



2026
NANOCON[®]

ABSTRACTS

**18th International Conference
on Nanomaterials - Research & Application**

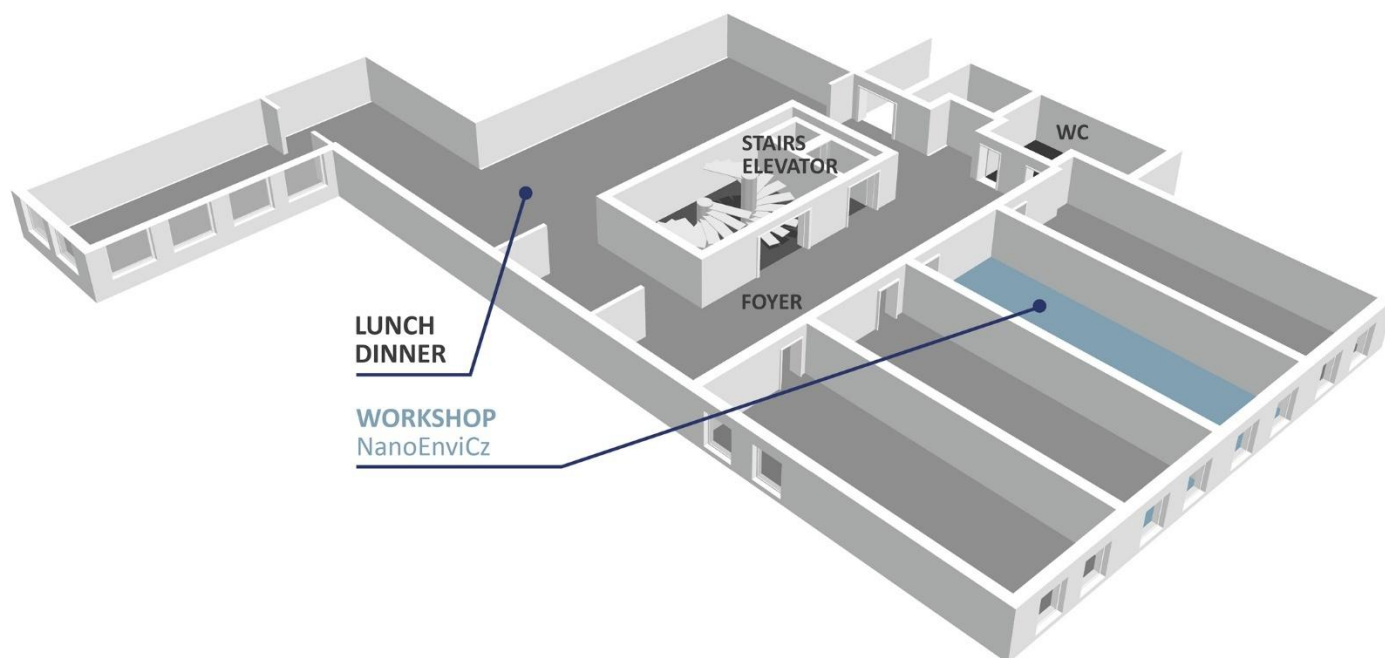
September 30 - October 2, 2026

Orea Congress Hotel Brno, Czech Republic, EU

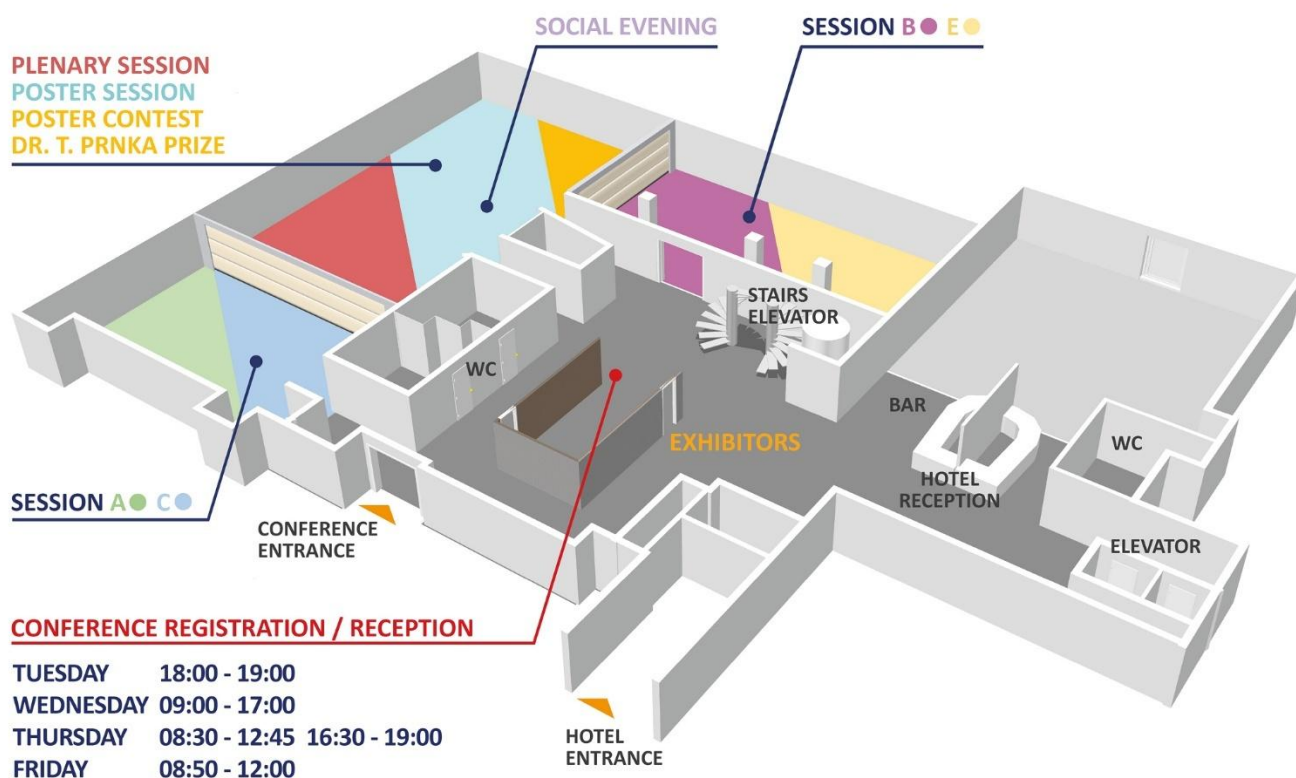


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TANGER Ltd.

The Czech Society for New Materials and Technologies
CATRIN - Regional Centre of Advanced Technologies and Materials



18th International Conference on Nanomaterials - Research & Application

ABSTRACTS

September 30 - October 2, 2026

Orea Congress Hotel Brno, Czech Republic

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Welcome from the Chairlady



For the eighteenth time, it is my great pleasure to welcome you, on behalf of the Organizing and Program Committees, to the NANOCON 2026 International Scientific Conference. This event focuses on advances in the nanoscale world, particularly in advanced nanomaterials.

Global markets for nanomaterials, nanoelectronics, and nanofabrication are projected to expand rapidly through 2030, driven by advances in quantum computing, next-generation energy systems, biomedical diagnostics, and AI-enhanced materials engineering.

This three-day conference brings together more than **two hundred participants from 28 countries**. The conference program addresses current trends in nanotechnology, including nanophotonics and optoelectronics, metamaterials, engineered surfaces and structures with tailored properties, advanced nanofluidics, lab-on-a-chip technologies and medical diagnostics, energy materials like nano-enabled solar cells, hydrogen technologies, or batteries, as well as nanosensors, MEMS, and semiconductor nanodevices.

Both keynote lectures will address these current trends in nanotechnology R&D and applications. The opening plenary lecture will be delivered by **Professor Dr. Klaus Müllen, Dr. h.c.**, Director Emeritus at the Max Planck Institute for Polymer Research in Mainz, Germany, and Visiting Scientist at the Nanotechnology Centre at the Technical University of Ostrava, Czech Republic. His presentation will focus on discoveries in the precise fabrication of graphene and graphene nanoribbons as a new generation of semiconductors, as well as core-shell hybrids consisting of carbon and inorganic materials in the form of discrete nanoparticles. He will also highlight the enormous application potential of these new materials.

Professor Dr. Francisco Javier Aizpurua of the Donostia International Physics Center (DIPC), Spain, will focus his plenary lecture on enhanced light-matter interactions in extreme metallic nanocavities.

NANOCON 2026 offers a rich program of lectures, poster presentations, and opportunities for networking, learning, and discussion. I hope that the **approximately 80 lectures and more than 100 posters** covering nanoparticle preparation, the characterization of their properties, and applications of nanomaterials and nanotechnology across various industries and sectors will attract your attention.

On Thursday afternoon, October 1, you are also invited to attend the **NanoEnvicZ workshop**, which will take place from 2:00 to 4:00 p.m.

I believe you will also be interested in the **range of scientific technologies, equipment, and nanomaterials** presented at the conference exhibition stands by several manufacturers and suppliers.

On behalf of the organizers—the conference company Tanger, the Czech Society for New Materials and Technologies, and the Czech Advanced Technology and Research Institute (CATRIN) at Palacký University Olomouc—I wish you a pleasant and inspiring time at **NANOCON 2026**.

Sincerely,

A handwritten signature in blue ink, appearing to read 'J. Shrbená Váňová'.

Jiřina Shrbená Váňová

Chairlady of the Program Committee of NANOCON'26

Time	TUESDAY, Sep 29	WEDNESDAY, September 30	THURSDAY, October 1	FRIDAY, October 2
8:00	REGISTRATION 18:00 - 19:00	REGISTRATION 9:00 - 17:00	REGISTRATION 8:30 - 12:45, 16:30 - 19:00	REGISTRATION 8:50 - 12:00
9:00		CONFERENCE OPENING PLENARY SESSION (10:30 - 12:00)	C (9:00 - 10:30)	C (9:00 - 10:30)
10:00			B (9:00 - 10:30)	E (9:00 - 10:30)
11:00		LUNCH 11:30 - 13:00	COFFEE BREAK 10:30 - 11:00	COFFEE BREAK 10:30 - 11:00
12:00			C (11:00 - 12:45)	C (11:00 - 12:15)
13:00	A (13:00 - 14:30)	B (13:00 - 14:30)	E (11:00 - 12:45)	E (11:00 - 12:30)
14:00	COFFEE BREAK 14:30 - 15:00	LUNCH 12:30 - 14:00	LUNCH 12:30 - 14:00	CONFERENCE FINAL CEREMONY Best Lecture Award (12:35)
15:00	A (15:00 - 16:30)			
16:00	COFFEE BREAK 16:30 - 17:00	B (15:00 - 16:30)	WORKSHOP NanoEnvCz (First floor) (14:00 - 16:00)	LUNCH 12:00 - 13:30
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Chairman, Chairlady

Prof. Dr. Radek ZBORIL

Palacký University in Olomouc, CATRIN-RCPTM &
VSB - Technical University Ostrava, Czech Republic

M.Sc. Jirina SHRBENA

Inova Pro Ltd., Prague, Czech Republic

MÜLLEN Klaus**Max Planck Institute for Polymer Research, Mainz,
Germany******* INVITED LECTURE *******From Energy to Quantum Computation: Graphenes and Graphene Nanoribbons as Multitalents**

Energy storage and transformation, transport of charges or spins, interaction of light and matter, responses to external stimuli or encoding information, all these processes are essential objects of modern technologies and societal needs, but they all depend on the availability of the right materials - even if not all physicists, engineers and political decision makers seem to be aware. These applications will be realized by introducing i) precisely fabricated graphenes (Gs) as bulk materials, ii) graphene nanoribbons (GNRs) as a new generation of semiconductors and iii) core-shell hybrids from carbons and inorganics as discrete nanoparticles. The present discovery journey will, thus, cover a broad functional range from batteries and supercapacitors to field-effect transistors, lasers as well as quantum computers. But it is synthesis-driven by demonstrating how properties and device performances depend on the methods of fabrication. Our most recent case are long elusive nanodiamonds. REFERENCES: Nature 2016, 2018, 2026; Science 2016; Nature Synthesis 2022; Nature Materials 2023; Nature Chemistry 2024, 2026; Nature Rev. Chem. 2017; Nature Commun. 2020, 2024, 2025; J. Am. Chem. Soc. 2022, 2023, 2024.

AIZPURUA Francisco Javier**Donostia International Physics Center,
San Sebastián, Spain******* INVITED LECTURE *******Addressing Enhanced Light-matter Interaction in Extreme Metallic Nanocavities**

A metallic nanogap is a superb configuration to explore the interplay between light and matter. Light scattered off, or emitted by matter in a nanogap carries the information of the surrounding electromagnetic environment with it. This situation becomes even more appealing when a single molecule is located in such a nanocavity or in its proximity, with the molecule playing an active role either in the electromagnetic coupling with the nanocavity, or even participating in processes of charge injection and transfer, as revealed through cutting-edge molecular spectroscopy. In this talk, the process of interaction between molecular emitters and a nanocavity will be theoretically addressed to trace the ultrafast dynamics of electrons photo-emitted from nanogaps [1], to understand ultra-resolution of molecular photoluminescence in extreme picocavities [2], or to reveal non-linear regimes in molecular optomechanics [3]. Many of the theoretical insights will be interpreted in the context of state-of-the-art experimental results in nanocavity-enhanced molecular spectroscopy and microscopy. REFERENCES: [1] "Sub-femtosecond electron transport in a nanoscale gap", M. Ludwig, G. Aguirregabiria, F. Ritzkowsky, et al. Nature Phys. 16, 341-345 (2020); [2] "Tip-enhanced molecular fluorescence microscopy with atomic-scale resolution", A. Rośławska, K. Kaiser, S. Canola, et al., Rev. of Mod. Phys. 98, 025007 (2026); [3] "Molecular Optomechanics Approach to Surface-Enhanced Raman Scattering", R. Esteban, J. J. Baumberg, and J. Aizpurua. Acc. Chem. Res. 55, 1889-1899 (2022).

SESSION A - E

SESSION A

NANOMATERIALS FOR ELECTRONIC, MAGNETIC AND OPTIC APPLICATIONS. CARBON NANOSTRUCTURES, QUANTUM DOTS

Chairmen

Prof. Dr. Eduard HULICIUS

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Preparation of Nanomaterials / 2D Materials / QD / Nanocatalysis

ZAJÍČKOVÁ Lenka

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Czech Republic**

***** INVITED LECTURE *****

Optical Properties of Fluorescent Nitrogen-containing Carbon Quantum Dots

Carbon quantum dots (CQDs) are quasi-spherical nanoparticles with crystalline graphitic core, and nitrogen and oxygen-containing functional groups. They have fascinating fluorescent properties associated to their band gap tuned by varied nanometer size sp²-core and defects controlled by edge configuration and functional groups. However, the optical properties of solvothermally-synthesized dots could also be affected by the presence of unreacted species or small organic molecules. The intense excitation-independent photoluminescence (PL) was indeed attributed to molecular fluorophores, which may be surface-bound or embedded in the carbon matrix. In this work, I will discuss the origin of the optical properties of nitrogen-doped CQDs obtained by three methods. Two of them use the chemical reaction of glucose and ethylenediamine and, therefore, the structure of N-CQDs could in principle contain molecular fluorophores, especially in the case of spontaneous reaction that, after 5 months, resulted in N-CQDs exhibiting similar structural properties, optical absorption in the UV-VIS range, and PL emission [1] as those synthesized in the microwave reactor [2]. The third method is a recently discovered unique extraction of N-CQDs from plasma-deposited amorphous organic thin films with amino groups. Thanks to films' partial water solubility, the presence of fluorescent nanoparticles was detected in water extracts. High-resolution TEM proved that the nanoparticles are graphitic, and their PL spectra have similarities to N-CQDs from glucose and ethylenediamine. REFERENCES: [1] J. Gómez, M. Sulleiro, N. Pizúrová et al., Appl. Surf. Sci. 610 (2023) 155536; [2] J. Gómez, M. Sulleiro, A. Dolečková et al., J. Phys. Chem. C 125 (2021) 21044.

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SCIORTINO Alice

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Engineering Luminescent Carbon Nanodot Supraparticles as Optical Metamaterials

Carbon nanodots (CDs) are promising fluorescent nanomaterials for photonic and optoelectronic applications, although their implementation in solid-state devices is often hindered by aggregation-induced quenching. Here, we demonstrate the fabrication of carbon nanodot superparticles (SPs) through an emulsion-templated self-assembly strategy and investigate the effect of polyethylene glycol (PEG) functionalization on their structural organization and optical properties. Bare CDs together with PEG400- and PEG3000-functionalized CDs were assembled into compact spherical superstructures with diameters ranging from hundreds of nanometers to a few micrometers, as confirmed by electron microscopy. Optical characterization revealed that PEG functionalization induces a reproducible blueshift of the emission together with an increase in photoluminescence quantum yield and excited-state lifetime, both before and after assembly. Remarkably, these optical improvements are preserved in the superparticles, demonstrating that controlled hierarchical assembly effectively suppresses the aggregation-induced quenching typically observed in carbon-based nanomaterials. The results indicate that PEG acts as an efficient spacer, modulating interparticle interactions while maintaining the emissive properties of the individual nanodots. The environmental stability of the superparticles was also investigated. Photobleaching measurements performed under controlled atmospheres show that water vapor strongly accelerates emission quenching, whereas the optical response remains significantly more stable under nitrogen. These findings suggest that humidity penetrates the superparticle architecture, disrupting interparticle interactions and partially degrading the assembled structure. Overall, this work demonstrates that emulsion-templated assembly provides an effective route toward luminescent carbon-based optical metamaterials with tunable photophysical properties, while highlighting the importance of encapsulation strategies to ensure long-term environmental stability for practical applications.

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Tunable Dual-Wavelength Lasing With Random Mode Competition in Rod-Shaped Graphene Quantum Dots

Atomically precise graphene quantum dots, also known as nanographenes, are an emerging family of light emitting nanomaterials which behave as highly efficient solution-processable emitters, thanks to their tunable optical transitions with narrow bandwidth and near-unity photoluminescence quantum yields [1]. Despite these outstanding photophysical properties, optical gain from nanographenes remains scarcely reported in the literature. Here, we demonstrate amplified spontaneous emission and lasing from solutions of rod-shaped nanographenes composed of exactly 114 sp^2 carbon atoms (C114) [2], explored in different optical cavity geometries. By tuning nanographene concentration, we achieve lasing emission from two distinct spectral peaks, and we fully characterize the lasing dynamics and properties of the emitted laser beam. Furthermore, with an appropriate choice of the experimental conditions, we were able to observe a stochastic interplay and competition between the relative intensities of the two lasing modes. This tunable dual-peak lasing behavior establishes nanographenes as a versatile platform for multi-wavelength lasing applications, paving the way for nanographene-based coherent light sources in next-generation organic photonic devices. REFERENCES: [1] M. Reale et al. Carbon 206, 45 (2023); [2] Medina-Lopez et al., Nat. Commun. 14, 4728 (2023).

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MESSINA Fabrizio

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Carbon Dot Random Lasers with Controllable Coherent and Incoherent Emission

Random lasers (RLs) have emerged as an attractive class of laser sources offering unique advantages over conventional lasers in selected photonic applications. Carbon dots (CDs) are a well-established family of sustainable and versatile

fluorescent nanomaterials for applications ranging from sensing and bioimaging to optoelectronics. Despite their promise as gain media for RLs, achieving stable, controllable and unambiguous random lasing from CDs remains challenging, and systematic studies of the statistical properties of their emission are still scarce. Here, we demonstrate random laser (RL) emission from CDs dispersed together with TiO₂ nanoparticles acting as scattering centers [2]. The lasing behavior is systematically investigated under different excitation conditions using established statistical methods to analyze the emission spectra. The CD-based RL exhibits ultranarrow coherent lasing peaks (~0.7 nm) superimposed on a broader incoherent RL background (~10 nm), with the relative contribution of the two regimes tunable by the experimental conditions. We further exploit the emitted light for speckle-free imaging of biological tissues and microparticles, highlighting the practical potential of these sources. These results establish CDs as environmentally friendly, low-cost gain media for random lasers with tunable emission characteristics, paving the way for sustainable photonic light sources for imaging and optoelectronic applications. REFERENCES: [1] A. Sciortino et al. Chem. Mater. 30, 1695 (2018); [2] A. Pramanik et al. ACS Photonics 11, 3055 (2024).

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Leveraging Plastic Waste for Sustainable Production of Carbon Dot Materials: An Investigation of the Optical Properties

Plastic waste contributes significantly to environmental challenges due to its persistent nature and low global recycling rates. In this context, upcycling plastic polymers into carbon-based nanomaterials offers a sustainable alternative, as most plastics are composed of carbon. In this study, polystyrene (PS) waste is used as a rich aromatic carbon precursor for the synthesis of solid-state fluorescent carbon dots (SS-CDs) via a simple thermal approach. The proposed method leverages a spontaneous separation process, in which the SS-CDs isolate during the solvothermal reaction in ethanol, preventing non-radiative recombination and enabling robust solid-state emission. This phase separation is driven by the developing immiscibility of the hydrophobic units of SS-CDs as they nucleate from the initially soluble PS precursor, eliminating the need for complex post-synthesis separation. The resulting SS-CDs exhibit excitation-independent photoluminescence with a broad emission spanning 400-650 nm, an average lifetime of 4.5 ns, and a moderate photoluminescence quantum yield (PLQY) of 19 % in toluene. Structural characterization indicates a low degree of surface oxidation of the SS-CDs, contributing to stable solid-state optical behavior. This ability to generate solid-state emissive carbon dots directly from plastic waste highlights a sustainable route toward value-added nanomaterials with potential applications in solid-state lighting and optical sensing, while providing a platform for further optimization of structure-property relationships.

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Preparation of Nanomaterials / Nanoenergy / Physics of Surfaces

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***** INVITED LECTURE *****

Spintronics with Compensated Magnets

Ferromagnets have long been the foundation of spintronics applications. However, materials with compensated magnetic order, such as antiferromagnets, offer distinct advantages, including faster dynamics and a wider range of available materials. This has spurred significant research into antiferromagnetic spintronics, leading to many exciting discoveries [1]. Despite these advancements, antiferromagnets are often not considered robust sources of coherent spin currents.

Recently, a new class of compensated magnets, altermagnets, has been identified, combining key advantages of both ferromagnets and antiferromagnets and offering promising potential for spintronics applications [2,3]. In this talk, I will briefly introduce the concept of altermagnetism and present several materials that can host altermagnetic order and that we have studied experimentally. I will focus on some of the experimental verifications of altermagnetic materials [4-6]. I will then discuss our studies of electronic spin transport in these systems, including the observation of the anomalous Hall effect in a single layer of an altermagnetic material and its thermoelectric counterpart, the anomalous Nernst effect [7]. Next, I will focus on heterostructures containing altermagnets and show that they can behave similarly to ferromagnets in generating robust spin currents [7]. Finally, I will discuss the implications of altermagnetism for magnon-mediated spin currents [8]. REFERENCES: [1] T. Jungwirth et al., Nature Nanotechnology 11, 231-241 (2016); [2] L. Šmejkal et al., Physical Review X 12, 040501 (2022); [3] C. Song, HR et al., Nature Reviews Materials, 1-13 (2025); [4] R. D. Gonzalez Betancourt, HR et al., Physical Review Letters 130, 036702 (2023); [5] H. Reichlová et al., Nature Communications 15, 4961 (2024); [6] A. Badura, HR et al., Nature Communications 16, 7111 (2025); [7] J. Mencos, HR et al., arXiv:2512.17427; [8] M. Leiviskä, HR et al., Physical Review Materials 9, 084403 (2025)

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Comparative TCAD Analysis of Planar α -Ga₂O₃ and Silicon MOSFETs: A Material-Limited Approach to Breakdown Voltage Estimation

Alpha-phase gallium oxide (α -Ga₂O₃) is a promising ultra-wide bandgap semiconductor with a critical electric field of approximately 5.2 MV/cm for high-power electronics. This study presents a planar MOSFET comparison between α -Ga₂O₃ and silicon (Si) using Silvaco Atlas simulations. To isolate the intrinsic material advantage, both devices were simulated with an identical planar structure (1 μ m channel/drift region, equal doping and gate dielectric thickness), representing a material-limited rather than a technologically fair comparison, since neither device was optimized for its material. The Si device exhibited a threshold voltage of 0.62 V, a drain current of 0.75 A at a gate overdrive of 3.4 V and drain voltage of 9 V, an on-resistance of 0.464 Ω ·cm², and an avalanche breakdown voltage of 9.13 V (Selberherr model). For α -Ga₂O₃, due to unstable impact ionization convergence, breakdown was instead estimated using an electric-field criterion, identifying the drain voltage at which the peak field reaches the material's critical field. α -Ga₂O₃ exhibited a threshold voltage of 2.78 V, a drain current of 0.88 A at a comparable overdrive, an on-resistance of 0.869 Ω ·cm², and an estimated breakdown voltage of 48 V, roughly 5.3 times higher than Si. Despite the higher on-resistance, the Baliga power figure of merit shows a 14.8 times improvement for α -Ga₂O₃ over Si, confirming its strong intrinsic potential even under identical, non-optimized structural constraints. This advantage was found to increase with temperature, reaching approximately 17 times at 500 K.

