In this study, the vibrational and optical properties of a $Lu_{1.5}Y_{1.5}Al_4ScO_{12}:Pr^{3+}$ garnet were investigated using Raman and high-resolution luminescence spectroscopy. Their combined use enabled an analysis of the volumetric and spatial distribution of the dopant in the crystal structure, revealing a segregation phenomenon that is crucial for improving crystal growth processes and tailoring material properties.

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Analysis of Hyperfine Structure and Isotope Shifts in Chromium via Atomic Beam Spectroscopy

Sandra Nowacka[1], Przemysław Głowacki[1], Danuta Stefańska[1], Andrzej Krzykowski[1]

[1]Institute of Materials Research and Quantum Engineering , Poznan University of Technology, Piotrowo St. 3, Poznan 60-965, Poland
e-mail: sandra.nowacka@student.put.poznan.pl

This presentation focuses on the analysis of experimental spectroscopic data of chromium atoms obtained at the Department of Quantum Engineering and Metrology (DQEM) laboratory at the Poznan University of Technology. The theoretical background includes a discussion of the fine and hyperfine structure of atomic energy levels, as well as the laser-induced fluorescence (LIF) technique used for measurements. The experimental setups employed to acquire the spectra are also presented.

Six spectral lines of chromium were analyzed, including one reference line used to verify the accuracy of the method. For each of the lines studied, the hyperfine structure constants A and B of energy levels involved in the transitions were determined. Based on the calculated center-of-mass positions of individual isotopes, isotopic shifts were also obtained for each spectral line. Additionally, the integral intensities of isotope-specific signals were determined, and their relative contributions were compared with the natural isotopic composition of chromium.

The results provide new values of hyperfine structure constants previously unavailable in the literature and enable an assessment of the applicability and limitations of the atomic beam method for studying chromium spectral lines.

Functionalized Orbital Reconstructive Implants with Polyphenol-Cerium Coating as Platform for Targeted Fluoroquinolones Delivery

Kamila Czerniak[1], Jakub Reczkowski[1], Mariusz Sandomierski[1]

[1] Institute of Chemical Technology and Engineering, Poznan University of Technology,
ul. Berdychowo 4, 61-131 Poznań, Poland
e-mail: kamila.czerniak@student.put.poznan.pl

Orbital fractures are among the most common injuries of the facial skeleton and frequently require the use of reconstructive implants. Although polymeric biomaterials, including polypropylene meshes, are widely used in orbital reconstruction for their biocompatibility and favorable mechanical properties, postoperative complications continue to pose a significant clinical challenge [1]. In particular, bacterial infections resulting from biofilm formation on the implant surface may lead to inflammation, impaired wound healing, and, in severe cases, the need for revision surgery [2]. Therefore, surface modifications of implants may enable targeted antibiotic delivery and enhance the antimicrobial properties of such biomaterials, representing an important area of research. Polyphenols constitute a diverse group of natural compounds that have been widely investigated for biomaterials modification due to their favorable properties, such as strong antioxidant capacity and metal-chelating ability. Epigallocatechin gallate (EGCG) is known for its ability to neutralize free radicals; moreover, due to the presence of multiple hydroxyl groups, it can form stable complexes with metal ions [3]. Such coordination serves as a platform for further modification. Cerium exhibits antibacterial and anti-inflammatory properties and demonstrates strong coordination ability, enabling it to form complexes with fluoroquinolone antibiotics [4]. Fluoroquinolones are broad-spectrum antibacterial agents active against both Gram-positive and Gram-negative bacteria and are commonly used to treat various bacterial infections, including those associated with biofilm formation on implant surfaces. Furthermore, due to the presence of adjacent carbonyl and carboxyl groups, fluoroquinolones are able to form stable chelate complexes with metal ions, which may enable their local delivery from the implant surface [5]. Such a strategy for drug immobilization on the implant surface may contribute to reducing the risk of post-implantation microbial infections. In this study, the surface of polypropylene meshes used as orbital reconstructive implants was functionalized by synthesizing polyphenol-cerium (EGCG-Ce^{3+}) coating, creating a platform for the targeted delivery of fluoroquinolones (norfloxacin, ciprofloxacin, levofloxacin, ofloxacin). The obtained biomaterials were characterized using UV-Vis spectroscopy, HPLC, FT-IR, SEM, and ICP-MS. The results indicated the effectiveness of the proposed surface modification strategy, revealing the material's capacity for antibiotic adsorption and controlled release, and demonstrating the potential of the developed biomaterial to reduce postoperative bacterial infections in orbital reconstruction.

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Towards Sensitive Lead Detection: Optimized Ion-Selective Electrodes and Their Analytical Parameters

Martyna Drużyńska[1], Nikola Lenar[1], Beata Paczosa-Bator[1]

[1]Faculty of Materials Science and Ceramics, AGH University of Krakow, Kraków, Poland
e-mail: druzynska@agh.edu.pl

Lead contamination remains a critical global concern due to its persistent toxicity, bioaccumulative nature, and widespread occurrence in water, food, and industrial environments. The accurate, cost-effective, and rapid detection of lead ions (Pb^{2+}) is essential for protecting public health and ensuring environmental safety [1-3].

Ion-selective electrodes (ISEs) have evolved over the years into reliable tools for ion analysis. All-solid-state electrodes are a type of electrochemical sensor that do not contain an internal solution, which makes them mechanically robust and easy to use. This study presents the validation of a newly developed and optimized lead-selective electrode, with particular focus on its analytical performance and practical applicability [4-5].

The electrode design is based on incorporating conductive nanomaterials directly into the polymer membrane. This design solution is characteristic for single-piece electrodes. In this case, graphene was used as electron-to-ion transducer. The membranes were applied onto glassy carbon (GC) disc electrodes using a drop-casting method. The validation process included determining key analytical parameters such as the limit of detection, linear response range, signal repeatability.

The chronopotentiometry method was applied to evaluate electrical properties, whereas potentiometric measurements assessed basic analytical parameters such as sensitivity and repeatability. The modified electrodes exhibited a near-Nernstian response to lead ions over a broad linear concentration range.

Embedding carbon materials directly into the membrane enabled the transport of lead ions across a wide concentration range, significantly improving the sensor's analytical performance compared with electrodes based on unmodified polymer membranes.

The developed ion-selective electrode provides a rapid, simple, and cost-effective analytical tool. It is expected to be useful for environmental monitoring, particularly for the detection of lead contamination. These findings demonstrate that carbon-based modification enhances sensor performance and suggest promising directions for the development of advanced potentiometric sensors.

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An experimental study of bulk HfS_2, ZrS_2 and $HfSe_2$ monocrystal surfaces exposed to ambient air

Katarzyna Kwiecień[1], Piotr Kałuziak[1], Jan Raczyński[1], Agnieszka Puchalska[2], Anna Dychalska[3], Edyta Chłopocka[3], Dawid Kot[4], Łukasz Majchrzycki[1], Mirosław Szybowicz[3], Leszek Jurczyszyn[2], Mariya V. Dobrotvorska[5], Mikołaj Lewandowski[5], Wojciech Koczorowski[1]

[1]Institute of Physics, Poznań University of Technology, Poznań, Poland
[2]Faculty of Physics and Astronomy, University of Wrocław, Wrocław, Poland
[3]Institute of Materials Research and Quantum Engineering, Poznań University of Technology, Poznań, Poland
[4]IHP - Leibniz-Institut für Innovative Mikroelektronik, Frankfurt (Oder), Germany
[5]NanoBioMedical Centre, Adam Mickiewicz University, Poznań, Poland
e-mail: katarzyna.kwiecien@doctorate.put.poznan.pl

HfS_2, ZrS_2, and $HfSe_2$ belong to the group IV transition metal dichalcogenides (TMDs). These materials are promising for next-generation electronics due to their tunable band gaps (1–2 eV) and high predicted carrier mobilities at room temperature [1]. While many TMDs are chemically inert, group IV TMDs oxidize when exposed to air. Understanding how this oxidation affects their physical properties and surface morphology is critical for their use in electronic devices.

In this study, we investigate bulk HfS_2 and ZrS_2 monocrystals exposed to ambient air and compare our findings to the observations we made for the oxidized $HfSe_2$ [2]. Scanning electron microscopy (SEM) and atomic force microscopy (AFM) images reveal clear differences in surface morphology: $HfSe_2$ develops characteristic selenium-rich blisters, while the sulfur-based TMDs (HfS_2 and ZrS_2) show the formation of pits with electronic and mechanical properties that differ from those of the surrounding area. Further Raman spectroscopy data reveals that $HfSe_2$ vibrational modes change rapidly due to the ambient air exposure of the material, whereas the vibrational properties of HfS_2 and ZrS_2 remain stable. Finally, X-ray photoemission spectroscopy (XPS) and energy-dispersive X-ray spectroscopy (EDX) show that the sulfur-based TMDs are significantly more chemically stable in ambient air than $HfSe_2$.

These results offer a comprehensive description of the surface oxidation of chosen TMDs, which is crucial in the context of the material selection and technological processing requirements for future group IV TMD-based devices.

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Applications of Artificial Neural Networks in Human-Robot Interaction: Methods, Data, and Challenges

Aleksandra Świetlicka

Institute of Automatic Control and Robotics, Poznan University of Technology,
61-131 Poznan, Poland
email: aleksandra.swietlicka@put.poznan.pl

This presentation will discuss the role of artificial neural networks (ANNs) and machine learning in Human-Robot Interaction (HRI). It will begin with an overview of the main types of HRI, including social, sensory-based, and collaborative interactions, in order to provide context for how robots engage with humans in different scenarios. Subsequently, the use of modern AI models, particularly Graph Neural Networks (GNNs), will be presented in the context of recognizing human behavior, processing natural language, and modeling complex relationships within interactions.

Special attention will be given to multimodal data, including visual, textual, and physiological signals, and to the ways in which combining these sources can enhance the quality and naturalness of interaction. Selected examples from recent research, such as gesture recognition and dialogue analysis, will also be discussed.

A significant part of the presentation will focus on data-related challenges. Issues such as limited dataset availability, high costs of data collection, annotation complexity, and ethical considerations will be addressed. The presentation will conclude with an outline of current limitations, including model interpretability and bias, as well as potential future directions aimed at developing more robust and human-centered HRI systems.

High-Precision Carrier-Phase Positioning in 5G-Advanced

Jakub Nikonowicz

Institute of Multimedia Telecommunications, Poznan University of Technology, ul. Polanka 3, 61-131 Poznan, Poland
e-mail: jakub.nikonowicz@put.poznan.pl

5G-Advanced networks provide the technical framework for centimeter-level positioning through carrier-phase (CP) measurements. This study investigates the signaling and configuration procedures for obtaining CP observables from 5G waveforms, as well as the role of multi-frequency carrier-phase processing in enabling high-accuracy ranging. Key technical challenges, including integer ambiguity resolution and Non-Line-of-Sight propagation, are addressed to ensure positioning robustness in complex radio environments. Carrier-phase-based localization is investigated as a terrestrial alternative in GNSS-denied scenarios using dedicated 5G infrastructure, particularly in dense urban applications.

How not to be pushed out of the job market in the age of AI?

Tomasz Jagiełka

Poznan University of Technology, Faculty of Computing and Telecommunications, ul. Piotrowo 3, 60-965 Poznan, Poland
e-mail: tomasz.m.jagielka@gmail.com

Mental work is easy to replace when it is well defined. In this presentation I would like to show how generative AI and agents are changing technical work: programming, data analysis, research, cybersecurity and process automation. I will focus on which tasks are the easiest to automate today, how to defend against this in a smart way, and how to use AI to your advantage.

The presentation is aimed at people who are just entering the job market, as well as those who already work but feel that some of their skills may become less important in the age of AI. I will discuss what direction of development is worth choosing, which competences are likely to become more important, and how to practically build professional resilience. I want to show that the best strategy is not to compete with AI in the tasks where it is already strong, but to develop the kinds of skills that are harder to automate and more valuable in real work.

I will also talk about how not to use AI in a way that makes us weaker, meaning how not to give all thinking to the tools and how not to produce things that only look good, but are poor in quality. This is especially important in technical roles, where shallow analysis, insecure code or weak research may still have serious consequences even if the output looks convincing.

Participants will leave the presentation with concrete examples of changes in technical roles, a map of risks and opportunities, and a checklist of actions that can be implemented already now.

Adaptive Fractional Differencing Theory for Volatility Forecasting using Bayesian Optimization

Mohammed Sofiyan Ul Ehsan[1], Saleha Firdous[2], Burhan Ali Memon[3], Mohammed Ahtesham Ul Hasnain[2]

[1]Faculty of Computing and Telecommunications, Poznan University of Technology, Piotrowo 2, 60-965, Poznan, Poland

[2]Department of MBA & Finance, MESCO Institute of Management & Computer Sciences (MIMCS), Mustaidpura, 500006 Hyderabad, India

[3]Department of Industrial Engineering, University of Naples Federico II, C.so Umberto I, 40, 80138 Napoli NA, Italy

e-mail: Sofiyan.mohammed@student.put.poznan.pl

Financial time series exhibit two conflicting properties: they are non-stationary (mean and variance drift over time) yet possess long memory [1][3] (past values influence future values for long periods). Standard integer differencing $\boldsymbol{d}$ likewise taking the first (d=1) or second (d=2) difference resolves non-stationarity but at the cost of destroying memory. Fractional differencing (order $\boldsymbol{d} \in [0,1]$) offers a middle ground: it applies a power-series expansion of the differencing operator, retaining a controlled amount of memory while achieving stationarity. The choice of d and the truncation lag **ρ** (number of historical terms retained in days) critically shape the resulting features, yet existing work either picks d by stationarity tests [2] or embeds optimization inside model architectures [4]; Maitra [5][6] develops adaptive frameworks but targeting theoretical foundations and global-equity classification rather than volatility regression on emerging markets[7]. No prior study treats both d and ρ as a jointly tuned preprocessing layer, optimized end-to-end against a task-specific forecasting loss. Moreover, whether the optimal d for one prediction task transfers to another remains untested. This paper addresses these gaps with a Bayesian Tree-structured Parzen Estimator (TPE) search (Optuna, 100 trials per asset) that jointly optimizes d and ρ against the walk-forward QLIKE loss of a Random Forest volatility model across 50 Nifty50 stocks (Normalised into dollar-bars, January 2022-February 2026). The volatility-regression-calibrated d* and classification-calibrated d* are statistically uncorrelated (multi-seed Pearson r = 0.019, bootstrap 95% CI [−0.16, 0.20]), providing the empirical evidence that optimal memory retention is task-dependent. Proposed BO-AFD-Vol model beats integer differencing on 82% of assets (Wilcoxon p = 0.0001), task-agnostic fractional differencing on 56%, and the standard HAR-RV benchmark[8] on 92% of assets ($p < 0.0001$). These findings establish that the fractional integration order should be treated as a tunable interface between historical memory and the prediction objective, not a fixed market property.

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A machine learning–assisted approach for early tooth decay detection using Raman spectroscopy

Julia Mirońska[1], Oliwier Necelman[1], Igor Szymczak[1] , Mikołaj Nowak[1]

[1] Poznan University of Technology, 61-138 Poznan, Piotrowo street 3
e-mail: igor.szymczak@student.put.poznan.pl

Early detection of dental enamel demineralization is critical for enabling non-invasive diagnosis and preventive treatment. Conventional methods, including visual-tactile examination and radiographic imaging, remain limited in their sensitivity to early-stage lesions and may involve mechanical damage or exposure to ionizing radiation. Raman spectroscopy provides a non-destructive alternative by capturing the chemical composition of enamel; however, its clinical adoption is constrained by the need for expert interpretation of complex spectral data.

In this study, we propose a machine learning-assisted framework for automated classification of healthy and carious enamel using Raman spectra. Given the high-dimensional and sequential nature of spectral data, we evaluate three computational approaches using: MiniRocket, XGBoost, and Deep Sets. MiniRocket [1] leverages convolutional kernels to exploit time-series-like characteristics of spectra. XGBoost uses manually engineered domain features [2] as a high-interpretability baseline. Deep Sets [3], a permutation-invariant architecture, processes raw, variable-length spectra without requiring interpolation.

All models achieved high enamel detection performance, with area under the curve (AUC) values exceeding 0.97 under specific polarization conditions. Interpretability analysis using Shapley values revealed that the Deep Sets model prioritizes known biophysical markers of demineralization, including the $\boldsymbol{\nu_1 PO_4^{3-}}$ band position and full width at half maximum (FWHM). Additionally, the model identified peak prominence as an informative feature, capturing structural mineral changes across the spectrum. Qualitative validation on independent real-world tooth samples demonstrated strong agreement between model-generated probability maps and visually observable lesions.

These findings highlight the potential of combining Raman spectroscopy with machine learning to enable objective, automated, and real-time dental diagnostics. Prior work in Raman-based caries detection has largely relied on manual expert labelling or unsupervised learning, whereas the proposed approach integrates both interpretable feature-based methods and flexible deep learning architectures to improve robustness and clinical applicability. Overall, this supports the advancement of early, non-invasive diagnostics and contributes to the broader shift toward preventive dentistry and data-driven decision support.

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Application and Optimization of Vision Transformers for Retinal Pathology Classification in OCT Images

Kamil Dalil[1], Sławomir Maćkowiak[1]

[1]Faculty of Computing and Telecommunications, Poznan University of Technology,
61-138 Poznan, 3 Piotrowo street
e-mail: kamil.dalil@student.put.poznan.pl

Optical Coherence Tomography (OCT) is essential for diagnosing retinal conditions like CNV, DME, and Drusen. Recently, Vision Transformers (ViTs) have emerged as powerful alternatives to CNNs, using self-attention mechanisms to capture complex patterns in medical imaging [1].

This study compares three architectures - ViT, DeiT [2], and Swin Transformer [3] - to identify the most effective model for retinal disease classification. The goal was to refine the top-performing model through Optuna-based hyperparameter optimization and a cost-sensitive weighting strategy designed to increase the model's penalty for misclassifying subtle pathological features, particularly within the Drusen class.

The research followed a structured methodology: baseline evaluation, exhaustive hyperparameter optimization of the superior Swin Transformer, and the integration of class-specific weighting. Furthermore, an interpretability-based verification step was implemented using heatmap visualizations to audit the model's focus, ensuring that classification decisions align with clinical anatomical markers rather than image noise.

The Swin Transformer provided the most robust baseline. Notably, Optuna optimization did not yield significant benefits. However, targeted class weights successfully improved predictive performance. Heatmaps confirmed global classification logic.

The study confirms the high efficacy of the Swin Transformer in OCT classification. The results indicate that while the model is inherently robust, fine-tuning via class-specific weighting can further assist in distinguishing difficult pathologies, offering practical insights into the deployment of Transformer-based models in automated medical diagnostics. Ultimately, by evaluating these architectures under clinical-like constraints, this study serves as a critical validation of whether Vision Transformers are fundamentally suited for medical decision support, rather than merely achieving high benchmarks on static datasets.

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A multimodal system for houseplant recognition

Maria Musiał

Faculty of Computing and Telecommunications, Poznan University of Technology, Piotrowo 3, 60-965 Poznan, Poland
e-mail: maria.musial@student.put.poznan.pl

I present a multimodal application designed for plant care, centered on a recognition module for classifying houseplant species. The primary objective is to achieve high-accuracy, fine-grained classification using lightweight models for deployment on edge devices. The system was trained on a custom-curated dataset composed of images sourced from the internet, a factor that introduces significant real-world variability and poses an additional challenge for model generalization.

The nature of plant images is inherently fine-grained; many houseplants exhibit extreme similarities in color, texture, and leaf morphology. This creates narrow inter-class variance that make fully automated discrimination particularly difficult. To address this, we evaluate two architectures with approximately 5 million parameters to ensure low latency: EfficientNet-B0 [1], a CNN utilizing inverted bottleneck residual blocks, and Tiny ViT [2], a lightweight Vision Transformer. Both models utilized transfer learning from ImageNet-1k. To combat the low inter-class variance, we implemented Label Smoothing Cross Entropy and Focal Loss, which yielded a 25% accuracy improvement over standard Cross Entropy.

Experimental results indicate that while EfficientNet-B0 achieves a slightly higher Top-1 accuracy of 88.79% (Top-3: 95.58%), Tiny ViT offers superior inference efficiency. Tiny ViT recorded a Top-1 accuracy of 87.31% and a Top-3 accuracy of 94.78%, while achieving a significantly lower latency of 20.9 ms, compared to 26.0 ms for the CNN baseline. Notably, Tiny ViT performed very good despite the threat of data starvation often associated with Transformer architectures when trained on smaller, specialized datasets. Due to lower latency and sufficient accuracy, Tiny ViT was chosen for deployment.

To maximize practical reliability, the system positions the user as the final decision-maker. Rather than providing a single, potentially ambiguous prediction, the application presents the three most probable species. This allows the user to perform a final visual verification, leveraging human perception to distinguish subtle features that remain a challenge for automated systems, thereby ensuring an accurate and reliable plant care experience.

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Enhancing Ligand Predictions using Equivariant Neural Networks and Probabilistic Sampling

Agata Bielska[1], Jakub Radziejewski[1], Ashley Jurga[1], Adam Mazur[1], Dariusz Brzeziński[1,*]

[1] Institute of Computing Science, Poznan University of Technology, Poland
[*] Corresponding author. dariusz.brzezinski@cs.put.poznan.pl

CryoEM is a cost-accessible and increasingly dominant technique for determining macromolecular structures [1], yet it lacks the standardized pipelines and automated ligand identification tools established for X-ray crystallography. Interpreting cryoEM Coulomb potential maps remains error-prone [2, 3], and existing approaches — from iterative fitting [4] to deep learning methods such as MinkLoc3Dv2 [5] were not designed with the rotational symmetries of 3D density data in mind. With cryoEM training datasets substantially smaller than their X-ray counterparts, architectures that exploit geometric structure become especially attractive.

We evaluate two equivariant architectures, E3NN [6] and Clifford-Steerable CNNs [7], that encode E(3) symmetry directly, guaranteeing rotation-invariant predictions without data augmentation, and compare them against the non-equivariant MinkLoc3Dv2 baseline [5]. We further introduce probabilistic density-weighted sampling, which constructs point clouds by upweighting regions of higher Coulomb potential, as an alternative to uniform sampling [5, 8].

On 34,671 cryoEM ligand blobs, equivariant models consistently outperform the non-equivariant single-modality baseline. E3NN achieves 65.5% accuracy and 97.3% top-10 accuracy versus 63.1% and 92.3% for MinkLoc3Dv2 on cryoEM alone. Probabilistic sampling further improves top-10 accuracy for both architectures: E3NN reaches 97.5%, surpassing even the mixed-modality MinkLoc3Dv2 (97.4%) trained on nearly 20× more X-ray data. The Clifford model with probabilistic sampling attains the best macro recall (0.186) of any method, indicating stronger identification of rare ligand classes, a critical property for drug discovery targeting novel compounds [9].

These results show that equivariant inductive biases, combined with density-aware sampling, yield meaningful gains for cryoEM ligand identification without relying on large X-ray datasets. As cryoEM becomes the method of choice for structural biology [1, 10], equivariant approaches offer a principled foundation for automated ligand identification pipelines natively suited to this modality.

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AI-Assisted Zeolite Design through Retrieval-Augmented Scientific Language Models

Marzena Halama[1], Konrad Połys[1], Joanna Domańska[1]

[1]Institute of Theoretical and Applied Informatics Polish Academy of Sciences, 44-100 Gliwice
Bałtycka 5
e-mail: mhalama@iitis.pl

Designing materials such as zeolites is a major challenge due to the wide range of possible structures and synthesis conditions [1]. Furthermore, knowledge on this subject is widely scattered across numerous publications and experimental notes. Therefore, large language models (LLMs) represent a promising tool for building knowledge bases, supporting the analysis of scientific literature [2], although their responses may be incomplete or fallible. In addition, in the case of zeolites, the relationship between material properties and their topology is of crucial importance [3], which limits the effectiveness of approaches based solely on text. In this study, we investigate a Retrieval-Augmented Generation (RAG) approach extended with a multimodal component that combines textual and structural information.

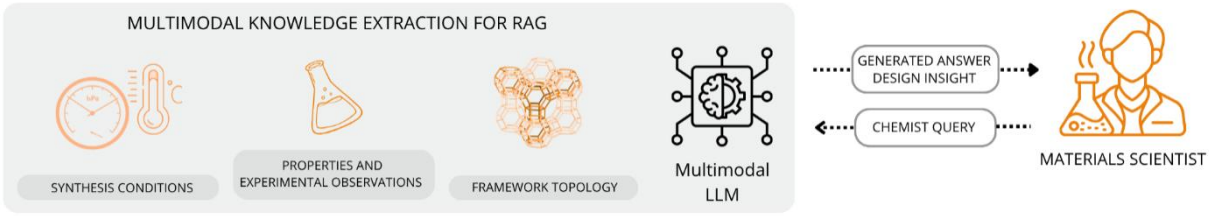

Figure 1. A multimodal RAG pipeline that combines literature, experimental notes, and structural topology to assist chemists in zeolite design and synthesis.

In this work, we propose a system based on the RAG approach (see Fig. 1.), which draws on knowledge from two sources: information on the synthesis and properties of materials obtained from text sources, and information on the topology of structures derived from images of zeolite frameworks.

Textual data are processed using LLM-based extraction to obtain structured representations of synthesis conditions and material properties, while structural images are transformed into graph-based representations that capture framework topology. These complementary representations are integrated within a multimodal retrieval pipeline and used to augment LLM reasoning in a question-answering setting.

Experimental evaluation demonstrates that incorporating structural information improves the accuracy and reliability of model responses compared to text-only approaches, particularly in topology-related tasks. The results highlight the importance of combining textual and structural knowledge for modeling structure–property relationships in zeolites. We demonstrate that such a solution can assist chemists in the design and synthesis of new zeolites. Moreover, the system can act as an intelligent agent, assisting the user at subsequent stages of the process.

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Student Project of a Radio Telescope for Observing the Neutral Hydrogen Emission Line

Aleks Czarnecki[1], Marek Marczak[1], Robert Bartkowiak[1], Judyta Ferenc[1], Bartosz Berezowski[1]

Spectrum Student Science Club, Poznan University of Technology
Faculty of Computing and Telecommunications, Institute of Radiocommunications
ul. Polanka 3, 61-131 Poznań, Poland
e-mail: spektrum@put.poznan.pl

The presentation describes the design, implementation, and commissioning of a compact radio telescope installed on the faculty rooftop, intended for both educational use and research observations of neutral hydrogen at 1420 MHz and solar radio emission.
The system comprises a 1.9 m parabolic dish equipped with a feed horn, a low-noise amplifier, an 8-bit SDR receiver, and a dual-axis azimuth–elevation drive. A dedicated control and supervision framework was developed, including software for automated calibration, object tracking, data acquisition, transmission to a central server, preliminary spectral analysis, and data visualization.
The presentation will cover the radio-frequency signal chain architecture, implemented radio frequency interference (RFI) mitigation techniques, and observation methodologies such as drift-scan and active tracking. Experimental results will be presented, including solar observations and preliminary detections of selected extragalactic sources. Particular attention is given to measured signal-to-noise ratios (SNR) and the limitations imposed by 8-bit quantization on the dynamic range of the system.
The conclusion summarizes the current findings and outlines planned future enhancements and system extensions.

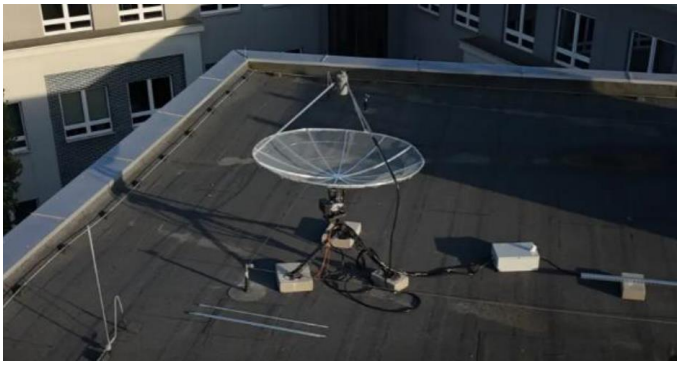

Fig. 1. Photo of the student radio telescope on the roof of the Faculty of Computing and Telecommunications at Poznan University of Technology.

Smartwatch-Based Assessment of Greenery Levels Influence on Well-Being

Aleksander Hański[1], Michał Żurawski[1], Mukhammad Sattorov[1], Marcelo Sagot-Better[2], Dariusz Brzeziński[1]

[1] Faculty of Computing and Telecommunications, Poznan University of Technology, ul. Piotrowo 3, 60-965 Poznan, Poland
[2] Faculty of Architecture, Poznan University of Technology, ul. Jacka Rychlewskiego 2, 61-131 Poznan, Poland
e-mail: aleksander.hanski@student.put.poznan.pl

Understanding how everyday urban environments influence well-being requires measurement approaches that impose minimal cognitive and behavioral disruption while capturing immediate responses as individuals move through real-world settings. Conventional paper- and smartphone-based questionnaires are inherently intrusive: they divert visual attention, interrupt ongoing activity, and can alter momentary affective states simply by requiring users to stop, focus, and interact with a comparatively large device or physical medium. These methods also rely on retrospective recall, introduce transcription errors when responses must be rewritten or digitized, and limit the feasibility of frequent, momentary reporting needed to capture stress-related fluctuations during everyday mobility.

Here, we present the design, implementation, and preliminary evaluation of a smartwatch-based ecological momentary assessment system that enables real-time recording of affective state, perceived environmental qualities, and perceived greenery levels during urban exposure with substantially reduced disruption. We developed an Android smartwatch application consisting of three brief questionnaire screens: (1) self-reported valence and arousal using a modified interface inspired by Russell's circumplex model [1] and the Affect Grid [2], (2) subjective perception of the surrounding environment, and (3) perceived level of greenery. The interface constrains input to a circular region while excluding the neutral center; continuous valence and arousal values are recorded, with discrete emotion labels providing intuitive feedback to support rapid and decisive reporting. Location data collection is implemented at the operating system level and functions reliably in outdoor settings.

The system was tested during two workshop sessions in Poznan and in Ripatransone, Italy. The resulting dataset suggests a positive association between perceived greenery and reported valence. These findings demonstrate the feasibility of smartwatch-based assessment as a low-distraction alternative to traditional questionnaires, enabling continuous, real-time investigation of how urban greenery influences well-being in everyday contexts.

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How Celebrities Influence the Stock Market: An Explainable Machine Learning Approach

Dawid Siera[1], Julian Mikołajczak[2], Anatol Kaczmarek[1], Paulina Paszkowiak [1]

[1] Faculty of Computing and Telecommunications, Poznań University of Technology, ul. Piotrowo 3, 60-965 Poznań, Poland
[2] Faculty of Control, Robotics and Electrical Engineering, Poznań University of Technology, ul. Piotrowo 3, 60-965 Poznań, Poland
e-mail: dawid.siera@student.put.poznan.pl

A single social media post from a high-profile individual can trigger rapid, unpredictable fluctuations in stock prices. This work presents a machine-learning framework designed to capture, predict, and explain such celebrity-driven market dynamics. We assemble a dataset combining posts from selected high-profile X accounts, Google Trends search-interest data for the relevant companies, products and keywords, as well as historical stock prices over the same period. A deep learning model is then trained on this data to predict short-term price movements from public sentiment and attention [1].

The key contribution of this research lies in moving beyond prediction toward explanation of market dynamics during times of high volatility. Moving beyond conventional forecasting, the framework employs Explainable AI (XAI) techniques to trace the trained model's decision-making process backward during periods of elevated market volatility. By tracing predicted outputs back to the exact input features that produced them, the system isolates and pinpoints the specific X post, search keyword, or trend spike that exerted the strongest directional influence on a given stock's valuation. The result is a transparent tool that links complex financial shifts to distinct social phenomena, opening new possibilities for risk monitoring, market integrity research, and the study of coordinated influence campaigns.

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Bridging the Memory Wall for Quantum Simulation with Processing-in-Memory

Tomasz Kazulak[1], **Paweł T. Wojciechowski**[1]

[1] Faculty of Computing and Telecommunications, Poznan University of Technology,
61-138 Poznan, 3 Piotrowo street
e-mail: tomasz.kazulak@student.put.poznan.pl

Tensor-network contraction provides a powerful mathematical framework for the classical simulation of quantum circuits, yet its performance on conventional architectures is often bottlenecked by memory bandwidth and data-movement costs. On CPUs and GPUs this frequently manifests as a memory-bound regime, as shown by roofline analyses where kernels sustain only about 2–30% of peak compute [1].

We are exploring the mapping of these networks onto Processing-in-Memory (PIM) architectures, focusing on the first commercially available PIM device produced by UPMEM. To map the research landscape, we conducted a systematic review of 316 records. Only one study, PIMutation [2] on UPMEM, demonstrates PIM for state-vector quantum simulation (2.99x speedup with 25.23% energy reduction at 16 qubits, and 16.51x with 75.29% at 32 qubits), and none address tensor-network contraction on PIM.

Through this evidence mapping, we found that adapting contraction heuristics to UPMEM DPUs (Data Processing Units) requires a shift from minimizing floating-point operations to strictly minimizing host-mediated data transfers. Specifically, any architectural mapping must account for severe preliminary constraints, such as the limited 64 KiB local WRAM (Working RAM) capacity, the fatal performance tax caused by the lack of native floating-point units, and the complete absence of direct inter-DPU communication.

I will first introduce the foundational concepts of Processing-in-Memory, quantum circuit simulations, and tensor networks, demonstrating how these distinct domains intersect through the findings of my systematic review. To address the hardware constraints identified in the literature, I will then present an early architectural mapping that utilizes a modular Host-PIM dispatch system. I will detail how this architecture isolates NP-hard pathfinding and collective aggregations on the host CPU, while using a Dynamic Heuristic Router to distribute tasks across specialized dense, sparse, and memory-cheap PIM execution routes. Finally, I will discuss the data format optimizations required to bypass software floating-point emulation, concluding with an outline of my comparative evaluation plan against traditional CPU and GPU baselines.

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POSTERS

Interaction between potential anticancer substances and model cell membranes

Julia Balcerzak[1], Katarzyna Dopierała[1]

[1]Poznan University of Technology, Faculty of Chemical Technology, Institute of Chemical Technology and Engineering, 61-131 Poznan, Berdychowo 4, Poland
e-mail: julia.balcerzak@student.put.poznan.pl

Cancer remains one of the greatest challenges of modern medicine. Therefore, intensive research is continuously conducted to identify new anticancer agents characterized by high selectivity and limited toxicity toward healthy cells. One promising research strategy involves targeting the cell membrane. This concept was developed on the assumption that modifications in lipid composition and structural organization of the membrane can significantly influence cellular function and determine its response to treatment. Differences in the physicochemical properties of cancerous and normal cell membranes may provide a basis for the selective action of potential therapeutic substances [1,2].

Studying membrane properties and their changes induced by physical, chemical and biological factors is critically dependent on model cell membranes. Membrane models are simplified, synthetic lipid assemblies designed to replicate the essential characteristics of biological membranes under controlled experimental conditions. They are vital to the design and development of efficient drug delivery systems [3].

The aim of this study was to evaluate the effect of LAM182, a compound exhibiting potential anticancer activity, on model cell membranes representing normal and pathological brain tissue membranes. The experiments were conducted using Langmuir lipid monolayers which were subjected to a series of analyses, including determination of surface pressure (π) – area (A) isotherms, relaxation plots, surface potential change (ΔV)–area (A) and compression modulus (Cs^{-1}) – area (A) dependences. Based on the conducted studies, it can be concluded that LAM182 exhibits the ability to selectively interact with model cancer cell membranes and may therefore be considered a promising candidate for further research on oncological treatment methods.

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Preparation and characterization of hydrogels with potential application in bioprinting

Tobiasz Banaszek[1], Ariadna B. Nowicka[1,2], Mirosław Szybowicz[1]

[1] Faculty of Materials Engineering and Technical Physics, Poznan University of Technology, Piotrowo 3, 60-965 Poznań
[2] Institute of Physical Chemistry, Polish Academy of Sciences, Warsaw 01-224 Poland
e-mail: tobiasz.banaszek@doctorate.put.poznan.pl

3D printing has found many practical applications in everyday life, ranging from the automotive industry and architecture to medicine. One type of printing that can be applied in the pharmaceutical industry is extrusion printing, specifically the Direct Ink Writing (DIW) method, which is currently one of the most promising tools in the field of additive manufacturing of functional materials and biomedical structures. This process is based on the layer-by-layer deposition of semi-solid bio-inks through precise nozzle control, which allows for the creation of complex geometries while simultaneously controlling material properties [1]. A key advantage of extrusion printing is its material versatility. It allows for the use of cells as well as active substances or drugs[lit]. Additionally, the ability to precisely control the rheological parameters of bio-inks, including shear-thinning, simultaneously ensures printability and spatial stability of structures during the extrusion process [2]. Thanks to these properties, DIW can find wide application in tissue engineering, drug delivery systems, and tissue modeling.

In bioprinting, particular attention is paid to bio-inks based on naturally derived substances. These include, among others, hydrogels based on sodium alginate and gelatin. Alginate-gelatin systems are of interest due to their biocompatibility, biodegradability, and favorable rheological properties [3]. Alginate enables rapid ionic cross-linking (e.g. using Ca^{2+} ions), thereby ensuring the structural stability of the prints. Gelatin, in turn, improves the material's bioactive properties, including its ability to support cell adhesion, and increases the system's viscosity, which plays a role during the extrusion process [3][4]. The combination of these two biopolymers allows for the production of bio-inks with optimized and appropriate stiffness, similar to soft tissues [4]. It is worth noting here that alginate-gelatin hydrogels can be modified by introducing appropriate additives into the hydrogel. These additives can include both active ingredients and fillers used in medications [3]. Therefore, these hydrogels may in the future enable the creation of personalized medications that will aid in the treatment of individual patients.

This paper presents the results of the preparation and characterization of bio-inks based on sodium alginate and gelatin for extrusion-based 3D printing. Raman spectroscopy will be the primary measurement technique used to analyze the constituent materials and the resulting hydrogels. The results obtained demonstrate the potential of these materials for further research.