LASKOWSKI Łukasz

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New Strategies for the Design and Synthesis of Multifunctional Nanomaterials for Photonics, Catalysis, Medicine, and Artificial Intelligence: One Material, Many Functions

Multifunctional nanomaterials increasingly rely not only on chemical composition, but also on the spatial organization of active units at the nanoscale. In this contribution, I will discuss strategies for designing silica-based nanostructured materials in which molecular or atomic centers are distributed on surfaces or inside ordered mesopores. A key element is the two-dimensional solid-solvent strategy, enabling controlled deposition and separation of active species while preserving accessibility and inter-site communication. The first class of materials involves nanostructured silicas modified with molecular magnetic units. Their controlled distribution on silica surfaces provides a route toward engineering magnetic interactions, signal amplification, and collective responses relevant to neuromorphic concepts and physical neural networks. The second class is based on SBA-15 mesoporous silica functionalized with separated copper centers. In this architecture, Cu-O-P units anchored through propyl-phosphonate ligands act as atomically dispersed catalytic sites. Such materials operate as single-atom catalysts and nanozyme-like systems capable of trigger-free generation of reactive oxygen species, with potential applications in antimicrobial coatings, self-disinfecting filters, and synthetic enzyme platforms. The same principle of spatially controlled active centers can also be extended to photonics. Recent results on

single-molecule inorganic chromophores confined in SBA-15 show that SHG and THG responses are governed not only by local coordination chemistry, but also by synthesis-controlled inter-unit spacing. This opens a route to tunable nonlinear optical materials for photonics and optical neural networks. Together, these examples illustrate a general design concept: one nanostructured silica platform can be transformed into materials with magnetic, catalytic, biomedical, and photonic functions by controlling the distribution and interactions of active centers.

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Magnetically Active Hydrogels for 4D Printing: From Agarose-Based Ink to DIW Printhead Prototype

This work presents the development of a direct ink writing (DIW) printhead for four-dimensional (4D) printing and the formulation of a magnetically active hydrogel ink. 4D printing extends conventional 3D printing by enabling printed structures to change their properties over time in response to external stimuli. Magnetically active hydrogels are materials able to deform when subjected to external magnetic field. Their potential uses include biomedical applications, such as surgical grippers and soft robotic systems for targeted drug delivery. A DIW printhead for a Prusa 3D printer was designed using a heated syringe filled with hydrogel ink, extruded through a conical needle by a powered piston. At the nozzle tip, magnetic particles are oriented by magnetic field generated by four perpendicular magnetic poles allowing omnidirectional orientation of the magnetic particles. The ink consists of an agarose matrix filled with carbonyl iron microparticles (CIP). Samples containing 10-60 wt% CIP were prepared and their rheology was characterised. All formulations exhibited pseudoplastic behaviour, and their viscoelastic moduli increased linearly with CIP concentration. The effective elastic modulus in compression was determined, revealing a pronounced stiffness increase under applied magnetic field. In higher concentrations particle debonding and extraction by magnetic field occurred. The main drawbacks of the current ink are sedimentation, oxidation and debonding of the CIP.

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Heterointerface-Induced Charge Transfer Kinetics in Sputtered MoTe₂-MoS₂ Nanocomposite for High-Performance Ambient NO₂ Detection

The present research reports a nanostructured MoTe₂-MoS₂ n-n heterojunction-based gas sensor developed on a Silicon (Si) substrate, demonstrating room-temperature (RT, 30 °C) nitrogen dioxide (NO₂) sensing. A controlled and one-step magnetron co-sputtering approach is utilized to deposit MoTe₂-MoS₂ nanocomposite thin film on a Si substrate, producing a uniform, dense, and porous nanoscale morphology. Herein, surface analysis and structural characterization of the MoTe₂-MoS₂/Si sensor reveal a rough and defect-rich morphology with abundant exposed edge sites, which significantly enhances the availability of active adsorption sites for effective gas sensing. The developed MoTe₂-MoS₂/Si heterostructured sensor delivers an exceptional sensor response of 74.4% with an ultrafast response/recovery time of 7.5/2 s towards 25 ppm NO₂ at RT. Additionally, the present sensor showcases highly reproducible and consistent behaviour over a wide range of NO₂ concentrations (1-60 ppm), along with remarkable selectivity against common potential interfering gases (NO₂, H₂S, NH₃, CO, H₂) and a low detection limit of 700 ppb. This study provides critical insights into NO₂ sensing induced by heterointerface band modulation and defect-assisted adsorption at the sensor's surface, thereby providing a strong foundation for a reliable platform for high-performance NO₂ gas sensors based on the MoTe₂-MoS₂ heterostructure.

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Preparation of Nanomaterials / Nanocomposites

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Infrared Probing of Molecularly Induced Electronic Changes in Hydrogen-Terminated HPHT Nanodiamonds

Hydrogen-terminated high-pressure high-temperature nanodiamonds (HPHT H-NDs) combine nanoscale dimensions and high crystallinity with an unusual surface electronic structure that enables interfacial charge transfer, charge-carrier accumulation, and the generation of highly reducing solvated electrons under illumination. A distinctive spectroscopic signature of this charge-responsive interface is a narrow infrared transmission window near 1330 cm^{-1} , attributed to Fano-type destructive interference between the zone-center diamond phonon and a continuum of near-surface charge carriers [1]. Here, we show that the spectral profile of this feature is sensitive to the interfacial molecular environment of HPHT H-NDs. The response was first observed during interactions with polymers such as methylcellulose, chitosan, and polyvinylidene fluoride [2,3], and was subsequently investigated more systematically using ionic surfactants, where the integrated area of the transmission window was found to correlate with electrical conductivity. Most recently, the approach was extended to per- and polyfluoroalkyl substances (PFAS), comparing C4 and C8 compounds with carboxylate and sulfonate headgroups. Comparative FTIR analysis reveals that PFAS adsorption depends strongly on nanodiamond type and molecular structure: hydrogenated detonation nanodiamonds retain both sulfonate- and carboxylate-terminated PFAS, whereas HPHT H-NDs show the strongest adsorption for the long-chain sulfonate PFOS. Remarkably, however, all investigated PFAS induce a pronounced 1330 cm^{-1} transmission window in HPHT H-NDs, indicating that even weakly adsorbed species can measurably perturb the near-surface electronic structure. Such molecularly induced electronic changes may be directly relevant to reported photocatalytic PFAS degradation, in which solvated electrons play a key role [4,5]. The results establish the 1330 cm^{-1} transmission feature as a promising infrared spectroscopic probe of molecularly induced charge transfer and carrier redistribution at H-ND interfaces, with the potential to support mechanistic understanding and the rational design of nanodiamond-based photocatalytic systems.

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Combining Electron Microscopy and Machine-Learning Potentials To Study Chiral Helicene Adsorption on Co-Doped ZnO Surfaces

Understanding how chiral π -conjugated molecules interact with different crystallographic facets of magnetic oxide surfaces is essential for the design of hybrid materials for spintronic and magnetoelectronic applications. We reveal, by scanning electron microscopy, a pronounced facet dependence in the morphology of CoO deposited on four crystallographically distinct ZnO surfaces; the polar (0001) Zn-face and ("000" "1" " ") O-face, and the nonpolar ("10" "1" " " "0") and ("11" "2" " " "0") faces, ranging from sparse, fine particulate clusters on the two polar faces, through coarse fiber- and rod-like features on ("10" "1" " " "0"), to dense, interleaved nanoflake ("rose-like") aggregates on ("11" "2" " " "0"). This facet-selective organization motivates a computational investigation of Co and [7]-helicene adsorption on the same facets using density-functional tight-binding (DFTB) and machine-learning interatomic potentials. Spin-polarized DFTB, enabled by newly identified Co-Zn Slater-Koster parameters, gives Co adsorption energies in the range -4.52 to -5.81 eV across the four facets, binding most strongly on the nonpolar ("11" "2" " " "0") facet. We used this DFTB reference to benchmark five pretrained universal machine-learning potentials; M3GNet-MP-PES and M3GNet-MP-DIRECT-PES (2021), and three successive generations of MACE-MP-0 (L0 and L1, 2023; L2, 2024), by their agreement with the relaxed DFTB geometry across all four facets. MACE-MP-0 L2 (2024) reproduces the DFTB geometry and energetics most closely, while M3GNet-MP-PES (2021) achieves comparable agreement at roughly one-quarter of the computational cost: M3GNet-MP-DIRECT-PES (2021) diverges from both, which dedicated pair-potential energy scans trace to a spurious long-range (2-4 Å) repulsive artifact absent from the other four potentials. The adsorption of helical π -conjugated molecules on transition-metal-doped polar oxide surfaces poses a stringent test for machine-learning interatomic potentials, combining mixed ionic-covalent bonding, localized

dopant d-states, and dispersion-dominated molecule-surface coupling; MACE-MP-0 L2's higher-order equivariant message passing captures this combination better than the other models tested, while remaining transferable across all four ZnO terminations. These combined experimental and computational results establish MACE-MP-0 L2 as a reliable, DFTB-validated foundation model for subsequent studies of magnetism in this chiral-molecule/magnetic-oxide system.

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Vacancy Mediated Bonding and Polarity Controlled Quantum Confinement at CsPbBr₃/ZnO Nanoscale Interfaces

ZnO is among the most widely used electron-transport oxides owing to its high carrier mobility and strongly facet-dependent surface properties, while CsPbBr₃ (CPB) is a chemically simple, defect-tolerant model perovskite. Interfaces between such halide perovskites and charge-selective metal-oxide layers are crucial for controlling carrier injection, band alignment, energy conversion, photoluminescence, scintillation, and long-term device stability. Yet the atomistic mechanisms linking oxide surface polarity and vacancy chemistry to interfacial bond formation and opto-electronic properties remain largely unresolved. Here we combine theoretical simulations with machine-learning force-field optimization and dielectric-dependent hybrid DFT with experimental facet-resolved PL, XPS, SEM, and Kelvin-probe measurements across all four low-index ZnO orientations with deposited CPB (nano)crystals. We identify three nanoscale bonding regimes (Zn-Br bridging, Pb substitution at Zn vacancies, and dangling bond mediated adsorption) that jointly control interfacial coupling. Cooperative Pb substitution at Zn vacancy with Zn-Br bridging on Zn-terminated ZnO yields the highest binding energy for PbBr₂-terminated CPB, more than twice that of CsBr-terminated CPB (−4.47 eV), and drives the strongest band edge re-hybridization observed. XPS confirms the predicted Pb-O/Zn-Br bridges. Kelvin probe shows the largest work function shift on the lowest coverage Zn-terminated ZnO surface. A few strongly bonded nanoscale crystals rather than high density coverage can thus control the interfacial dipole. On the other hand, the O-terminated ZnO surface uniquely drives oxygen-mediated bromide extraction that etches CPB crystallites into quantum-dot-like domains, giving a 3 times larger PL blue shift. These results establish ZnO facet polarity and vacancy coordination as atomic scale design parameters governing opto-electronic properties and offering practical concepts for scintillators and photodetector engineering. The authors acknowledge financial support from the Czech Science Foundation project No. 24-12872S and the program “Strategy AV 21” of the Czech Academy of Sciences.

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Observation of Heterogeneous Elements Doping Sites within Nano-diamonds and Exploration of The Potential Application in Photocatalytic Hydrogen Production

Nano-diamonds (NDs) have attracted attention for various potential applications, such as catalysis and electronics. NDs are also known to exhibit photoluminescent properties as a result of various impurity embedding during synthesis. Moreover, the conduction band minimum (CBM) of diamond is located close to the vacuum level, and its energy position can be modulated by surface termination. In particular, hydrogen-terminated diamond is known to exhibit a negative electron affinity, in which the CBM lies above the vacuum level. As a result, photoexcited electrons generated by band-gap excitation are expected to possess exceptionally strong reducing power. However, surface sp²-bonded carbon components can act as recombination sites for photogenerated charge carriers, thereby significantly deteriorating the photocatalytic efficiency. Therefore, in this work, the surface sp² components of NDs were systematically analyzed using Transmission electron microscopy (TEM) and Electron Energy Loss Spectroscopy (EELS), and the potential implications for photocatalytic and electronic applications of NDs are also discussed.

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FATHI Jafar

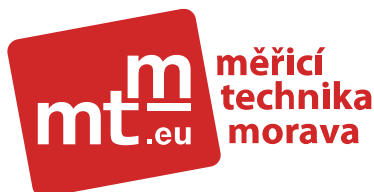
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Application of Plasma-Catalytic Pyrolysis-Derived CNTs-nZVI Nanocomposites as Supercapacitor Electrode Materials

CNTs-nZVI nanocomposites produced by plasma-catalytic pyrolysis were evaluated as supercapacitor electrode materials. The material was synthesized in a single-step process from methane and Fe₂O₃ using a water/argon-stabilized plasma torch, enabling simultaneous methane conversion, iron oxide reduction, and CNT growth. As-synthesized, acid-treated, and thermally/acid-treated materials were fabricated into symmetric supercapacitor electrodes. The thermally/acid-treated sample exhibited the best electrochemical performance, achieving an areal capacitance of 9.7 mF cm⁻² and a specific capacitance of 12.1 F g⁻¹ at scan rate of 0.1 V s⁻¹. It also retained approximately 90% of its capacitance after 10,000 cycles, indicating good cycling stability. These results demonstrate the potential of plasma-derived CNTs-nZVI nanocomposites for energy-storage applications.

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SESSION B

INDUSTRIAL AND ENVIRONMENTAL APPLICATIONS OF NANOMATERIALS

Chairmen

Prof. Dr. Radek ZBOŘIL	Palacký University in Olomouc, CATRIN-RCPTM, Czech Republic
Prof. Dr. Miroslav ČERNÍK	Technical University of Liberec, Czech Republic
Prof. Dr. Miloslav PEKAŘ	Brno University of Technology, Czech Republic
Dr. Jan MACÁK	CEITEC BUT / University of Pardubice, Czech Republic

Environmental Applications

ARNAULT Jean-Charles

French Alternative Energies and Atomic Energy Commission, Paris-Saclay, France

*** INVITED LECTURE ***

Nanodiamond as a Photocatalyst: Towards PFAS Degradation Under Solar-type Illumination

Nanodiamonds (ND) are currently investigated for their valuable and combinable properties in the fields of quantum technologies, nanomedicine and energy. In addition, their semiconducting behavior inherited from bulk diamond, combined with the surface chemistry, brings photocatalytic assets. UV-illuminated hydrogenated nanodiamonds have been used as sources of solvated electrons for CO₂ reduction [1]. Despite the bandgap (5.5 eV), several recent studies revealed a ND photoactivity in the visible range leading to H₂ production comparable to TiO₂ [2] or CO₂ reduction [3]. After giving a state of art of ND photoactivity, the present lecture will focus on the complete and fast photodegradation of perfluorooctanoic acid (PFOA) to fluorine ions under solar-type illumination using highly crystalline hydrogenated milled nanodiamonds (H-MND). One pioneering study has been reported on the degradation of PFOS under deep UV light (254 nm) using hydrogenated detonation nanodiamonds as a source of solvated electrons [4]. While that study paves the way for the use of ND in PFAS degradation, several key aspects remain to be explored such as the influence of ND surface chemistry and crystalline quality, the associated underlying mechanisms and if solar-type illumination can be used instead of deep UV. Under comparable conditions, H-MND outperforms conventional standalone photocatalysts, even in aerobic environments and under solar-type irradiation. These findings highlight the potential of H-MND to serve as an effective solution for PFAS remediation, whether used as a simple and reusable standalone photocatalyst or integrated into more advanced hybrid systems [5]. REFERENCES: [1] Zhang et al., Diam. Relat. Mater. 78 (2017) 24-30; [2] Marchal et al., Adv. Energy Sustain. Res. 5 (2024) 1-8; [3] Yoshikawa et al., Carbon N. Y. 218 (2024) 118689; [4] Maza et al., Appl. Catal. B Environ. 325 (2023) 122306; [5] Jimenez et al., doi.org/10.26434/chemrxiv-2025-zp563-v2

HOBBS Christopher

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Chemical Accuracy in Computational Prediction of PFAS-Cyclodextrin Binding for Remediation Strategies

Cyclodextrin (CD) is a naturally occurring cyclic oligosaccharide molecule which has remarkable properties owing to the hydrophobic cavity of the CD, shown to bind a vast array of molecules including pharmaceuticals, pesticides, and more recently PFAS. PFAS, being per-/poly-fluoroalkyl substances are increasingly illustrated to be a troublesome pollutant due to their persistence, resistance, and toxicity. With remediation technologies currently inept for many of the PFAS present, CD and their derivatives have become the focus of much research as a strategy for capture of these problematic PFAS. Except for NMR titrations, which is exceptional for observing the site-specific interactions between PFAS-CD complexation, there has been no direct thermodynamic analysis of PFAS-CD complexation using calorimetry, also highly limited computational predictions for PFAS-CD binding. This work presents the first systematic DFT-level investigation of PFAS-CD binding, applying Grimme's CREST/CENSO multilevel strategy to the homologous series PF4 through PF8 with native β -CD, whereby we achieve chemical accuracy ($\text{MAE} = 0.71 \text{ kcal mol}^{-1}$) against experimental ITC measurements.

Findings show that electronic energies correlate nearly perfectly with experimental total free energies. Further, chain-length selectivity is governed primarily by electronic interactions—specifically van der Waals forces and electrostatics—with solvation and entropic corrections contributing an approximately constant offset. Notably, van der Waals interactions occur with anchoring by three carboxylate-to-primary-rim hydrogen bonds. Energy decomposition revealed that differential solvation penalties discriminate the binding affinity, which could explain why shorter chains, found to insert more deeply, bind more weakly because desolvation costs outweigh favorable geometry. This validated workflow could enabling computational screening of modified CDs and alternative PFAS structures for rational system design.

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Harnessing the Light-Driven Potential of Carbon Dots in Artificial Photosynthesis

Carbon dots have emerged as attractive photoactive nanomaterials for artificial photosynthesis owing to their tunable optical properties, photostability, low toxicity, and scalable synthesis. Beyond their radiative behavior, they can also serve as multifunctional photocatalytic platforms capable of light harvesting, charge separation, electron storage, and redox catalysis. This presentation introduces a bioinspired carbon-dot system designed to mimic selected functional elements of cytochrome c oxidase. In this concept, triethanolamine acts as the sacrificial electron donor, the carbon-dot domain functions as an electron reservoir, and copper-containing porphyrin-like motifs serve as catalytic sites for oxygen reduction. Structural, optical, and light-induced EPR analyses are used to follow the key charge-transfer steps and connect them with hydrogen peroxide photoproduction, highlighting the potential of carbon dots for enzyme-inspired solar-to-chemical conversion.

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From MXene hEterostructures to Interfacial Atomic-Scale Engineering for Efficient Photocatalytic Remediation

MXene-based heterostructures offer a versatile platform for photocatalytic environmental remediation due to their conductivity, interfacial tunability, and ability to promote efficient charge transfer. In my previous studies, I reported Ti_3C_2 MXene vacancy-confined Mn_3O_4 hierarchical heterostructures for selective Z-scheme photocatalysis and Ti_3C_2 MXene@ CeO_2 heterostructures for secondary-pollution-free degradation of pharmaceutical drugs. These works established key design principles for enhancing charge separation and photocatalytic performance. In the ongoing MSCA project MXClean, I extend this concept toward atomic scale MXene-based systems (i.e., single atom and nanoclusters) for the degradation of emerging organic contaminants. This presentation will connect past results with current research directions and highlight opportunities for designing next-generation MXene catalysts for sustainable water treatment.

HÝBL Vojtěch
Elmarco s.r.o., Liberec, Czech Republic

*** COMMERCIAL PRESENTATION ***

Electrospinning as a Promising Approach for Preparing Membranes for Water Treatment and Liquid Filtration

Electrospun nanofiber membranes have gained increasing attention for water purification and desalination. The electrospinning process enables fabrication of membranes with high permeability and selectivity, tunable surface properties, tailored to specific contaminants. Polymers such as polyvinylidene fluoride (PVDF), polyimide (PI), polyethersulfone (PES), polyamide 6 (PA6), polyacrylonitrile (PAN) and biopolymers like cellulose acetate (CA) or chitosan can be selected or blended to optimize performance [1]. For industrial-scale production, needleless electrospinning, as developed by Elmarco, offers high-throughput manufacturing and facilitates commercial application. Moreover, Elmarco presents examples of already prepared nanofiber layers, which should be useful for liquid filtration. These samples, prepared from polymers mentioned above, could be used as starting point for optimization of these membranes for a specific field of liquid filtration. Another key advantage of electrospun membranes is the ease of structural and surface modification. Hydrophilic or modified hydrophobic surfaces help reduce fouling and improve water flux. Post-treatment methods, such as plasma treatment or thermal annealing, enhance membrane stability and allow precise surface tuning [2]. Nanoparticle integration—using materials like TiO₂, silver or graphene oxide—further improves ion exchange, adsorption, antimicrobial action, and photocatalytic activity [3]. These combined strategies have demonstrated high desalination efficiency and long-term durability. Ongoing progress in green solvents, bio-based polymers, and scalable production supports future development. In conclusion, electrospinning offers a flexible and sustainable platform for developing advanced membranes to meet the demands of modern water treatment and desalination. REFERENCES: [1] Ma, Z. et al. (2019). Surface modification of electrospun membranes for improved water treatment performance. *Journal of Membrane Science*, 580, 366-381; [2] Yin, J. et al. (2016). Nanomaterials in electrospun membranes for water treatment. *Advanced Materials*, 28(22), 4353-4367; [3] Liu, F. et al. (2020). Electrospun nanofiber membranes for advanced desalination and water purification. *ACS Applied Materials & Interfaces*, 12(45), 50072-50091.

Industrial Applications / Nanoenergy

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Entropy-Engineered Multi-Metallic MOFs Unlock High-Performance Ammonium-Ion Storage

Aqueous ammonium ion batteries (AABs) are an emerging sustainable energy technology owing to their high ionic conductivity, safety, low cost, and non-metallic charge carrier. 1,2 However, their practical applicability is restricted by low energy density, a narrower potential window, and poor cycling stability. 3,4. An entropy-engineered amino group-functionalized metal-organic framework (EnMOF-NH₂) is reported as a promising cathode for high-performance AABs. EnMOF-NH₂ consists of five metal nodes (Co, Ni, Fe, Mn, Mo) and an amino-functionalized benzene dicarboxylic acid linker (BDC-NH₂), which provides multiple redox centers, enhanced structural stability, and abundant hydrogen bonding sites for efficient NH₄⁺ storage. The incorporation of Mo metal nodes into the multi-metallic MOF can strengthen the metal-ligand interaction and suppress the metal dissolution, while amino-functionalized BDC provides polarity to the framework and enables fast NH₄⁺ storage through hydrogen bonding. EnMOF-NH₂ achieves a high reversible capacity of 130.8 mAh g⁻¹ at 0.3 A g⁻¹ in 1.0 M (NH₄)₂SO₄, outperforming the non-amino-functionalized EnMOF-BDC. It exhibits excellent rate capability, and capacity increases to 162% after 2500 cycles. A full cell coupled with an EnMOF-NH₂ cathode and perylene tetracarboxylic dianhydride (PTCDA) anode shows a wide voltage window of 0.01-1.8 V and retains 83% capacity over 1000 cycles.

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Bio-based Self-Standing Hard Carbon and Activated Carbon Electrodes for Sustainable Energy Storage

Conventional supercapacitor electrodes rely on composites containing binders and conductive additives deposited on metallic current collectors, increasing electrochemically inactive mass and processing complexity. In this work, self-standing, binder-free electrodes were fabricated directly from cellulose fiber-based fabrics (regular structure, fiber diameter $\sim 10\ \mu\text{m}$) and electrospun lignin-based fibers (random structure, fiber diameter $\sim 2\ \mu\text{m}$). Their tailored fibrous structures also enable facile incorporation of heteroatoms during precursor preparation. Structural and chemical characterization was performed using XRD, BET, EDX, XPS, and SEM. Hard carbons were prepared by tailored stabilization and carbonization. The final carbonization temperature was optimized to control interlayer spacing, electrical conductivity, and porosity. Stable hard carbon sheets exhibited interlayer spacing above $0.37\ \text{nm}$ up to $1400\ ^\circ\text{C}$, suitable for Na-ion intercalation, while maintaining a low specific surface area (SBET as low as $22\ \text{m}^2\ \text{g}^{-1}$). Activated carbons were produced by additional CO_2 activation. Activation temperature, time, and gas flow were optimized to obtain mechanically stable porous carbon sheets with surface areas up to $2200\ \text{m}^2\ \text{g}^{-1}$. Activated carbon electrodes delivered a specific capacitance of $196\ \text{F}\ \text{g}^{-1}$ and an energy density of $49.5\ \text{Wh}\ \text{kg}^{-1}$ in symmetric supercapacitor cells using an organic electrolyte. Hard carbon electrodes were evaluated in half-cells against metallic Na, and both materials were combined in an asymmetric HC/AC Na-ion capacitor. Initial devices demonstrated promising performance by combining the high energy density of batteries with the fast-charging capability of supercapacitors. These results demonstrate a viable, simplified, binder-free, and conductive carbon electrode architecture for supercapacitors, Na-ion batteries, and Na-ion capacitors.