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Hydrogen Peroxide Decomposition: Reaction Analysis and Environmental Impact of the Reaction

Sonia Ajtner[1], Weronika Borowczyk[1], Marianna Bocianowska[1], Weronika Czasnowicz[1], Alicja Wolska[1]

[1] Poznan University of Technology, Faculty of Chemical Technology, Berdychowo 4, 60-965 Poznan, Poland
e-mail: weronika.borowczyk@student.put.poznan.pl, weronika.czasnowicz@student.put.poznan.pl, marianna.bocianowska@student.put.poznan.pl

Current developments in the fuel sector focus on finding innovative, environmentally friendly energy sources. In this context, concentrated hydrogen peroxide (H_2O_2) is receiving particular attention. Despite this compound's long history, its unique oxidizing properties and versatility in energy conversion processes make it a key component of modern propulsion and energy systems [1]. Hydrogen peroxide decomposition is a highly exothermic and heterogeneous catalytic reaction in which potassium permanganate (VI) is used as the catalyst. The following equations illustrate the redox reactions between H_2O_2 and $KMnO_4$ [2]:

$$2MnO_4^- + 5H_2O_2 + 6H^+ \rightarrow 2Mn^{2+} + 5O_2 + 8\,H_2O \quad (1)$$

$$2MnO_4^- + 3H_2O_2 \rightarrow 2MnO_2 + 3O_2 + 2OH^- + 2\,H_2O \quad (2)$$

When considering the use of hydrogen peroxide as a fuel, the environmental impact of the decomposition reaction occurring in the vehicle drive system was assessed. The use of this fuel has been shown to have many advantages. Hydrogen peroxide decomposes only into water and oxygen, and therefore does not contribute to emission of any pollutants or toxic byproducts. The high oxidation potential of H_2O_2 ensures more complete fuel combustion, which measurably reduces emissions of particulate matter, carbon monoxide and unburned hydrocarbons. In electrochemical systems and fuel cells, this substance plays a dual role: as an oxidizer and as an energy carrier, constituting a pillar of low-emission energy technologies. An additional advantage of hydrogen peroxide is the absence of the need to build complex storage infrastructure. All this makes hydrogen peroxide a promising component in the development of eco-friendly propulsion systems [3, 4].

The main aim of the study is to comprehensively analyse the decomposition process of hydrogen peroxide (H_2O_2). The research focuses on determining the optimal substrate solution concentration and precisely determining the volume of the released gaseous product. A significant element of the study is the analysis of the process kinetics and the identification of key factors determining the reaction rate. Furthermore, the study attempts to assess the environmental impact of the studied process, taking into account the ecological aspects of the reagents used. Given the growing demand for sustainable energy sources, it is essential to understand how such processes affect the environment.

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Polyurethane-metal organic frameworks composites: innovative materials with outstanding properties

Adam Borwin[1], Joanna Gościańska[2], Aleksander Ejsmont[2], Agata Domańska[1], Filip Ciesielczyk[1], Przemysław Bartczak[1]

[1]Poznan University of Technology, Faculty of Chemical Technology, Institute of Chemical Technology and Engineering, 61-131 Poznan, Berdychowo 4, Poland
[2]Adam Mickiewicz University in Poznan, Faculty of Chemistry, 61-614 Poznan, Uniwersytetu Poznanskiego 8, Poland
e-mail: adam.borwin@student.put.poznan.pl

Polyurethanes (PUR) are one of the leading and rapidly growing classes of polymers due to their unique properties. Depending on the substrates selection and the polyol-to-diisocyanate ratio, they can be classified into flexible and rigid foams, elastomers, thermoplastics, and adhesives. PUR materials are widely used across various fields. Their range of application continues to expand as a result of research on increasingly advanced additives, including fillers designed to enhance the functional properties of final products [1,2].

Among the compounds that have been successfully used as additives in polyurethane materials are metal–organic frameworks (MOFs). These materials constitute an innovative class of porous structures characterized by exceptionally high surface area, reaching up to 10 000 m^2/g. Their unique properties and structural diversity have enabled their application in gas storage, separation membranes, water purification, drug delivery systems, and as contrast agents in magnetic resonance imaging. Owing to their high application potential, MOFs have attracted considerable scientific interest. Given the relatively short history of these materials, new application methods are still being developed, and the growing number of studies on MOFs provides a foundation for the development of advanced technologies [3,4].

In this study, the influence of a representative metal-organic framework (ZIF-8) on the basic physicochemical and functional properties of polyurethane materials was investigated for the first time. The novel composites obtained by combining materials with distinct properties may exhibit significant application potential. The fabricated elastomeric composites were subjected to a series of analyses, including contact angle measurements, water absorption tests, mechanical testing, and thermogravimetric (TG) analysis, in order to evaluate their physicochemical and functional performance. The development of new metal-organic structures opens broad opportunities for further research on polyurethane composites utilizing porous materials as fillers.

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Biocatalytic Techniques for Synthesis of Active Pharmaceutical Ingredients

Zofia Bukowska[1], Jakub Zdarta[1]

[1] Institute of Chemical Technology and Engineering, Faculty of Chemical Technology, Poznan University of Technology, Berdychowo 4, 60-965 Poznań, Poland
e-mail: zofia.bukowska@student.put.poznan.pl

The necessity for efficient and sustainable methods for synthesizing pharmaceutically active compounds has led to an increased interest in biocatalysis.[1] Enzymes offer distinct advantages over traditional chemical approaches due to their high selectivity and catalytic efficiency. However, their broader application is often constrained by limited stability and poor reusability.[2,3]

The objective of this study was to design and assess biocatalytic systems for the production of active pharmaceutical ingredients (APIs), with a particular focus on enzyme immobilization as a means of improving catalytic properties. The focus of the study was to ascertain the impact of silica-based supports and surface modification techniques on the immobilization efficiency and activity of ω-transaminase.

The findings indicated that the nature of the silica support and the selected surface modification method exerted a substantial influence on the characteristics of the immobilized enzyme. The utilization of polyethylenimine or 3-Aminopropyltriethoxysilane/glutaraldehyde system in the functionalization process resulted in substantial alterations to the material's morphology, thereby enhancing the attachment of enzymes. Furthermore, the immobilized enzymes exhibited retained catalytic activity, thereby substantiating the efficacy of the immobilization approach.

The findings indicate that appropriate immobilization strategies can enhance the stability and usability of enzymatic systems. The developed biocatalysts show promise for application in multi-enzyme cascade processes, potentially enabling more efficient and streamlined synthesis of pharmaceutical compounds.

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How mucin contorls lipid interfaces: insights from langmuir monolayer studies

Karolina Choniej[1], Monika Rojewska[1]

[1]Poznan University of Technology, Faculty of Chemical Technology, Institute of Chemical Technology and Engineering, 61-131 Poznan, Berdychowo 4, Poland
e-mail: karolina.choniej@student.put.poznan.pl

Biological membranes form the fundamental barrier separating cellular interiors from external environments, with their physicochemical properties largely governed by lipid composition and interactions with surrounding molecules. At mucosal epithelial surfaces, mucins—highly glycosylated proteins responsible for protection and hydration—form a crucial and dynamic interface with these cellular membranes. This study aims to investigate the biophysical interactions between mucin (MUC-2) and model lipid membranes to understand how mucins modulate lipid behavior at the molecular level. [1]

Using the Langmuir monolayer technique, diverse lipid models (DPPC, DOPE, DOPG, DOPC, cholesterol, and sphingomyelin) were analyzed across different subphases (PBS at pH 7.4, HCl at pH 2.0, and mucin solution at pH ~6.8). The interfacial behavior was comprehensively evaluated by recording surface pressure–area (π–A) isotherms, calculating the surface compressibility modulus (Cs^{-1}), and measuring surface potential as a function of molecular area. Furthermore, the stability of the monolayers was assessed via isobaric relaxation measurements (at a constant physiological surface pressure of $\pi = 30$ mN/m) under both static and dynamic (forced circulation) subphase conditions. [2]

That findings demonstrate that the presence of mucin significantly modifies the structural and physicochemical properties of the model lipid monolayers. These results provide vital biophysical insights into the mechanisms of protein–lipid interactions, suggesting that mucins actively regulate membrane dynamics and stability under physiological conditions. Ultimately, understanding these interfacial phenomena sheds light on how the mucosal environment impacts the transport, permeability, and absorption efficiency of active pharmaceutical compounds at the molecular level. [3]

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Hydrophobic Modification of Polyamino Acids for Self-Assembled Polymeric Nanocarriers Formation

Anna Chrząszcz[1], Krzysztof Szczepanowicz[1]

[1]Jerzy Haber Institute of Catalysis and Surface Chemistry, Polish Academy of Sciences, Niezapominajek 8, 30-239 Krakow, Poland
e-mail: anna.chrzaszcz@ikifp.edu.pl

Nanomaterials play an increasingly important role in modern medicine, particularly in the development of advanced drug delivery systems. Nanomedicine focuses on designing carriers that enable controlled and targeted delivery of active compounds, reducing systemic toxicity while improving therapeutic efficacy. Among various approaches, polymeric nanostructures based on amphiphilic macromolecules are of particular interest due to their ability to self-assemble in aqueous environments.

In this work, preliminary studies on the synthesis and characterization of amphiphilic polyelectrolytes for potential drug delivery applications are presented. Hydrophilic polymers, poly(glutamic acid) (PGA) and poly-L-lysine (PLL), were chemically modified by the introduction of hydrophobic moieties using carbodiimide-mediated coupling (EDC/NHS). Depending on the polymer structure, hydrophobic chains were covalently attached via reactions of activated carboxyl groups with appropriate nucleophiles, leading to partial substitution of functional groups and the formation of amphiphilic derivatives. As a result, the obtained systems are capable of self-assembly into polymeric micelles in aqueous media.

The formed nanostructures are expected to exhibit a core–shell architecture, in which hydrophobic domains constitute the micellar core enabling encapsulation of poorly water-soluble compounds, while hydrophilic polyelectrolyte chains form the outer shell, providing colloidal stability and facilitating interactions with biological environments. The influence of synthesis parameters, including the molar ratio of reagents and the degree of substitution, on the physicochemical properties of the obtained materials was investigated. The formation and size distribution of the nanostructures were analyzed using dynamic light scattering (DLS), while chemical modification was confirmed by infrared spectroscopy (FTIR). The presented results demonstrate that controlled hydrophobic modification of polyelectrolytes is a promising strategy for the design of self-assembled polymeric nanocarriers and provides a basis for further studies on drug encapsulation and controlled release.

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Characterization and application of choline oxalate salt in electrochemical energy storage systems

Julianna Czerniawska[1], Joanna Fijałkowska[1], Xymena Gross[1], Jakub Tomasz[1], Beata Sikora[1], Adam Borwin[1], Julia Marecka[1], Piotr Gajewski[1], Katarzyna Szcześniak[1], Agnieszka Marcinkowska[1], Łukasz Popenda[2]

[1] Poznan University of Technology, Institute of Chemical Technology and Engineering, 61-131 Poznań, Berdychowo 4, Poland
[2] Adam Mickiewicz University in Poznan, NanoBioMedical Centre, 61-614 Poznań, Wszechnicy Piastowskiej 3, Poland
e-mail: julianna.czerniawska@student.put.poznan.pl

Choline oxalate is a promising component of safe, environmentally friendly aqueous electrolytes due to its biocompatibility and high ionic conductivity. Choline is considered a low-toxicity, biodegradable substance due to its crucial role in physiological processes in the human body. For example, choline is essential for the proper functioning of the liver, muscles, and brain, and it serves as a precursor to the neurotransmitter acetylcholine [1].

Furthermore, choline-based salts are attractive candidates for electrolyte applications, as they can decrease the crystallization temperature of aqueous electrolytes, enabling their use at lower temperatures than conventional electrolytes [2]. Oxalic acid, on the other hand, is widely used in combination with transition metals in various electrochemical energy storage devices. The main advantages of these components include high specific capacitance and pseudocapacitance behavior, which makes them particularly suitable for supercapacitor applications. Additionally, oxalic acid is relatively inexpensive and eco-friendly [3].

This research aimed to synthesize high-purity choline oxalate and evaluate its potential application in energy storage devices. The first stage of the study was to develop an effective method for salt synthesis. To confirm its high purity and an appropriate anion-to-cation ratio, Nuclear Magnetic Resonance (NMR) and Fourier Transform Infrared Spectroscopy (FTIR) were performed.

The second stage focused on preparing aqueous electrolytes containing choline oxalate at various molar concentrations. Next, their ionic conductivity was measured as a function of concentration and temperature. Finally, the selected electrolytes were tested in electrochemical capacitors.

The results confirmed the high purity of the synthesized choline oxalate salt and the expected anion-to-cation ratio of 1:2. Furthermore, the findings indicate its potential as an environmentally friendly aqueous electrolyte for electrochemical devices capable of operating at lower temperatures than devices using conventional electrolytes.

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UAV-Based Testbed for Satellite Link Resilience Assessment

Judyta Ferenc[1], **Jakub Hędrzak**[1]

[1]Poznan University of Technology, Jacka Rychlewskiego 1, 61-131 Poznań, Poland
e-mail: judyta.ferenc@student.put.poznan.pl, jakub.hedrzak@student.put.poznan.pl

A UAV-based testbed for the experimental evaluation of satellite link resilience against intentional electromagnetic interference is presented. The developed system, employing a software defined radio controlled by a single-board computer, enables the generation of controlled interference during an actual satellite overpass. A jamming trial scenario and the results of experiments conducted on the downlink between the SONATE-2 satellite and the Gaia 100 ground station in Kąkolewo are presented. The results confirm that an appropriate selection of interference signal parameters disrupts the transmission by causing a loss of synchronization in the ground station's demodulator.

Chitosan hydrogels as potential biomedical dressings

Daria Frontczak[1], Aleksandra Grząbka-Zasadzińska[2]

[1] Institute of Chemical Technology and Engineering,Poznan University of Technology, 60-965 Poznan, Poland, Berdychowo 4
e-mail: daria.frontczak@student.put.poznan.pl

Chitosan-based hydrogels constitute a promising class of biomaterials due to their physicochemical as well as biological properties. They are characterized by a high water content, which enables them to maintain a moist environment that plays a crucial role in the wound healing process [1]. Chitosan, a natural polysaccharide derived from chitin, additionally exhibits intrinsic antibacterial properties, making it particularly attractive for biomedical applications [2]. To enhance the mechanical and functional properties of hydrogels, various crosslinking methods are employed. Chemical crosslinking using agents such as glutaraldehyde enables the formation of a stable three-dimensional network. Furthermore, the application of ionic crosslinking, for instance through the use of calcium ions, provides additional structural reinforcement [3]. The incorporation of bioactive additives, such as zinc ions, contributes to increased antimicrobial activity and supports tissue regeneration processes [4]. In this study, chitosan–alginate hydrogels were prepared using a dual crosslinking system involving both chemical and ionic mechanisms, which enabled the development of materials with optimized properties. The obtained hydrogels were thoroughly characterized in terms of their swelling capacity, structural features, release of residual crosslinking agent, and antibacterial activity against *Escherichia coli* and *Bacillus cereus*. The results demonstrated that both the qualitative and quantitative composition of the hydrogels significantly affect their functional performance. The presence of zinc ions markedly enhanced the antibacterial activity of the materials, while the crosslinking method influenced both the swelling behavior and the structural stability of the hydrogels. The findings indicate that properly designed chitosan-based hydrogels may serve as advanced, functional materials with significant potential in wound dressing applications as well as in the broader field of regenerative medicine.

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Research on the properties of magnetoactive elastomers for use in soft robotics

Weronika Hein[1], Skarbimir Grabowski[2], Michał Zawieja[3], Jakub Bernat[2], Agnieszka Marcinkowska[1], Piotr Gajewski[1]

[1] Institute of Chemical Technology and Engineering, Poznan University of Technology, 60-965 Poznan, Poland, Berdychowo 4
[2] Institute of Automatic Control and Robotics, Poznan University of Technology, 61-138 Poznan, Poland, Piotrowo 3A
[3] Institute of Computer Science, Poznan University of Technology, 61-138 Poznan, Poland, Piotrowo 2
e-mail: weronika.hein@student.put.poznan.pl

Magnetoactive elastomers (MAEs) based on silicone matrices have recently attracted significant interest in soft robotics due to their combination of the high elasticity of silicone elastomers with a controllable response of the magnetic filler to magnetic fields. The development of micro- and mechatronic systems controlled by magnetic fields opens up new possibilities in untethered robotics, particularly in applications that require operation in hard-to-reach environments, such as minimally invasive medicine and micromanipulation.

The goal of this project is to develop a magnetic field based framework for estimating the orientation and position of a magnetoactive element in a global reference frame, with a view toward subsequent magnetic actuation using a permanent magnet (PM). The work addresses key sensing challenges in untethered magnetic devices (UMD), where limited onboard capabilities and strongly nonlinear field interactions make reliable state estimation difficult [1, 2].

To enable controlled data acquisition and real-time processing, a dedicated experimental platform has been constructed. It comprises three triaxial RM3100 magnetometers, a Xilinx Kria KR260 FPGA board for synchronized acquisition and preprocessing, and two servo-driven positioning mechanisms used to set known orientations of the PM and the MAE.

In the current project stage, the platform is used to generate labeled datasets by systematically varying PM/MAE orientations and recording multi-sensor magnetic field vectors. These data are then used to train a neural network estimator that maps magnetic measurements to the MAE orientation and, in later stages, to its position.

The next step is to transfer the estimator from the controlled setup to scenarios where the MAE is placed freely within the workspace, providing the basis for subsequent closed-loop control.

In parallel, magnetoactive elastomers are synthesized and characterized to quantify how filler type and concentration influence mechanical response (deformation, stiffness) and magnetic field induced behaviour. The knowledge gained from analyses supports the estimation task by providing insight into the expected variability and nonlinear behaviour of MAE responses under magnetic field excitation, ultimately contributing to improved robustness and accuracy of the estimator in real operating conditions.

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Zinc- and zirconium-based BIO-MOFS derived from L-glutamic acid for applications in controlled drug release

A. Hejna [1], A. Domke[1], M. Jakubowski[1,2], M. Sandomierski1

[1]Poznan University of Technology, Faculty of Chemical Technology,
Institute of Chemical Technology and Engineering, Poznan, Poland
[2] Poznan University of Technology, Faculty of Mechanical Engineering,
Institute of Mechanical Technology, Poznan, Poland
e-mail: amelia.hejna@student.put.poznan.pl

Metal–organic frameworks (MOFs) are among the most extensively investigated nanomaterials due to their high specific surface area, high porosity, and tunable structural architecture. A particularly interesting subgroup is represented by bio-MOFs, which are synthesized using naturally derived linkers and may be applied as carriers for active pharmaceutical substances [1,2].In this study, zinc- and zirconium-based bio-MOFs derived from L-glutamic acid were synthesized and evaluated as ciprofloxacin delivery systems. L-glutamic acid, as a natural amino acid capable of coordinating metal ions, represents an attractive ligand for the synthesis of biocompatible MOF structures [3,4]. Ciprofloxacin is a fluoroquinolone antibiotic with a broad spectrum of antibacterial activity, particularly against Gram-negative bacteria. Its mechanism of action involves the inhibition of bacterial DNA gyrase and topoisomerase IV, leading to impaired DNA replication and bacterial cell death. Due to its high biological activity, as well as the limitations of conventional administration, including rapid drug release, systemic adverse effects, and the risk of promoting antimicrobial resistance, ciprofloxacin is an important model drug for the development of controlled release systems [5]. The obtained materials were characterized using SEM, EDS, and FT-IR analyses, as well as particle size and zeta potential measurements. Their ciprofloxacin sorption capacity and drug release profiles were also investigated at pH 7.4 and pH 5, corresponding to physiological conditions and acidic environments typical of inflammation sites and the tumor microenvironment, respectively. The results showed that both materials effectively adsorbed ciprofloxacin. Zn-MOF retained approximately 194 μg, whereas Zr-MOF retained approximately 250 μg of the drug per 20 mg of carrier. Clear differences in the release profiles were observed. The zinc-based material released almost the entire amount of the drug within the first 7 hours, while the zirconium-based material released only about 35% of the retained ciprofloxacin during the same period, indicating a more prolonged release behavior. In conclusion, zinc- and zirconium-based bio-MOFs derived from L-glutamic acid demonstrated high ciprofloxacin sorption capacity and distinct, metal-dependent release profiles. Zn-MOF may be suitable for systems requiring a rapid antibacterial effect, whereas Zr-MOF shows greater potential as a carrier for prolonged and controlled drug release. These findings indicate that the selection of the metal center may be an effective strategy for tuning the properties of ciprofloxacin delivery systems.

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Green Metal Recovery from E-Waste Using Methanesulfonic Acid (MSA)-Based Solvents

Tharunika Gurumoorthy[1,2], Magdalena Emmons-Burzyńska[2], Magdalena Regel-Rosocka[2]

[1] School of Chemical and Biotechnology, SASTRA Deemed To Be University, Thirumalaisamudram, Thanjavur, Tamil Nadu 613401, India
[2] Institute of Chemical Technology and Engineering, Faculty of Chemical Technology, Poznan University of Technology, Berdychowo Street 8, 61-131 Poznan
email: tharunikagurumurthy09@gmail.com

The rapid increase in production of electronic waste (e-waste) has intensified the requirement of an environmentally friendly and sustainable metal recovery techniques, particularly for valuable metals such as copper and silver. In line with *green chemistry* and *circular economy* principles, methanesulfonic acid (MSA) is a promising, alternatives to conventional acids, due to its low toxicity and high leaching efficiency [1]. However, optimizing leaching conditions for efficient metal recovery remains challenging because of e-waste complexity. Recent studies have demonstrated that green solvent, such as carboxylic acid-based deep eutectic solvents (DES), can achieve efficient and selective metal recovery under mild conditions, offering a useful benchmark for MSA-based processes [2].

E-waste from discarded computers was ground and sieved to 63-355 µm fraction. Two leaching agents were used, **A:** Bet-MSA DES containing MSA as a hydrogen bond donor and betaine (Bet) acting as a hydrogen bond acceptor, **B:** 4.2 M MSA solution. A 30% H_2O_2 solution was added as an oxidant. A 0.1 g of e-waste powder was treated at S/L (solid/liquid) = 1/50 g/cm^3, with 5 cm^3 of the leaching solution (3 cm^3 of A or B +, 0, 1 or 2 cm^3 of H_2O_2 or deionized water).

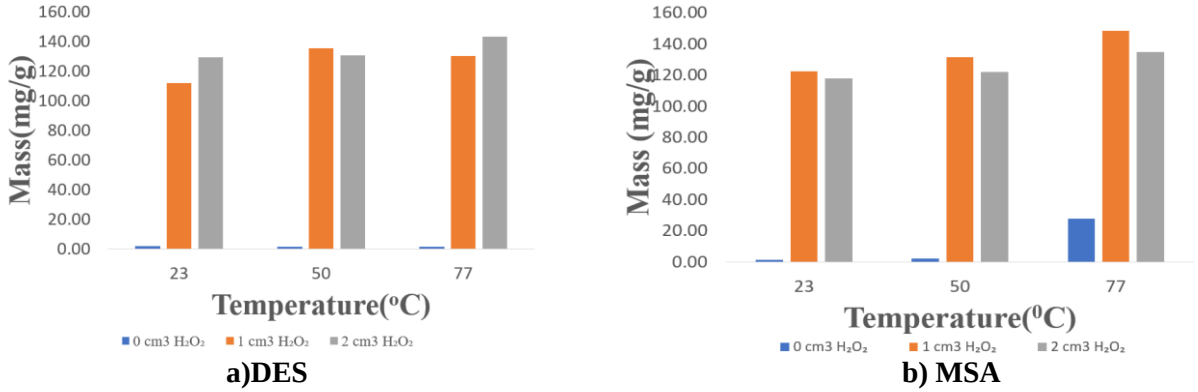

***Fig. 1**: Effect of temperature and H_2O_2 presence on Cu leaching from e-waste using a) DES and b) MSA.*

The results indicate that MSA-based leaching systems provides efficient recovery of metals while minimizing environmental impact. Furthermore, integrating statistical modelling for experiment validation enhances process optimization and supports the development of sustainable hydrometallurgical technologies. This work also promotes advancement in urban mining as green metal recovery strategy and emphasizes the role of environmentally benign solvents in achieving sustainable resource utilization.

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Enhanced Physical Properties of BNFO/GNPs/LC Nanocomposites

Gulzar Hussain[1], Eryk Wolarz[1], Mariusz Ślachciński[2]

[1]Faculty of Materials Engineering and Technical Physics, Poznan University of Technology, Jacka Rychlewskiego 1 St, 61-131 Poznań, Poland
[2]Institute of Chemistry and Technical Electrochemistry, Poznan University of Technology, 4 Berdychowo St., 60-965, Poznań, Poland
e-mail: gulzar.hussain@doctorate.put.poznan.pl

Nd^{3+}-substituted $BiFeO_3$ (BNFO) and BNFO/5 wt% GNPs/6 wt% LC nanocomposites were synthesized using sol-gel auto-combustion and ultrasonication techniques. The influence of GNPs and LC on the structural, surface morphological, and dielectric properties of BNFO was investigated. X-ray diffraction (XRD) analysis indicated a distorted rhombohedral perovskite structure within the space group R3c. The average crystallite size decreased from 64.27 ± 3.20 nm to 58.28 ± 4.23 nm following the incorporation of GNPs and LC. SEM images of BNFO/GNPs/LC reveal distinct textures: BNFO, GNPs in sheet-like form, and LC in rod form, indicating the morphological characteristics of the prepared nanocomposite. The EDX analysis confirms the elemental composition and successful formation of the synthesized sample. AFM was utilized to assess the surface roughness of both BNFO and BNFO/GNPs/LC nanocomposites. The frequency-dependent dielectric properties of BNFO/GNPs/LC nanocomposites were examined, demonstrating a consistent decrease in specific resistance (Ω-cm) and loss angle (°) as frequency increased. These results indicate that the conduction mechanism is primarily governed by hopping charges. The findings suggest that the synthesized nanocomposites are promising candidates for high-frequency dielectric energy storage applications.

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Comparative Thermal Performance Analysis of Porous TPMS Lattice Heat Sinks

Welteji Iticha[1], **Tomasz Stręk**[2]

[1,2] Institute of Applied Mechanics, Poznan University of Technology, Poznan, Poland
e-mails: welteji.iticha@doctorate.put.poznan.pl, tomasz.strek@put.poznan.pl

The advancement toward compact size and high power density in electronic devices has intensified the demand for enhanced heat dissipation efficiency [1,2]. Traditional air cooling techniques, typically based on fin geometries, are often inadequate under high thermal loads due to their limited surface area and non uniform airflow distribution [3-5]. Recent advances in additive manufacturing have enabled the fabrication of complex porous structures, such as triply periodic minimal surfaces (TPMS), which offer enhanced thermal performance owing to their high surface area and interconnected architectures [6].

This study presents a comparative analysis of different TPMS geometries subjected to design variables, including flow rate, heat load, relative density, and lattice size. Three TPMS structure (Gyroid, Diamond, and I-WP) were selected for evaluation. The 3D Model of the heat sink structure were generated using MS Lattice, and numerical simulations were performed using the finite element method in COMSOL Multiphysics to evaluate thermal behavior, fluid flow profile, pressure drop, and overall thermal performance. During analysis, water is used as working fluid and it enters to the heat sink (HS) channel with constant inlet velocity, while uniform heat load is applied at the base. Heat is conducted through the HS structure and subsequently dissipated to the environment via convective transport at the outlet boundary. The outer channel walls are assumed to be adiabatic with no slip condition. A set of governing equations, including energy equation and Brinkman equation, was used to compute heat transfer and fluid flow in the porous medium, respectively.

The results indicate that increasing fluid flow velocity enhances heat transfer performance due to more effective heat removal from the source. Among the evaluated structures, Gyroid TPMS HS demonstrated the highest thermal performance. Overall, the study demonstrates the significant influence of heat sink geometry on performance metrics such as the Nusselt number and friction factor, revealing the balance between enhanced heat transfer and increased pumping power.

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Three-dimensional TiO_2-based photocatalytic matrices for selective pharmaceutical removal from aqueous solutions

Marta Jaruga[1], Michał Cegłowski[1], Adam Kubiak[1]

[1]Adam Mickiewicz University, Poznań, Faculty of Chemistry, Department of Supramolecular Chemistry
Uniwersytetu Poznańskiego 8, 61-614 Poznań
e-mail: marta.jaruga@amu.edu.pl

Titanium dioxide (TiO_2) is a pivotal material in photocatalysis due to its chemical stability, non-toxicity, and strong oxidative properties. However, its powdered form faces practical limitations, such as recovery difficulties, agglomeration, and restricted active surface area, which hinder broader applications [1]. To address these issues, designing TiO_2 in 3D structures, such as sponges, offers significant advantages. Three-dimensional architectures not only facilitate better handling and recovery but also provide enhanced light penetration, increased mass transfer, and a larger effective surface area [2,3]. The sponge-like matrices mimic natural systems, ensuring a more uniform distribution of active sites and improved interaction with target pollutants, making them particularly promising for environmental and energy applications. To overcome these challenges, research has focused on modifying the structural and morphological properties of TiO_2 [4,5]. This study proposes the use of biomimetic sponge matrices as templates for TiO_2 deposition. Inspired by the hierarchical and porous architectures found in nature, these structures enable precise control over TiO_2 crystallization. While sponges have been previously utilized for TiO_2 deposition, no comprehensive study has directly compared different sponge matrices within a single investigation. Moreover, the influence of the sponge structure itself on the deposition process and resulting material properties remains largely unexplored. The resulting three-dimensional (3D) materials, developed in this study, feature uniform TiO_2 coverage, enhanced active surface area, improved light absorption, and more efficient charge separation, all contributing to superior photocatalytic performance. The development process involved careful selection of sponge matrices and advanced deposition techniques such as sol-gel processes and hydrothermal synthesis. Material characterization using SEM, XRD, and UV-Vis spectroscopy provided a detailed understanding of the relationship between structure and photocatalytic activity. The effectiveness of these innovative 3D TiO_2 materials was demonstrated in the degradation of pharmaceutical contaminants like ketoprofen in wastewater. These materials significantly outperformed conventional TiO_2 powders and also showed promise in hydrogen generation under solar irradiation. In conclusion, biomimetic sponge matrices offer a transformative approach to designing next-generation photocatalysts, addressing the limitations of conventional TiO_2 and paving the way for more efficient and sustainable systems for water purification, environmental remediation, and energy production.

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Discovering Influence of Social Media on Stock Market

Dawid Siera[1], Julian Mikołajczak[2], Anatol Kaczmarek[1], Paulina Paszkowiak [1]

[1] Faculty of Computing and Telecommunications, Poznań University of Technology, ul. Piotrowo 3, 60-965 Poznań, Poland
[2] Faculty of Control, Robotics and Electrical Engineering, Poznań University of Technology, ul. Piotrowo 3, 60-965 Poznań, Poland
e-mail: anatol.kaczmarek@student.put.poznan.pl

A single social media post from a high-profile individual can trigger rapid, unpredictable fluctuations in stock prices. This work presents a machine-learning framework designed to capture, predict, and explain such celebrity-driven market dynamics. We assemble a dataset combining posts from selected high-profile X accounts, Google Trends search-interest data for the relevant companies, products and keywords, as well as historical stock prices over the same period. A deep learning model is then trained on this data to predict short-term price movements from public sentiment and attention [1].

The key contribution of this research lies in moving beyond prediction toward explanation of market dynamics during times of high volatility. Moving beyond conventional forecasting, the framework employs Explainable AI (XAI) techniques to trace the trained model's decision-making process backward during periods of elevated market volatility. By tracing predicted outputs back to the exact input features that produced them, the system isolates and pinpoints the specific X post, search keyword, or trend spike that exerted the strongest directional influence on a given stock's valuation. The result is a transparent tool that links complex financial shifts to distinct social phenomena, opening new possibilities for risk monitoring, market integrity research, and the study of coordinated influence campaigns.

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Biobased systems for controlled release of plant bioactives

Michał Kapczyński[1], Adam Grzywaczyk[1], Ewa Kaczorek[1]

[1]Institute of Chemical Technology and Engineering, Poznań University of Technology, Berdychowo 4, 61-131 Poznań, Poland
e-mail: michal.kapczynski@student.put.poznan.pl

Plant-derived bioactive compounds are widely investigated for pharmaceutical and cosmetic applications due to their diverse biological activity and natural origin. These compounds exhibit properties such as antioxidant, anti-inflammatory, and antimicrobial activity, making them promising therapeutic agents [1,2]. Additionally, their potential synergistic interactions may enhance their overall biological effectiveness [3,4]. However, their practical application is limited by unfavorable physicochemical properties, including low solubility, poor stability, and limited bioavailability, as well as restricted permeability across biological membranes [5,6].To address these limitations, advanced delivery systems based on cyclodextrins and liposomes have been developed, enabling improved solubility, stability, and transport of bioactive compounds [7,8].

The present study focuses on the design and development of hybrid supramolecular delivery systems aimed at improving the physicochemical performance and biological potential of selected plant-based compounds. The prepared systems were characterized by particle size and zeta potential measurements, and their activity against *Escherichia coli* was also evaluated. The results demonstrated improved dispersion stability and enhanced physicochemical properties compared to unformulated compounds, along with noticeable antibacterial activity.

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Search Area Estimation for Missing Persons in Mountainous Terrain

Jakub Kędra

Faculty of Computing and Telecommunications, Poznan University of Technology, 60-965 Poznań, Piotrowo 3
e-mail: jakub.kedra@student.put.poznan.pl

Search and rescue operations in mountain environments are challenged by difficult terrain, limited time, and uncertainty regarding the possible location of a missing person. In such conditions, estimating the area in which the person may be located is essential for prioritizing field operations and improving the allocation of rescue resources. The problem is complex because human movement in mountainous terrain is influenced by multiple factors, including topography, accessibility, travel time, and assumptions about how a missing person may move in unfamiliar or demanding conditions.

This project investigates methods for delineating potential search areas for missing persons by comparing search-area estimation methods and movement models adapted to mountainous terrain. The research is focused on the comparison of multiple movement models and search-area estimation approaches. In particular, the study examines how different assumptions about movement cost, terrain constraints, and spatial representation influence the extent and shape of the predicted search area. This research builds on a broad body of literature on search theory, lost person behavior, and computational modeling of movement and search areas in complex environments [1–4].

The analyzed models and methods include approaches based on travel time, movement cost, and terrain accessibility, as well as different ways of representing space and possible movement paths. These models are used to estimate the area that could be reached from a known or assumed starting location under specific environmental and temporal constraints. Comparing such approaches makes it possible to evaluate how strongly the predicted search area depends on the adopted modeling assumptions.

The main objective of the research is to identify which modeling choices are the most informative and useful for representing possible areas of movement in mountain search scenarios. An additional goal is to assess how differences between models may affect the interpretation of uncertainty and, consequently, operational search planning.

The expected outcome of the study is a comparative framework for evaluating search-area estimation methods in mountain environments and a better understanding of how terrain-aware movement modeling can support decision-making in search and rescue operations.

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Functional Cellulose Acetate Membranes Modified with Sulfobetaine and Platinum Nanoparticles for Hemodialysis Applications

Oliwia Konieczka[1], Aleksandra Domke[1], Marta Woźniak-Budych[2], Katarzyna Staszak[1]

[1]Institute of Chemical Technology and Engineering, Poznan University of Technology, 61-131 Poznan, Poland, Berdychowo 4
[2]NanoBioMedical Centre, Adam Mickiewicz University, 61-614 Poznan, Poland, Wszechnicy Piastowskiej 3
e-mail: oliwia.konieczka@student.put.poznan.pl

The kidneys are vital organs responsible for maintaining internal balance in the human body. Their roles include controlling water and electrolyte levels, regulating acid-base homeostasis, eliminating metabolic waste, and producing hormones involved in blood pressure regulation, calcium-phosphate balance, and red blood cell formation [1]. Chronic kidney disease has become a significant global health concern and often requires renal replacement therapies such as dialysis, which generate substantial healthcare costs [2]. Dialysis is widely used in the treatment of patients with end-stage renal disease as well as acute kidney injury. The process is based on the use of artificial semi-permeable membranes that enable the removal of toxic metabolites and excess fluids from the bloodstream, primarily through diffusion. This allows for the effective elimination of compounds such as urea and creatinine [3,4]. The present study focused on the development of cellulose acetate membranes incorporating platinum nanoparticles formed directly within the material. Membrane fabrication was carried out using the phase inversion method, with the addition of 3-(N,N-dimethylmyristylammonio)propanesulfonate (SB), which acted as a stabilizing agent and influenced transport properties. The obtained membranes were analyzed using scanning electron microscopy (SEM), and their performance was evaluated in terms of model uremic toxin removal, wettability, and protein adsorption. The results demonstrated that the inclusion of platinum nanoparticles enhanced antifouling properties, as evidenced by decreased adsorption of bovine serum albumin (BSA). Membranes denoted as 0Pt and 10Pt exhibited comparable adsorption levels (around 120 $\mu g/cm^2$), while those containing 30Pt and 50Pt showed a marked decrease, suggesting successful modification of the membranes. In addition, the presence of SB led to a considerable decrease in contact angle values from around 65° (without SB) to values close to 0°, confirming improved hydrophilicity. Overall, the combined incorporation of the SB additive and platinum nanoparticles improved membrane performance, highlighting their potential for application in hemodialysis.

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Development of an electrochemical tongue for the detection of date-rape drugs

Joanna Koprowska[1], **Emilia Witkowska-Nery**[1]

[1] Institute of Physical Chemistry Polish Academy of Science, 01-224 Warszawa, ul. Kasprzaka 44/52
e-mail: jkoprowska@ichf.edu.pl

The tongue consists of thousands of taste cells, making it a model sensor array. Striving for nature's perfection, humans imitate it by arranging synthetic sensing parts and tying them together with data analysis into a sensor array. Such an approach proves itself for the complex challenge of tasting, making it an ideal tool for complex, forensic samples, often containing drink/food items. The project, financed by NCN Sonata BIS (2023/50/E/ST4/00639), explores the tongue concept by swapping taste cells with electrodes and our brain with data analysis using machine learning algorithms to detect date-rape drugs. The human tongue often fails to detect the danger of drug-spiked drinks or food; here's where the electrochemical tongue can shine. Sensitive methods like differential-pulsed voltammetry (DPV) combined with a wide range of low-cost electrode materials can result in a portable and accessible psychoactive substances sensor, for the victims as a prevention, and for the law enforcements in the crucial first hours at the crime scene.

Substances commonly used for incapacitation of the victim are counterfeit medications from benzodiazepine or opioid groups, which is why alprazolam (Xanax), flunitrazepam (Rohypnol) and codeine phosphate (from OTC drugs) were first tested. Preliminary results from water and vodka solutions have been gathered using low-cost, carbon-based working electrodes, later interfering species shall be expanded by the introduction of more complex matrices. The electrode materials explore a range of carbon structures from carbon black (CB), through graphene oxide (G), detonation nanodiamonds (DND), graphite and carbon nanotubes (CNT). These were incorporated into conductive filaments based on polylactide(PLA)/CB or PLA/G, by melting them together. Simple, paper-based, hand-drawn graphite electrodes were also incorporated. Tested electrochemical cells follow the low-cost philosophy by application of a paper interface holding the sample solution, as well as screen-printed counter and reference electrodes, using carbon and silver inks. New composites show promise as a part of a bigger sensor array for the Y/N detection of aforementioned sedatives.

Figure 1 Picture of an electrochemical cell using a paper interface /w sample's solution, screen-printed counter and reference electrodes, and 3d printed PLA/CB working electrode.