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Collaboration: **Johannes Kepler University (JKU) Linz, Center for Surface and Nanoanalytics (ZONA), Linz, Austria; University of Belgrade - Faculty of Physical Chemistry & Serbian Academy of Sciences and Arts, Belgrade, Serbia; Technical University of Liberec - Department of Physics, Liberec, Czech Republic**

SHRIVASTAV Vishal
**VSB - Technical University of Ostrava, Ostrava,
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Metal Organic Frameworks and Their Heterostructures for Supercapacitor and Batteries Applications

Metal-organic frameworks (MOFs) have emerged as versatile functional materials for electrochemical energy storage owing to their high surface areas, tunable pore structures, compositional diversity, and well-defined metal-ligand coordination environments. These characteristics provide opportunities for engineering electrode materials with abundant electroactive sites and efficient ion transport. However, the intrinsically low electrical conductivity and, in some cases, limited structural stability of pristine MOFs remain important challenges for their direct application in supercapacitors and rechargeable batteries. The integration of MOFs with conductive and electrochemically active components to construct heterostructured architectures offers an effective strategy to overcome these limitations. The structure-property relationship in these materials is strongly governed by factors such as pore architecture, particle morphology, composition, heterointerface characteristics, and electronic structure. Rational interfacial engineering can therefore enhance specific capacitance or capacity, rate capability, cycling stability, and overall energy and power characteristics. Despite significant progress, challenges related to electrical conductivity, scalability, long-term stability, reproducibility, and understanding of interfacial charge-storage mechanisms. Continued development of precisely engineered MOF heterostructures is expected to provide new opportunities for the design of high-performance electrode materials for next-generation supercapacitors and rechargeable batteries.

Collaboration: **Materials and Environmental Lab, Technical University of Ostrava (VSB-TUO), Ostrava, Czech Republic; Palacky University, Olomouc, Czech Republic**

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**VSB - Technical University of Ostrava, CEET,
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From Ferroic Order to Spin Polarization: New Paradigms for Next-Generation Energy Conversion

Emerging polarization-driven phenomena are opening new opportunities for designing high-performance materials for sustainable energy conversion. Beyond conventional approaches based on electronic structure engineering and adsorption energetics, ferroic order, including ferroelectricity, ferromagnetism, and piezoelectricity, provides powerful means to

regulate charge separation, carrier transport, and interfacial reaction kinetics. More recently, electron spin has emerged as an additional degree of freedom for controlling catalytic reactions, particularly the oxygen evolution reaction, where the spin-selective formation of triplet oxygen imposes an intrinsic kinetic limitation. In this talk, I will present an overview of our ongoing and recent research on polarization engineering for solar energy conversion, with particular emphasis on ferroelectric, piezoelectric, and spin-polarized photoelectrocatalysis. First, I will discuss our work on nanocolumnar ferroelectric photoelectrodes and quantum dot-integrated piezoelectric systems, demonstrating how ferroic polarization can enhance charge separation and photoelectrochemical performance. I will then introduce our monolithically integrated multilayer photoanodes that exploit magnetically induced spin polarization to promote spin-selective charge transport during water oxidation. Finally, I will discuss how the convergence of ferroic order, spin engineering, and polarization-driven phenomena is establishing new paradigms for the design of next-generation electrochemical and photoelectrochemical systems, paving the way toward efficient and sustainable energy conversion technologies.

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Mechanical Behavior and Reliability of Ionomer-Bound Carbon Electrode Films for Hydrogen Energy Devices

Electrode films are key functional components in hydrogen energy devices such as polymer electrolyte membrane fuel cells (PEMFCs) and water electrolyzers. Their nanoscale architecture, composed of catalyst particles, ionomer binders, and interconnected pores, enables efficient proton, electron, and gas transport, but also makes the electrodes susceptible to mechanical degradation under environmental stresses. Changes in temperature and humidity can induce swelling, shrinkage, and structural rearrangement of the ionomer phase, leading to deformation, cracking, and delamination. Under subzero conditions, freezing of confined water can generate additional internal stresses and further accelerate mechanical failure. This work investigates the mechanical reliability of ionomer-bound electrode films, with emphasis on nanostructural evolution under environmental stresses, intrinsic mechanical characterization using free-standing tensile testing, and strategies for improving mechanical robustness, including mitigation of freeze-induced damage. The findings provide insight into the relationship between nanoscale structure and macroscopic mechanical degradation and offer guidance for the design of more durable electrodes for hydrogen energy applications.

RANJAN Bhanu

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Pseudocapacitive Storage in Molybdenum Oxynitride Nanostructures Reactively Sputtered on Stainless-Steel Mesh towards All-Solid-State Flexible Supercapacitor

Exploiting pseudocapacitance in rationally engineered nanomaterials offers greater energy storage capacities at faster rates. The present research reports a high-performance Molybdenum Oxynitride (MoON) nanostructured material deposited directly over stainless-steel mesh (SSM) via the reactive magnetron sputtering technique for flexible symmetric supercapacitor (FSSC) application. The MoON/SSM flexible electrode manifests remarkable Na⁺-ion pseudocapacitive kinetics, delivering exceptional ~881.83 F.g⁻¹ capacitance, thanks to the synergistically coupled interfaces and junctions between nanostructures of Mo₂N, MoO₂, and MoO₃ co-existing phases, resulting in enhanced specific surface area, increased electroactive sites, improved ionic and electronic conductivity. Employing 3D Bode plots, b-value, and Dunn's analysis, a comprehensive insight into the charge-storage mechanism has been presented, revealing the superiority of surface-controlled capacitive and pseudocapacitive kinetics. Utilizing PVA-Na₂SO₄ gel electrolyte, the assembled all-solid-state FSSC (MoON/SSM || MoON/SSM) exhibits impressive cell capacitance of 30.7 mF.cm⁻² (438.59 F.g⁻¹) at 0.125 mA.cm⁻². Moreover, the FSSC device outputs superior energy density of 4.26 μWh.cm⁻² (60.92 Wh.kg⁻¹) and high power density of 2.5 mW.cm⁻² (35.71 kW.kg⁻¹). The device manifests remarkable flexibility and excellent electrochemical cyclability of ~91.94% over 10,000 continuous charge-discharge cycles. These intriguing pseudo-capacitive performances, combined with lightweight, cost-effective, industry-feasible, and environmentally sustainable attributes, make the present MoON-based FSSC a potential candidate for energy-storage applications in flexible electronics.

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Industrial Applications / Catalysis

MACÁK Jan

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Noble Metals by Atomic Layer Deposition Electrocatalysis: from Single Atoms to Nanoparticles

Platinum group metals such as Pt, Ru, Pd, Ir, etc., have superior performance for various catalytic applications. Due to their scarcity, efforts were being made to reduce or replace these noble metals. Atomic Layer Deposition (ALD) is one among the best technique to facilitate lowering of loading mass on a support of interest [1-6]. This presentation is focused on the growth of noble metal nanostructures - from single atoms, through atomic clusters up to nanoparticles - by Atomic Layer Deposition (ALD) on various substrates. They demonstrate an excellent electrocatalytic performance [1-3] for the hydrogen evolution reaction (HER). Due to the governing surface energy variations between noble metals and support surfaces, the growth initiates as single atoms, continues through atomic clusters to nanoparticles (NP) and with a further increase in ALD cycles the agglomeration among NP's dominates over the individual NP size increase, thus developing thin films of relatively higher thickness. For electrocatalytic applications, it is important to choose the right substrates. Among the available ones, carbon papers (CP) and titania nanotube (TNT) layers are best choices considering their physio-chemical properties, availability, vast literature, and low costs incurred using these as support substrates in electrocatalysis and photocatalysis. The presentation will introduce and describe the synthesis of Pt, Pd, Ru and Ir nanostructures - starting from single atoms, through NPs to solid films by ALD on CP substrates and TNT layers with high aspect ratios [2] and QCM crystals [3]. It will also include the corresponding physical and electrochemical characterization and encouraging results obtained in electrocatalysis. REFERENCES: [1] B. Bawab et al., Chem. Eng. Journal 482 (2024) 148959; [2] C. Schott et al., ACS Catalysis 15 (2025) 9035; [3] Thalluri, S.M., et al. Small. 19 (2023) 2300974; [4] Thalluri, S.M., , Energy Environmental Materials 8 (2025) e12864; [5] B. Bawab et al., Electrochim. Acta 429 (2022) 141044; [6] J. Rodriguez Pereira et al., Electrochimica Acta. 556 (2026) 148256.

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SINGH Amisha

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Photochemical Cleavage of Alkynes to (Deuterated) Aldehyde using Bromide

The oxidative cleavage of alkynes represents a fundamental transformation for converting simple feedstock chemicals into synthetically valuable intermediates. However, the high bond dissociation energy of the carbon-carbon triple bond has posed significant challenges to achieving this transformation in a single, efficient step. In this study, we present an alternative strategy that enables the chemo selective oxidative cleavage of aromatic terminal alkynes under visible-light irradiation. This catalyst-free protocol proceeds under mild conditions, exhibits broad functional group tolerance, and offers a sustainable solution to a long-standing synthetic challenge. Using, lithium bromide and oxygen as the C-C bond activator, a catalyst free, organo-photochemical method for the chemo selective oxidation of aryl alkynes is devised. This process presents a wide spectrum of functional group sustainability and exhibits remarkable selectivity towards the cleavage of aromatic C-C triple bonds over comparable aliphatic scaffolds. In the presence of functional groups that are sensitive to oxidation, this method also permits the selectivity of aryl alkynes. The reaction procedure also supports excellent deuteration of aldehyde in situ when paired with a HAT reagent and deuterium oxide. The deuteration is highly selective to the aldehyde site alone in presence of other active sites as well, increasing the effectivity and selectivity of the reaction procedure.

ORSÁG Martin

Charles University, Prague, Czech Republic

Enhancing the Stability of ORR Catalysts Through Rhodium Doping

Hydrogen-fueled proton exchange membrane fuel cells (PEMFCs) are a promising technology for transition to a climate-neutral economy. However, the cost and stability of oxygen reduction reaction (ORR) catalysts for PEMFCs cathode remain important issues, as the current platinum-based catalysts are expensive. Enhancing the stability of catalysts could potentially lower the overall cost by extending the operational lifetime of fuel cells. One of the main mechanisms through which ORR catalyst degradation can manifest, alongside other paths including Ostwald ripening and particle detachment, is Pt dissolution. Preventing Pt dissolution is crucial to increase stability, as lost Pt atoms decrease active surface area and lead to decay of ORR catalyst activity. In the present study, we investigated magnetron-sputtered Pt_{100-x}Rh_x (x = 0, 6, 12 and 19) bimetallic alloys in conditions relevant for ORR catalysis. By controlling the alloy composition, the relationships between the composition, oxidation behavior and stability were studied. The alloys were characterized using a wide range of techniques, including scanning electron microscopy (SEM), scanning flow cell inductively coupled plasma mass spectrometry (SFC ICP-MS), energy-dispersive X-ray spectroscopy (EDX), synchrotron radiation X-ray photoelectron spectroscopy (SRPES), electrochemical X-ray photoelectron spectroscopy (EC-XPS), and cyclic voltammetry (CV). We have examined the surface electronic structure and alloy formation using SRPES. SFC ICP-MS measurements have provided insight into the initial stages of dissolution of Pt and Rh in Pt-Rh alloys, connecting doping Pt with Rh with lower Pt dissolution. We used EC-XPS to explore the electronic structure and potential-dependent changes of oxidation states, and compared the findings with Pt-Rh dissolution dynamics investigated using SFC ICP-MS.

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CHERUVATHOOR POULOSE Aby VSB - Technical University of Ostrava, CEET, Ostrava, Czech Republic

Functionalized Graphene Catalysts for Circular-Carbon Chemistry: Glycerol Upcycling, Biodiesel Synthesis, and Alcohol Upgrading

Finite fossil resources and fragile energy supply chains are driving the search for sustainable routes to fuels and chemicals. We report a functionalized graphene catalyst platform in which covalent grafting of amino acid and aminosulfonic acid groups tunes acidity and surface affinity, and delivers strong performance across several reactions relevant to a circular carbon economy. A taurine functionalized graphene solid acid catalyst converts glycerol to solketal under solvent free, room temperature conditions, with high activity, 7508 mmol g⁻¹ h⁻¹, and near quantitative selectivity, 99.9%.¹ Theoretical analysis indicates that taurine plays a dual role, it increases Bronsted acidity and strengthens adsorption of polar reactants, which together explain the high rate and selectivity. Using the same design logic, an aminosulfonic acid functionalized graphene catalyst enables efficient biodiesel production. It shows high activity and selectivity for esterification of oleic acid to fatty acid methyl esters, and it converts common vegetable oils via transesterification. Two additional aminosulfonic acid variants show similar catalytic behavior, supporting the conclusion that paired amino and sulfonate functionalities are central to generating strong acidity.² We also extend the approach to alcohol upgrading. An amino acid modified graphene scaffold stabilizes Rh at very low loadings and, after mild activation, forms cooperative metal ensembles that convert ethanol to n butanol at comparatively low temperature with good recyclability. In situ DRIFTS supports a bifunctional mechanism, atomically dispersed Rh sites dominate ethanol dehydrogenation, while nearby ultra small Rh aggregates promote subsequent C-C coupling and hydrogenation steps. Overall, functionalized graphene provides a practical route to recyclable catalysts that couple tunable acid chemistry with controlled metal speciation for glycerol valorization, biodiesel synthesis, and ethanol C-C coupling. REFERENCES: [1] Cheruvathoor Poulouse, A.; Medved', M.; Bakuru, V. R.; Sharma, A.; Singh, D.; Kalidindi, S. B.; Bares, H.; Otyepka, M.; Jayaramulu, K.; Bakandritsos, A.; Zbořil, R., Acidic graphene organocatalyst for the superior transformation of wastes into high-added-value chemicals. *Nat Commun* 2023, 14 (1), 1373; [2] Cheruvathoor Poulouse, A.; Bares, H.; Zaoralová, D.; Dědek, I.; Otyepka, M.; Bakandritsos, A.; Zbořil, R., Aminosulfonated Graphene as a Catalyst for Efficient Production of Biodiesel from Fatty Acids and Crude Vegetable Oils. *Chemsuschem* 2025, 18 (12), e202402488.

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BHATTACHARJEE Sudip

VSB - Technical University of Ostrava, Ostrava, Czech Republic

Harnessing CO₂ as a C1 Feedstock: Urea, Carbonate and Carbamate Synthesis from Amines Using Zn Single-Atom Catalysts on Ce-SiO₂ Interfaces

The efficacious use of CO₂ as a sustainable C1 feedstock is still extremely challenging considering its kinetic inertness and thermodynamic stability. In this work, we report for the first time the design and development of a Zn-based single-atom catalyst (Zn SAC) anchored on a CeO₂-SiO₂ mesoporous support, which simultaneously enhance oxygen vacancy concentration, surface acidity and surface basicity. The extensive characterization results revealed that the incorporation of isolated Zn active sites into the Ce-SiO₂ porous framework construct a synergistic catalytic environment, where oxygen vacancies facilitate CO₂ activation, while the balanced acidic and basic sites promote effective interaction with amine substrates (Figure 1). This tailored catalyst exhibits exceptional performance in the conversion of CO₂ and various amines into value-added chemicals, including urea and carbamate derivatives. Notably, the reaction proceeds efficiently under relatively mild conditions, achieving high activity at a low CO₂ pressure of 1 MPa and lower reaction times compared to conventional systems [1-3]. The enhanced catalytic behavior is attributed to the atomically dispersed Zn centers, which maximize metal utilization efficiency and provide well-defined active sites for CO₂ adsorption and activation. In contrast to previously reported catalytic systems that predominantly employ bulk metal catalysts often requiring high metal loadings and exhibiting lower turnover numbers (TON) the present Zn SAC system in heterostructure demonstrates superior catalytic efficiency, improved TON, and significantly reduced metal usage. The results imply the critical role of single-atom catalysis in tuning surface properties and advancing CO₂ valorization strategies. This study provides new insights into the rational design of multifunctional catalysts for sustainable chemical transformations involving CO₂ in the field of academia as well as industry.

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KUMAR Sourav

VSB - Technical University of Ostrava, Ostrava, Czech Republic

Conjugated Microporous Polymer as an Efficient Metal-free Photocatalyst for Visible-Light-Induced C(sp)-C(sp) Coupling Reaction

Carbon-carbon bond-forming reactions constitute one of the most fundamental transformations in organic synthesis, providing efficient access to highly functionalized molecules that serve as key intermediates in pharmaceuticals, natural products, and functional materials. Among these, the construction of C(sp)-C(sp) bonds through the homocoupling of terminal alkynes represents a straightforward and atom-economical strategy for the synthesis of valuable 1,3-diynes. However, these transformations are predominantly achieved using transition-metal catalysts, often requiring expensive metals, harsh reaction conditions, or stoichiometric oxidants, thereby limiting their sustainability and practical applicability. Herein, we report a metal-free visible-light-mediated C(sp)-C(sp) homocoupling of phenylacetylenes enabled by a rationally designed donor-acceptor porous organic polymer (Pyr-PT) photocatalyst. The extended conjugated framework, incorporating electron-rich pyrene donor units and electron-deficient acceptor moieties, promotes efficient photoinduced charge separation under visible-light irradiation, generating long-lived charge carriers capable of driving the catalytic transformation without the need for any transition-metal cocatalyst. Mechanistic investigations suggest that upon

visible-light excitation, the Pyr-PT porous organic polymer undergoes effective electron transfer, while oxidation of sodium benzenesulfinate generates a reactive radical species that mediates hydrogen atom abstraction (HAT) from the terminal alkyne to produce a C(sp)-centered alkynyl radical. Subsequent radical coupling affords the corresponding 1,3-diynes with high efficiency. The porous architecture, visible-light absorption, and enhanced charge-transport properties of the polymer collectively contribute to its excellent photocatalytic performance. This work provides a sustainable and environmentally benign strategy for C(sp)-C(sp) bond formation under mild conditions and demonstrates the potential of donor-acceptor porous organic polymers as efficient metal-free photocatalysts for challenging organic transformations.

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Industrial Applications

YOSHIKAWA Taro

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*** INVITED LECTURE ***

Precise Nanometer-Scale Manipulation and Deposition of Detonation Nanodiamonds onto Substrates: Techniques and Applications

Detonation nanodiamonds (DNDs) have attracted considerable interest for a wide range of applications, including quantum devices, sensors, lubricants, and diamond film growth. While significant progress has been achieved in the preparation and dispersion of DND colloids, the controlled deposition of DNDs onto solid substrates remains a key challenge for many solid-state applications. In this presentation, two recently developed DND deposition techniques are introduced. The first technique enables nanometer-scale ordered arrangement of DNDs on substrate surfaces. By combining electron-beam lithography with local surface functionalization, surface charge polarity is selectively controlled, allowing electrostatic deposition of DNDs into line-and-space and dot-array patterns with feature sizes down to several tens of nanometers. The second technique is an electrostatic layer-by-layer deposition process employing DND colloids with opposite zeta potentials. Alternating immersion in positively and negatively charged DND suspensions enables homogeneous buildup of multilayer DND coatings. Applications of these techniques are also presented. The ordered arrangement method has been applied to patterned growth of nanocrystalline diamond films, offering a potential bottom-up route for fabrication of diamond-based micro/nanoelectromechanical devices. The layer-by-layer deposition method has been used to fabricate diamond photocatalytic electrodes for visible-light-driven CO₂ reduction. The results demonstrate that DND layer thickness strongly influences the photoelectrochemical performance and reduction activity. These findings highlight new opportunities for integrating DNDs into advanced electronic, photonic, and energy-conversion devices.

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Nanodiamond/carbon Nanotube Hybrid Electrodes: Between Oxygen Evolution Reaction and Hydroxyl Radicals Generation

Carbon nanotubes (CNTs), due to the lack of edge sites, remain structurally stable at extremely high current densities up to tens of kA/cm². This makes them a good candidate for the construction of high performance electrodes, at which oxygen evolution reaction occurs (OER) [1]. Another reaction in which CNTs may be considered is hydroxyl radical generation (HRG) used to mineralization of organic pollutants. The one-electron pathway of HRG with standard potential of +1.8 V vs. SHE competes with the more favored four-electron pathway of OER, whose standard potential is +1.23 V vs. SHE. In this study, we show that nanodiamonds (NDs) permanently adsorb on CNTs in liquid phase that results in creation of stable ND@CNT hybrids. Direct electron transfer between NDs and CNTs is manifested itself through a shift of the Raman G and 2D bands in CNTs. ND@CNT electrodes show slower kinetics of OER than pristine CNT electrodes. On the other hand, the efficiency of *OH generation probed by methylene blue degradation is higher on ND@CNT anodes. The effect of suppressing the OER and enhancing *OH generation efficiency is easily tuned by adjusting the nanodiamond content in the hybrid system. In this way, we demonstrate that the electrocatalytic properties of hybrid systems composed of sp²- and sp³-bonded nanocarbons can be controlled. REFERENCES: [1] P. Szroeder et al. Molecules 30 (2025) 1265. ACKNOWLEDGEMENTS: The

research was funded by the Ministry of Science and Higher Education under the program 'Regional Initiative of Excellence' in years 2024-2027, Project No. RID/SP/0048/2024/01.

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NASERI JODA Nasrollah

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Centrifugally Spun ZnO Fibers: Synthesis, Properties, and Applications

One-dimensional nanostructured materials have attracted considerable attention owing to their high surface area and unique functional properties. [1-2]. Among the available fabrication techniques, centrifugal spinning has emerged as a scalable and cost-effective method for producing polymeric and inorganic fibers [3-5]. Centrifugal spinning is a simple, scalable fiber fabrication technique that uses centrifugal force to produce continuous fibers and is less sensitive to environmental conditions than conventional methods [6]. In this work, a novel approach for the synthesis of zinc oxide (ZnO) fibers is presented that is based on centrifugal spinning from optimized spinning solutions, followed by tailored annealing. To the best of our knowledge, this is the first study demonstrating the synthesis of ZnO fibers via centrifugal spinning using a polymeric precursor. The antibacterial properties [7] and vulcanization performance [8] of the resulting ZnO fibers were evaluated and compared with those of commercial ZnO nanoparticles (NPs). Initially, precursor fibers were produced by centrifugal spinning using polyvinylpyrrolidone (PVP) and zinc nitrate solutions. The precursor fibers were annealed at 500°C and subsequently milled to an average length of 6.6 μm. Morphological, structural, and surface characterization was performed using SEM, XRD, and BET, followed by antibacterial and vulcanization testing. The ZnO fibers exhibited superior antibacterial activity and enhanced vulcanization performance compared with commercial ZnO nanoparticles. These findings demonstrate that ZnO fibers represent a promising and more sustainable alternative to conventional ZnO nanoparticles, enabling reduced ZnO loading in rubber vulcanization without compromising performance while offering enhanced antibacterial functionality. REFERENCES: [1] S.K. Satpathy, et al., Mater. Today Commun. 28 (2021) 102725; [2] A. Machín, et al., Materials 14 (2021) 2609; [3] P.K. Chennam, et al., J. Mater. Res. Technol. 28 (2024) 2199-2205; [4] N.N. Joda, et al., J. Ind. Text. 54 (2024); [5] N.N. Joda, et al., Appl. Surf. Sci. 686 (2025) 162132; [6] J. Ahmed, et al., Nanobiotechnol. 16 (2024) e1916; [7] N.N. Joda, et al., RSC Advances, in review; [8] N.N. Joda, et al., Polymer testing, in review.

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HALANUR Manohara

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Molecular Precursor-Induced Electronic Reconstruction of 2D Graphitic Carbon Nitride for Efficient Visible Light-Driven Peroxymonosulfate Activation

Graphitic carbon nitride (g-C₃N₄) has emerged as a promising metal-free photocatalyst for solar-driven environmental remediation; however, its practical application is hindered by rapid charge-carrier recombination and inefficient oxidant activation. Herein, we demonstrated a simple molecular precursor-assisted thermal reconstruction strategy to tailor the electronic structure of melamine-derived g-C₃N₄ using choline chloride. The treatment transforms bulk g-C₃N₄ into exfoliated 2D nanosheets with an enlarged specific surface area and reconstructed electronic structure. Spectroscopic analyses reveal suppressed photoluminescence quantum yield together with enhanced non-radiative charge-transfer pathways, indicating more efficient separation and utilization of photogenerated charge carriers. The engineered 2D g-C₃N₄ exhibits remarkable photocatalytic activation of peroxymonosulfate (PMS) under visible-light, enabling broad range of organic micropollutants degradation. The catalyst maintains high activity over a wide range of pollutant concentrations, across a broad pH window, and in different water matrices, achieving complete degradation of contaminants within 10 min under optimized conditions. The enhanced performance is attributed to molecular precursor-induced electronic reconstruction, which promotes efficient interfacial charge transfer and photo-induced PMS activation without the need for metal cocatalysts. In sum, the findings provide facile design principles for defect-engineered graphitic materials with improved photoelectronic functionality for environmental applications.