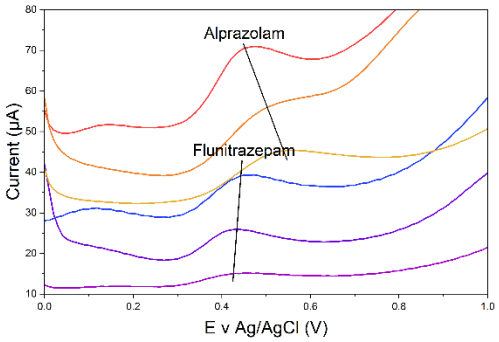

Figure 2 DPV comparison of alprazolam vs flunitrazepam signal in the electrolyte solution, scan rate 150 mV/s, step 10 mV.

Solution Processable and Printable Organic Near Infrared Emitters for Biomedical Applications

Wiktoria Kowalczyk[1], **Piotr Ślęczkowski**[1]

[1] Lodz University of Technology, Department of Molecular Physics, Stefana Żeromskiego 116, Łódź
e-mail: 234642@edu.p.lodz.pl

This work builds upon the FRET donor–acceptor architecture recently reported by Martínez-Denegri *et al.* [1], in which thermal annealing of an HBT-derived excited-state intramolecular proton transfer (ESIPT) donor blended with a curcuminoid acceptor yielded tuneable visible emission. In the present work, that curcuminoid acceptor is replaced by the near-infrared thermally activated delayed fluorescence (TADF) emitter TPA-DCPP, first introduced by Wang *et al.* [2], to shift the emission into the NIR-I biological transparency window (700–900 nm) while retaining the thermal tunability and solution processability of the original system.

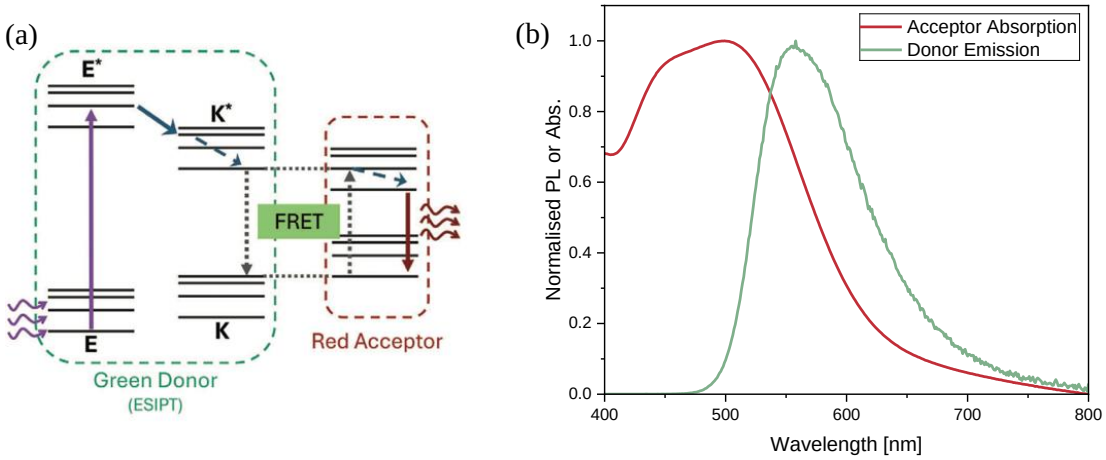

Figure 1. (a) Jablonski diagram of the ESIPT–FRET photocycle, adapted from Martínez-Denegri et al. (2025). (b) Normalised emission of the neat ESIPT donor (green) overlaid with the absorption spectrum of TPA-DCPP (red), measured in this work. The spectral overlap satisfies the resonance condition for Förster energy transfer.

Spin-coated thin films of the ESIPT donor blended with TPA-DCPP were subjected to systematic thermal annealing and sonication protocols, and their optical, morphological, and chromatic evolution was tracked by UV-Vis, photoluminescence, and atomic force microscopy. The donor undergoes an irreversible, kinetically governed transition from a granular texture to a well-ordered fibrillar network, whereas the acceptor remains structurally featureless; in donor–acceptor blends, this donor-matrix densification modulates the local separation and FRET efficiency, yielding a pronounced, concentration- and time-dependent hypsochromic shift of the NIR emission. The feasibility of inkjet deposition was preliminarily verified by formulating a jettable ink whose Ohnesorge number, derived from pycnometric density, pendant-drop surface tension, and viscosity, lies within the stable jetting window (0.07–1.00), confirming that the platform is amenable to printing. These observations establish the first thermally tuneable, solution-processed NIR-TADF FRET system and provide the essential thin-film groundwork for the future realisation of flexible, inkjet-printed OLEDs intended for wearable photobiomodulation.

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Fluorescence lifetime imaging reveals phase-specific behaviour of zeaxanthin in dehydrated lipid membranes

Anna Lągowska[1], Jacek Łyskawa[1], Hanna Orlikowska-Rzeźnik[1], Łukasz Piątkowski[1]

[1] Faculty of Materials Engineering and Technical Physics, Poznan University of Technology, 61-138 Poznan, Piotrowo 3
e-mail: anna.lagowska@doctorate.put.poznan.pl

Zeaxanthin (ZEA) is a polar xanthophyll which incorporates into lipid bilayers in a transmembrane orientation, with its hydroxyl groups anchored at the membrane interfaces. Studies, both experimental and computational, have shown that its localisation, orientation, and dynamics depend strongly on membrane composition, including lipid packing, degree of unsaturation, and the presence of cholesterol [1–3]. In particular, xanthophylls preferentially associate with more disordered, unsaturated lipid environments and modulate membrane physical properties such as ordering and permeability.

In this study, we investigate the fluorescence lifetime of zeaxanthin in phase-separated model membranes composed of egg sphingomyelin, 14:1 phosphatidylcholine, and cholesterol (1:1:1), using fluorescence lifetime imaging microscopy (FLIM) under controlled dehydration. We observe a pronounced decrease in fluorescence lifetime as hydration decreases, with a significantly stronger effect in the liquid-disordered (L_D) phase compared to the liquid-ordered (L_O) phase.

Recent studies have shown that dehydration induces the redistribution of cholesterol towards unsaturated lipid regions, driving substantial reorganisation of interfacial interactions, particularly in L_D domains [4]. These changes include reduced hydration, altered polarity, and increased structural heterogeneity. The stronger decrease in lifetime observed in the L_D phase is therefore consistent with ZEA being more sensitive to dehydration-induced changes in disordered lipid environments. It can be assumed that non-radiative decay pathways dominate ZEA's fluorescence, and therefore, the observed shortening of the lifetime indicates enhanced energy dissipation efficiency in perturbed membrane environments.

Although the molecular origin of the observed changes in lifetime remains to be fully resolved, our results demonstrate that FLIM of intrinsic carotenoid fluorescence is a sensitive probe of membrane-state-dependent changes, linking the organisation of lipids and environmental perturbations to the photophysical behaviour of carotenoids.

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Effects of dehydration on model cell membranes probed by Atto 633-DOPE using Fluorescence Lifetime Imaging Microscopy

Jacek Lyskawa[1], Emilia Krok[1], Lukasz Piatkowski[1]

[1] Poznan University of Technology, Faculty of Materials Engineering and Technical Physics
Institute of Physics, 61-138 Poznan, Piotrowo 3
e-mail: jacek.lyskawa@doctorate.put.poznan.pl

Water is fundamental for maintaining biological activity of all living organisms [1]. Yet, certain organisms have developed an extraordinary mechanism of survival under extreme dehydration conditions, which is known as anhydrobiosis [2]. Organisms such as tardigrades, nematodes and yeasts accumulate high levels of carbohydrates, such as trehalose, which help maintain membrane stability during drying. Eukaryotic cell membranes are not naturally designed to tolerate dehydration, as they evolved to function in water-rich environments. Nevertheless, variety of key biological processes such endo- and exocytosis, neurotransmission, viral entry, fertilization and biomolecules adsorption, depend on localized or temporary dehydration of the lipid bilayers [3]. The indispensable connection of these membrane fusion events with transient, local dehydration of two merging lipid bilayers highlights the critical importance of understanding the molecular properties of membranes under dehydration conditions.

In this study, we used lipid bilayers formed on a solid support which, owing to the precisely tuned lipid profile, naturally undergo phase separation into liquid disordered (L_d) and ordered (L_o) phase. These synthetic membrane systems can be visualized either by probe-based mechanical scanning using atomic force microscopy or through the selective labelling of membrane components with fluorescent probes. The latter, while enabling visualization, also encodes substantially more information about both synthetic and native cell membranes, including the diffusion of membrane components, lipid packing, membrane fluidity, or hydration level. Labelling of membranes, combined with Fluorescence Lifetime Imaging Microscopy (FLIM) enables quantitative mapping of membrane properties by reporting on the local molecular environment of fluorescent probes.

In this investigation we monitored hydration-dependent fluorescence lifetime of Atto 633-DOPE, a promising fluorescent probe whose lifetime has previously been used to study membrane kinetics and mechanisms such as flip-flop [4]. We observed that dehydration of lipid membranes caused the fluorescence lifetime of Atto 633 to decrease in the L_d phase by approximately 20%. Furthermore, changes in hydration level promoted the migration of this L_d-labelling probe to the L_o phase, as previously revealed by scanning membrane topography, under dehydration conditions, using atomic force microscopy [5]. In the L_o phase, we observed a fluorescence lifetime approximately 15% longer than in the L_d phase and found it to be more stable throughout the dehydration. The migration of the lipid probe under dehydration revealed a surprising change in its initial preferential localization within disordered phase. At the same time fluorescence lifetime mapping of the molecules provided information about increasing structural heterogeneity within membrane, which was initiated by the lowering of hydration state. These results are not only important for understanding lipid membrane dynamics under dehydration, but also shed a completely new light on using Atto 633-DOPE probe as an acceptor in Förster Resonance Energy Transfer studies in complex, phase separated synthetic membranes.

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Aqueous choline–phosphate electrolytes: synthesis and electrochemical investigation for energy storage devices

Jan Malczak[1], Seyed Amirhossein Sanei[1], Piotr Gajewski[1], Agnieszka Marcinkowska[1], Qamar Abbas[1]

[1] Institute of Chemical Technology and Engineering, Poznan University of Technology, 60-965 Poznan, Poland, Berdychowo 4
e-mail: jan.malczak@student.put.poznan.pl

The development of safe and environmentally friendly electrolyte systems remains a key challenge in modern electrochemical energy storage technologies. Choline-based salts have recently attracted attention due to their low toxicity, high water solubility, and chemical stability, offering a promising alternative to conventional aqueous and organic electrolytes. Several studies, including those reported by Abbas et al. [1-3], have demonstrated the applicability of choline-based electrolytes, such as choline nitrate, in electrochemical capacitors.

Among them, choline dihydrogen phosphate (CDHP) is a particularly interesting candidate for electrochemical capacitors. However, aqueous solutions of CDHP exhibit slightly acidic pH, which narrows the electrochemical stability window to approximately 1.3–1.4 V due to hydrogen evolution. It has been shown that increasing the pH toward neutral values may extend the operating voltage up to 1.5–1.6 V.

In this context, the incorporation of a second salt, choline hydrogen phosphate (CHP), provides a simple approach to modifying electrolyte properties. The addition of CHP not only shifts the pH toward neutral values but also affects ionic conductivity and ion transport behaviour, which may contribute to improved electrochemical performance.

In this work, aqueous choline–phosphate electrolytes based on CDHP and mixed CDHP + CHP systems were synthesized via a controlled neutralization route. The obtained electrolytes were characterized in terms of their physicochemical properties, including pH, ionic conductivity, and temperature-dependent behaviour. Particular attention was given to the influence of electrolyte composition on physicochemical properties and electrochemical performance under varying conditions.

The electrochemical performance of the developed systems was evaluated in electrochemical double-layer capacitors (EDLCs) using carbon-based electrodes. A comparison between single-component (CDHP) and mixed (CDHP + CHP) electrolytes revealed differences in electrochemical stability with comparable charge storage behaviour. The mixed systems exhibited a tendency toward improved operational stability and more favourable transport characteristics, which enabled operation at slightly extended voltage ranges.

The obtained results indicate that electrolyte composition, particularly the anion type and ratio, influences the physicochemical and electrochemical properties of aqueous choline-based systems. These effects are reflected in changes in physicochemical properties, ionic transport and electrochemical performance. Overall, choline–phosphate electrolytes show potential as safe and sustainable materials for energy storage applications.

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Polymer Gels Containing Choline Lactate

Julia Marecka[*1], **Piotr Gajewski**[*1], **Xymena Gross**[1], **Jakub Tomasz**[1], **Adam Borwin**[1], **Joanna Fijałkowska**[1], **Julianna Czerniawska**[1], **Beata Sikora**[1], **Katarzyna Szcześniak**[1], **Agnieszka Marcinkowska**[1]

[1]Faculty of Chemical Technology, Poznań University of Technology, 61-131 Poznań, Jacka Rychlewskiego 1
e-mail: *@julia.marecka@student.put.poznan.pl, piotr.gajewski@put.poznan.pl

Polymer hydrogels, thanks to their unique physicochemical properties resulting from high water content, flexibility, and the possibility of modifying their properties by selecting appropriate monomers and functional additives, are a promising group of materials for electrochemical applications [1, 2]. Of particular interest are choline salt systems, which are a valuable substitute for classical ionic liquids [3]. The addition of choline lactate allows for the production of stable hydrogels with limited migration of the liquid phase, which reduces electrolyte leakage. This makes them promising compounds for use as safe, non-drying electrolytes in supercapacitors [4].

In this work photocurable polymer gels based on acrylic and methacrylic monomers (including 2-hydroxyethyl methacrylate – HEMA or poly(ethylene glycol) diacrylate – PEGDA) were synthesized. The composition of the polymer matrix was modified by changing the proportion of crosslinking monomer as well as addition of monomer with choline cation. The materials were subjected to UV photopolymerization, and the gels were then evaluated for their homogeneity, flexibility, mechanical resistance, and ionic conductivity parameters. The research focused on the impact of composition on structural stability and ion transport.

Results revealed that the right selection of monomer proportions and choline lactate content enables the improvement of ionic conductivity of prepared hydrogels. The samples were characterized by high flexibility and good conductivity, which is a promising direction for the construction of energy storage devices.

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Biofortification of *in vitro Pleurotus djamor* biomass – organic and inorganic additive strategies

Alicja Matyjewicz[1], Anna Tuśnio[1], Bożena Muszyńska[3], Beata Paczosa-Bator[1], Agata Krakowska[1,2]

[1]Department of Analytical Chemistry and Biochemistry, Faculty of Materials Science and Ceramics, AGH University of Krakow, Al. Mickiewicza 30, 30-059 Krakow, Poland
[2]Department of Inorganic and Pharmaceutical Analytics, Faculty of Pharmacy, Jagiellonian University Medical College, ul. Medyczna 9, 30-688 Krakow, Poland
[3]Department Of Medical Plant and Mushroom Biotechnology, Jagiellonian University Medical College, ul. Medyczna 9, 30-688 Krakow, Poland
e-mail: amatyjewicz@agh.edu.pl

Modern diets, often dominated by highly processed foods, contribute to widespread deficiencies of essential minerals such as magnesium (Mg) and zinc (Zn), underscoring the need for natural, nutrient-dense functional food sources [1]. In this context, edible mushrooms are increasingly recognized as promising functional food ingredients due to their ability to accumulate essential minerals and produce bioactive compounds [2]. One approach to further enhance their nutritional value is targeted biofortification, in which medium supplementation enables controlled modulation of mineral content in fungal biomass [3]. γ-Polyglutamic acid (γ-PGA), a natural biopolymer with strong metal-chelating properties, may additionally facilitate mineral uptake and improve bioavailability [4].

The aim of this study was to evaluate the effect of medium supplementation with $ZnCl_2$, $MgCl_2$, γ-PGA, and their combinations on biomass growth and mineral accumulation in *Pleurotus djamor* mycelial cultures. Mycelium was cultivated on a control medium and on media enriched with individual additives or additive combinations, and biomass yield was recorded after cultivation. The contents of Mg and Zn in lyophilized biomass were determined using flame atomic absorption spectrometry.

The results revealed distinct effects of the tested additives. γ-PGA strongly stimulated mycelial growth and produced the highest biomass, while $MgCl_2$ also enhanced growth and its combination with γ-PGA showed an additional synergistic increase. In contrast, $ZnCl_2$ reduced biomass formation, and the $ZnCl_2$+γ-PGA variant caused the most pronounced inhibition. For mineral accumulation, γ-PGA alone elevated Mg content, $MgCl_2$ further increased enrichment, and the $MgCl_2$+γ-PGA combination yielded the highest Mg levels. $ZnCl_2$ supplementation increased Zn content approximately fourfold, whereas γ-PGA alone had only a minor effect; however, the $ZnCl_2$+γ-PGA combination unexpectedly resulted in Zn levels lower than in the control.

These findings indicate that γ-PGA-assisted magnesium enrichment effectively enhances the functional value of *Pleurotus djamor* biomass, while the antagonistic interaction between γ-PGA and Zn supplementation highlights the need for careful optimization of zinc-based biofortification strategies.

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Study of fluorophore release form cellulose triacetate-based fluorescent membranes under static conditions

Maciej Matysik[1], Katarzyna Nowak[1], Katarzyna Bielicka – Daszkiewicz[1], Piotr Michałowski[1,2]

[1] Institute of Chemical Technology and Engineering, Poznan University of Technology, 60-965 Poznań, Berdychowo 4
[2] Institute of Bioorganic Chemistry, Polish Academy of Sciences, 61-704 Poznań, Noskowskiego 12/14
e-mail: maciej.matysik@student.put.poznan.pl

Polymeric inclusion membranes (PIMs) based on cellulose triacetate (CTA) constitute an important group of materials used in separation processes and sensing systems. A key aspect of their functionality is their ability to retain and controllably release active compounds, such as fluorophores, which is directly related to the structural stability of the membrane and the molecular interactions between its components. In particular, the balance between polymer–plasticiser–fluorophore interactions and external interactions (e.g. with the solvent) plays a significant role, determining the system's durability and its resistance to desorption processes.

The results obtained indicate that CTA membranes exhibit high stability in an aqueous environment, as confirmed by low values of mass loss, most often below 2%. An exception is the CTA:2-NPOE (90:10) system with quinine salt (~9%), which suggests limited compatibility of this fluorophore with the relatively hydrophobic CTA matrix and its greater tendency to migrate into the aqueous phase. In most cases, increasing the plasticiser content (70:30) did not lead to a significant deterioration in stability, indicating that hydrophobic interactions and the limited solubility of both the plasticiser and the fluorophores dominate in the aqueous environment. At the same time, the slight but noticeable increase in mass loss for systems containing HDEHP (to approx. 2-2.3%) can be attributed to its partial polarity and its ability to interact more weakly with the polymer matrix, which favours its gradual extraction.

Significantly greater changes were observed in the methanol environment, where mass losses exceeded 20%, particularly for systems with a higher plasticiser content (70:30). The highest values (~25-30%) were observed for the CTA:2-NPOE and CTA:DBS systems, which clearly indicates intensive extraction processes of both the plasticiser and, to some extent, the fluorophore. Methanol, as a solvent of medium polarity and with the ability to form dipole interactions, effectively competes with intramembrane interactions, leading to a loosening of the structure and increased mobility of the components. Additionally, its small molecules facilitate penetration into the voids within the polymer matrix, which aids the diffusion and leaching of low-molecular-weight components.

Analysis of the influence of membrane composition clearly indicates that systems with a higher polymer content (90:10) exhibit significantly greater stability, both in water and in methanol. This is due to the maintenance of the polymer phase's continuity, which limits the mobility of the plasticiser and fluorophore and reduces the availability of diffusion pathways. In systems richer in plasticiser (70:30), however, there is an increase in free volume and the formation of microheterogeneous regions, which act as preferential sites for the initiation of extraction processes. This phenomenon can be interpreted in terms of a deterioration in thermodynamic compatibility and a reduction in intermolecular interaction energy within the system.

The results obtained indicate that the stability of CTA membranes is determined both by the chemical nature of the plasticiser and its concentration, as well as by the properties of the external solvent. In particular, environments with higher polarity and a greater ability to penetrate the polymer structure significantly intensify desorption processes. From the perspective of practical applications, this implies the need to optimise the membrane composition to maximise internal interactions and minimise susceptibility to extraction, which is crucial for the design of stable and effective PIM systems.

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The Influence of Molecular Compatibility and Surface Properties on the Stability of Polymeric Inclusion Membranes

Piotr Michałowski[1,2], Dorota Jakubczyk[2], Łukasz Ławniczak[1], Katarzyna Adamska[1], Katarzyna Bielicka – Daszkiewicz[1]

[1] Institute of Chemical Technology and Engineering, Faculty of Chemical Technology, Poznan University of Technology, Berdychowo 4, PL-61131 Poznań
[2] Institute of Bioorganic Chemistry, Polish Academy of Sciences, Noskowskiego 12/14, PL-61704 Poznań
e-mail: piotr.michalowski@doctorate.put.poznan.pl

The aim of the study was to investigate the stability and surface properties of polymeric inclusion membranes (PIMs) in terms of the molecular compatibility of their components and their potential applications in separation processes. Particular attention was paid to the mechanisms of intermolecular interactions between the membrane components and their influence on the structure, durability and functionality of the systems.

Two- and three-component membranes based on cellulose triacetate, polyvinyl chloride and chitosan, modified with plasticisers of varying polarity, were synthesised. Plasticisers played a key role in regulating the physicochemical properties of the membranes, influencing the segmental mobility of the polymer chains by weakening intermolecular interactions, such as dispersion forces and dipole interactions. Consequently, this led to an increase in the elasticity of the systems and a reduction in the glass transition temperature. At the same time, it was demonstrated that an excess of plasticiser caused the formation of microheterogeneous domains, which promoted swelling processes and increased membranes' susceptibility to degradation in polar environments.

Stability studies were conducted under varying conditions of polarity, temperature and pH, which enabled identification of the dominant destabilisation mechanisms. In polar environments, the key phenomenon was the competition between polymer-plasticiser and polymer-solvent interactions, leading to plasticiser extraction and the reorganisation of the membrane structure. In turn, changes in pH affected the degree of protonation of functional groups (particularly in the case of chitosan-based membranes), which modified the nature of intermolecular interactions and the stability of the system.

Surface characterisation was carried out using inverse gas chromatography (IGC), which enables determination of the dispersive component of surface energy and acid-base parameters. The results indicated a predominance of dispersive interactions; however, the presence of plasticisers led to significant changes in the donor-acceptor character of the surface. This was interpreted as an effect of electron density redistribution and changes in the accessibility of functional groups on the membrane surface, which directly influences its sorption properties and separation selectivity. Thermodynamic compatibility analysis was performed using Hansen solubility parameters (HSP), which allow the total cohesive energy to be broken down into dispersive, polar and hydrogen-bonding components. It was demonstrated that membranes with a high polymer matrix content (90:10) achieved the highest stability, which results from the preservation of structural continuity and the limitation of excessive plasticiser mobility. Complementary quantum-chemical calculations (DFT) were employed, enabling the analysis of the interaction energies between components and their preferred spatial configurations. The cellulose triacetate-dibutyl sebacate systems exhibited the highest stability, which is consistent with the experimental results. Analysis of the results indicate that the matching of polarity parameters and the ability to form weak intermolecular interactions (including donor-acceptor interactions) is crucial for the stability of the system.

The results confirm that an integrated approach, combining experimental methods (IGC), physicochemical models (HSP) and molecular calculations, is an effective tool for designing stable PIM membranes with controlled surface properties and high separation efficiency.

Choline glycolate: synthesis, characterization, and evaluation as a water-based electrolyte

Amelia Miller[1], Joanna Fijałkowska[1], Julianna Czerniawska[1], Beata Sikora[1], Piotr Gajewski[1], Katarzyna Szcześniak[1], Agnieszka Marcinkowska[1]

[1]Faculty of Chemical Technology, Poznan University of Technology 60-965 Poznan, Berdychowo 4
e-mail: amelia.miller@student.put.poznan.pl

In recent years, global demand for low-impact, biodegradable compounds with potential industrial applications has increased significantly. Choline cation, a naturally occurring compound present in plant and animal tissues, is of particular interest due to its environmentally friendly character, low toxicity, and versatile physicochemical properties [1]. Choline-based systems are considered promising components in sustainable chemistry. They are biodegradable and can easily take part in interactions such as hydrogen bonding and ionic interactions, which makes them useful in different applications, including materials science, green solvents, and electrochemical systems [2].

When choline is combined with organic acids, such as glycolic acid, it can form ionic compounds with adjustable properties. These materials may be an alternative to more traditional compounds in processes where reducing environmental impact is important.

Aqueous solutions of choline salts have also been investigated as electrolytes for electrochemical capacitors. In particular, choline nitrate-based systems exhibit high ionic conductivity and eutectic-like behavior, which significantly suppresses crystallization and enables operation at sub-zero temperatures. Compared to conventional inorganic electrolytes such as Na_2SO_4 or Li_2SO_4, choline-based electrolytes benefit from reduced ion pairing and improved ionic transport, highlighting their potential as environmentally friendly and biodegradable electrolytes for energy storage applications [3]. Overall, choline-based salts represent a growing class of environmentally friendly compounds with significant potential in industrial and electrochemical applications.

In this work, choline glycolate was successfully synthesized, and its structure was confirmed by NMR spectroscopy. Its physicochemical properties were systematically investigated. Aqueous electrolytes based on this salt exhibit high ionic conductivity, confirming their suitability as promising electrolytes for advanced energy storage devices.

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Refining RNA Models: A Protocol for Resolving Structural Entanglements

Mikolaj Mlynarczyk[1], Simón Poblete[2], Marta Szachniuk[1,3]

[1] Poznan University of Technology, 61-131 Poznań, Jacka Rychlewskiego 1
[2] Universidad San Sebastian, Santiago, Chile
[3]Institute of Bioorganic Chemistry, PAS, 61-704 Poznań, Noskowskiego 12/14
e-mail: mikolaj.mlynarczyk@cs.put.poznan.pl

Entangled RNA 3D structure models are frequently discarded from subsequent analyses, although the regions outside the entanglements may still adopt correct folds. In some cases, energy minimization can remove these artifacts [1]. However, this process is neither explicitly controlled by the user nor intended to specifically correct such topological issues. To address this limitation, we developed the first protocol dedicated to resolving entanglements in RNA structural models.

The disentanglement protocol [2] was tested on RNA structures predicted in CASP and RNA-Puzzles experiments, using a benchmark set of 195 entangled models previously detected with the RNAspider webserver [3]. In total, these structures contained 329 entanglements, classified into two main types: interlaces and lassos.

Our approach relies on SPQR coarse-grained simulations [4] to separate entangled structural elements. Subsequently, atomistic details are restored and short molecular dynamics simulations are performed to reconstruct the original fold. Overall, the method successfully resolved pathological conformations in 81% of cases, disentangling 77% of interlaces and 40% of lassos. Importantly, the protocol reduced the Clashscore by an average of 88 while introducing only minor structural perturbations.

These results demonstrate that the proposed protocol effectively alleviates topological artifacts in RNA models, particularly in the case of interlaces, while highlighting the remaining difficulty of resolving lassos without disrupting the integrity of secondary structure.

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Desorption Behaviour of Fluorophores from Poly(vinyl chloride)-Based Membranes

Katarzyna Nowak[1], Maciej Matysik[1], Katarzyna Bielicka – Daszkiewicz[1], Piotr Michałowski[1,2]

[1] Institute of Chemical Technology and Engineering, Poznan University of Technology, 60-965 Poznań, Berdychowo 4
[2] Institute of Bioorganic Chemistry, Polish Academy of Sciences, 61-704 Poznań, Noskowskiego 12/14
e-mail: katarzyna.nowak@student.put.poznan.pl

Polymer inclusion membranes (PIMs) based on poly(vinyl chloride) (PVC) represent a significant alternative to cellulose triacetate-based systems, offering different mechanical properties and intermolecular interactions. Due to the more hydrophobic nature of PVC and its lower ability to form specific interactions (e.g. hydrogen bonds), the stability of such membranes is largely determined by their compatibility with the plasticiser and their ability to maintain a homogeneous structure. Analysis of fluorophore desorption processes under static conditions allows for the assessment of the durability of these systems and the identification of the mechanisms responsible for the loss of active components.

In a methanol environment, significantly greater variation in membrane behaviour was observed, depending on both the type of plasticiser and its content. PVC:2NPOE systems exhibited relatively high stability, with mass losses below 2%, indicating good compatibility of this plasticiser with PVC and stability of the formed phase. In contrast, membranes containing HDEHP underwent significant destabilisation, particularly at a higher plasticiser ratio (70:30), where mass losses reached values of up to ~26% for fluorescein and as high as ~43% for rhodamine B. This indicates intense extraction processes resulting from the competition between the interactions of the membrane components and methanol molecules, as well as increased mobility of the components in the system with a higher plasticiser content.

Similar, though less pronounced, effects were observed for the DBS plasticiser, where an increase in its content also led to greater weight loss, albeit to a lesser extent than in the case of HDEHP. Analysis of these relationships indicates that the stability of PVC membranes is strongly linked to the polarity and thermodynamic compatibility of the components. Systems with a lower plasticiser content (90:10) exhibit greater resistance to extraction, which results from a more compact structure and limited free volume. Conversely, increasing the plasticiser content leads to increased segment mobility and the formation of micro-regions rich in plasticiser, which act as sites for the initiation of desorption processes.

The results obtained clearly indicate that the stability of PVC membranes in polar environments is largely determined by the choice of plasticiser and its concentration. In particular, systems containing 2-NPOE exhibit the highest resistance to leaching of components, making them the most promising from the point of view of practical applications.

Tailoring Pregabalin Precursor Synthesis to Enhance Subsequent Biocatalytic Transformation

Malwina Nowak[1,*], Kalina Słowek[1], Jakub Zdarta[1]

[1] Institute of Chemical Technology and Engineering, Faculty of Chemical Technology, Poznan University of Technology, Berdychowo 4, 60-965 Poznań, Poland
e-mail: *malwina.nowak@doctorate.put.poznan.pl

Pregabalin ((S)-3-(aminomethyl)-5-methylhexanoic acid) is a γ-aminobutyric acid (GABA) analogue widely used in the treatment of epilepsy, neuropathic pain, fibromyalgia, and generalized anxiety disorder [1]. Its pharmacological activity is strictly stereoselective, with only the S-enantiomer exhibiting therapeutic effects. In recent years, biocatalysis has become increasingly important in the synthesis of active pharmaceutical ingredients, for example through the use of ω-transaminases enabling efficient enantioselective production of (S)-pregabalin [2]. The synthesis of pregabalin relies on the formation of key intermediates that govern the efficiency of subsequent transformations and the overall process yield. One such crucial intermediate is methyl 3-formyl-5-methylhexanoate, which serves as a direct precursor in final steps leading to pregabalin.

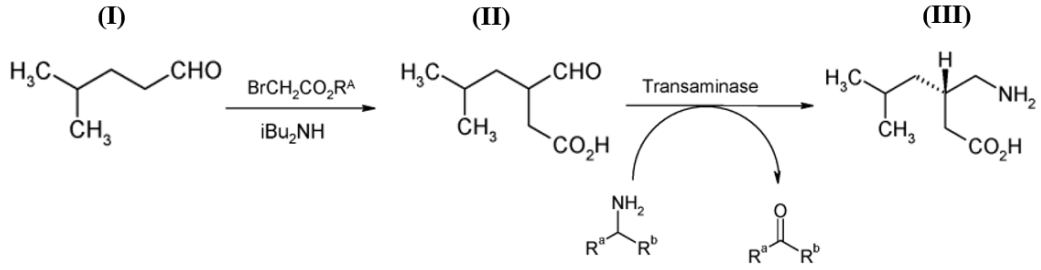

Figure 1: Steps of pregabalin synthesis. (I) – 4-methylpentanal, (II) - methyl 3-formyl-5-methylhexanoate, (III) – pregabalin.

In this study, the first step in the synthesis of a key intermediate, methyl 3-formyl-5-methylhexanoate, was investigated with particular focus on the effect of the molar ratio of 4-methylpentanal to methyl bromoacetate on conversion, efficiency yield, and product purity. The results demonstrated a strong dependence of reaction efficiency on reagent proportions: the highest conversion (80.0%) was achieved at a molar ratio of 1.25:1, whereas under stoichiometric conditions it did not exceed 42%. Higher-quality intermediates led to more efficient enzymatic hydrolysis, reaching up to 91.7% conversion rate compared to 73.7% for lower-quality samples. These findings highlight the critical importance of optimizing early-stage synthesis conditions, as the quality of the intermediate directly determines the efficiency of subsequent steps and the overall effectiveness of pregabalin production.

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Investigating Radical Cation Dynamics in Carbazole-Based Polymeric Structures via Spectroelectrochemistry

Julia Owczarska[1], Renata Rybakiewicz-Sekita[2], Roman Gańczarczyk[3], Sandra Pluczyk-Małek[4], Agnieszka Powała[5], Teresa Żołek[5], Krzysztof Noworyta[1], *

[1] Institute of Physical Chemistry, Polish Academy of Sciences, Kasprzaka 44/52, 01-224, Warsaw, Poland
[2] Institute of Mathematics, Faculty of Science and Mathematics, Cardinal Stefan Wyszyński University in Warsaw, Kazimierza Wóycickiego 1/3, 01-938 Warsaw, Poland
[3] Warsaw University of Technology, Faculty of Chemistry, Noakowskiego 3, 00-664 Warsaw, Poland
[4] Faculty of Chemistry, Silesian University of Technology, Akademicka 2A, 44-100 Gliwice, Poland
[5] Department of Organic and Physical Chemistry, Faculty of Pharmacy, Medical University of Warsaw, Banacha 1, 02-097 Warsaw, Poland
e-mail: jowczarska@ichf.edu.pl

The presented research characterizes two branched carbazole monomers (Figure 1) designed with cross-linking capabilities. By varying the number of phenyl rings, the study evaluates how specific structural motifs influence the electronic and morphological features of the resulting macromolecular frameworks. The investigation focused on the electroactivity of both the precursor monomers and the polymer films synthesized via potentiodynamic electrodeposition.

Following deposition, the polymer films underwent rigorous electrochemical characterization to determine the reversibility of redox processes and the nature of charge transport mechanisms. To further probe the electronic properties of the systems, in situ UV-Vis-NIR spectroelectrochemistry together with Electron Paramagnetic Resonance (EPR) spectroscopy were employed [1]. Changes in electronic transitions and formation of paramagnetic species during the redox processes of the conjugated systems have been followed. The relationship between the structure of monomers and the resulting redox properties, as well as, optical and magnetic signatures was analyzed.

Scanning Electron Microscopy (SEM) imaging revealed the impact of monomer design on film uniformity and porosity. In order to better understand the observed behaviour, Density Functional Theory (DFT) calculations were applied to model the geometric and electronic configurations of the studied compounds, offering theoretical support for the observed polymerization mechanisms. Collectively, these computational and experimental results elucidate the fundamental polymerization pathways, providing a mechanical framework for this class of carbazole derivatives.

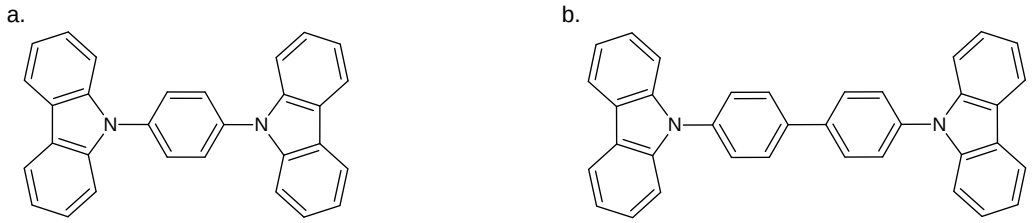

Figure 1. Investigated crosslinking carbazole-based structures: a. Carb-Phe-Carb, b. Carb-Phe-Phe-Carb.

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raGNRArok: graph neural network detection of non-canonical GNRA motifs from RNA 3D atomic coordinates

Jan Pielesiak[1], Marcel Buczkowski[1], Tomasz Żok[1]

[1] Poznan University of Technology, Jacka Rychlewskiego 1
e-mail: jan.pielesiak@doctorate.put.poznan.pl

Background: RNA structural motifs are recurrent 3D elements that govern folding and functional specificity. Motifs such as the GNRA tetraloop contain non-canonical base-pairing interactions that existing annotation-dependent tools struggle to detect reliably, which hampers large-scale structural mining and validation.

Main findings: raGNRArok detects non-canonical GNRA motifs directly from PDBx/mmCIF atomic coordinates by extracting geometric features (torsion angles, planar angles, euclidean distances) from sliding 8-nucleotide windows and feeding them to candidate graph neural network architectures (GCN and GAT), from which the best-performing model is selected. We evaluated it against classical machine-learning models (Naive Bayes, Logistic Regression, Decision Tree, Random Forest, Support Vector Machine, and a simple Feed-Forward Neural Network) serving as baselines for comparison.

Biological relevance: GNRA tetraloops are among the most prominent recurrent RNA motifs, playing critical roles in RNA tertiary folding, structural stability, and protein/RNA recognition.

Significance: To our knowledge, raGNRArok is the first tool to detect GNRA motifs directly from atomic coordinates without requiring prior annotated base pairs, removing a major bottleneck in RNA structural bioinformatics.

Zinc and Copper – modified polydopamine layers - new strategy for the functionalization of artificial polyester ligaments

Martyna Pruszkowska-Barszcz[1], Jakub Reczkowski[1], Mariusz Sandomierski[1]

[1]Institute of Chemical Technology and Engineering, Poznan University of Technology,
61-131 Poznań, ul. Berdychowo 4,
e-mail: martyna.pruszkowska-barszcz@student.put.poznan.pl

The limited regenerative capacity of ligaments, due to their complex structural and functional organization, suggests that rehabilitation alone may be insufficient after injury or rupture. Therefore, surgical treatment is frequently required, and effective reconstruction remains a significant challenge in regenerative medicine, with important clinical aspects.

Modern research in this field aims to develop improved therapeutic strategies. The dynamic development of biomaterials engineering has led to the creation of synthetic implants to replace these tissues, offering both mechanical strength and favourable biological properties [1]. Firstly, among the materials used, polymers, especially polyesters, are gaining importance due to their high mechanical strength, stability, and capacity for surface modifications aimed at improving tissue integration [2]. Secondly, it should be noted that during implantation procedures, infections and local inflammatory responses may occur, which can give rise to serious complications and have negative impacts on clinical outcomes [3]. Consequently, preventing these effects has become a key objective. One modern strategy is to coat material surfaces with active layers capable of binding metal ions and antimicrobial agents, enabling their gradual and controlled release.

Polydopamine is a widely used biomimetic polymer that forms stable coatings on biomaterial surfaces and enables the binding of metal ions; therefore, it is considered a promising material for the surface modification of polyester artificial ligaments. Additionally, its versatility allows for further functionalization [4].