GARAPATI Meenakshi Seshadhri **Institute of Thermomechanics of the CAS,
Prague, Czech Republic**

Effect of Carrier-Gas Hydrogen Concentrations on Spark-Ablated Platinum Catalyst Layers for PEMFCs

Proton exchange membrane fuel cells (PEMFCs) offer clean energy conversion and high power density. However, their wider use is limited by the high cost of platinum and the dependence of conventional catalyst layers on PFSA-based ionomer. In this work, spark ablation was used to produce platinum nanoparticles and deposit them directly on the gas diffusion layers (GDLs). The resulting catalyst layers were ionomer-free and contained no PFSA. The catalytic activity of platinum nanoparticles synthesized under different hydrogen concentrations in the carrier gas and the effects of total platinum loading in the catalyst layers were evaluated in PEMFC single-cell studies with an active area of 5 cm². Adding hydrogen to the carrier gas improved the Pt utilization and increased the power density. Catalyst layers prepared with up to 5% H₂ performed better than those deposited without H₂ in carrier gas. This improvement can be linked to reduced Pt oxidation during the nanoparticle formation and deposition. Additionally, increasing H₂ concentration to 7% did not further improve PEMFC performance, suggesting that a higher concentration may adversely affect the stability or the nanostructure of the Pt catalyst. Increasing Pt loading improved the maximum power density, but the performance is not proportional to the additional Pt. Based on the single-cell results, catalyst layers were deposited with 5% H₂ and tested in a three-cell PEMFC stack with an active area of 25 cm², demonstrating their suitability beyond single cells. These results show the potential of hydrogen-assisted spark ablation to produce high-purity Pt nanoparticles and ionomer- and PFSA-free catalyst layers for PEMFC applications.

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SESSION C

BIONANOTECHNOLOGY, NANOMATERIALS IN MEDICINE

Chairmen

Prof. Dr. Anton FOJTÍK

Czech Technical University in Prague, Czech Republic

Prof. Dr. Jiří HOMOLA

Institute of Photonics and Electronics of the CAS, Czech Republic

Prof. Dr. Bohuslav REZEK

Czech Technical University in Prague, Czech Republic

Bio Applications / Nanomedicine

DONG Mingdong

Aarhus University (iNANO), Aarhus, Denmark

***** INVITED LECTURE *****

Reversible Amyloid Peptide Crystallization: Implications for Biomaterial Design

Amyloid self-assembly is widely associated with degenerative human disorders, yet it also offers a versatile platform for constructing highly ordered biomaterials. Amyloid peptides can organize into diverse architectures, including fibrils, particles, and crystals, with crystalline assemblies representing particularly stable states. Precisely directing transitions among these structures—and reversibly controlling their crystallization—remains a significant challenge. Here, we investigate the formation and dissolution of macroscopic amyloid crystals in response to changes in temperature, pH, ionic strength, and solvent environment. In situ microscopy is employed to follow the dynamics of crystal disassembly and to elucidate how external conditions reshape the underlying self-assembly landscape. Examining the reversible switching between assembled and disassembled states provides mechanistic insights into amyloid nucleation, growth, stability, and dissolution. This work highlights the critical role of environmental factors in determining amyloid structure and demonstrates how reversible crystallization may serve as a design principle for responsive biomaterials. More broadly, the ability to modulate amyloid assemblies across multiple length scales could facilitate the development of adaptive peptide-based materials with tunable structures, stability, and functionality.

FUCIKOVA Anna

Charles University, Prague, Czech Republic

Single-Particle and Ensemble Characterization of Biomolecular (protein) Corona Formation and Cell-Nanoparticle Interactions

Despite decades of research on nanoparticles (NPs) and quantum dots, predicting how they behave in biological systems remains difficult. Standard characterization methods usually measure average ensemble properties, masking subtle batch variations and surface heterogeneities that drive unexpected cell responses, protein misfolding, or inflammatory cascades. In this work, we combine single-particle topographic profiling with biological testing to investigate how nanoparticle surface chemistry governs biomolecular corona formation and cellular toxicity. To achieve high-resolution single-particle characterization, we utilized a custom-modified Bio-AFM system (JPK NanoWizard 3 upgraded with a Vortis™ 2 controller)

mounted on an inverted optical microscope (Olympus IX-73). By inserting a custom path filter after the excitation diode, we achieved a 3-fold increase in detector signal and a 3x-10x improvement in signal-to-noise ratio over standard setups, enabling sub-nanometer resolution with a noise level of 10-25 pm in air. By combining this sub-nanometer topography with Cryo-TEM, SEM, FTIR, and standard toxicology assays, we resolve single-particle features alongside ensemble behavior. We observed significant changes in the mechanical properties of the cell membrane upon NP uptake.

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Collaboration: Department of Chemical Physics and Optics, Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic; Institute of Pathological Physiology, First Faculty of Medicine, Charles University, Prague, Czech Republic

YÖNEY Bengisu

Masaryk University, Brno, Czech Republic

Analysis of Biofilm Formation in Staphylococcus Aureus and Staphylococcus Epidermidis using Electrochemical Impedance Spectroscopy and Atomic Force Microscopy

Bacterial biofilms are structured microbial communities associated with persistent infections and increased tolerance to antimicrobial treatment. Rapid and reliable monitoring of bacterial biofilm formation remains an important challenge for biosensing platforms. In this study, a disposable, low-cost printed circuit board-based biparametric gold electrodes combined with electrochemical impedance spectroscopy (EIS) were employed for label-free monitoring of biofilm formation by Staphylococcus aureus and Staphylococcus epidermidis by measuring changes in charge-transfer resistance (R_{ct}). Poly-L-lysine surface modification was applied to enhance bacterial attachment. Biofilm formation was associated with an increase in R_{ct} of approximately 90 kΩ for S. epidermidis and 60 kΩ for S. aureus compared with the control. In contrast, electrodes incubated with amoxicillin-treated cultures exhibited R_{ct} values similar to those of the control, indicating inhibition of biofilm formation. Optical microscopy after safranin staining and atomic force microscopy (AFM) provided complementary information on biofilm. AFM revealed significantly higher root mean square (RMS) surface roughness for S. aureus biofilms, whereas S. epidermidis formed smoother and more compact biofilms. Furthermore, AFM analysis confirmed effective inhibition of biofilm formation on amoxicillin-treated electrodes, as characteristic biofilm structures were not observed at all. Overall, the developed platform exhibited distinct electrochemical responses to biofilm formation and its inhibition. These findings demonstrate the potential of the low-cost sensing platform as a practical label-free tool for monitoring bacterial biofilms and assessing antibiofilm activity.

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FLAK Dorota

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Development of MRI Contrast Agents Based on Lipid Nanoparticle Hybrid Systems

Gadolinium-based formulations remain the primary positive (T₁) contrast agents (CAs) used in magnetic resonance imaging (MRI). Despite potential health risks associated with Gd³⁺ ions, their use cannot be eliminated, which drives the search for safer and more efficient contrast-enhancing systems. Nanotechnology provides promising opportunities for this purpose, particularly through nanoparticle-based platforms that incorporate paramagnetic species into self-assembled lipid nanoparticles to form hybrid contrast agents. Lipid-based nanocarriers are especially attractive due to their high biocompatibility, physicochemical stability, and ability to facilitate intracellular delivery of contrast-providing entities. Importantly, they may enhance longitudinal relaxivity (r₁), particularly at clinically relevant magnetic fields, by modulating the local environment of paramagnetic centers. In this work, glyceryl monooleate-based lipid liquid crystalline nanoparticles are investigated as self-assembled platforms for MRI contrast agents (CAs). Hybrid constructs were prepared by incorporating nanoparticles of paramagnetic metal oxides with both hydrophilic and hydrophobic characteristics, specifically Gd₂O₃ and MnO, for comparison. The physicochemical and biological properties of the resulting systems were investigated, with particular emphasis on the relationship between nanoparticle internal structure, paramagnetic ion

loading efficiency (including estimates per nanoparticle), biocompatibility, and relaxation performance. The study also examines ion release profiles under different conditions, as well as the cellular uptake of the lipid nanoparticle-based hybrids and their in vitro MR imaging performance. The results demonstrate the potential of lipid nanoparticle-based hybrid systems for T₁-enhancing MRI CAs, while also highlighting challenges that must be addressed for future in vivo applications.

GABRIELIAN Lilit

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Green-Synthesized Silver Nanoparticles as Multifunctional Bioactive Nanomaterials

Green synthesis has emerged as a sustainable and cost-effective approach for nanoparticles production, utilizing biological sources as both reducing and stabilizing agents instead of conventional physicochemical methods. In this study, silver nanoparticles (AgNPs) were synthesized using extracts from the plants *Rumex obtusifolius* and *Moringa oleifera*, the green alga *Parachlorella kessleri*, and the cyanobacterium *Limnospira (Spirulina) platensis*, including its photosynthetic pigment phycocyanin. Successful AgNPs formation was confirmed by characteristic UV-Vis absorption peaks observed in the range of 410-470 nm. Transmission electron microscopy (TEM) and X-ray diffraction (XRD) analyses revealed crystalline nanoparticles with predominantly spherical or ellipsoidal morphologies and sizes ranging from 10 to 50 nm. Fourier transform infrared (FTIR) spectroscopy indicated the involvement of biomolecular functional groups in the formation and stabilization of AgNPs. The green-synthesized AgNPs exhibited broad-spectrum antibacterial activity at low concentrations (5-25 µg mL⁻¹) against both Gram-positive and Gram-negative bacteria, including *Staphylococcus aureus*, *Enterococcus hirae*, *Salmonella typhimurium* and *Pseudomonas aeruginosa*. Antifungal activity against *Aspergillus flavus*, *Penicillium aurantioviolaceum*, and *Trichoderma viride* was also observed, although higher concentrations were required. Furthermore, AgNPs synthesized using biomass of green alga *P. kessleri*, and phycocyanin from cyanobacterium *L. platensis* showed significant dose-dependent cytotoxicity against human lung adenocarcinoma A549 cells. Thus, these findings demonstrate that green-synthesized AgNPs are sustainable, multifunctional nanomaterials with promising antimicrobial and anticancer properties, highlighting their potential for future biomedical and biotechnological applications. ACKNOWLEDGEMENTS: This work was supported by the Higher Education and Science Committee of Armenia, in the frames of the Research project 24WS-1F025.

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Bio Applications / Nanotoxicity / Nanosafety / Nanomedicine

BLÁHA Luděk

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*** INVITED LECTURE ***

Predictive Environmental Toxicology of Materials: Interplays of Chemo-, Nano-, Micro- and Beyond

Predictive toxicology is a new but increasingly important element of environmental and health risk assessment, aiming to minimize unnecessary experimental testing and maximize the use of existing evidence and data. The most advanced framework is built around Adverse Outcome Pathways (AOPs), promoted by international regulatory bodies such as the European Commission and the OECD. AOPs utilize existing mechanistic knowledge to make scientifically sound predictions of higher-tier (in vivo) effects of novel entities. The presentation will first introduce predictive toxicology and existing tools, illustrated with our own research on adverse impacts on human health and ecotoxicity. The examples will cover emerging organic chemicals and their mixtures, as well as novel (nano)materials and their applications in real-life situations.

FÉROVÁ Marta
University of Ostrava, Ostrava, Czech Republic
Surfactant-Free Polystyrene Nanoparticles as a Model Nanoplastic for Studying Nano-Bio Interactions

Nanoplastics are increasingly recognized as an important class of emerging environmental contaminants, yet their interactions with biological macromolecules remain insufficiently understood. In particular, the use of commercially available polymer nanoparticles may complicate the interpretation of nano-bio interactions due to the presence of surfactants, stabilizers, or other surface-associated additives. In this study, surfactant-free polystyrene nanoplastics were prepared as a well defined model system for investigating their interactions with biologically relevant macromolecules. The resulting nanoparticles exhibited a hydrodynamic diameter of approximately 37 nm and were characterized using complementary physicochemical approaches, including dynamic light scattering and electrophoretic light scattering. Their interactions with human serum albumin, lysozyme, and chitosan were subsequently investigated to elucidate how different classes of biomolecules affect nanoparticle size, surface charge, and colloidal stability. Distinct interaction patterns were observed for the individual biomolecules. HSA increased the hydrodynamic diameter to approximately 70-77 nm, while cryo-TEM revealed predominantly discrete nanoparticles surrounded by a diffuse interfacial layer, consistent with the formation of a protein corona. In contrast, lysozyme induced a pronounced increase in particle size to approximately 220 nm and a reversal of the zeta potential, indicating substantial surface interaction and aggregation. Chitosan exhibited a different interaction mechanism, characterized by polymer-mediated bridging and the formation of interconnected nanoparticle structures. These findings highlight the importance of biomolecule-specific interactions in determining the colloidal behavior of nanoplastics at the nano-bio interface. ACKNOWLEDGEMENT: This work was financially supported by the European Union under the LERCO project number CZ.10.03.01/00/22_003/0000003 via the Operational Programme Just Transition.

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GRIGORYAN Anna
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Hepatic Effects of Orally Administered Zinc Oxide Nanoparticles in Rats: Relevance to Food Safety

Background: Zinc oxide nanoparticles (ZnO NPs) are increasingly used in food-related applications, raising concerns about toxicity. The liver is a site of nanoparticle processing and may be susceptible to structural and functional damage. Objective: To evaluate the morphofunctional response of the liver to oral exposure to ZnO NPs administered alone or with PSS in Wistar rats. Materials and Methods: Forty-eight male rats (90-120 g) were divided into acute and subacute exposure cohorts. Each cohort included four groups (n = 6): control, PSS, ZnO NPs, and ZnO NPs + PSS. Test substances were mixed with powdered chow. Acute exposure consisted of a single dose of 2000 mg/kg followed by 14 days of observation, whereas subacute exposure involved daily administration of 250 mg/kg for 14 days. Liver mass, liver-to-body-weight ratio, histological structure, hepatocyte nuclear characteristics, binucleated hepatocytes, and inflammatory cell activity were assessed. Results: Preliminary observations indicate exposure-dependent hepatic alterations, including hepatocyte degeneration, nuclear pyknosis, apoptosis, focal necrosis, sinusoidal dilation, and increased Kupffer-cell and lymphocytic activity. A higher proportion of binucleated hepatocytes and heterochromatin-rich nuclei may reflect compensatory adaptation accompanied by reduced functional activity. Changes appeared more pronounced after repeated exposure and in the ZnO NPs + PSS group. Conclusions: Oral exposure to ZnO NPs may induce structural injury and functional suppression in the liver while activating compensatory and inflammatory mechanisms. Final quantitative analysis will determine the magnitude and statistical significance of these effects. ACKNOWLEDGEMENT: This research was supported by the Armenian-Moldovan bilateral research project No. 26NARD-1A005 on nanoparticle safety.

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KARAPETYAN Anna
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Immune Response to Oral Exposure to Zinc Oxide Nanoparticles in Rats: Implications for Food Safety

Background: Zinc oxide nanoparticles (ZnO NPs) are increasingly used in food, biomedical, and industrial applications; however, their potential effects on immune organs remain insufficiently understood. Objective: To evaluate the response

of immune organs to oral exposure to ZnO NPs administered alone or in combination with PSS in Wistar rats. **Materials and Methods:** Forty-eight male Wistar rats (90-120 g) were divided into acute and subacute exposure cohorts. Each cohort included four groups ($n = 6$): control, PSS, ZnO NPs, and ZnO NPs + PSS. Test substances were mixed with powdered chow. Acute exposure consisted of a single dose of 2000 mg/kg followed by 14 days of observation, whereas subacute exposure involved daily administration of 250 mg/kg for 14 consecutive days. The thymus and spleen were examined using histological and morphometric methods. **Results:** Preliminary qualitative observations indicate a composition- and exposure-dependent immune response. The spleen showed signs of early reactive activation, including prominent lymphoid follicles and germinal centers, together with increased phagocytic and mast cell activity. In the thymus, reduced thymocyte density, particularly in the cortex, suggested possible stress-related lymphoid depletion. These changes were more pronounced after repeated exposure and in the combined ZnO NPs + PSS group. **Conclusions:** Oral exposure to ZnO NPs may activate peripheral immune mechanisms while inducing signs of thymic suppression. Final quantitative analysis will establish the magnitude and statistical significance of these effects. **ACKNOWLEDGEMENT:** This research was supported by the Armenian-Moldovan bilateral research project No. 26NARD-1A005 on nanoparticle safety.

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PVP-Functionalized ZnO Nanorod-Based Capacitive Humidity Sensor for Breath Monitoring and Morse Code Communication

Humidity sensors with high sensitivity, rapid response, and flexible device integration are increasingly important for real-time environmental monitoring, wearable electronics, and human-machine interface applications. In this work, a highly sensitive capacitive humidity sensor was developed using a PVP-functionalized ZnO nanorod sensing layer deposited on interdigitated electrodes patterned on a flexible PET substrate. The PVP modification plays an important role in improving the surface wettability and providing abundant active sites for water-molecule adsorption. In addition, the nanostructured ZnO sensing layer facilitates effective charge accumulation and capacitance modulation through adsorption/desorption behavior and interfacial polarization under varying humidity levels. The optimized PVP-ZnO sensor demonstrated excellent humidity-sensing performance, achieving an outstanding capacitive sensitivity of approximately 99,397.49% at 85% relative humidity. The sensor also exhibited fast dynamic behavior, with response and recovery times of 7 s and 10 s, respectively, under cyclic humidity exposure. Owing to this high sensitivity and rapid signal variation, the device was successfully applied to real-time respiration monitoring under different breathing conditions. Furthermore, humidity-triggered Morse code communication was demonstrated, confirming its potential for interactive sensing and wearable communication systems. These results indicate that PVP-functionalized ZnO nanorods are promising sensing materials for flexible, highly sensitive, and multifunctional capacitive humidity sensor platforms.

LASKOWSKA Magdalena

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Functionalised Mesoporous Silica Thin Films as ROS-Generating Antimicrobial Coatings

The increasing threat posed by pathogenic microorganisms, including drug-resistant strains, creates an urgent need for new antimicrobial materials that can complement or provide alternatives to conventional disinfectants and antibiotics. In this work, we present functionalised mesoporous silica thin films designed as antimicrobial coatings capable of generating reactive oxygen species (ROS). The developed material is based on a mesoporous silica framework incorporating copper phosphonate functional groups, which serve as single-atom catalytic sites responsible for ROS formation. The coatings were subjected to detailed physicochemical and structural characterisation, with particular emphasis on the relationship between the molecular structure of the functional groups and their ability to promote ROS generation. Vibrational spectroscopy enabled the identification of copper phosphonate functional groups and helped elucidate their role in ROS generation. The presence of ROS within the silica structure was further confirmed by fluorescence microscopy, providing direct evidence of oxidative activity within the coating. Microbiological studies revealed that the coatings effectively prevented biofilm formation and exhibited broad-spectrum activity against pathogens, while in vitro cytotoxicity assays showed no evidence of cytotoxicity toward healthy fibroblasts. These results demonstrate that copper phosphonate-functionalised mesoporous silica thin films are promising candidates for the development of durable antimicrobial surfaces with activity based on controlled ROS generation.

Bio Applications / Biosensing

BARILLARO Giuseppe

University of Pisa, Pisa, Italy

*** INVITED LECTURE ***

Implantable and Bioresorbable Optical Sensors for Precision Dignostics: from Analog to Digital Sensing

Implantable and bioresorbable optical sensors are emerging as powerful tools for precision diagnostics, enabling real-time, localized monitoring of clinically relevant biomarkers while eliminating the need for device retrieval after use. By combining biodegradable materials with tailored optical transduction and molecular recognition, these platforms can provide high spatial and temporal resolution directly at the site of interest. This talk will present the development of micrometer-thick nanoporous silica optical sensors functionalized with natural and synthetic receptors, including proteins and molecularly imprinted polymers. These implantable and bioresorbable sensing platforms paired with an electronic patch have been demonstrated for the detection of biomarkers and physiological parameters such as doxorubicin, propranolol, hemoglobin, and pH, illustrating the potential of analog optical sensing based on spectral shifts and fluorescence intensity changes. Moving beyond conventional analog readout, the talk will also introduce emerging digital sensing concepts based on fluorescence-encoded polymer microneedle arrays incorporating QR-code architectures. By converting biochemical information into discrete, machine-readable optical patterns, these platforms open new opportunities for simplified readout, smartphone-based diagnostics, multiplexed detection, and integration with digital health technologies. KEY REFERENCES: F. Abazar et al., *Advanced Materials*, e18935 (2026); M. Corsi et al., *Advanced Science*, e24369 (2026); M. Corsi et al., *Nature Review Electr Eng*, 2, 572 (2025); M. Corsi et al., *Science Advances* 11, eads0265 (2025); T. Di Giulio et al., *Small Methods*, 2401315 (2025); T. Di Giulio et al., *ACS Applied Materials & Interfaces*, 17, 12663-12675 (2025); T. Di Giulio et al., *ACS Applied Materials & Interfaces*, 16 (33), 43752-43761 (2024); E. Maurina et al., *Advanced Sensor Research*, 2400090 (2024); A. Paghi et al., *Advanced Materials*, 36 (24), 2309365 (2024); E. Mazzotta et al., *Small*, 19 (38), 2302274 (2023); A. Paghi et al., *Advanced Materials Technologies*, 8 (8), 2201600 (2023); M. Corsi et al., *Advanced Science*, 9 (22), 2202062 (2022); S. Mariani et al., *Nature Communications*, 9 (1), 5256 (2018).

HOMOLA Jiří

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Advanced Plasmonic Biosensors Based on Diffractive Structures and Functional Nanoparticles

Over the past two decades, biosensors based on optically excited surface plasmons (commonly referred to as plasmonic biosensors) have emerged as a principal tool for investigating biomolecular interactions in real time and have been widely investigated for the detection and quantification of chemical and biological species in a broad range of applications, including medical diagnostics, forensics, environmental monitoring, food safety, and security. This lecture presents two recent advances in plasmonic biosensor research. First, we introduce a novel plasmonic imaging sensor that couples light to surface plasmons through variable-period diffraction gratings. The proposed design overcomes the limited operating range of conventional plasmonic imaging systems, delivering high performance over a wider refractive-index range while retaining a compact optical configuration. Second, we describe a new approach to miRNA detection that combines digital, large-field-of-view plasmonic imaging capable of detecting individual gold nanoparticle labels - each corresponding to a single target miRNA molecule - with a molecularly triggered nanoparticle release (NPR) assay. We demonstrate the application of the NPR approach to detecting miRNAs associated with myelodysplastic syndromes and achieve a limit of detection of 15 aM, yielding sensitivity comparable to that of PCR.

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Photon-Upconversion Nanoparticle-Based Immunoassays for High-Throughput Biomarker Detection: Comparing Two Single-Molecule Approaches

Sensitive biomarker detection is crucial for diagnosing tumor diseases, enabling early-stage cancer diagnosis and treatment monitoring. Immunoassays offer high specificity via antibodies, but conventional labels (such as enzymes or fluorophores)

often lack sufficient sensitivity for low-abundance biomarker detection. Photon-upconversion nanoparticles (UCNPs) are lanthanide-doped nanocrystals that convert near-infrared radiation into shorter-wavelength emission, reducing optical background. Owing to this, they can be used as exceptionally sensitive immunoassay labels. Moreover, their emission spectra can be tuned via dopant composition. Here, we present two UCNP-based single-molecule platforms with high-throughput potential. The first approach is a homogeneous, AI-assisted assay using massively parallel spectroscopy (MPS). Two UCNP-antibody conjugates with distinct emission spectra bind the analyte; only sandwich immunocomplexes bearing both labels are counted as double spots. By omitting immobilization and washing steps, MPS combines the speed of homogeneous assays with high specificity. This technique was successfully applied for the first time for detecting PSA and p53. The second platform is a microfluidic device with a flow-through cell for ultrasensitive PSA detection. Magnetic beads (MBs), conjugated with anti-PSA antibody, enabled an MB-based upconversion-linked immunosorbent assay (ULISA) with digital single-molecule readout. This method achieved a detection limit of 1.04 pg·mL⁻¹ in 50% serum, with its practical applicability confirmed by strong correlation with a reference electrochemiluminescence assay (recovery 97-105%). Both methods demonstrated strong high-throughput potential: MPS through elimination of washing steps in a straightforward homogeneous format, and microfluidic MB-ULISA through automated flow-through digital counting for ultrasensitive detection. Overall, this work highlights versatility of UCNPs as labels for next-generation clinical diagnostics.