Initially, in this study, a polydopamine (PDA) layer was deposited on polyester artificial ligaments (PEAL). This stage aimed to create a functional surface capable of further modification. Subsequently, it was doped with Zn^{2+} and Cu^{2+} cations. As a result, a coating capable of adsorbing ciprofloxacin (CIPRO) and providing prolonged antimicrobial activity was obtained. Performed analyses found that the polydopamine coating was successfully formed, and effective sorption of ciprofloxacin on the PEAL surface occurred, as confirmed by UV-Vis spectrophotometry and Raman spectroscopy. Moreover, this modification significantly increased the hydrophilicity of the biomaterial and allowed the tested biomaterial to obtain antioxidant properties. Finally, it enabled the gradual and long-term release of the tested drug. The study also considered additional aspects, including antimicrobial properties and cytotoxicity. It was revealed that the modified biomaterial demonstrated promising performance in both areas. In general, the obtained results indicate that the modified polyester biomaterial has significant potential for application in implantology, and its properties may positively impact future developments in this field.

The project was financed by the Ministry of Science and Higher Education.

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Alverine-Loaded Lipid Bilayer–Graphene Oxide Hybrids as a Novel Nanomedicine Platform for Brain Cancer

Katarzyna Dopierała[1], Cristina Satriano[2], Irina Naletova[3], Francesco Attanasio[3], Agnieszka Kołodziejczak-Radzimska[1], Alicja Przybylska[1]

[1] Institute of Chemical Technology and Engineering, Poznan University of Technology, Berdychowo 4, 60-965 Poznań, Poland.
[2] Nano Hybrid Biointerfaces Laboratory (NHBIL), Department of Chemical Sciences, University of Catania, viale Andrea Doria, 6, 95125 Catania, Italy.
[3] Institute of Crystallography, National Council of Research (IC-CNR), via Paolo Gaifami, 18, 95126 Catania, Italy.
e-mail: alicja.przybylska@doctorate.put.poznan.pl

Alverine is a pharmaceutical agent used to relieve cramps or spasms of the stomach and intestines and is also under investigation for its ability to enhance the cytotoxic effects of the proteasome inhibitor MG132 in breast cancer cells [1].

Liposomes are nanosized [2] self-assembled lipid-based drug carriers. These vesicles form a bilayer or a concentric series of multiple bilayers that enclose an aqueous compartment [3,4] and are typically composed of glycerophospholipids, sphingomyelin and cholesterol [3]. Liposomes play a significant role in drug delivery, as they protect encapsulated substances from physiological degradation, extend the half-life of the drug, and control the release of drug molecules. Furthermore, they are considered to be biocompatible and safe [3]. Both small hydrophilic and hydrophobic drugs, as well as large molecules, can be encapsulated within liposomes [3,4].

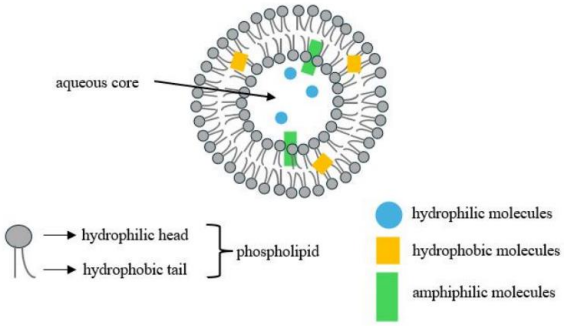

Fig. 1. A basic structure of a liposome [4].

The aim of this study was to investigate the physicochemical properties of liposomes as carriers for alverine citrate. A dye (rhodamine) and graphene oxide (GO) were incorporated into the liposomes, which were subsequently characterized using UV-Vis spectrophotometry and fluorimetry. In addition, in vitro studies were performed on human neuroblastoma SH-SY5Y cells and their retinoic acid-differentiated neuronal-like counterparts. The results demonstrated that graphene oxide–lipid hybrids can act as fluorescence-traceable drug delivery systems and indicated the potential of alverine as a candidate for repurposing in neural cancer models. The system presented here represents a multifunctional platform integrating therapeutic delivery with imaging capabilities.

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Modular Robotic Platform and Interactive Systems of the Robo Forge Science Club

Antoni Tomczak[1], Bartosz Zawłocki[1], Julia Szewczyk[1], Tomasz Rakowski[1]

[1]Robo Forge Science Club, Poznań Univesity of Technology, Institute of Mechanical Engineering, 61-138 Poznań, Jana Pawła II 24
e-mail: antoni.tomczak@student.put.poznan.pl, bartosz.zawlocki@student.put.poznan.pl, julia.szewczyk@student.put.poznan.pl, tomasz.rakowski@student.put.poznan.pl

The Robo Forge Science Club, operating at the Poznań University of Technology, is focused on the development of a proprietary, modular robotic platform. The project is based on the concept of interchangeable modules connected via a unified interface system, allowing for the rapid reconfiguration of the robot depending on current operational needs. The platform consists of three types of mobility bases - wheeled, tracked, and walking - and three functional attachments: a robotic arm, a spatial scanner with tracker, and an infotainment platform. Each component is designed and built from scratch by students from the mechanical, electronic, and programming sections of the club.

The modular architecture enables seamless reconfiguration of the robotic system to suit a wide range of tasks, from autonomous navigation and object manipulation to data acquisition and public engagement. The wheeled base offers high speed and energy efficiency on flat terrain, the tracked base provides stability on rough surfaces, and the walking base allows traversal of complex, uneven environments. The robotic arm attachment enables precise manipulation of objects, the spatial scanner facilitates environment mapping and obstacle detection with enabled seamless object tracking, and the infotainment platform supports human-robot interaction at events and exhibitions.

In addition to mobile robotics, the club develops smaller-scale projects demonstrating the practical applications of recognition and control systems. A notable example is the interactive "Sorting Hat", which utilizes built in sensors to interact with users in real time. This project serves as both an educational demonstration and a proof of concept for integrating engineering and everyday objects and the way they could be improved by doing so.

All projects undertaken by the Robo Forge Science Club are fully student-driven, combining competencies from mechanical engineering, electronics, and software development. The club's work aims to bridge the gap between academic knowledge and hands-on engineering experience, providing students with the opportunity to develop complex interdisciplinary systems in a collaborative environment

Concentration-Dependent Magneto-Mechanical Properties of Carbonyl Iron-Filled Elastomers for Soft Robotics

W. Ramocka,[1, 2] J. Bernat,[3] P. Gajewski,[4] W. Hein,[4] A. Marcinkowska,[4] T. J. Bednarchuk,[5] and K. Synoradzki[1]

[1] Institute of Molecular Physics, Polish Academy of Sciences, Poznań, Poland
[2] Poznań University of Technology,
Faculty Of Materials Engineering and Technical Physics, Poznań, Poland
[3] Poznań University of Technology,
Institute of Automatic Control and Robotics, Poznań, Poland
[4] Poznań University of Technology,
Institute of Chemical Technology and Engineering, Poznań, Poland
[5] Institute of Low Temperature and Structure Research,
Polish Academy of Sciences, Wrocław, Poland
e-mail: wiktoria.ramocka@student.put.poznan.pl

Magnetorheological elastomers (MREs) represent a promising class of functional materials for soft robotics due to the ability to couple mechanical response with an applied magnetic field. In this study, silicone-based composites with an Ecoflex 00-30 matrix filled with carbonyl iron powder (CIP) were investigated. A series of samples with varying filler concentrations was prepared and tested for their structural, magnetic, and mechanical properties. Density measurements were carried out using the Archimedes method, and the results indicate good agreement with the actual material composition. Structural analysis using X-ray diffraction (XRD) confirmed that the composite fabrication process does not affect the crystalline structure of the CIP particles. Magnetic characterization revealed that the composites exhibit soft magnetic behavior. The saturation polarization (J_s) was found to rise linearly with CIP concentration, growing from 0.21 T for 10 wt% to 1.43 T for 70 wt%. Analysis of the *B–H* curves further showed that the relative magnetic permeability (μ_r) shows a positive correlation with filler content, reaching a value of 2.98 at the highest concentration. Mechanical tests showed that although the addition of CIP improves stiffness and Young's modulus, this type of filler has the least impact on matrix elasticity compared to other magnetic additives. The Young's modulus (E) of Ecoflex 00-30 filled with CIP was found to increase with filler content, rising from 0.08 MPa for 10 wt% to 0.34 MPa for 70 wt%. This relationship indicates that precise tuning of mechanical properties can be achieved through appropriate selection of filler concentration, depending on application requirements. The obtained results provide a foundation for the design and optimization of silicone-based magnetorheological elastomers, enabling the development of efficient and reliable magnetically controlled soft actuators. Together with other tested composites, they will form a comprehensive dataset covering structural, magnetic, and mechanical properties, facilitating the selection of optimal materials for specific applications in soft robotic systems.

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From Waste to Function: Biocomposite Viscoelastic Polyurethane Foams

Patrycja Ratajszczak[1], Weronika Ejm[1], Przemysław Bartczak[1]

[1]Poznan University of Technology, Faculty of Chemical Technology, Institute of Chemical Technology and Engineering, Berdychowo 4, PL-60965 Poznań, Poland
e-mail: patrycja.ratajszczak@student.put.poznan.pl

Polyurethane materials represent one of the fastest-growing sectors within the polymer and composites industry. One of the less explored, yet promising, materials is viscoelastic foam. This type of foam is characterized by excellent cushioning properties and the ability to recover its original shape (shape memory). Due to these properties, it is widely used in everyday products, such as mattresses and pillows. In light of current trends, increasing attention is being paid to the development of biocomposites and the reduction of the environmental impact of the polymer industry. Additionally, research on natural fillers is being conducted increasingly frequently, particularly in the context of problematic waste from industrial and agricultural production [1-4]. However, this aspect has not been extensively investigated in viscoelastic foams so far.

This study focuses on the properties of viscoelastic polyurethane foams modified with natural fillers. Biofillers were obtained as waste from the production of black cumin seed and rosehip oil and were introduced into the foam at various concentrations. Research conducted on the synthesized composite foams involved analyzing the influence of plant-derived materials on key processing parameters as well as the physicochemical, structural, and mechanical properties of viscoelastic foam. Due to the specific properties of shape-memory foam, changes in parameters such as compression behavior, recovery time, and microbiological purity of the resulting composites were also evaluated.

The obtained results confirm the feasibility of using natural fillers in the production of viscoelastic polyurethane foam composites. The use of plant-based materials, often treated as waste, reduces costs and decreases the reliance on petrochemical-based raw materials in the production of viscoelastic foams. An additional benefit is the valorization of plant-based waste in other industrial sectors in accordance with the principles of the circular economy.

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High-field galvanomagnetic response of graphene and InSb-based hallotrons

Wiktoria Reddig[1], Piotr Kałuziak[1], Agnieszka Żebrowska[1], Marta Przychodnia[1], Tymoteusz Ciuk[2], Karolina, Piętak-Jurczak[2], Maciej J. Szary[1,2], Jan Raczyński[1], Wojciech Koczorowski[1], Semir El-Ahmar[1]

[1] Institute of Physics, Poznan University of Technology, 61-138 Poznań, Poland
[2] Łukasiewicz Research Network–Institute of Microelectronics and Photonics, 02-668 Warsaw, Poland
e-mail: wiktoria.reddig@doctorate.put.poznan.pl

Emerging technologies such as fusion energy systems and space applications increasingly demand electronic components capable of stable and predictable operation in multi-tesla magnetic fields over wide temperature ranges. Semiconductor Hall devices, particularly those based on InSb, are widely used in demanding conditions due to their high carrier mobility and sensitivity [1]. Controlled donor doping enables stabilization of electrical properties over broad temperatures. However, it simultaneously alters intrinsic transport properties and introduces trade-offs between sensitivity, thermal stability, and reproducibility. As a result, device performance may deviate from ideal behavior in strong magnetic fields. These limitations motivate the exploration of alternative materials for robust magnetic-field sensing, with graphene emerging as a promising candidate.

In this work, we present a comparative study of galvanomagnetic properties of two types of device-ready Hall sensor platforms: (i) p-type hydrogen-intercalated quasi-free-standing epitaxial graphene grown on 4H-SiC(0001) passivated with an Al_2O_3 [2], and (ii) heavily donor-doped InSb thin film deposited on semi-insulating GaAs substrate and protected with dielectric layer [3]. Both device types were integrated into CERDIP8 ceramic housing, ensuring suitability for operation in harsh environments. InSb structures with different doping levels were analysed to show the impact of transport properties on electrical response in strong magnetic field.

The galvanomagnetic response was investigated in magnetic fields up to 11 T at room temperature and under liquid-helium conditions. The graphene-based devices exhibit a monotonic and nearly linear Hall response across the full magnetic-field range, indicating weak magnetoresistive effects. In contrast, InSb-based sensors, due to intense doping, display significant nonlinearity and distortion in the transverse voltage at high magnetic fields. This effect originates from strong magnetoresistance, where the rapid increase of longitudinal resistance leads to mixing between longitudinal and transverse voltage components, distorting the Hall signal [4]. As a result, the usable magnetic-field range of semiconductor Hall devices becomes limited in the multi-tesla regime.

The results demonstrate that graphene Hall devices maintain superior stability of response under high magnetic field and cryogenic conditions. These findings highlight graphene as a promising material platform for reliable magnetic-field sensing in extreme environments where conventional semiconductor-based Hall sensors, such as InSb, may face intrinsic limitations.

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Choline-based monomers to designed photopolymerized Carriers in Transdermal Therapeutics

Beata Sikora[1], Veronika Fedorova[1], Wiktoria Patz[1], Piotr Gajewski[1], Agnieszka Marcinkowska[1]

[1]Faculty of Chemical Technology, Poznań University of Technology, 60-965 Poznań, Berdychowo 4
e-mail: beata.sikora@student.put.poznan.pl

Transdermal Drug Delivery Systems (TDDS) are an advanced system for administering Active Pharmaceutical Ingredients (API) through the skin, offering the key advantage of bypassing first-pass metabolism and thereby improving bioavailability [1,2]. In recent years, growing interest in controlled drug release has driven the development of these systems, with particular focus on factors enhancing drug stability and absorption.

Polymers, a major group of excipients, play a crucial role in pharmaceutical formulations due to their versatility and widespread application [3]. A significant challenge in drug delivery remains the low solubility of many compounds, which limits absorption and skin penetration. Polymers help overcome this issue by maintaining drugs in a dissolved state, stabilizing them as carriers, and improving biodegradability or responsiveness. One effective method for producing polymer-based transdermal gels is radical photopolymerization, in which light activates a photoinitiator to generate free radicals that initiate polymerization. This technique offers advantages such as controlled initiation, rapid reaction rates at room temperature, and solvent-free processing, making it highly valuable in medical applications [4].

This study aimed to develop a Transdermal Drug Delivery System based on photopolymerized polymer gels and to evaluate how polymer composition and the type of active pharmaceutical ingredient affect the functional properties of TDDS such as adhesion, cohesion, structural stability, swelling, and drug-release behavior. The work focused on formulations containing pure API (ketoprofen), with particular attention to their suitability for patient-friendly transdermal application, as well as emphasizing the importance of proper selection of composition of the polymer matrix in TDDS design.

The results showed that API incorporation generally reduced the mechanical stability and cohesion of the polymer matrix; however, appropriate selection of the polymer matrix composition enabled the development of TDDS with desirable performance characteristics and appropriate drug release profiles in model media.

It can be concluded that the selection and design of the polymer matrix are crucial for TDDS performance, as they directly determine adhesion, cohesion, and controlled drug release. The investigated photopolymerized gels demonstrated promising potential as transdermal drug delivery platforms, highlighting that the choose proper polymer composition is essential for achieving effective and reliable drug (for instance ketoprofen) delivery.

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From Humor to Influence: Multimodal & Multilabel Classification of Persuasive Techniques in Memes

Michał Skrzypek[1], Dmytro Romaniv[1], Patryk Maciejewski[1], Eliza Czaplicka[1], Dawid Wiśniewski[1]

[1] Poznan University of Technology, 61-131 Poznań, Jacka Rychlewskiego 1
e-mail: michal.skrzypek@student.put.poznan.pl

Memes have become a powerful tool for spreading disinformation through social networks, with both visual and textual elements, to shape public opinion. Memes with high persuasive effectiveness often use specific rhetoric and psychological techniques to modify observers' viewpoints. Identification of such techniques is critical in curbing disinformation dissemination. This study aims to address such a challenge through developing models capable of identifying persuasive techniques in memes, using both textual content and multimodal data. The proposed solution utilizes deep neural networks for hierarchical multilabel classification for 22 different persuasion techniques, allowing for systemic determination of used techniques. In addition, multimodal approaches are utilized in an investigation of both picture and text in a meme, and therefore a full-fledged solution to such a challenge is proposed.

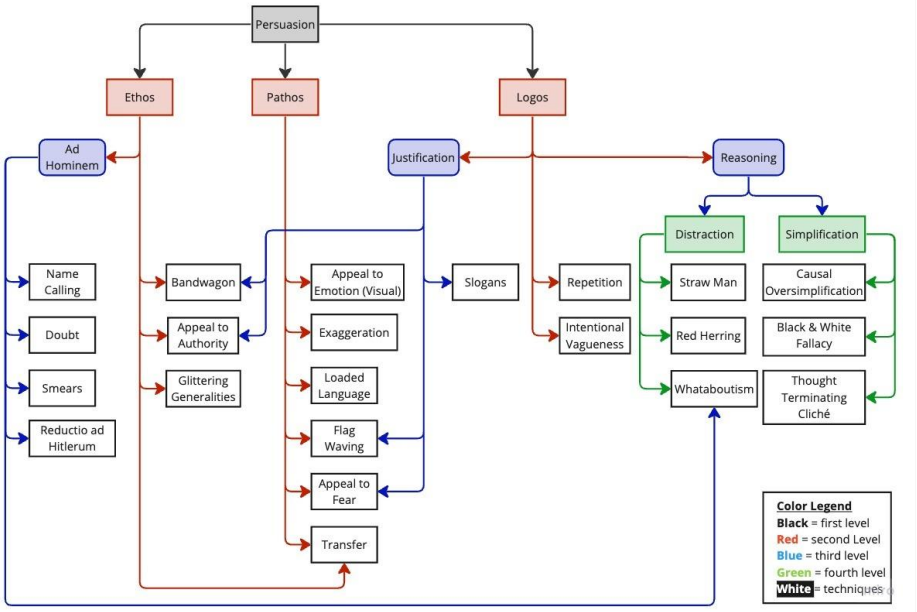

Fig. 1. Hierarchical structure of persuasion techniques based on ethos, pathos, and logos

The experiments performed under this study illustrate that combining picture descriptors with textual analysis significantly improves accuracy in persuasive technique determination. The results validate that multimodal approaches form an integral part of successful disinformation campaign identification. The work in this study constitutes a significant contribution in disinformation and natural language processing through providing new insights in multimodal integration and hierarchical classification for persuasive techniques' determination in a meme. The work sets a platform for future studies in curbing disinformation in social networks through computerized determination frameworks.

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Asymmetrical 2D Materials for Gas Sensing – A Comparative Study of NO_2 Adsorption on MoS_2, MoSSe and $MoSe_2$ Monolayers

Jerzy Sobkowski[1], Piotr Radomski[1], Maciej Szary[2]

[1] Institute of Materials Research and Quantum Engineering, Faculty of Materials Engineering and Technical Physics, Poznan University of Technology, 61-138 Poznan, ul. Piotrowo 3
[2] Institute of Physics, Faculty of Materials Engineering and Technical Physics, Poznan University of Technology, 61-138 Poznan, ul. Piotrowo 3
e-mail: jerzy.sobkowski@doctorate.put.poznan.pl

The development of highly selective and sensitive gas sensors remains a critical challenge in environmental monitoring and industrial safety. Transition-metal dichalcogenides (TMDs) have emerged as promising sensing materials, with their adsorption properties influenced by their chemical composition. Unlike conventional, commercially available sensors, which typically require elevated operating temperatures, TMD-based sensors can operate effectively at room temperature, making them highly attractive for next-generation gas-sensing applications.

While the influence of chalcogen substitution in symmetrical TMDs is well established [1,2], the effects of breaking the vertical symmetry of the monolayer remain less explored. In this work, density functional theory (DFT) is employed to investigate the adsorption of NO_2 on three related monolayers: symmetric MoS_2 and $MoSe_2$, and the equivalent asymmetric Janus structure MoSSe. Unlike conventional TMDs, Janus monolayers such as MoSSe possess different chalcogen atoms on their opposite surfaces, which breaks the out-of-plane symmetry and gives rise to unique physicochemical properties. In contrast to symmetric MoS_2 and $MoSe_2$, the Janus MoSSe monolayer possesses an intrinsic dipole moment arising from its non-equivalent chalcogen layers. This is expected to impact the interaction with various adsorbates, such as N2, O2, NO_x, SO_x or CO_x [2]. Here, the interaction is probed through NO_2 molecule, as the adsorption of this compound on conventional TMD is well understood.

By comparing these systems, we isolate the impact of structural asymmetry on molecule configuration, adsorption strength and charge transfer. The results reveal that MoSSe exhibits generally stronger adsorption characteristics compared to that on MoS_2 and $MoSe_2$. These findings demonstrate that structural asymmetry and intrinsic polarization of Janus MoSSe monolayers can be effectively utilized to tailor gas-surface interactions and optimize the sensitivity and selectivity of two-dimensional gas-sensing materials.

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Thermally Induced Correlation Effects in metal/$PtSe_2$ heterostructures studied by Raman Spectroscopy

Jan Raczyński[1], Michał Szczęsny[1,2], Semir El-Ahmar[1], Edyta Chłopocka[2], Mirosław Szybowicz[2], Dawid Kot[3], Wojciech Koczorowski[1]

[1] Institute of Physics, Poznan University of Technology, Piotrowo 3, 61-138 Poznan, Poland.
[2] Institute of Materials Research and Quantum Engineering, Poznan University of Technology, Piotrowo 3, 61-138 Poznan, Poland.
[3] IHP - Leibniz-Institut für innovative Mikroelektronik, Im Technologiepark 25, Frankfurt (Oder), 15236, Germany
e-mail: michal.szczesny@doctorate.put.poznan.pl

We present a systematic study of interfacial physics in meta/$PtSe_2$ heterostructures (metal = Ti, Cr, Ni, Pd Pt) employing temperature-dependent Raman spectroscopy (RT–473 K) and SEM imaging. The deposition of metallic overlayers with thicknesses of 10 and 15 nm results in a pronounced narrowing of phonon linewidths (up to 50%) and a significant increase in the I_{A1g}/I_{Eg} intensity ratio compared to bulk $PtSe_2$[1]. These effects are attributed to dielectric screening and work-function-dependent charge redistribution[2]. An analysis of the relationship between the E_g and A_{1g} phonon modes indicates that the introduction of metallic layers leads to the onset of compressive strain and charge carrier doping. At the same time, the inherent anharmonic behaviour of the lattice captured by the temperature-dependent coefficients remains largely unaffected and closely matches that observed in bulk $PtSe_2$. Furthermore, although annealing triggers metal-dependent morphological modifications, the core vibrational properties of the $PtSe_2$ lattice remain essentially unchanged. These findings provide insight into the electronic and mechanical coupling at metal–2D interfaces and highlight $PtSe_2$ as a robust platform for stable two-dimensional electronic applications[3].

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From Emulsion to Functional Coatings: Biocompatible Layer-by-Layer Nanocapsules with Phospholipids

Joanna Szechyńska[1], Joanna Odrobińska- Baliś[1], Krzysztof Szczepanowicz[1]

[1]The Jerzy Haber Institute of Catalysis and Surface Physical Chemistry of the Polish Academy of Sciences
e-mail: joanna.szechynska@ikifp.edu.pl

Targeted therapies employing nanocarriers represent a promising alternative to conventional chemotherapy, enabling the precise delivery of active agents directly to cancer cells while reducing toxicity toward healthy tissues. Among the available systems, nanocapsules fabricated using the layer-by-layer (LbL) approach have attracted particular attention. These systems consist of a drug-containing core surrounded by alternately deposited polyelectrolyte layers. Such an architecture provides stable protection of the therapeutic payload, enables controlled drug release, and allows precise tuning of capsule surface properties.

In this work, LbL nanocapsules were developed in which the synthetic surfactant sodium dioctyl sulfosuccinate (AOT) was replaced with a natural phospholipid mixture composed of phosphatidylethanolamine (PE) and phosphatidylcholine (PC), serving as stabilizers of an oil-in-water emulsion. The PE/PC mixture effectively stabilized the emulsion, enabling the formation of uniform nanodroplets encapsulating the active compound. The nanocapsule cores were subsequently coated with alternately charged polyelectrolyte layers, where poly-L-lysine (PLL) formed the positively charged layer and sodium hyaluronate (SHA) the negatively charged layer, resulting in a multilayer shell with controlled thickness and surface properties, ensuring structural stability and uniformity [1].

The physicochemical characterization of the nanocapsules was performed using dynamic light scattering (DLS) and zeta potential (ζ) measurements. Morphology and surface structure were evaluated by scanning electron microscopy (SEM) and confocal microscopy, while thermal stability was assessed using differential scanning calorimetry (DSC). Colloidal stability was examined under low-temperature storage conditions (4 °C) by monitoring changes in nanocapsule diameter, polydispersity index (PDI), and zeta potential. The obtained nanocapsules exhibited uniform spherical morphology, narrow size distribution, and high colloidal stability. The use of the PE/PC mixture enabled the development of systems with favorable physicochemical properties.

The developed nanoparticle platform represents a promising drug delivery strategy with potential for further functionalization, for example through the incorporation of targeting ligands or stimuli-responsive elements, opening opportunities for application in advanced targeted therapies and other pharmaceutical applications [1-2].

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Toothed Soft Pneumatic Gripper for Objects with Protruding Geometries

Natan Szymański

Poznan University of Technology, Institute of Mechanical Technology, 60-965 Poznań, Piotrowo 3
e-mail: natan.szymanski@student.put.poznan.pl

Soft pneumatic grippers are widely used when a stable, yet delicate grip is required. Typically, their operating principle is based on the deformation of elastic chambers under supplied air pressure. This deformation causes the actuators to wrap around the object and generate the grasping force needed for handling. Owing to their unique characteristics, such as limited force exerted on the object, cleanliness, adaptability, and dynamic operation, pneumatic soft grippers are used primarily in the food industry, although many sources highlight their potential in other fields as well. Despite these advantages, soft grippers also exhibit clear drawbacks, including limited load capacity and relatively low repeatability and accuracy compared with traditional mechanical or pneumatic solutions. Since soft grippers are mainly designed for manipulating round objects, they often struggle to lift items with irregular shapes or insufficient contact area, especially when the object includes loose or protruding elements such as cables or screws. As a result, components such as electronic parts, PCB boards with attached wiring, or fruits with foliage can be challenging to handle. This paper reviews recent concepts proposed in the literature that aim to address these limitations and improve the overall performance of soft grippers. It also introduces the concept of an elastic inflatable tooth integrated into the actuator's contact surface. The work includes both design considerations and real-world test results. The experiments primarily focused on evaluating the lifting success and failure rates for objects of various shapes and weights. Additional metrics, such as maximum exerted force and load capacity, were also recorded. To assess the behaviour of the modified gripper, a reference gripper with a smooth contact surface was designed and manufactured for comparison. Consequently, the testing chapter frequently presents results in a comparative format. The findings indicate that the proposed modification is beneficial in multiple scenarios and can enhance grasp reliability. Interestingly, the gripper was also able to grasp small objects using a new, unintended technique, which unexpectedly improved its stability during handling.

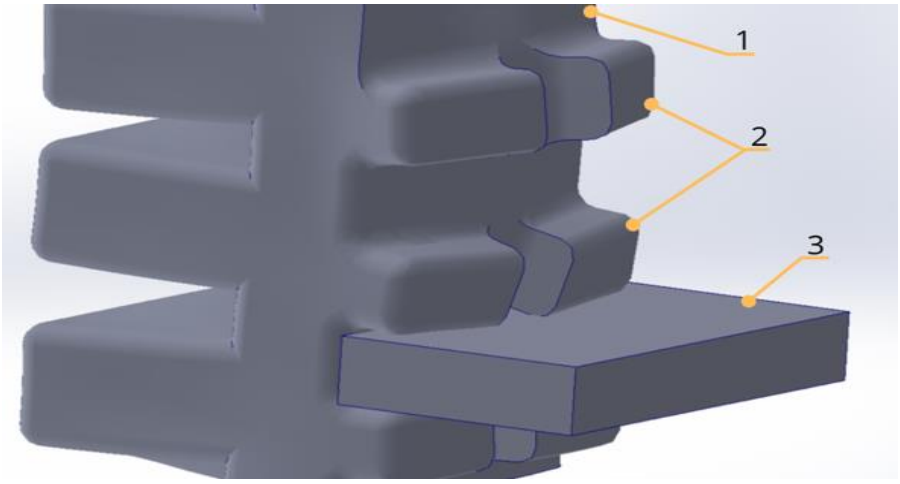

Figure 3. Toothed soft gripper (1) soft actuator, (2) elastic teeth, (3) grasped object.

Application of TiO_2 as an anode material in sodium-ion batteries

Izabela Wichlaj[1], Ewelina Rudnicka[2]

[1] Poznan University of Technology, Student, Berdychowo 4, PL-60965 Poznan, Poland
[2] Poznan University of Technology, Faculty of Chemical Technology, Institute of Chemistry and Technical Electrochemistry, Berdychowo 4, PL-60965 Poznan, Poland
e-mail: izabela.wichlaj@student.put.poznan.pl

INTRODUCTION: The dynamic development of energy storage technologies has led to the search for more economical and environmentally friendly alternatives for lithium-ion cells. Sodium-ion batteries (SIBs) have emerged as a promising solution due to the abundance and low cost of sodium [1]. However, a key challenge remains the development of anode materials characterized by high stability and performance. Titanium-based materials, including titanium dioxide (TiO_2) and sodium titanate ($Na_2Ti_3O_7$), are considered attractive candidates due to their low toxicity, structural stability, and appropriate redox potentials [2,3].

EXPERIMENTAL: The electrochemical properties of bulk TiO_2, nanostructured TiO_2 and sodium titanate ($Na_2Ti_3O_7$) were investigated. Electrodes were prepared by mixing the active materials with acetylene black and a PVdF binder. The study also evaluated the influence of different electrolytes, including 1 M $NaClO_4$ and 0.8 M $NaPF_6$ in EC:DMC. All tests were conducted in a half-cell configuration using metallic sodium as the counter electrode. Characterization was performed using galvanostatic charge/discharge (GCD), cyclic voltammetry (CV), and electrochemical impedance spectroscopy (EIS).

RESULTS: The results demonstrated that TiO_2 exhibits good stability and reversibility during sodium-ion insertion. The utilization of the nanostructured form significantly increased the specific capacity, reaching initial values of approximately 405 mAh/g (at 50 mA/g), compared to 122 mAh/g (at 50 mA/g) for bulk TiO_2 and 293 mAh/g (at 50 mA/g) for $Na_2Ti_3O_7$. Although the nanopowder delivered the highest capacity, it suffered from a larger irreversible capacity loss in the first cycle compared to the other materials. $Na_2Ti_3O_7$ showed excellent cyclic stability and a distinct voltage plateau, confirming its suitability for high-performance applications. CV analysis confirmed the characteristic redox pairs for titanium intercalation.

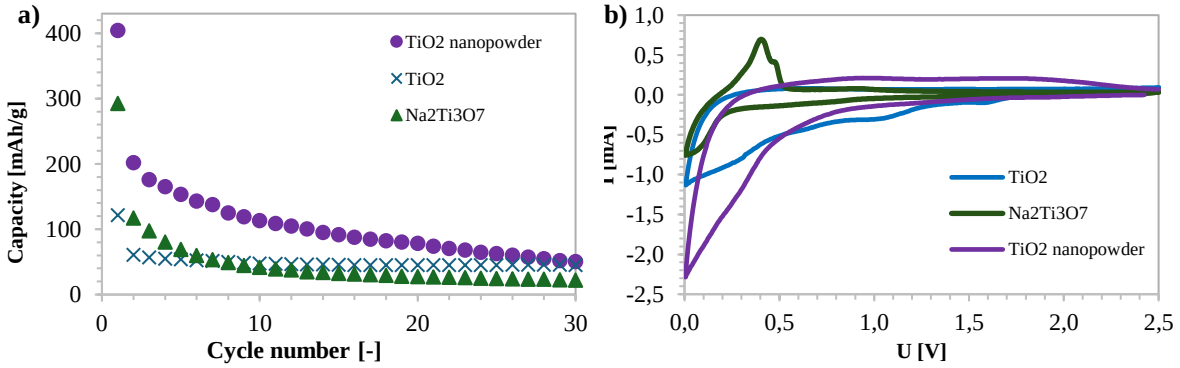

Figure 1. The electrochemical performance of the tested electrode materials a) galvanostatic charge/discharge curves at a current density 50 mA/g; b) cyclic voltammetry curve at a scan rate 0.5 mV/s.

CONCLUSIONS: Titanium-based materials are viable candidates for anodes in sodium-ion technology. While nanostructuring TiO_2 enhances capacity, $Na_2Ti_3O_7$ provides superior structural stability during long-term cycling. The choice of electrolyte salt and solvent plays a crucial role in SEI formation and overall impedance. The findings suggest that both material engineering and electrolyte optimization are essential for the commercialization of next-generation Na-ion batteries.

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Combining surface-enhanced Raman spectroscopy (SERS) and chemometric analysis to study patient blood plasma and leucemic cell lines for rapid detection and monitoring of acute leukemia

Patrycja Wiewiórowska[1], Marta Czaplicka[1], Sylwia Magdalena Berus[1], Aneta Kowalska[1], Agnieszka Kamińska[1]

[1] Institute of Physical Chemistry, Polish Academy of Sciences, Kasprzaka 44/52, 01-224 Warsaw, Poland
e-mail: patrycja.wiewiorowska@ichf.edu.pl

Surface-enhanced Raman spectroscopy (SERS) combined with chemometric analysis has emerged as a powerful tool for rapid, label-free biomedical diagnostics. In this study, we present an integrated approach for the detection and monitoring of acute lymphoblastic leukemia (ALL) based on SERS analysis of patient-derived blood plasma, supported by investigations on leukemic cell line models, including THP-1 and their genetically modified variants.

SERS measurements were performed using nanostructured silver-coated substrates fabricated via femtosecond laser ablation followed by physical vapor deposition. Spectral data from patient plasma samples collected at diagnosis, during treatment, and after therapy were analyzed alongside spectra obtained from THP-1 cell lines and their mutations to better understand molecular-level alterations associated with leukemic transformation and progression.

Characteristic Raman bands at 724, 1002, 1394, and 1450 cm^{-1}, assigned to nucleic acids, amino acids, and protein–lipid components, were identified as key discriminative features. Increased intensities of bands related to adenine and protein/lipid metabolism were observed in leukemic samples, reflecting enhanced nucleic acid turnover and metabolic dysregulation. Complementary studies on THP-1 cell lines and their mutated counterparts revealed mutation-dependent spectral variations, providing insight into biochemical changes associated with specific genetic alterations.

Multivariate statistical analysis, including partial least squares discriminant analysis (PLS-DA), enabled clear differentiation between control, diagnostic, and post-treatment patient samples, as well as between wild-type and mutated THP-1 cells. The integration of clinical samples with controlled cell line models strengthens the interpretability of spectral biomarkers and enhances model robustness.

The presented SERS–chemometric studies demonstrate strong potential as a rapid, minimally invasive diagnostic and monitoring tool for ALL, while the inclusion of THP-1 mutation studies provides a valuable framework for linking spectral signatures with underlying molecular mechanisms and supporting the development of personalized therapeutic strategies.

Saliva-Based Surface-Enhanced Raman Spectroscopy For Noninvasive Detection Of Salivary Gland Tumors

Ida Wiśniewska[1], Aneta Aniela Kowalska[1], Marta Czaplicka[1], Zuzanna Gronkiewicz[2], Sylwia Berus[1], Magdalena Data[2], Wojciech Kukwa[2], Agnieszka Kamińska[1]

[1] Institute of Physical Chemistry Polish Academy of Science, Kasprzaka 44/52, 01-224 Warsaw
[2] Czerniakowski Hospital, Medical University of Warsaw, ˙ Zwirki i Wigury 61, 02-091 Warsaw
e-mail: ida.wisniewska@ichf.edu.pl

Salivary gland tumors constitute a diagnostically challenging and highly heterogeneous group of neoplasms comprising numerous benign and malignant histological subtypes. Nearly 85% arise in the parotid gland, with pleomorphic adenoma, Warthin tumor and basal cell adenoma representing the most prevalent benign entities. Their morphological complexity and overlapping cytological features frequently hinder accurate preoperative detection and typing, often necessitating imaging and invasive procedures such as biopsy for definitive characterization and anatomical localization. The development of rapid, reliable and noninvasive strategies capable of simultaneously addressing detection, differentiation and precise localization therefore remains an unmet clinical need.

Here, we propose saliva-based surface-enhanced Raman spectroscopy (SERS) as a comprehensive diagnostic platform for salivary gland tumors. Saliva samples were collected from patients with pleomorphic adenoma, Warthin tumor or basal cell adenoma and from healthy controls. Integration of SERS spectral profiling with multivariate chemometric modeling enabled robust discrimination between tumor and control groups and revealed distinct molecular fingerprints characteristic of each benign tumor type, supporting accurate tumor typing.

Collectively, these findings establish saliva-based SERS profiling combined with multivariate analysis as a rapid, label-free and noninvasive strategy integrating tumor detection and histological differentiation within a single analytical framework. This approach offers a clinically translatable alternative to invasive diagnostic procedures and may enhance preoperative evaluation and postoperative monitoring of salivary gland tumors.

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Application of a Low-Cost Illuminance Sensor in Automated Lighting

Bartosz Wojciechowski[1, 2]

[1] Faculty of Mechanical Engineering, Poznan University of Technology, 1 J. Rychlewskiego St, 61-131 Poznan, Poland,
[2] Lina Medical Polska Sp. z o.o., 8A Rolna St, 62-080 Sady, Polska,
e-mail: kontakt@bwojciechowski.pl

This paper investigates the applicability of a low-cost illuminance sensor for use in different types of automated devices. Emphasis is placed on the advantages of low implementation cost and integration simplicity, which make such sensors attractive for scalable smart solutions, including Internet of Things (IoT) environments [1]. The study focuses on the calibration procedure of the selected sensor (BH1750) and evaluates its measurement inaccuracy under controlled conditions.

Experimental analysis was conducted in a darkroom to assess the influence of key lighting parameters, including light intensity, colour temperature, and spectral composition. These parameters were adjusted using an RGB LED photographic lamp via its configuration. Reference illuminance measurements were obtained using a calibrated spectrophotometer (CL-70F), enabling comparison with the sensor readings.

Results indicate that sensor performance is influenced by all of the tested parameters. For high colour temperature lighting (10,000 K), the ratio of reference illuminance to sensor output, defined as the correction factor, varied between 1.04 and 1.09 as light intensity changed. Additionally, across a broad portion of the visible spectrum (hue range 20–220), the correction factor ranged from 0.86 to 1.18, demonstrating relatively low sensitivity to spectral variations in comparison with other sensors [2].

These findings suggest that while low-cost illuminance sensors can provide acceptable measurement accuracy under varying lighting conditions, their reliability depends on proper calibration that accounts for both light intensity and spectral characteristics. The study highlights the necessity of context-aware correction models to ensure accurate data acquisition in automated lighting systems.

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