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Development of Resistive-Conductive Nanohybrid Interface for Electrochemical Cortisol Immunosensing

Electrochemical immunosensors are often limited by insufficient antibody loading, poor conductivity, and inadequate signal reproducibility, restricting their analytical performance and broader application in diagnostic biosensing. Nanodiamonds possess tunable surface chemistry and excellent bioconjugation capabilities, making them attractive materials for biosensing applications. Recent nanodiamond-gold nanoparticle hybrid platforms have demonstrated the potential of combining favorable biomolecule immobilization characteristics with enhanced electrochemical transduction for improved immunosensor performance. The aim of this work was to study the analytical performance of an electrochemical cortisol immunosensor incorporating a previously optimized HPHT-O/C-AuNPs/EDC_NHS/Ab/BSA/Ag nanohybrid interface on a gold screen-printed electrode (AuSPE). The study assessed the ability of the resistive-conductive nanohybrid architecture, which combines the high-surface-area, oxygen-functionalized properties of HPHT-O with the conductive electron-transfer pathways provided by C-AuNPs, to support sensitive, selective, and reproducible cortisol detection. Surface and compositional analyses by SEM, FTIR, and XPS confirm formation of the nanohybrid interface and antibody immobilization. Analytical performance was further evaluated using differential pulse voltammetry (DPV) and electrochemical impedance spectroscopy (EIS). Following EDC/NHS-mediated antibody immobilization, BSA blocking, and cortisol binding, the immunosensor exhibited a linear response over 1×10^2 to 3.625×10^4 pg/mL, with excellent calibration linearity ($R^2 = 0.9980$ for DPV and 0.9998 for EIS). Low detection limits of 14.21 pg/mL (DPV) and 9.41 pg/mL (EIS) were achieved. Compared with an AuSPE/HPHT-O/EDC_NHS/Ab/BSA/Ag interface, incorporation of C-AuNPs reduced the detection limit by up to 10-fold, while improving reproducibility ($RSD < 5\%$), selectivity ($< 5\%$ interference from structurally related steroid hormones), and analytical recovery in artificial saliva (95.2-102%). These results demonstrate that the rational integration of HPHT-O and C-AuNPs creates a synergistic nanohybrid architecture that couples high-capacity antibody immobilization with enhanced charge-transfer kinetics. The resulting improvements in sensitivity, reproducibility, and analytical accuracy support the potential of this platform for robust, non-invasive cortisol monitoring in point-of-care diagnostic applications.

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Sustainable Wireless Iontronic Kinesiology Patch Utilizing Nanoscale Electrical Double Layer Sensing for Joint Motion Monitoring

Human joint movements are important for diagnosing musculoskeletal health, estimating athletic performance, and tracking injury rehabilitation progress. However, developing wireless, sustainable wearable sensors that combine high-performance sensing with bio-based materials and sustainable end-of-life management remains challenging. Here, we present a sustainable wireless iontronic kinesiology patch (WI-KP) enabled by nanoscale electrical double-layer (EDL) mediated sensing for continuous human joint-motion monitoring. We fabricate the WI-KP using biocompatible cellulose and a bio-derived choline geranate ionic liquid, providing a sustainable materials platform for wearable iontronic sensing. The iontronic capacitive pressure sensor (ICPS) senses applied pressure via capacitance changes driven by EDL modification. The ICPS has sensitivities of 1.61 kPa^{-1} (1-10 kPa) and 0.59 kPa^{-1} (10-100 kPa). The sensor shows excellent stability over 10000 pressure-loading cycles. The WI-KP is carefully engineered and assessed for air permeation, hydrophobicity, and protection against pathogenic bacteria for user comfort. The WI-KP is engineered for circular end-of-life management through simple manual disassembly, facilitating its component reuse and recycling. We assessed the WI-KP for wireless joint motion monitoring of the finger, wrist, elbow, shoulder, knee, and ankle for both male and female users. We evaluated user comfort in 24-hour wear tests, including the accumulation of micron-scale environmental dust, exfoliated dead skin cells, and microscopic contaminants over time. This work demonstrates a promising approach toward sustainable, user-friendly next-generation iontronic wearables for continuous musculoskeletal motion monitoring.

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Bio Applications / Nanomedicine / Nanofibres

MORÁVKOVÁ Karolína
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In Vitro Dose-Dependent Response of Vaginal Epithelium to Satureja Montana-Loaded Nanofibers

Vulvovaginal candidiasis caused by *Candida albicans* remains one of the most common gynaecological infections, and the rising incidence of antifungal-resistant isolates increasingly limits the efficacy of standard azole and polyene therapies. The essential oil of *Satureja montana*, dominated by the phenolic monoterpenes carvacrol and thymol, exhibits pronounced antifungal activity against *Candida albicans*, but is also known to cause dose-dependent cytotoxic effects on mammalian cells when applied directly, limiting the therapeutic use of the free extract. In this study, electrospun nanofiber mats incorporating *Satureja montana* extract at increasing concentrations are fabricated through electrospinning technology and characterized in terms of morphology, structure and physicochemical properties. The application site-relevant biological response is assessed in vitro on a human vaginal epithelial cell model using a dose-dependent cytotoxicity assay and compared with the response to the free extract applied at equivalent concentrations. Owing to the controlled and gradual release of the active compounds from the polymeric carrier, the nanofiber-incorporated extract is found to provide improved cytocompatibility with vaginal epithelium across the tested concentration range. These results are in direct contrast to the free extract, for which pronounced dose-dependent cytotoxicity is observed. These findings support *Satureja montana*-loaded nanofibers as a localized alternative for the treatment of vaginal candidiasis caused by *Candida albicans* strains.

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Nanofibrous Platforms Incorporating Drug-Loaded Carriers for Controlled Topical Drug Release

Nanofibrous materials have emerged as promising drug delivery platforms owing to their high surface area, interconnected porous structure, and versatility in polymer formulation development. Recent research has increasingly focused on the development of composite systems capable of achieving controlled and sustained drug release. In this context, silica-based xerogels represent attractive carrier materials due to their porous architecture, ease of fabrication, and cost-effective production compared with aerogels. This study presents the development of xerogel-integrated nanofibrous platforms for topical drug delivery. Model drug-loaded silica xerogels were incorporated into a biocompatible polyvinyl alcohol (PVA) polymer solution and subsequently processed into nanofibrous webs via electrospinning. The proposed carrier system aims to combine the high drug-loading capability of porous xerogels with the favorable structural characteristics of nanofibers, creating a favorable platform for controlled drug release. The fabricated webs were characterized in terms of their morphological and physicochemical properties. The in vitro release performance of the composite systems was investigated using Franz diffusion cells equipped with synthetic membranes, and the release kinetics were compared with those of nanofibrous systems containing only the model drug. The results demonstrate the potential of xerogel-integrated nanofibrous structures to modulate drug release and improve the performance of topical delivery systems. The findings provide valuable insights into the relationship between carrier structure and release behavior, highlighting the potential of these composite nanostructured platforms for localized and controlled therapeutic delivery.

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Limnospira-Derived Antibacterial ZnO Nanoflowers

Green synthesis of nanomaterials represents an emerging and rapidly developing area of nanotechnology that has attracted considerable scientific interest in recent years. Due to their unique morphology and physicochemical properties, zinc oxide nanoflowers (ZnO-NFs) show great potential for applications in biomedicine, diagnostics, biotechnology, catalysis, biosensors and wastewater treatment [1,2]. This study presents the biosynthesis of ZnO-NFs using the biomass of the cyanobacterium *Limnospira* (*Spirulina*) *platensis* Pc-005 (Microbial Depository Center, NAS, Yerevan, Armenia) and investigates their antibacterial activity against the opportunistic pathogenic bacteria *Staphylococcus aureus* MDC5233, *Salmonella typhimurium* MDC1759 and *Pseudomonas aeruginosa* Gar 3. The synthesised ZnO-NFs were characterized by UV-Vis spectroscopy and X-ray diffraction (XRD). UV-Vis analysis revealed an absorption peak at 360 nm, while XRD confirmed high crystallinity (97.6% based on lattice refinement) and nanometer-scale crystallite sizes (18.6 ± 4.0 nm). Transmission electron microscopy (TEM) demonstrated a characteristic nanoflower-like morphology. The green-synthesized ZnO-NFs exhibited significant concentration-dependent antibacterial activity against *S. aureus* and *S. typhimurium*, as evidenced by the inhibition of bacterial growth rate and colony formation. The ZnO-NFs exhibited antibacterial activity with a minimum inhibitory concentration (MIC) of 50 µg/mL against *S. aureus*, *S. typhimurium* and *P. aeruginosa*, whereas the minimum bactericidal concentration (MBC) was 100 µg/mL for all tested strains. Due to their large surface area, nanoflowers can interact with bacterial membrane, causing loss of cellular integrity, metabolic disruption, generation of ROS, and ultimately bacterial death [2]. These results highlight the potential of ZnO-NFs as eco-friendly antibacterial agents. REFERENCES: [1] D. S. Chormey et al., "Nanoflower synthesis, characterization and analytical applications: a review," *Environmental Chemistry Letters*, vol. 21, no. 3, pp. 1863-1880, 2023; [2] A. Hezam et al., "The correlation among morphology, oxygen vacancies and properties of ZnO nanoflowers," *Journal of Materials Science: Materials in Electronics*, vol. 29, no. 16, pp. 13551-13560, 2018. FUNDING: This work was supported by the Higher Education and Science Committee of Armenia, in the frames of Research project 25RG-1F098.

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Czech Republic**

Immobilization of Lignin-Based Antimicrobial Nano/microparticles on Plasma-Modified Polymer Nanofibers

Lignin, one of the most abundant renewable phenolic biopolymers, exhibits antibacterial, antioxidant, and UV-blocking properties. Compared with bulk lignin, synthesizing nanoparticles (NPs) enables new applications, providing enhanced surface area, reactivity, and aqueous dispersibility. Polymer nanofibers (NFs) serve as excellent carriers for NPs. We have already demonstrated that temperature-sensitive NFs can be coated without compromising their structure with plasma polymers (PPs) [1, 2] and that plasma modifications can mediate the immobilization of lignin NPs on those nanofibrous mats [3]. Building on our previous findings, we investigated newly synthesized lignin particles incorporating chitosan (ChiLi NPs) and boric acid (BA microparticles (MPs)) to further enhance antimicrobial performance. In suspension, both particle types inhibited *E. coli* and *S. Aureus*, with ChiLi NPs exhibiting the strongest antimicrobial effect (ALR > 7.4 against both strains). To achieve particle attachment, we explored three plasma surface modifications of NFs: O₂ plasma treatment and the deposition of carboxyl and amine PPs. Stable immobilization of positively charged ChiLi NPs was achieved on negatively charged O₂ plasma-treated and carboxyl PP-coated NFs. BA-MPs exhibited high surface coverage on NFs irrespective of the plasma modification employed. Although both particle types were successfully immobilized, only ChiLi-functionalized NFs exhibited measurable antibacterial activity against *E. coli* (ALR ≈ 1), indicating that particle composition plays an important role in the antimicrobial performance of the resulting nanofibrous materials.

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ŘÍHOVÁ Martina

**Brno University of Technology, CEITEC, Brno,
Czech Republic**

Vapor Phase Infiltration of ZnO Nanocrystals Into Biodegradable Fibers for Dermatologic Applications

Vapor Phase Infiltration (VPI) enables the incorporation of metal oxides into polymer materials [1,2]. Among other applications, it allows the development of active antibacterial polymer-inorganic composites [3,4] and photocatalysts [5]. Such functionalized polymer materials could be particularly interesting for biomedical applications, where localized and efficient antibacterial activity is required. Acne vulgaris is a serious dermatological disease affecting a significant part of the population. Currently, available therapeutics are effective only at high concentrations, which has a negative environmental and economic impact. In particular, ZnO nanoparticles (NPs) have a great potential in various biomedical applications due to their specific properties and antibacterial activity [6,7,8]. In this study, VPI was used to infiltrate polyvinyl alcohol (PVA) fibers with ZnO for the treatment of Acne vulgaris. The fibers were prepared from biodegradable polymers using an innovative centrifugal spinning technique [9] and subsequently subjected to VPI using diethyl zinc and water, leading to the formation of ZnO both within the fibers and on the fiber surfaces [3]. The fibers were infiltrated with ZnO via VPI using 1 to 128 cycles. The resulting fibers with infiltrated ZnO nanocrystals were comprehensively characterized using SEM, TEM, XRD, and EDX. Antibacterial testing revealed that PVA fibers infiltrated with ZnO nanocrystals starting from 32 VPI cycles effectively inhibited the growth of acne-causing bacteria. Moreover, the homogeneous distribution of ZnO nanocrystals within the fibers enabled the immediate release of Zn²⁺ ions while preserving the fibrous structure, in contrast to fibers containing ZnO nanoparticles, which directly blended into the spinning solution [3]. The presentation will demonstrate that fibrous carriers combined with active ZnO nanocrystals [3] prepared via VPI represent a highly promising material, showing significant potential for the treatment of Acne vulgaris. Vapor Phase Infiltration (VPI) enables the incorporation of metal oxides into polymer materials [1,2]. Among other applications, it allows the development of active antibacterial polymer-inorganic composites [3,4] and photocatalysts [5]. Such functionalized polymer materials could be particularly interesting for biomedical applications, where localized and efficient antibacterial activity is required. Acne vulgaris is a serious dermatological disease affecting a significant part of the population. Currently, available therapeutics are effective only at high concentrations, which has a negative

environmental and economic impact. In particular, ZnO nanoparticles (NPs) have a great potential in various biomedical applications due to their specific properties and antibacterial activity [6,7,8]. In this study, VPI was used to infiltrate polyvinyl alcohol (PVA) fibers with ZnO for the treatment of Acne vulgaris. The fibers were prepared from biodegradable polymers using an innovative centrifugal spinning technique [9] and subsequently subjected to VPI using diethyl zinc and water, leading to the formation of ZnO both within the fibers and on the fiber surfaces [3]. The fibers were infiltrated with ZnO via VPI using 1 to 128 cycles. The resulting fibers with infiltrated ZnO nanocrystals were comprehensively characterized using SEM, TEM, XRD, and EDX. Antibacterial testing revealed that PVA fibers infiltrated with ZnO nanocrystals starting from 32 VPI cycles effectively inhibited the growth of acne-causing bacteria. Moreover, the homogeneous distribution of ZnO nanocrystals within the fibers enabled the immediate release of Zn²⁺ ions while preserving the fibrous structure, in contrast to fibers containing ZnO nanoparticles, which directly blended into the spinning solution [3]. The presentation will demonstrate that fibrous carriers combined with active ZnO nanocrystals [3] prepared via VPI represent a highly promising material, showing significant potential for the treatment of Acne vulgaris.

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SESSION D

MONITORING AND TOXICITY OF NANOMATERIALS

- papers moved to SESSION C

Chairmen

Ing. Jan TOPINKA, DrSc.

Institute of Experimental Medicine of the CAS,
Czech Republic



SESSION E

ADVANCED METHODS OF PREPARATION AND CHARACTERIZATION OF NANOMATERIALS

Chairmen

Dr. Petr Klapetek

Czech Metrology Institute, Czech Republic

Dr. Oldřich Schneeweiss

Institute of Physics of Materials of the CAS,
Czech Republic

Dr. Michael Solar

Czech Technical University in Prague, Czech Republic

Nanocharacterization / Metrology

Yacoot Andrew

National Physical Laboratory, Teddington, United Kingdom

***** INVITED LECTURE *****

The Use of the Lattice Parameter of Silicon for Dimensional Nanometrology and Bringing Metrology to High-Speed Atomic Force Microscopy

The international length metrology community has identified the need for novel standards for length metrology that are not based on lithographically produced artefacts calibrated using optical microscopy or devices fitted with optical interferometers. When the International System of Units (the SI) was updated in 2018, the lattice parameter of silicon was adopted as a secondary standard of length for dimensional nanometrology. Its use is described in the *Mise en Pratique* for the metre [1] - the formal document from the International Bureau of Weights and Measures that describes how the SI unit of length should be realized in practice. The talk will cover the three prescribed methods using the silicon lattice for length metrology: monoatomic height standards for calibration of atomic force microscopes (AFMs) together with the processing of associated AFM data [2]; counting atoms in transmission electron microscope images to measure the linewidth structures used in semiconductor metrology [3]; and X-ray interferometry for sub-nanometre nanopositioning and error measurement in displacement sensors [4]. The last decade has seen a growth high-speed AFMs, however, many applications have been without metrology. In some cases, the high-speed of the scanning stage is at the expense of motion accuracy affecting both the image quality and the ability to extract reliable quantitative data from the image. The talk will show how metrology can be applied to high speed-AFM to make it a quantitative technique [5], how quantitative large area images can be obtained without the need for image stitching, and how errors in stage motion can be measured and their effect removed from measurement data [6]. REFERENCES: [1] <https://www.bipm.org/en/publications/mises-en-pratique/> accessed August 2026; [2] Garraes J et al. 2020 Algorithms for using silicon steps for scanning probe microscope evaluation *Metrologia* 57 064002; [3] Dai G et al. 2017 Comparison of line width calibration using critical dimension atomic force microscopes between PTB and NIST *Meas. Sci. Technol.* 28 065010; [4] Pisani M, et al. 2012 Comparison of the performance of the next generation of optical interferometers, *Metrologia* 49 455-467; [5] Heaps E et al. 2020 Bringing real-time traceability to high-speed atomic force microscopy *Meas. Sci. Technol.* 31 074005 (11pp); [6] Heaps E et al. 2025 Large area high-speed atomic force microscopy with arbitrary scan path playback *Meas. Sci. Technol.* 36 066213 (8pp).

MAJCHRZYCKI Łukasz
Poznan University of Technology, Poznan, Poland
Atomic Force Microscopy Investigation of Structure-property Relationships in Thermally Reduced Single-Layer Graphene Oxide

Two-dimensional materials exhibit unique surface, electrical, and mechanical properties, making them promising candidates for nanoscale coatings and functional interfaces. However, establishing a direct relationship between atomic-scale chemical modifications and local mechanical interactions remains a challenge for graphene oxide (GO)-based systems. In this work, atomic force microscopy (AFM) was employed to investigate the influence of controlled thermal reduction of single-layer graphene oxide flakes on their nanoscale properties. Thermal treatment up to 150 °C, associated with the removal of oxygen-containing functional groups, resulted in a decrease in GO flake thickness and an increase in nanoscale electrical conductivity measured by conductive AFM. AFM force spectroscopy revealed the dependence of tip-GO adhesion on the applied normal load. For pristine GO, increasing the applied load resulted in enhanced adhesion, which is attributed to an increase in the real contact area, allowing more oxygen-containing surface functional groups to interact with the AFM tip. With increasing reduction degree, the adhesion force dependence on the applied load reaches a plateau, indicating a stabilization of the tip-GO contact area. Friction force microscopy measurements demonstrated velocity-dependent friction behavior with several distinct regimes associated with different nanoscale dissipation mechanisms. Molecular dynamics simulations complemented experimental results by extending the accessible sliding velocity range and providing atomistic insight into friction mechanisms, including stick-slip behavior at the AFM tip-GO interface. The combination of AFM-based characterization and molecular dynamics simulations establishes a direct correlation between chemical modification of graphene oxide, nanoscale surface interactions, and friction mechanisms, highlighting AFM as a powerful approach for understanding the functional properties of two-dimensional materials. ACKNOWLEDGEMENTS: This work was supported by the National Science Centre in Poland under Project No. 2020/37/B/ST8/02023. REFERENCES: [1] Weiss, M., Majchrzycki, Ł., Borkowska, E., Cichomski, M., Ptak, A. (2021), Tribology International, 162, 107133; [2] Weiss, M., Majchrzycki, Ł., Skonieczny, R., Florjan, D., Ptak, A. (2025), Tribology International, 201, 110203.

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SOCACIU-SIEBERT Liana
SPECS Surface Nano Analysis GmbH, Berlin, Germany

*** COMMERCIAL PRESENTATION ***

EnviroMETROS: The Future of Surface Hybrid Metrology

The relevance of ultrathin films and 2D materials in modern devices is continuously increasing, prompting a growing interest in the chemical analysis of these multilayer systems and their surfaces. A thorough characterization of stoichiometries, composition, and depth distribution of elements is crucial. The novel EnviroMETROS series revolutionizes the field of surface hybrid metrology and serves as an ideal tool for routine analysis in this research and development field. It is a unique metrology platform for the chemical analysis of ultrathin films and 2D materials that allows for a detailed characterization of stoichiometries, composition and depth distribution of elements. In combination with optical and other analytical techniques it enables depth dependent composition analysis of unsurpassed precision, reliability and repeatability. The new EnviroMETROS series consists of fully automated XPS/HAXPES metrology systems consequently designed for depth dependent chemical analysis of samples, utilizing multi-wavelength X-ray excitations and parallel angle detection (PARXPS). Furthermore, it can work in variable atmospheres from UHV to NAP-conditions. The (NAP)-XPS/HAXPES analysis is accompanied by several measurement techniques on the same spot, like UPS/IPES/REELS for electronic structure studies, small spot XPS and SEM/SAM for chemical mapping correlated to morphology, LEISS for ultimate surface sensitivity, Raman as well as IRRAS as optical methods for structural information. It can be used for large samples (EnviroMETROS LAB) as well as wafer handling (EnviroMETROS FAB). The presentation will highlight the details of the EnviroMETROS series, as an ideal tool for routine analysis of ultrathin films and 2D materials for modern devices and give an insight into the large field of applications.

Co-authors: **POHLENZ Dieter, DIETRICH Paul, THISSEN Andreas**

FEDOR Adam
***Institute of Physics of Materials of the CAS, Brno,
Czech Republic***
An Al-N-Si Interatomic Potential for Molecular Dynamics Simulations of Nanodevices

Aluminum Nitride (AlN) is a critical material for nanodevices, next-generation electronics and particularly optoelectronics, where AlN-based piezoelectric microelectromechanical systems (MEMS) mirrors provide the rapid, low-power beam steering essential for modern LiDAR applications. However, device efficiency is heavily influenced by nanoscale defect interactions. Our work utilizes molecular statics and dynamics simulations to investigate the structural properties of the AlN epitaxial layer on a Si substrate, applying an innovative empirical model that consistently describes covalent bonding. A primary focus is the analysis of the complex interfaces between AlN and silicon substrates, which is essential for integrating these nanostructured semiconductors with existing technologies and optimizing epitaxial growth. Accurately simulating these interfaces requires highly reliable interatomic potentials. To this end, we have developed a robust Tersoff-style potential for the Al-N-Si subsystem, parameterized using Density Functional Theory (DFT) calculations. We validate this potential on the silicon (111) surface, encompassing 1x1, 2x1, $\sqrt{3}\times\sqrt{3}$ and 7x7 reconstructions. To investigate early-stage nanomaterial epitaxy, we initially simulate the deposition of a single Aluminum atom, evaluating surface placement and substitutional doping, before modeling a complete Al layer to observe its effect on surface reconstruction. Because epitaxial growth typically follows an alternating deposition pattern initiated by Aluminum, therefore, understanding this initial substrate-atom interaction is critical for minimizing dislocation densities and enhancing device efficiency. Furthermore, we benchmark our potential against established models, specifically the Jelinek (2012) MEAM and Starikov (2020) ADP potentials, to evaluate its comparative accuracy in capturing nanoscale interfacial behavior.

Co-authors: **FIKAR Jan, GRÖGER Roman**

Collaboration: **CEITEC - Central European Institute of Technology, Brno, Czech Republic**

MANI Balamurugan
***VSB - Technical University of Ostrava, Ostrava,
Czech Republic***
Electronic Structure Modulation of Single-Atomic Sites for Efficient and Selective Semihydrogenation of Alkynes

The selective semihydrogenation of alkynes to alkenes is an important transformation for the production of fine chemicals and polymer intermediates yet achieving high activity while suppressing over-hydrogenation remains a persistent challenge. Single-atom catalysts (SACs) provide an attractive platform for addressing this limitation because their isolated metal centers offer well-defined coordination environments and tunable electronic structures. In this work, we discuss how electronic structure modulation at single-atomic sites can be used to control the adsorption and activation of alkynes and hydrogen while steering the reaction toward the desired alkene products. In particular, heteroatom coordination and metal-support interactions provide an effective means of tuning the electronic structure of the active centers and promoting selective hydrogenation pathways while suppressing excessive hydrogenation of the resulting alkene. The isolated nature of the active sites further limits ensembles responsible for consecutive hydrogenation, providing an additional strategy for improving alkene selectivity. Combining catalyst synthesis, advanced structural characterization, catalytic evaluation, and theoretical calculations, we establish relationships between the local electronic structure of single-atomic sites and their catalytic behavior. This work demonstrates that rational electronic and spatial engineering of isolated metal centers can provide a promising route toward efficient and highly selective semihydrogenation of alkynes, while offering opportunities to reduce the reliance on conventional noble-metal nanoparticle catalysts.

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ÖZTEMUR SEZGIN Janset
Istanbul Technical University, Istanbul, Turkey
Fabrication and Characterization of Heparin-Loaded PCL/PVA Bicomponent Fibrous Surfaces for Small Diameter Vascular Grafts

Cardiovascular diseases remain a leading cause of mortality worldwide, and vascular grafts are widely used for the treatment of damaged or occluded blood vessels. However, thrombosis at the graft surface remains a major clinical challenge, particularly for small-diameter vascular grafts, thereby limiting their long-term success. Therefore, the development of innovative graft materials with improved hemocompatibility is needed. In this study, bicomponent fibrous

surfaces composed of polycaprolactone (PCL) and polyvinyl alcohol (PVA) were fabricated for small-diameter vascular graft applications, combining the mechanical strength of PCL with the hydrophilic, drug-carrying capacity of PVA, and heparin was loaded into the fibers to provide antithrombotic activity and prevent clot formation on the graft surface. Neat and heparin-loaded PCL/PVA surfaces exhibited uniform fibers with diameters within the range of 1.3-1.5 μm , and heparin loading did not have a significant effect on surface morphology. Moreover, pore diameter and porosity were evaluated, with porosity exceeding 75% for all samples, supporting cell infiltration. Contact angle measurements revealed a hydrophobic character predominantly reflecting the properties of PCL, regardless of heparin incorporation. Cytocompatibility was assessed by seeding human umbilical vein endothelial cells (HUVECs) on the fibrous surfaces and monitoring viability via the MTS assay on days 3, 7, and 14. An increase in viability was observed across all surfaces, indicating that the fabricated PCL/PVA bicomponent fibers support cellular activity from day 3 to day 14. These findings suggest that heparin-loaded PCL/PVA bicomponent fibrous surfaces possess favorable morphological and biological properties for small-diameter vascular graft applications.

Nanocharacterization / Technics

ČÍŽEK Jakub

Charles University, Prague, Czech Republic

***** INVITED LECTURE *****

Positron Annihilation Spectroscopy

Positron annihilation spectroscopy (PAS) is a nondestructive technique used to characterize open volume defects in solids, such as vacancies, vacancy clusters, dislocations, and grain boundaries. Delocalized positrons probe the interstitial sites of the crystalline lattice. When a material contains open volume defects, positrons can be trapped there, allowing them to examine the local electron density and chemical environment of these defects. There are two key observables related to the positron annihilation process: the positron lifetime in the sample and the Doppler shift in the energy of annihilation gamma rays. Positron lifetime spectroscopy can identify the types and concentrations of defects present in a sample, while coincidence Doppler broadening provides information about the local chemical environment of those defects. Hydrogen absorbed in solids occupies interstitial sites within the crystalline lattice, which are the same regions analyzed by delocalized positrons. Additionally, hydrogen is attracted to open volume defects and tends to segregate at the inner surfaces of these defects. Not only does hydrogen bind to existing open volume defects in the material, but its absorption also introduces new defects. The interaction between hydrogen and various defects, along with the defects created by hydrogen, can significantly impact physical properties of materials. This phenomenon can be thoroughly investigated using PAS, and it will be illustrated in the talk.

PTAK Arkadiusz

***Poznan University of Technology, Poznań,
Poland***

Mechanisms Governing Nanoscale Dry Friction

Understanding the physical mechanisms governing dry friction at the nanoscale is essential for improving the reliability of micro- and nanoelectromechanical systems and for developing strategies to control friction and wear. Although numerous studies have demonstrated the influence of sliding velocity, normal load, and temperature on friction, a consistent physical interpretation of these dependencies remains challenging. In this work, we present a unified physical interpretation of dry nanoscale friction based on quantitative atomic force microscopy experiments and nonequilibrium molecular dynamics simulations. Friction measured over broad ranges of sliding velocity, normal load, and temperature is analysed using the Prandtl-Tomlinson and Dudko-Hummer-Szabo models for thermally activated processes. Our results show that sliding velocity, normal load, and temperature shift the operating point on the interaction potential between the contacting surfaces, thereby changing the dominant energy dissipation mechanism. As a consequence, the system undergoes transitions between stick-slip-, smooth-sliding-, and adhesive-friction-dominated regimes. Rebinding effects additionally influence the friction force, particularly at low loads and low sliding velocities. Experimental friction data can be represented using a unified velocity-to-load parameter, revealing a characteristic friction minimum associated with these transitions. Molecular dynamics simulations reproduce the experimentally observed behavior and provide atomistic insight

into the underlying mechanisms. The proposed framework establishes a consistent physical basis for understanding and predicting dry nanoscale friction by linking operating conditions to the interaction potential and the resulting energy dissipation mechanisms. It also provides practical guidelines for tailoring operating conditions to minimize friction and wear.

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BAALOU DJ Oussama

**Palacký University Olomouc, RCPTM, CATRIN,
Olomouc, Czech Republic**

Study of the Complex Cation Disorder and Electron Density Distribution in High-Entropy Spinel Oxides Using Combined Rietveld Refinement and Maximum Entropy Method Analysis

High-entropy materials, particularly oxides, have attracted significant attention recently due to their multicomponent composition enabling broad control over electronic structure, surface properties, and defect chemistry, including mixed-valence centres and oxygen vacancies that influence charge generation, accumulation, transfer, and the functional properties. In this work, a combined Rietveld structure refinement (RSR) and the Maximum Entropy Method (MEM) was used as a helpful tool to gain insight into the crystal and electronic structures and electron-density distribution of a type of these materials from X-ray powder diffraction data. $\text{Mg}(\text{Mn}_{0.2}\text{Cr}_{0.2}\text{Co}_{0.2}\text{Fe}_{0.2}\text{Ni}_{0.2})\text{O}_4$ has been used as a model high-entropy spinel oxide (HEO) for the investigation. The HEO was initially synthesised using the co-precipitation method, followed by analysis through X-ray diffraction (XRD), and subsequently refined using RSR. The results from the theoretical RSR calculations and the experimental XRD data were nearly identical. The phase was accurately identified, and a structural model was established, characterised by a cubic form with the space group $\text{Fd}\bar{3}\text{m}$ and lattice parameters of $A = 8.40 \text{ \AA}$. The atomic positions, cation-site occupancies, oxygen positional parameter, and unit-cell volume were also provided. The MEM electron-density map constructed reveals electron-density accumulation between the metal cations and oxygen anions, suggesting partial covalent character in the metal-oxygen bonds. The diffuse electron-density distribution observed on the crystallographic planes indicates substantial disorder at the spinel B-sites. Rietveld-MEM combined analysis has proven to be a suitable tool for providing a detailed representation of the material's structure and offers insight into the relationship between its structural disorder and functional properties.

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ŠEC Karel

Nicolet CZ, Prague, Czech Republic

*** COMMERCIAL PRESENTATION ***

Multidimensional Vibrational Spectroscopy: integration of μ -IR, nano-IR, Raman and AFM for multi-scale surface characterization

Scattering-type Scanning Near-field Optical Microscopy (s-SNOM) is a scanning probe approach to optical microscopy and spectroscopy bypassing the ubiquitous diffraction limit of light to achieve a spatial resolution below 10 nanometer. New possibilities emerging with new correlative system attocube Ira-SCOPE, which allows comprehensive spectroscopic material analysis and chemical identification with micro- to nanometer resolution by seamlessly merging modern Laser-Direct Infrared (LDIR) reflection absorption spectroscopy, state-of-the-art confocal Raman micro-spectroscopy, and high-sensitivity nano-IR technologies such as nano-FTIR and AFM-IR imaging & spectroscopy. Combining these micro and nano mapping options in one instrument will be described via examples from microbiology, polymer, graphene transistor and Metal Organic Framework (MOF) research.

Co-authors: *CERNESCU Adrian*

Collaboration: *Attocube GmbH, Germany*

YADAV Ankit***Institute of Physics of Materials of the CAS, Brno,
Czech Republic*****A New Method to Construct Realistic Nanocrystalline Grain Boundaries: Cylindrical Sintering vs. Voronoi Tessellation in Atomistic Aluminum Simulations**

Conventional Voronoi tessellation methods often produce overly idealized grain boundaries in atomistic simulations of nanocrystalline materials, artificially inflating mechanical properties and leading to discrepancies with experimental measurements. To address this, we introduce a cylindrical sintering method to construct nanocrystalline aluminum thin-film samples with wider, more disordered grain boundaries than conventional Voronoi models, while preserving deterministic control over grain size, shape, and orientation. Molecular dynamics simulations using the Modified Embedded-Atom Method (MEAM) potential developed by Pascuet et al. (2015) show that the cylindrical sintered samples consistently exhibit lower mechanical properties than conventional hexagonal Voronoi structures owing to their heightened structural disorder at the boundaries. Common neighbor analysis and dislocation extraction analysis confirm that deformation is dominated by grain-boundary-mediated plasticity. Consequently, both sample types exhibit an inverse Hall-Petch relationship under uniaxial tension, where overall mechanical strength decreases with reducing grain size. Overall, this cylindrical sintering approach offers a physically realistic, geometrically controlled framework that bridges the gap between idealized Voronoi models and complex experimental microstructures.

Co-authors: **BAJTOŠOVÁ Lucia, CIESLAR Miroslav, FIKAR Jan**

Collaboration: **Central European Institute of Technology, Brno University of Technology, Brno, Czech Republic; Charles University, Faculty of Mathematics and Physics, Prague, Czech Republic**

REMEŠ Zdeněk***Institute of Physics of the CAS, Prague,
Czech Republic*****Photoluminescence and Photocurrent Spectra of Co-doped ZnO Thin Films Prepared by Pulsed Laser Deposition**

Optical properties were measured using photocurrent and frequency resolved photoluminescence spectroscopy (f-resolved PL). In our previous papers [Z. Remeš et al, J. Phys. Conf. Ser. 2712 (2024) 012004, Z. Remeš et al, J. Phys. Conf. Ser. 2931 (2024) 012011, and Z. Remeš et al, Phys._Scr. 100 (2025) 115910] we presented an upgrade of our spectrofluorometer optimize to measure the phase shift between sinusoidal UV excitation and PL emission at low temperature (4 K) using lock-in amplifier. Here we apply this method to evaluate the mean PL decay time of Co-doped ZnO thin films grown by pulsed laser deposition (PLD). The work was supported by the Czech Science Foundation projects 24-10607J and by Operational Program Jan Amos Komenský (OP JAK) financed by ESIF and the MEYS (Project No. LASCIMAT - CZ.02.01.01/00/23_020/0008525).

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Collaboration: **Faculty of Electrical Engineering, Czech Technical University in Prague, Prague, Czech Republic**

OROLÍN Jakub***Measurement Technic Moravia Ltd., Zastávka,
Czech Republic******** COMMERCIAL PRESENTATION *******Beyond the SuperTunnel: New Frontiers in Microscopy, Manipulation & Detection**

Electron microscopy is evolving beyond conventional imaging, opening new possibilities for high-resolution observation, precise manipulation and advanced analytical characterization. This presentation will introduce selected new technologies that push the capabilities of modern electron microscopy in these directions. A particular focus will be placed on CIQTEK electron microscopy and its SuperTunnel electron optics column technology, designed to enable high-resolution imaging at low accelerating voltages. The second part will introduce Imina nanorobotic solutions for precise manipulation, probing and positioning at the micro- and nanoscale, enabling manipulation and in-situ experiments across different microscopy and characterization techniques. The final part will focus on the latest developments in Bruker analytical detectors, including the new XFlash 7200 FIRE four-segment EDS detector with unique 200 mm² active area, XFlash FlatQUAD

2Lcombining highly efficient EDS with simultaneous BSE imaging, and the eWARP TKD detector for fast, high-resolution nanoscale crystallographic characterization. Together, these technologies demonstrate how modern microscopy is moving beyond simply seeing a sample towards correlated imaging, manipulation and analytical insight.

ZHOU Yazhou

***VSB - Technical University of Ostrava, Ostrava,
Czech Republic***

Single-Atom Catalysts: Design, Synthesis, and Catalytic Applications

Heterogeneous catalysis plays an indispensable tool in modern industrial processes. When supported nanoparticles are downsized to the single-atom limit, the resulting single-atom catalysts (SACs) have proven special value¹. These individually dispersed metal sites possess defined coordination structures and enabled reaction pathways that differ from traditional heterogeneous catalysis. While offering high stability even in harsh environments, and maximum utilization of catalytic metals, SACs also satisfy the key goals of a sustainable chemistry. Nevertheless, limited reproducibility and scalability of SAC preparation hinder their further practical applications, and efficient methods of SAC synthesis are urgently needed. A major challenge is to prepare single-atom sites on the catalyst support with high density while avoiding aggregation of metal atoms. This challenge can be traced to the trade-off between diffusion and stabilization of metal atoms during the pyrolysis process. In this talk, several approaches will be presented^{2,3}. These methods will discuss how the metal resources including ions, organometallic complexes, and particles are transformed into single atoms and their possible mechanisms. This work is a critical step forward toward a scalable synthesis and widespread application of dense SACs and pavs the way for the development of further economically feasible catalyst systems

FRIÁK Martin

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Czech Republic***

Applications of Classical and Quantum Random Number Generation in Solid-State Physics Calculations

Random-bit generation is essential for numerical simulations, statistical sampling, optimization, and cryptography. In this work, we compare binary sequences produced by a classical pseudorandom-number generator and a present-day quantum-computer processor. We place a particular emphasis on small samples in which an approximately equal proportion of the two possible measurement outputs (zeros and ones) is desirable. We aim at solid-state physics applications where random displacement of atoms are important for computing materials properties of crystals, such as phonons. In particular, considering positive and negative random displacements of atoms in the computational cell, we generated the random data by both classical pseudorandom-number generator and IBM quantum computer. These data are divided into small blocks and evaluated using the mean and variance of the fraction of ones, bit-string frequencies, Shannon entropy, inter-qubit correlations, temporal autocorrelation, chi-square tests, and the Fano factor. Preliminary results suggest that, under certain conditions, quantum-hardware outputs may exhibit smaller fluctuations in the block-wise fraction of zeros and ones than classical pseudorandom sequences. Such sub-binomial behavior may originate from hardware noise, readout errors, or correlations between qubits and successive measurements. Although reduced variance does not imply higher randomness or better cryptographic quality, it may be advantageous in applications requiring balanced small binary samples, such as displacement of atoms in solid-state physics calculations.

KOLLEBOYINA Jayaramulu

***VSB - Technical University of Ostrava, Ostrava,
Czech Republic***

Synergistic Surface Functionalization of Metal-Organic Polyhedra for Advanced Energy Technologies

Metal-organic polyhedra (MOPs) represent a unique class of discrete, zero-dimensional porous materials that serve as molecular cages for constructing hierarchical porous architectures. Unlike extended frameworks, MOPs offer tunable solubility, rich surface chemistries, and modular functionalities, making them highly versatile for applications in gas storage and separation, catalysis, and energy harvesting. However, their broader utilization has been limited by challenges such as moisture sensitivity, inadequate mechanical stability, and the presence of complex, often inaccessible pore structures. To address these limitations, strategies have been explored to enhance hydrolytic stability, including the incorporation of hydrophobic functional groups and integration with polymer matrices. Our group has advanced this field by designing MOP-based materials with improved robustness and functionality through both covalent and coordinative

functionalization. These modifications are achieved either by introducing pre-functionalized linkers during synthesis or via post-synthetic modifications, enabling fine-tuned control over MOP surface chemistry. Such tailored MOPs have been successfully employed in heterogeneous catalysis, electrochemical CO₂ reduction reactions (CO₂RR), energy storage, and triboelectric nanogenerator-based energy harvesting. This talk will highlight our recent progress in engineering MOPs as multifunctional platforms, emphasizing how structural design and surface chemistry together drive stability, reactivity, and application potential in sustainable energy and environmental technologies. REFERENCES: [1] S. Ippili, G. S. Kumar, A. Sharma, Y. Ko, S. Hong, M. Goddati, H. Saini, J. Lee, T.-Y. Yang, S. Siddhanta, V. Jella, S.-G. Yoon and K. Jayaramulu, *Advanced Energy Materials*, 2024, 14, 2402260; [2] A. Sharma, R. David, S. Srivastava, V. R. Hathwar, S. Siddhanta, M. Otyepka and K. Jayaramulu, *Applied Materials Today*, 2025, 45, 102805; [3] S. Ippili, V. Jella, S. J. Jyothi, S. Kment, R. Zboril, S.-G. Yoon and K. Jayaramulu, *Small*, 2025, 21, 2503772; [4] S. Ippili, G. S. Kumar, A. Sharma, Y. Ko, S. Hong, M. Goddati, H. Saini, J. Lee, T.-Y. Yang, S. Siddhanta, V. Jella, S.-G. Yoon and K. Jayaramulu, *Advanced Energy Materials*, 2024, 14, 2402260; [5] K. Jayaramulu, S. Mukherjee, D. M. Morales, D. P. Dubal, A. K. Nanjundan, A. Schneemann, J. Masa, S. Kment, W. Schuhmann, M. Otyepka, R. Zbořil and R. A. Fischer, *Chemical Reviews*, 2022, 122, 17241-17338.

Collaboration: Hybrid Porous Materials Lab, Department of Chemistry, Indian Institute of Technology Jammu, India



NanoEnviCz

SYMPOSIUM ON NANOMATERIALS FOR ENVIRONMENTAL AND HUMAN HEALTH PROTECTION

Chairman

Assoc. Prof. Dr. Martin KALBAC

J. Heyrovsky Institute of Physical Chemistry of the CAS,
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Preparation of Nanofiber-based Materials for Energy Storage Applications

Our fabrication approach of nanomaterials utilizes a versatile, easily scalable, and zero-waste hybridspinning technology that combines electrostatic and centrifugal force. A key advantage of this semi-industrial system is its dual-head configuration, which enables the simultaneous spinning of different polymers achieving interwind membrane structures composed of various polymers and/or direct surface functionalization during the production process. One of the applications of this technology in our laboratory is the design of novel, fire-retardant functional separators for lithium-ion batteries based on NMC and LFP cathode materials. Compared to commercially available separators based on polyolefins, evaluating the spun separators demonstrates significantly reduced internal resistance, enhanced active material utilization, and a sustained high specific capacity at elevated discharge rates. Beyond energy storage, the versatility of our dual-head system allows for direct, single-step functionalization of nanofiber membranes. Therefore, we will demonstrate various applications of this technology in the field of environmental applications and biotechnology. ACKNOWLEDGEMENTS: The authors acknowledge funding from the European Union's Horizon Europe research and innovation program under Grant Agreement No. 101147457 (INERRANT) and the involvement in No. 101104022 (Battery 2030+ CSA). The authors acknowledge the assistance provided by the Research Infrastructure NanoEnviCz (No. 90266), supported by the Ministry of Education, Youth, and Sports of the Czech Republic under Project No. LM2023066.

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GULDANOVÁ Radka

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Analytical Capabilities of the NanoEnviCz Infrastructure: Navigating Characterization Challenges from Fluorinated Polymers to Natural Biomatrices

As a part of the NanoEnviCz research infrastructure, our laboratories at the Technical University of Liberec (TUL) offer a collaborative environment for the synthesis, characterization, and testing of functional nanomaterials. We are pleased to share our analytical capabilities with the broader scientific community to support detailed structural, surface, and quantitative studies. For instance, complex structural elucidation and deeper insights into polymer crosslinking can be carefully evaluated using an FTIR spectrometer with an FTIR microscope and FT-Raman module, alongside Solid State NMR (JEOL 400 MHz). Additionally, reliable surface area and porosity determination via BET analysis (Autosorb 6100 XR-XR) provides an essential foundation for subsequent toxicological testing routinely conducted by our colleagues. When highly

sensitive pollutant quantification is required, we can utilize advanced mass spectrometry platforms, including HPLC/MS/MS, GC/MS/MS, and the Sciex X500R QTOF. We illustrate the practical application of these techniques through our work on cyclodextrin (CD)-based sorbents for micropollutant capture. In our research, we continue to utilize materials based on fluorinated polymers, such as PVDF. These synthetic carriers are highly valued not only for their excellent material properties but also for their straightforward analyzability. Their clean spectral background makes them ideal, easily traceable model systems for confirming successful chemical modifications, such as active CD layer grafting. However, given the growing environmental concerns surrounding fluorinated substances, alongside our shared commitment to sustainability, there is a natural drive to shift away from these synthetic carriers toward natural, bio-based materials, such as nanocellulose or chitosan. This transition brings significant analytical challenges due to complex matrix interferences and severe spectral overlapping, which can completely mask the signals of active modifications. Consequently, finding ways to successfully characterize these natural matrices represents our current major challenge. We are at the very beginning of this journey—actively exploring new analytical protocols and revisiting classical methodologies to overcome these hurdles. Through the collaborative framework and shared equipment of NanoEnviCz, we aim to tackle this complex issue together, hoping to eventually pave the way for the precise optimization of next-generation, bio-based water remediation technologies.

SAZAMA Petr

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From Nanoscale Understanding to Sustainable Catalytic Technologies

This contribution demonstrates how comprehensive analyses provided by the NANOENVICZ research infrastructure advance the development of high-performance nanomaterials for sustainable catalytic technologies. By connecting material synthesis with complementary structural, textural, spectroscopic, microscopic, and catalytic investigations, the infrastructure enables researchers to identify the properties that govern catalytic activity, selectivity, and stability. Recent studies illustrate this integrated approach across environmental and energy catalysis. Advanced characterization of porous metal silicates revealed how the distribution of active sites and the chemical nature of their surroundings can be deliberately adjusted to improve catalytic performance. Studies of modified zeolites showed that controlling acidity and pore architecture is essential for the efficient conversion of renewable biomass-derived molecules into valuable chemicals and fuel components. The infrastructure also supported catalytic valorization of carbon dioxide and methane. Analysis of metal species confined in zeolite frameworks and hierarchical pore systems provided insight into the activation of these stable molecules and into their transformation into fuels and platform chemicals. Together, these examples highlight the decisive role of comprehensive, integrated analytical methods in moving from empirical catalyst testing toward knowledge-driven materials design. NANOENVICZ provides the expertise, instrumentation, and collaborative environment required to relate nanoscale structure to function, accelerate the optimization of catalytic materials, and support the development of cleaner processes for renewable feedstock conversion, circular carbon utilization, and sustainable energy production. ACKNOWLEDGEMENTS: This work was supported by the Czech Science Foundation (25-16545S) and the Research Infrastructure NanoEnviCz funded by the Ministry of Education, Youth and Sports of the Czech Republic (No. LM2023066).

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Overview of a Novel Possibility for Cooperation within the NanoEnviCz Project

In recent years, we have had the opportunity to upgrade and innovate the instrumental techniques to offer potential users of the LRI NanoEnviCz cooperation, reflecting the needs in the field of nanomaterials and nanotechnologies for environmental protection. The LRI NanoEnviCz proposes support for student theses at all degree levels and is formed by specialists from three universities and three academic institutions. All institutions have experience with syntheses and characterization of nanomaterials, detection of contaminants or decontamination of pollutants, studying toxicity, etc. The research topics focus on reactive sorbents, sorbents, photocatalysts, catalysts, etc. at the Institute of Inorganic Chemistry of the Czech Academy of Sciences. These materials are typically metal oxides or hydroxides, 2D materials (h-BN, graphene-based materials, MoS₂, etc.), double-layered hydroxides or alkoxides, MOFs, MAX and MXene phases, functionalized ionic liquids and their derivatives, nano- or microplastics, etc. Zeolites are one of the most common sorbents for several uses.

Our focus was on the sorption of radionuclides. Several types of the zeolites were chosen for the effective uptake of Sr^{2+} and Cs^{+} . We characterized the prepared materials and studied their sorption mechanisms. **ACKNOWLEDGEMENT:** The authors acknowledge the assistance provided by the Research Infrastructure NanoEnviCz, supported by the Ministry of Education, Youth, and Sports of the Czech Republic under Project No. LM2023066.

SIKOROVÁ Jitka

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NanoEnviCz: From Laboratory to Field Measurements by Mobile Exposure Chamber

Understanding the health effects of airborne particles and combustion-related pollutants requires exposure systems that could reproduce realistic aerosol mixtures and allow their characterization. An exposure chamber designed for both laboratory and field studies is presented. The system enables dilution, conditioning, and delivery of aerosols originating from a wide range of emission sources, while maintaining flexibility for different experimental scenarios and biological models. An important feature of the proposed platform is the ability to perform particle exposure and aerosol measurements at the same time. The exposure chamber is designed to operate in parallel with an extensive suite of analytical instruments, allowing real-time characterization of particle number concentration, size distribution, chemical composition, gaseous co-pollutants, and other relevant aerosol properties during biological exposure experiments. This approach reduces uncertainty caused by aerosol source fluctuation and ensures that the exposure is well characterized. The chamber will be a key part of a mobile laboratory equipped with additional state-of-the-art monitoring instruments planned for further development and better services provided by the research infrastructure NanoEnviCz. This mobile setup will allow both measurements and biological exposure experiments to be performed simultaneously in field or near-source environments. Its flexible and modular design will support a wide range of nanoparticle types, gaseous pollutants, and emission sources. By combining mobility, advanced monitoring capabilities, and controlled exposure conditions in a single platform, the system will provide a powerful tool for studying nanoparticle toxicity, complex airborne pollutant mixtures, and the relationships between emission sources, exposure characteristics, and biological responses. **ACKNOWLEDGEMENTS:** This work was supported by the Ministry of Education, Youth and Sports of the Czech Republic (the Research Infrastructure NanoEnviCz, LM2023066).

PETR Martin

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XPS Surface Characterization: Capabilities, Applications and Examples

The presentation will provide a brief overview of the analytical infrastructure and services offered by UPOL within NanoEnviCz, with a focus on surface and nanoscale characterization. The main part will introduce X-ray photoelectron spectroscopy (XPS) as a powerful tool for investigating the elemental composition and chemical states of materials at the surface. The principles, capabilities, and limitations of XPS will be briefly discussed, followed by selected examples demonstrating its application in the characterization of surface modifications, oxide layers, catalytic materials, and nanostructured systems. The aim is to demonstrate how XPS can provide information beyond elemental composition and contribute to understanding the surface chemistry and properties of advanced materials. **ACKNOWLEDGEMENTS:** The authors acknowledge the assistance provided by the Research Infrastructure NanoEnviCz (No. 90266), supported by the Ministry of Education, Youth, and Sports of the Czech Republic under Project No. LM2023066.



POSTER SESSION (A - E)

POSTER SESSION A

Nanocomposites, Magnetic, Metal and Oxidic Nanomaterials & Other Nanostructures

KOLEVA Mihaela

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Influence of Laser Pulse Duration on PLD Growth and Annealing of Plasmonic Composite Nanostructures

This work investigates the synthesis of Ag/ZnO composite nanostructures by pulsed laser deposition (PLD) and laser annealing. Laser systems that generate nanosecond (15 ns) and picosecond (10 ps) pulses were used in the experiments. The nanosecond and picosecond laser regimes were employed to evaluate the effect of pulse duration on the morphology, structural characteristics, and optical properties of the deposited films. The laser nanostructuring enabled controlled formation of Ag nanoparticles, allowing precise tuning of their morphology and enhancement of the local electromagnetic field. The optical properties were studied with emphasis on the localized surface plasmon resonance (LSPR) of Ag nanoparticles and its influence on the photoluminescence of ZnO. Enhanced near-band-edge ultraviolet emission was observed, attributed to plasmon-exciton coupling and localized electromagnetic "hot spots" generated by the Ag nanoparticles. Numerical simulations of the electromagnetic field distribution quantified the dependence of "hot-spot" intensity on nanoparticle size, shape, and surrounding medium. The combined experimental and theoretical results demonstrate the potential of studied Ag/ZnO nanocomposites for plasmon-enhanced sensing and optoelectronic applications.

ACKNOWLEDGMENTS: The financial support from the Bulgarian Academy of Sciences (Project No. IC-CZ/03/2025-2026) within the framework of the bilateral agreement between BAS and the Czech Academy of Sciences is gratefully acknowledged.

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KADDECHE Mourad

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Khemis miliana, Algeria***

Simulation of Gate Field Plated- HEMT based on AlGaIn/GaN Heterostructure

Gallium Nitride (GaN) is extensively utilized in wireless telecommunications and radar systems due to its exceptional material and electrical characteristics, including a broad bandgap and elevated breakdown field. These characteristics make GaN more suitable for high-voltage and high-temperature applications compared to many other materials. We study the influence of the various geometrical and physical parameters of the transistor on the electrical characteristics based on two-dimensional numerical simulations in order to obtain a structure conducive to good operation. Our simulation results shows that the device designs based on GFP-HEMT AlGaIn/GaN heterostructures is a promising candidate for high frequency and high power applications.

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KALKOZOVA Zhanar
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Hydrogen Plasma-Induced Surface Defects in ZnO Nanorods for Enhanced Photoelectrochemical Performance

Vertically aligned ZnO nanorods were synthesized on FTO substrates using a two-step process combining spin coating and chemical bath deposition, followed by low-power hydrogen plasma treatment [1]. The influence of hydrogen plasma on the structural, optical, electrical, and photoelectrochemical properties of ZnO nanorods was systematically investigated. Structural and morphological analyses confirmed preservation of the hexagonal wurtzite phase and vertical nanorod alignment after plasma exposure, indicating that the treatment predominantly affects the near-surface region without compromising the overall structural integrity. Spectroscopic studies revealed redistribution and partial passivation of surface-related defect states. Photoluminescence measurements showed strong suppression of defect-related visible emission together with an approximately sevenfold enhancement of near-band-edge emission, demonstrating effective modification of defect-assisted recombination pathways. Hydrogen plasma treatment significantly improved the electrical properties of ZnO nanorods. The sheet resistance decreased from 17.5 ± 2.0 to $0.30 \pm 0.07 \Omega \text{ sq}^{-1}$, accompanied by a substantial increase in carrier mobility. Mott-Schottky analysis revealed an increase in donor density from 2.85×10^{19} to $4.53 \times 10^{19} \text{ cm}^{-3}$. These changes resulted in enhanced photoelectrochemical activity, with the photocurrent density at 1.23 V vs RHE increasing from 160 to 250 $\mu\text{A cm}^{-2}$. Electrochemical impedance spectroscopy further demonstrated a decrease in charge-transfer resistance, confirming improved interfacial charge-transfer kinetics. The combined results demonstrate that controlled hydrogen plasma treatment simultaneously passivates deep-level defect states and modifies shallow donor states in ZnO, leading to improved electrical conductivity, reduced recombination losses, and more efficient charge separation and transport. Hydrogen plasma processing therefore represents a promising surface defect-engineering strategy for optimizing ZnO nanorod photoanodes for photoelectrochemical applications.

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Metallic Base Mirrors as a Strategy to Enhance SERS Performance of Conducting Polymer Substrates

Conducting polymers have recently shown strong potential in analytical chemistry as alternative substrates for Surface-Enhanced Raman Scattering (SERS) spectroscopy. Among these, poly(3,4-ethylenedioxythiophene) polystyrene sulfonate (PEDOT:PSS) has shown promise for detecting organic dyes. However, its intrinsic SERS performance remains lower than that of traditional plasmonic nanomaterials, limiting its effectiveness for low-concentration analyte detection. To address this limitation, this study introduces a straightforward approach using a sandwich architecture that integrates sputter-deposited metallic base films with spin-coated, thermally cured PEDOT:PSS films. The metallic base layer acts as a "mirror" that, depending on its reflectivity, substantially modifies the SERS performance of the resulting coating. Among the tested metals (Al, Au, Ag, Pd, Cu, W, and V), aluminium was identified as optimal, enabling nearly an order-of-magnitude enhancement of the methylene blue SERS signal compared to PEDOT:PSS deposited on conventional Si wafers. ACKNOWLEDGEMENTS: This work was supported by the Czech Science Foundation (grant no. 24-12197S).

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Bi₂S₃/H-Nanocrystalline Diamond Heterostructures for Selective NO₂ Gas Sensing

The development of selective and sensitive gas sensors operating at or near room temperature is important for environmental monitoring with a focus on industrial safety and overall air-quality control. Among emerging sensing materials, bismuth sulfide (Bi₂S₃) has recently attracted considerable attention for low-temperature NO₂ detection due to its layered structure and strong interaction with oxidizing gas molecules affecting its surface charge-transfer processes and electrical conductivity. Formation of Bi₂S₃-semiconductor heterostructures can further amplify/enhance NO₂ adsorption-induced electrical changes. In this work, Bi₂S₃ is combined with hydrogen-terminated nanocrystalline diamond (H-NCD)

aiming to develop heterostructure gas-sensing platforms with controllable electrical response and enhanced selectivity. The H-NCD surface provides a 2D hole-like conductive channel, while the $\text{Bi}_2\text{S}_3/\text{H-NCD}$ interface introduces an additional pathway for interfacial charge redistribution. The electrical response of the heterostructures to NO_2 was investigated as a dependency of gas concentration, operating temperature (50 or 100°C), optical excitation and initial device resistance. At temperature of 50°C , the response increased with NO_2 concentration (1-100 ppm) and peaked approximately at 275% for the devices with high initial resistance (1-10 k Ω), compared with values at 180% and 25% for devices with low initial resistance (below 1 k Ω). Repeated exposure to 100 ppm NO_2 revealed that the initial resistance influences both the magnitude and temporal stability of the sensor response. Measurements performed under optical excitation additionally produced a distinct photo-induced effect resulting in negative photocurrent response. The achieved results demonstrate that the sensing properties of $\text{Bi}_2\text{S}_3/\text{H-NCD}$ heterostructure are affected by a) NO_2 absorption on Bi_2S_3 surface; b) its morphology and surface chemistry; and c) the initial electrical state and charge-transport at the heterostructure interface. Engineering the $\text{Bi}_2\text{S}_3/\text{H-NCD}$ interface and the initial device resistance therefore offers a promising route toward low-temperature selective NO_2 detection and potentially multifunctional sensing architectures compatible with chemiresistive and acoustic sensor platforms.

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Aerosol Jet Printing of Nanodiamond Architectures for Three-Dimensional Diamond Growth

Aerosol jet printing (AJP) provides a maskless and digitally controlled route for the spatial deposition of nanodiamond particles, enabling the printed structures to serve as nucleation templates for subsequent chemical vapor deposition (CVD) of diamond. In this work, the AJP process was optimized for nanodiamond suspensions with nominal particle sizes of 5, 50, 100, and 150 nm printed on Si substrates. The influence of particle size, nozzle diameter, printing parameters, and printing multiplicity on the morphology and geometrical stability of the resulting structures was investigated. Both planar nucleation patterns and three-dimensional nanodiamond architectures were fabricated. By controlling the material deposition and toolpath, structures ranging from porous particle networks to dense and continuous features were obtained. The most reproducible three-dimensional printed structures were achieved using a 150 μm nozzle. Repeated printing allowed stacking of up to 200 deposited layers, resulting in features approximately 150 μm high and 200 μm wide. This demonstrates that AJP can extend nanodiamond patterning from conventional planar nucleation layers to bulk microstructures with controlled geometry and porosity. The printed nanodiamond structures served directly as nucleation templates for selective-area diamond growth using microwave plasma-enhanced CVD. Both porous and dense core-shell architectures were successfully formed, whereas the conformally shaped shell consisted of either intrinsic or electrically conductive boron-doped diamond crystals. The developed approach combines additive nanodiamond patterning with CVD growth and provides a flexible route towards complex geometrically controlled diamond microstructures with tailored morphology, surface area, and opto-electrical properties with potential application in high-surface-area electrodes and sensor architectures.

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Real-time insight into CsPbX_3 quantum dots formation process

Photoluminescence quantum yields exceeding 90 %, tuneable emission across the entire visible spectrum and short radiative carrier lifetimes make lead halide perovskite quantum dots (QDs) promising candidates for a wide variety of optoelectronic devices. Despite these advantages, their commercialization is hindered by poor stability arising from the dynamic binding of native ligands: oleic acid (OA) and oleylamine (OAm), which makes a repassivation process necessary to maintain QDs optical performance. Direct insight into the formation of these QDs allows for the optimization of repassivation parameters, helping to accelerate research progress. In this work, we investigated the effect of OA and OAm ligands on CsPbX_3 QDs during their formation via the hot injection method, using in situ photoluminescence (PL) to capture

rapid changes such as defect formation and size variations. We identified a transient blue shift of the PL spectra at the onset of ice cooling, which is more pronounced when cooling from higher initial temperatures or under enhanced mixing dynamics. Under these conditions, slowed proton exchange between OA and OAm allows acidic surface etching of the QDs by OA. Subsequent in situ repassivation using a stronger binding ligand produces a pronounced redshift, driven by reduced native ligands influence and effective surface stabilization that repairs uncoordinated surface defects. Transient blue shift at the start of ice cooling process provides a real-time indicator to optimize the timing of in situ QD repassivation, ensuring optimal optoelectronic performance and stability. **ACKNOWLEDGEMENTS:** We would like to acknowledge the support of project 24-11652S (GACR).

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Comparative Study of Argon Plasma and Other Post-Processing Methods for PLA-C Electrodes

Controlled surface modification is a vital approach in the development of materials with applications in sensing, electronics, and catalysis. Additive manufacturing techniques such as Fused Filament Fabrication enable rapid and cost-effective production of composite electrodes, including poly(lactic acid) with carbon additives (PLA-C). However, the printing process often leads to the development of layers of insulating polymer that hamper the charge percolation path, diminishing electrochemical performance. To overcome this, various post-processing methods such as laser ablation, chemical treatment, or plasma etching can be employed to modify surface layers of PLA-C. Argon plasma treatment enables physical etching of the surface, effectively removing insulating layers and exposing embedded conductive carbon structures. Moreover, such an approach is distinguished by low entry cost, in comparison to laser ablation, does not rely on toxic chemicals like dimethylformamide, and creates fairly uniform surface, unlike mechanical polishing. In this work, we investigate the effects of argon plasma treatment, with the use of custom platform utilizing plasma torch, mounted on the modified 3D printer head. We compare obtained samples to other common post-processing methods of PLA-C electrodes. Electrochemical characterization demonstrates that plasma annealed PLA-C samples exhibit improved charge transfer kinetics and have enhanced current response in the presence of the redox pair compared to the untreated samples. Both, elaborated processing setup and optimized parameters allow for high reproducibility and controllability, while ensuring environmental sustainability and keeping costs low, which can be utilized for rapid manufacturing and prototyping workflows.

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POPIELARSKI Pawel

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Time-Resolved Luminescence under Synchrotron Radiation and Electroluminescent Properties of Macrocyclic Schiff-Base Compounds for OLED Applications

The luminescence properties of the macrocyclic Schiff-base compounds L1, S1 and S2 were investigated using UV-Vis absorption spectroscopy, fluorescence spectroscopy and time-resolved luminescence spectroscopy under synchrotron radiation excitation. The fluorescence spectra recorded in chloroform under excitation at 350 nm showed emission maxima in the range of 498-500 nm for the macrocyclic (2+2) compounds L1 and S2, whereas the macrocyclic (3+3) compound S1 exhibited an emission maximum at 549 nm. In the solid state, the compounds showed bathochromically shifted emission bands due to differences in intermolecular interactions, conformational changes and structural stiffness. The basic luminescent properties of the L1 and S2 powder samples were additionally studied using time-resolved luminescence spectroscopy under excitation by pulsed synchrotron radiation at 12 K. The emission spectra recorded under excitation at 180 and 260 nm showed dominant emission bands peaked at 598 and 535 nm, respectively. The photoluminescence excitation spectra, monitored at the corresponding emission maxima, were characterised by dominant bands at 7.56 eV

for L1 and 7.60 eV for S2. These bands were assigned to the exciton creation energies associated with the emission centres of the macrocyclic compounds. The decay kinetics of L1 were close to single-exponential, with a decay time of 1.28 ns, whereas S2 showed strongly non-exponential decay behaviour, indicating a more complex luminescence mechanism. Three OLEDs with the ITO/PEDOT:PSS/emissive layer/Al structure were constructed using L1, S1 and S2 doped with PVK as the emissive layer. OLED-L1, OLED-S2 and OLED-S1 exhibited electroluminescence maxima at 543, 538 and 574 nm, respectively. The differences in the emission maximum values were attributed to variations in molecular structure, chirality, intermolecular interactions and the electronic effects of the substituents. OLED-S2, containing an electron-withdrawing bromo substituent, showed the highest maximum luminance of 219 cd m⁻² and the highest current efficiency of 0.25 cd A⁻¹. The obtained results confirm that the investigated macrocyclic compounds are promising emissive materials for green and yellow OLED applications.

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2D Nanostructures

GORAWSKA Sonia

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Microwave-Assisted Synthesis of BiFeO₃-MWCNT Nanocomposites: Effect of Carbon Nanotube Loading and Annealing Time on Morphology and Homogeneity

Bismuth ferrite (BiFeO₃, BFO) is a prominent multiferroic material widely investigated for photocatalytic, electronic, and energy storage applications. However, precise control over phase purity, particle dispersion, and morphology remains a significant challenge. Herein, we present a rapid, microwave-assisted solvothermal approach for the fabrication of BFO-MWCNT-COOH nanocomposites with varying functionalized carbon nanotube contents, as well as pristine BiFeO₃. The synthesis was carried out in N,N-dimethylformamide (DMF) using bismuth and iron nitrate precursors in the presence of urea, followed by microwave treatment at 150°C for 15 min. To evaluate crystallization behavior and phase evolution, the synthesized powders were calcined at 500°C for different durations (30, 60, and 90 min). The influence of MWCNT loading and thermal treatment parameters on the structural homogeneity, phase composition, and surface morphology was systematically investigated. The preliminary findings demonstrate that microwave-assisted synthesis combined with optimized annealing conditions provides effective control over BFO crystallization and its uniform distribution along the carbon nanotube scaffold, offering a promising route toward tailored multifunctional nanomaterials.

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KURTYKA Klaudia

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The Role of Nanoscale Dimensions and Interconnectivity in the Electrochemical Performance and Structural Stability of Hollow 3D Graphitic Structures during Cycling

This study investigates the key role of nanoscale dimensions and interconnectivity in hollow three-dimensional graphitic structures (3D-GS) and their influence on electrochemical properties in lithium-ion batteries, as well as their impact on electrode degradation after cycling. 3D-GS with selected particle sizes (300 nm, 100 nm, and 10 nm) were synthesized using chemical vapor deposition (CVD). Optimization of the process parameters resulted in a reproducible number of graphene layers for all structure sizes. The materials were characterized using complementary microscopic, spectroscopic, and X-ray techniques. Scanning electron microscopy (SEM) and transmission electron microscopy (TEM) provided essential

insights into the morphology and interconnectivity of the 3D-GS and were particularly effective in assessing their complex structure. Comprehensive electrochemical studies included cyclic voltammetry, impedance spectroscopy, and galvanostatic cycling tests. To better understand their electrochemical behavior, 3D-GS-based electrodes were characterized after 0 (initial state), 1, 2, 10, and 100 cycles using, among others, scanning electron microscopy (SEM), X-ray diffraction (XRD), and Raman spectroscopy. The obtained results reveal the evolution of 3D-GS microstructure and structural stability during cycling, highlighting their potential for improving lithium-ion battery performance. **ACKNOWLEDGEMENT:** This work was supported by the National Science Centre, Poland within the PRELUDIUM-20 project (No. 2021/41/N/ST5/03636) and by mobility project No. PAN-24-20 of the Polish Academy of Sciences and the Czech Academy of Sciences.

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N-alkylated Fluorographene: A Metal-free Electrocatalyst for the Hydrogen Evolution Reaction

Designing graphene-based metal-free electrocatalysts is crucial due to their reduced costs, tunable molecular structures, superior electronic conductivity and substantial tolerance under fluctuating pH conditions. In this work, we have covalently functionalized fluoride graphite with n-octyl amine (OA), n-dodecyl amine (DDA), and n-octadecyl amine (ODA) via a facile nucleophilic substitution reaction to prepare three different N-alkylated fluorographene materials, OA-FGr, DDA-FGr, and ODA-FGr, respectively. Different characterization techniques have collectively confirmed their successful formation by providing information about their functionality, stacking, chemical interactions, morphology and textural properties. Moreover, electron paramagnetic resonance spectroscopy has been used to verify not only the functionalization but also the electrocatalytic properties. The synthesized materials have been utilized to prepare working electrodes to record linear sweep voltammetry (LSV) curves under acidic conditions (0.5 M H₂SO₄) and in an inert atmosphere at a scan rate of 5 mV s⁻¹. ODA-FGr has demonstrated superior performance to its counterparts (OA-FGr and DDA-FGr), with an overpotential (η) of 530 mV at 10 mA cm⁻² and a Tafel slope of 80 mV dec⁻¹. Moreover, ODA-FGr has shown excellent durability, stability and reproducibility. Notably, the positive role of the alkyl chain length of amine molecules and their covalent functionalization is observed in improving HER performance and is found to be related to their amphiphilic nature and fluorine-to-nitrogen ratio. These results support our hypothesis about the role of longer alkyl chains, covalent bonding, and the amphiphilic nature of the materials in enhancing HER activity, and thus, they can be crucial in designing future electrocatalysts.

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Physicochemical Characterization of Phosphorus-Embedded Bilayer Nanographenes with Chalcogenide Substitution

Nanographenes (NGs) are atomically precise fragments of graphene with tunable electronic and optical properties through structural modification and heteroatom incorporation [1]. Among these, hexabenzocoronene (HBC)-based bilayer [7]helicenes provide versatile platforms for investigating how structural and electronic modifications influence molecular properties. While heteroatoms such as nitrogen, oxygen, and sulfur have been incorporated into related π -extended frameworks [2], phosphorus-containing analogues remain comparatively unexplored. In particular, a central phosphole ring offers an opportunity to examine the influence of phosphorus within an otherwise closely related nanographene framework. Here, we present a series of phosphorus-embedded bilayer nanographenes developed as a complementary extension of an existing library of HBC-based bilayer [7]helicenes. Three derivatives bearing phosphine oxide (P=O), sulfide (P=S), and selenide (P=Se) functionalities were prepared, providing a systematic platform to investigate the role of the

phosphorus center and its chalcogenide environment. The influence of these structural modifications was investigated using absorption and emission spectroscopy, cyclic voltammetry, chiroptical spectroscopy, and DFT calculations. The redox properties were found to depend on the oxidation state and chalcogenide coordination of phosphorus, while optical measurements revealed distinct changes in the absorption and emission profiles across the series. All three compounds exhibited clear electronic circular dichroism (ECD) and circularly polarized luminescence (CPL), with the nature of the chalcogenide influencing the dissymmetry factors (gabs and glum). These results establish phosphorus-embedded bilayer nanographenes as complementary members of the HBC-based helicene family and highlight the central phosphole environment as a structural parameter for tuning their electronic, optical, and chiroptical properties. REFERENCES: [1] Borissov, A, et. al. Chem.Rev. 2022, 122, 565-788; [2] Reger, D., et al. Angew. Chem. Int. Ed. 2021, 60, 18073- 18081.

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Synthesis, Optical, and Physicochemical Properties of a Novel Phosphorus-Doped Hexabenzocoronene Nanographene

Molecular nanographenes are defined as structurally precise, two-dimensionally extended polycyclic systems representing one of the most dynamically developing classes of modern organic materials. Due to their structural rigidity and unique optoelectronic properties, nanographenes find broad application as functional chromophores and organic semiconductors in field-effect transistors, advanced photovoltaics, sensors, and bioimaging.[1] A key strategy for refining their physicochemical parameters is doping the π -conjugated system with heteroatoms.[2] Introducing elements such as phosphorus into the aromatic system dramatically alters electron distribution, modulates HOMO-LUMO energy levels, and significantly enhances the luminescent properties and photostability.[3] Furthermore, the incorporation of a phosphorus atom enables diverse post-functionalization reactions, including oxidation, borylation, alkylation, and coordination to metals. These transformations allow for efficient tuning of key molecular properties, thereby tailoring the compounds for targeted applications. Building on our synthetic expertise in introducing phosphorus heterocycles into aromatic systems,[4-6] we have prepared a phosphorus-containing nanographene based on a hexabenzocoronene scaffold (Scheme 1) and investigated its optical and physicochemical properties. REFERENCES: [1] Martin, N. et al. J. Am. Chem. Soc. 2024, 146, 32222-32234; [2] Stępień et al., Chem. Rev. 2022, 122, 565-788; [3] Romero-Nieto, C. et al. Materials Today Chemistry 2021, 22, 100604-100628; [4] Beránek et al., Org. Lett. 2022, 24, 4756-4761; [5] Beránek et al., Adv. Synth. Catal. 2025, 367, e202401203; [6] Beránek et al., J. Org. Chem. 2026, 91, 6884-6894.

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Continuum Modeling of van der Waals Interactions and Encapsulation of Carbon Nanotubes in MoS₂ Nanotubes

Nanomaterials play a vital role in the development of nanoscale devices, including oscillators, signaling systems, and drug delivery platforms. In this study, the van der Waals interactions between carbon nanotubes and molybdenum disulfide nanotubes are investigated using a continuum approximation based on the 6-12 Lennard-Jones potential. Two key aspects are examined: the suction energy governing the encapsulation of a carbon nanotube into a semi-infinite molybdenum disulfide nanotube, and the equilibrium radial offset of a carbon nanotube confined within the host nanotube. Analytical expressions for the interaction energy and the corresponding axial force are derived and evaluated numerically for a range of armchair and zigzag configurations. The results indicate that encapsulation is energetically favorable when the inter-tube gap approaches the equilibrium van der Waals spacing, while insufficient radial clearance leads to dominant repulsive interactions that hinder insertion. Furthermore, the equilibrium radial offset decreases systematically as the inter-tube gap narrows, approaching a nearly concentric configuration at optimal spacing. The proposed continuum model provides an efficient and physically transparent framework for predicting stable configurations of carbon nanotube-molybdenum disulfide nanotube systems, offering a valuable complement to computationally intensive atomistic simulations.

Films / Layers

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Photoluminescence Properties of In-situ Ni-doped Polycrystalline CVD Diamond Film

The negatively charged nickel vacancy centre (NiV-) in diamond is a promising spin qubit candidate with predicted inversion symmetry, large ground state spin-orbit splitting to limit phonon-induced decoherence, and emission in the near infrared range. Some of its optical properties overcome challenges associated with the well-known silicon-vacancy (SiV) defect in diamond. This study presents the excitation wavelength-dependent Raman and photoluminescence (PL) properties of the Ni-doped polycrystalline diamond films. Diamond films with thicknesses of 0.3, 0.5, and 2.8 μm were deposited in a microwave plasma chemical vapor deposition (MWCVD) system on Si substrates. Nickel doping was realized using a Ni foam as a solid precursor. This resulted in the in-situ incorporation of Ni into the diamond crystals during the MWCVD growth process, forming NiV centres alongside SiV colour centres. The Raman and PL spectra of the samples were measured at room temperature using four different excitation wavelengths: 442, 488, 633 and 785 nm. The PL spectra confirmed the presence of the NiV centres at ~ 880 nm and SiV centres at ~ 736 nm. The surface morphology of the samples was characterized by scanning electron microscopy. The crystal size varied from 100 nm to 2 μm depending on the thickness of the diamond film. The optical properties and the surface morphology of the samples were compared with those of reference samples grown under the same process conditions without Ni precursor. This work was supported by the Slovak Research and Development Agency (project # APVV-23-0361) and used large research infrastructure CzechNanolab (the MEYS project no. LM2023051). M.V. acknowledges support from the project IM-2023-87 funded by the Slovak Academy of Sciences via the programme IMPULZ 2023.

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Sputtering of NiO Thin Films for Piezoresistive Ceramic Pressure Sensors

Ceramic piezoresistive pressure sensors are widely used in applications requiring mechanical robustness, chemical resistance, and operation over broad pressure ranges. Their performance is strongly influenced by the properties and geometry of the strain-sensitive resistive layer deposited on the ceramic diaphragm. In this work, nickel oxide (NiO) thin films are investigated as an alternative piezoresistive material for integration on monolithic ZrO_2 pressure-sensor diaphragms. NiO thin films are prepared by reactive DC magnetron sputtering from a metallic Ni target in an Ar/O_2 atmosphere. The influence of deposition conditions on film growth, electrical resistance, and suitability for the fabrication of strain-sensitive elements is investigated. Particular attention is given to the substantially higher electrical resistivity of NiO compared with conventional metallic sensing layers, requiring optimization of both the deposition process and resistor geometry. The NiO layers are characterized in terms of thickness, electrical properties, morphology, and piezoresistive response under mechanical loading. Based on the mechanical stress distribution in the ZrO_2 diaphragm, the position and geometry of the sensing elements are optimized for integration into a full Wheatstone bridge. The obtained results are compared with previously investigated sputtered metallic sensing layers. The study evaluates the potential of reactively sputtered NiO as a functional thin-film material for highly sensitive ceramic pressure sensors.

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Causal and Domain-Aware Explainable AI for Process-Property Modelling of Perovskite Semiconductor Thin Films

Machine learning offers new opportunities to connect semiconductor nanomaterial composition, thin-film fabrication, and device performance, but purely predictive relationships can be unstable across studies and may conflict with established materials knowledge. This work presents a reproducible framework combining domain-aware feature engineering, causal

modelling, and explainable artificial intelligence for process-property analysis of halide-perovskite semiconductor thin films and solar-cell devices. The openly available Perovskite Database provides human-readable information on absorber composition, functional device layers, synthesis and processing procedures, device architecture, band gap, and photovoltaic performance. Regularized linear regression, decision trees, random forests, and gradient-boosted trees are compared for predicting power-conversion efficiency and related device metrics from selected material, process, and device-stack variables. Domain knowledge is incorporated through semantically grouped features, process-sequence constraints, and a strict separation of upstream fabrication conditions, intermediate material properties, and downstream performance quantities. An engineering-informed directed acyclic graph represents assumed dependencies among composition, deposition method, annealing conditions, layer structure, band gap, and device performance. SHAP-based explanations are complemented by resampling-based stability analysis and causal guardrails to prevent predictive feature importance from being interpreted directly as an intervention effect. The framework explicitly addresses missing data, study-to-study variation, and literature-derived selection effects. It provides an auditable basis for identifying reproducible process-property relationships and for supporting explainable, data-driven design of perovskite semiconductor nanomaterials and thin-film devices.

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Transport Characterization of Exfoliated Layered Tellurides as a Platform for Spin-orbit Heterostructures

Layered transition metal tellurides represent an important class of materials for studying electronic transport phenomena associated with strong spin-orbit coupling and possible topological electronic states. In this work we report preliminary transport measurements on mechanically exfoliated telluride flakes prepared from bulk crystals and transferred onto Si/SiO₂ substrates. Electrical characterization was performed using the van der Pauw configuration, allowing determination of sheet resistance and Hall coefficient. The obtained Hall measurements demonstrate measurable carrier transport in exfoliated samples and confirm the feasibility of electrical characterization of thin telluride flakes. These initial results establish a basis for further magnetotransport investigations and for the fabrication of telluride-based heterostructures aimed at studying spin-orbit-driven transport phenomena.

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POSTER SESSION B

Industrial Applications - Catalysis, Nanofibres, Thin Films, Layers

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Oxidation Engineering of Magnetite Nanoparticles for High-Performance Au-Based Catalysts

Iron oxide magnetic nanoparticles belong to one of the most extensively studied classes of magnetic nanomaterials. While their magnetic properties and biocompatibility are well recognized, their surface chemistry offers additional functionality, including the intrinsic ability to adsorb and even reduce other species. These properties arise from the nanoparticles' high specific surface area, which can reach several hundred $\text{m}^2 \text{g}^{-1}$, as well as from their reductive capacity, which naturally decreases with a declining $\text{Fe}^{2+}/\text{Fe}^{3+}$ ratio—that is, upon transitioning from stoichiometric magnetite to maghemite nanoparticles. In this study, we leverage the redox-active $\text{Fe}^{2+}/\text{Fe}^{3+}$ couple for the direct reduction of Au^+ precursors and their subsequent anchoring onto a reactive magnetic iron oxide platform in a single-step process. A systematic investigation revealed that the oxidation state of iron critically governs the catalytic performance of the resulting materials. In addition to the oxidation state, we examined the influence of magnetic carrier particle size and noble metal loading on catalytic activity. Notably, catalysts prepared using the finely tuned native reductive and adsorptive properties of the magnetic supports achieved catalytic activities exceeding those of more sophisticated systems requiring additional stabilizing and anchoring agents or chemical reductants. These findings demonstrate that magnetite and maghemite nanoparticles function not merely as passive carriers but as active participants in catalyst formation and performance. This approach simplifies the synthesis, minimizes chemical waste, and yields highly efficient, magnetically recoverable catalysts suitable for sustainable applications.

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Dual-Plasmon Active Catalyst for Methanol Oxidation

Fuel cells arise as a perspective technology for energy storage and related conversion of chemical energy into electrical energy. Among them, direct methanol fuel cell (DMFC) is promising candidate due to its high energy density, easy handling of methanol and green production of methanol. Platinum is widely used catalyst for methanol oxidation reaction (MOR) but suffers from poisoning by adsorbed intermediates and high price. Thus, the actual research trends are focused on the minimalization of Pt amounts in the catalyst structure with conservation of overall efficiency. In this work, we propose plasmon assisted catalysis as an efficient photoelectrochemical technique. This method is based on the generation of hot charge carriers which can boost the overall MOR efficiency. We prepared Pt catalyst on gold nanoparticles decorated Ti_3C_2 MXene to better exploit visible light spectrum with combining two plasmon-active components: gold and MXene. The applicability of the prepared material for MOR was confirmed by cyclic voltammetry and chronoamperometric measurements. Furthermore, the contribution of both plasmon active centres was examined. It has been shown that MXene serves as an efficient substrate for Pt anchoring, but gold provides stronger enhancement of achieved current density. Proposed approach allows us to significantly decrease the amounts of Pt used and to efficiently utilize visible light for photo-electrochemistry.

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Protonic Acid Doping of Carbon Nanotubes for HER and OER Electrocatalysis

Surface modification of carbon nanotubes (CNTs) with protonic acids is a simple method for tuning their structural, electronic, and electrocatalytic properties [1]. Acid treatment introduces oxygen-containing functional groups onto the CNT surface and modifies its electronic structure, which affects the electrochemical performance of the material [2]. The aim of this work was to investigate the influence of sulfuric acid (H_2SO_4), nitric acid (HNO_3), and acetic acid (CH_3COOH) on the electronic structure, sheet resistance, and electrocatalytic properties of CNTs. CNT films were immersed in the selected acid solutions and characterized by Raman spectroscopy, sheet resistance measurements, and linear sweep voltammetry. Electrochemical measurements toward the hydrogen evolution reaction (HER) and oxygen evolution reaction (OER) were carried out in 0.1M KOH using a rotating glassy carbon disk electrode (3 mm diameter) at 1600 rpm and a scan rate of 10 mV s^{-1} . The largest increase in the Raman G-band frequency was observed for H_2SO_4 -treated CNTs, where ω_{G} increased from 1572.96 cm^{-1} to 1604.56 cm^{-1} . The lowest sheet resistance was obtained for CNT/ HNO_3 ($2.12 \times 10^3 \Omega/\text{sq}$), whereas CNT/ H_2SO_4 exhibited $3.47 \times 10^3 \Omega/\text{sq}$. The CNT/ H_2SO_4 electrode showed the highest OER activity with the lowest overpotential ($\eta_{10} = 558 \text{ mV}$), whereas CNT/ HNO_3 , CNT/ CH_3COOH , and pristine CNTs exhibited 676, 655, and 830 mV, respectively. Acid treatment also modified the HER onset potential. The results demonstrate that the electrocatalytic performance of CNTs is governed primarily by acid-induced changes in their electronic structure rather than by sheet resistance alone. The proposed protonic acid doping strategy offers a simple route toward carbon-based electrode materials for alkaline water electrolysis, where efficient HER and OER electrocatalysts are required [3].

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Mechanical Treatment of Zinc Oxide Toward Enhanced Mechano-ATRP

Mechanically mediated atom transfer radical polymerization (mechanoATRP) utilizes piezoelectric materials to promote catalyst regeneration under mechanical stimulation. While ZnO has emerged as an efficient piezoelectric agent for mechanoATRP, the influence of its structural state on polymerization performance remains unexplored. Here, ZnO particles were subjected to ball milling to investigate how this mechanical treatment affects their ability to mediate the mechanoATRP of methyl acrylate. Ball-milled ZnO exhibited markedly enhanced polymerization activity compared with pristine ZnO under otherwise identical reaction conditions. The enhancement was particularly pronounced during the initial stage of polymerization and was accompanied by improved control over the molar-mass distribution while maintaining good agreement between the experimental and theoretical molar masses. These observations demonstrate that the performance of ZnO in mechanoATRP is not determined solely by its chemical composition but can be substantially altered by mechanical processing. The findings suggest that the structural state of piezoelectric agents represents an important and largely overlooked parameter in the development of efficient mechanoATRP systems.

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Morphology Control and Catalytic Properties of $\text{Fe}_5(\text{PO}_4)_4(\text{OH})_3 \cdot 2\text{H}_2\text{O}$ and Its Calcined Products

$\text{Fe}_5(\text{PO}_4)_4(\text{OH})_3 \cdot 2\text{H}_2\text{O}$ is a green crystalline compound that, according to the literature, has mostly been investigated for photocatalysis [1] and as a precursor for lithium iron phosphate batteries [2]. Despite the numerous $\text{Fe}_5(\text{PO}_4)_4(\text{OH})_3 \cdot 2\text{H}_2\text{O}$

morphologies reported [3], morphology control and its influence on catalytic properties remain insufficiently explored. This study focuses on the hydrothermal synthesis of $\text{Fe}_5(\text{PO}_4)_4(\text{OH})_3 \cdot 2\text{H}_2\text{O}$ in the presence of the disodium salt of β -glycerophosphate (GPH). Under hydrothermal conditions, GPH serves as a phosphate source that undergoes gradual homogeneous hydrolysis, allowing greater control over crystal growth, which could be beneficial for preparing various morphologies. In this work, several morphologies were obtained by varying the Fe:P ratio, reaction time, temperature, and the concentrations of FeCl_3 and GPH. Although the photocatalytic activity of $\text{Fe}_5(\text{PO}_4)_4(\text{OH})_3 \cdot 2\text{H}_2\text{O}$ is moderate, calcination is suggested as one way to address this limitation. FePO_4 (α -quartz-type structure), formed by calcination of $\text{Fe}_5(\text{PO}_4)_4(\text{OH})_3 \cdot 2\text{H}_2\text{O}$, is particularly interesting because it is piezoelectric and could thus be used in piezocatalysis. Because morphology is preserved after calcination, precursor design enables indirect tailoring of piezocatalytic properties. This strategy opens a new research direction for exploiting $\text{Fe}_5(\text{PO}_4)_4(\text{OH})_3 \cdot 2\text{H}_2\text{O}$ as a precursor to prepare piezoelectric material, which, to the best of our knowledge, has not yet been reported in the literature.

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Synergistic surface chemistry in rhodium metal-organic polyhedra for tunable electrochemical CO₂-to-syngas conversion

The creation of electrocatalysts with high activity, selectivity, and durability is a major issue in the sustainable shift to a net-zero economy. Here, we have coordinated 5-cyanoisophthalate with Rh(II) paddlewheel units to create Rh₂[5-cyanoisophthalic acid]₂₄ (RhMOP-CN). Using catalyst-modified gas diffusion electrodes (GDE), RhMOP-CN was assessed for the electrochemical CO₂ reduction reaction. It demonstrated CO/H₂ ratio of roughly 1:1 with Faradaic efficiencies (FE) of FE_{CO} = 51.6% and FE_{H₂} = 44.1% at a current density of 15 mA cm⁻² and FE_{CO} = 51.2% and FE_{H₂} = 51.1% at 25 mA cm⁻². Additionally, RhMOP-CN's better syngas selectivity was demonstrated by the synthesis of a variety of Rh MOPs with various surface functional groups (proton, sulfonate, and amine). RhMOP-CN's exceptional endurance and stability over virgin metal-organic frameworks (MOF)/MOP catalysts in long-term applications are further demonstrated by the fact that its structural integrity held up even after thorough alkaline treatment and post-electrocatalytic assessments. Additionally, Rh centers and surface groups stabilize eCO₂RR intermediates, improving CO selectivity, according to DFT modeling. This work emphasizes how functional groups and metal centers work together to provide effective dual-site catalysts for the electrochemical conversion of CO₂ to syngas.

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Influence of Atmospheric Plasma Treatment on the Performance of Flax Fibre Composites

Atmospheric-pressure plasma treatment has been widely investigated as an environmentally friendly approach for improving fibre-matrix adhesion in natural fibre composites. In this work, flax fabrics were treated using Diffuse Coplanar Surface Barrier Discharge (DCSBD) and Volume Dielectric Barrier Discharge (VDBD) prior to manufacturing multilayer composites with polyurethane (PU) foils. The influence of plasma treatment on interfacial adhesion, tensile and flexural properties was evaluated. T-peel testing demonstrated a pronounced improvement in laminate interfacial adhesion after DCSBD treatment, whereas VDBD produced only a moderate enhancement. The superior performance of DCSBD is attributed to its more homogeneous surface activation, leading to stronger bonding between the flax fabric and the PU film. However, despite the significantly higher peel strength, neither tensile nor flexural tests showed a corresponding increase in the mechanical performance of the composites. In most cases, prolonged plasma exposure resulted in a slight reduction of strength, indicating that the overall mechanical behaviour was governed by factors other than interfacial adhesion, such as fibre integrity, laminate architecture or impregnation quality. Although the improved interfacial adhesion did not result in higher static tensile or flexural properties, the marked increase in peel strength suggests that

plasma treatment effectively modifies the fibre-matrix interface. This enhanced interface is expected to play a more significant role under e.g. long-term environmental exposure or cyclic loading, where interfacial degradation becomes a dominant failure mechanism.

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Surface Modification of Glass Fibre Sizing Using a DCSBD Plasma Jet

Glass fibre reinforced polymer (GFRP) composites are increasingly used in civil engineering applications due to their favourable mechanical properties, low weight and corrosion resistance. The performance of these materials is strongly influenced by the fibre-matrix interface, which is affected by the chemical and physical properties of the fibre sizing. Modification of the sizing layer can provide a way to influence the surface properties of glass fibres and their adhesion behaviour. Plasma treatment can introduce polar functional groups onto the fibre surface, which may modify surface energy and influence adhesion with polymer matrices. In this work, glass fibres were treated using a diffuse coplanar surface barrier discharge (DCSBD) plasma jet operated with nitrogen and synthetic air as working gases. The influence of plasma treatment on the surface chemistry of the fibre sizing was investigated by X-ray photoelectron spectroscopy (XPS). Changes in adhesion behaviour after plasma treatment were evaluated using a Scotch tape test. The comparison of nitrogen and synthetic air plasma treatments provides information about the effect of the working gas on the surface modification process. The results provide insight into the effect of DCSBD plasma jet treatment and working gas composition on the surface modification of glass fibre sizing.

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Methodology for Assessing Algal Biofouling Resistance of Photoactive Coatings on Building Stone

The laboratory trials were carried out to evaluate the resistance of building stone surfaces to algal biofouling. A porous quartz sandstone material with high water absorption was selected as the substrate material, which was treated with a hydrophobic poly(alkyl siloxane)-based coating containing photoactive exfoliated g-C₃N₄ nanoparticles. The sandstone plates (95 × 20 × 5 mm) were submerged in glass cultivation columns (i.d. 37 mm) containing a culture of the microalga *Chlorella vulgaris*. Three types of samples were investigated: untreated sandstone, sandstone treated with poly(alkyl siloxane) coating, and sandstone treated with the poly(alkyl siloxane) coating incorporating g-C₃N₄ nanoparticles. The cultivation columns were illuminated with a VIS source (continuous photosynthetically active radiation at 650 μmol m⁻² s⁻¹). After 10 days of exposure, the microalgal growth was evaluated. In the second series, comparative trials were carried out in a flow-through chamber using the same materials and the same algal species. The microalgal culture was allowed to flow over the surfaces of coated and uncoated sandstone plates (100 × 40 × 10 mm) at regular intervals while being exposed to the same type of illumination. The results demonstrated both the advantages and the limitations of the proposed testing methodologies and provided a basis for the further development of procedures for evaluating photoactive coatings for building stone.

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Industrial Applications - in Construction, Energy Production, in Consumer and Other Industries

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Mechanical Performance of Glass Ionomer Cement Modified With Hexagonal Boron Nitride Nanoparticles

This study investigated the influence of hexagonal boron nitride (h-BN) nanoparticles incorporated into glass ionomer cement (GIC) on its chemical composition and mechanical performance. The GIC was modified with 0.5 wt.% and 1.0 wt.% h-BN, and the successful incorporation of the nanoparticles was confirmed using chemical analysis. The mechanical performance of the modified materials was assessed by measuring compressive strength, flexural strength, and surface microhardness testing. The incorporation of h-BN nanoparticles resulted in a slight, but significant, increase in compressive strength. In contrast, flexural strength was enhanced, particularly in specimens containing 0.5 wt.% h-BN. However, specimens containing 1.0 wt.% h-BN exhibited greater scatter in the measured flexural strength values, suggesting a less homogeneous dispersion of nanoparticles within the GIC matrix. Surface microhardness increased significantly in the 1.0 wt.% h-BN group ($p < 0.05$), indicating improved resistance of the material surface to localised plastic deformation. Overall, the results demonstrate that incorporating h-BN nanoparticles can enhance the surface mechanical performance of GIC without adversely affecting its bulk mechanical properties. The effectiveness of the reinforcement, however, depends strongly on nanoparticle concentration and dispersion within the matrix. These findings highlight the potential of h-BN nanoparticles as a reinforcing nanofiller for GICs and provide a basis for further optimisation of nanoparticle distribution and evaluation of the long-term mechanical stability and clinical performance of the modified materials.

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Development of Self-Cleaning Glass for Building Facades Using Laser Surface Structuring

Maintaining the cleanliness of building facades, particularly glass surfaces requires significant water consumption and high maintenance costs especially in high-rise urban environments. This work aims to develop an environmentally friendly self-cleaning glass through nano-scale surface engineering to achieve hydrophobic behavior and reduce dust accumulation. The glass surface was modified using nano-scale laser surface structuring followed by chemical surface treatment to enhance water repellency without the need for detergents or frequent manual cleaning. The hydrophobic performance of the modified glass was evaluated through water contact angle and sliding angle measurements. In addition, the optical transmittance of the nano-structured glass was experimentally measured to investigate the influence of surface modification on light transmission properties. The study also discusses the potential impact of controlled optical transmittance on reducing solar heat gain through building facades, which may contribute to lowering cooling energy demand in buildings. Future work will focus on evaluating the thermal performance and economic feasibility of the proposed approach including potential reductions in water consumption and facade cleaning costs. The proposed concept demonstrates the potential of nano-structured hydrophobic glass as a sustainable solution for energy-efficient and low-maintenance building facades.

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AIVAZIAN Aleksei**University of Chemistry and Technology Prague,
Prague, Czech Republic****Plasmon-Assisted Lithium Deposition on Mesoporous Gold for Energy Conversion and Ammonia Production**

The development of advanced lithium-assisted nitrogen reduction reaction (Li-NRR) requires improved control over electrochemical lithium deposition. In particular, reducing the energy required for lithium-ion reduction and controlling interfacial processes are of considerable interest for ammonia production and middle conditions. Plasmonic nanostructures offer a promising approach to influence electrochemical reactions through light-induced localized electromagnetic fields and injection of hot charge carriers. In this work, we investigate the effect of plasmonic excitation on the Li⁺ electrochemical reduction on plasmon active mesoporous Au (mAu) surface. The mAu surface was created using the micelle-assisted approach. The presence of mesoporous and plasmonic properties were confirmed using SEM and UV-Vis measurements. Subsequently, an electrochemical cell was assembled using a platinum counter-electrode, mAu working electrode and a silver wire as the reference electrode. Tetrahydrofuran (THF) containing lithium bis(trifluoromethanesulfonyl)imide (LiTFSI) was used as the electrolyte. Prior to the electrochemical measurements, the lithium salt was dried to minimize residual moisture, while the electrochemical cell was purged with argon to establish an inert atmosphere. During electrochemical experiments, aimed on the Li reduction on mAu surface, the mesoporous gold electrode was illuminated with wide spectrum light source to excite localized surface plasmon(s). The photoelectrochemical measurements revealed a pronounced change in the lithium reduction behavior upon plasmonic excitation, indicating that illumination facilitates the electrochemical deposition of lithium compared with the non-illuminated system. The state of deposited lithium was investigated by the range of characterisation methods, with the main attention on the oxidation state, formation of undesired Li oxide, carbonate and fluoride. Especial attention was focused on the surface morphology and Li distribution across pAu surface as well as on the Li reactivity. Obtained results allow to claim that plasmon excitation can be involved electrochemical processes relevant to Li-NRR and future energy-conversion technologies. ACKNOWLEDGEMENTS: This work was supported by the project 26-22285S.

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KRÁL Lubomír**Institute of Physics of Materials of the CAS, Brno,
Czech Republic****Influence of MAX Phase on Kinetic of Magnesium Hydrogenation**

Magnesium is considered as one of the most promising materials for solid-state hydrogen storage mainly due to its high gravimetric hydrogen capacity and low weight. However, the practical utilization of magnesium-based systems is significantly hindered by the high thermodynamic stability of magnesium hydride (MgH₂) and its inherently slow hydrogen sorption kinetics. Therefore, the development of effective catalysts capable of enhancing the hydrogenation and dehydrogenation behavior of magnesium remains an important research objective. In the present study, the catalytic effect of two different MAX phases (commercial and experimental) on the formation kinetics of MgH₂ was systematically investigated. The composite materials were prepared by mechanically mixing commercially available magnesium powder with MAX phases possessing a comparable particle size. The blending procedure was performed manually using a laboratory mortar inside a glovebox under a purified inert atmosphere. This preparation strategy was selected to preserve the initial particle size of the magnesium powder and to achieve a sufficiently homogeneous distribution of the MAX phases on the particle surfaces. Furthermore, it minimized the influence of particle size reduction and the introduction of severe structural defects, allowing the catalytic contribution of the MAX phases to be evaluated independently of these additional factors. Hydrogenation experiments were carried out using a Sieverts-type apparatus (Setaram PCTPro). The hydrogen absorption kinetics were measured within the temperature range of 250-350 °C. The effect of the MAX phases on both the hydrogen absorption and desorption kinetics was assessed and compared with the behaviour of unmodified magnesium powder.

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Tailoring Electrical Properties of TiO₂ Nanotube Layers by MoS₂ Nanoflake Modification and Annealing-Induced Phase Transformations

TiO₂ nanotube (TNT) layers represent promising nanostructured semiconductor platforms for sensing [1,2], photoelectrochemical [3] and electronic applications. Their functional properties strongly depend on crystallinity and phase composition, which can be tailored by post-synthesis annealing. Previous works have shown that MoS₂ decorated TNT layers are very promising anodes in Li-ion batteries [4] and for photocatalytic gas-phase decomposition of model organic pollutants [5]. In this work, TiO₂ nanotubes, decorated by MoS₂ nanoflakes using Atomic Layer Deposition (ALD) are investigated with respect to their electrical response and thermally induced structural evolution. Special attention is paid to the presence of different TiO₂ crystalline phases, such as anatase and rutile, whose formation is governed by the annealing temperature. The combination of TiO₂ nanotubular morphology with MoS₂ nanoflakes on their surface and additional ALD TiO₂ interlayer, is expected to influence charge transport both in-plane as well as through-plane of the TiO₂ nanotubes. The study aims to correlate annealing temperature, phase composition and MoS₂ surface modification with changes in the electrical characteristics of the hybrid nanostructure. ACKNOWLEDGEMENT: We acknowledge CzechNanoLab Research Infrastructure (ID 90251), supported by MEYS CR. REFERENCES: [1] S. Ng et al., Adv. Eng. Mater. 2017, 1700589; [2] S. Ng et al., ACS Appl. Mater. Interfaces 2020, 12, 33386-33396; [3] R. Zazpe et al., Nanoscale 2018, 10, 16601; [4] H. Sopha, FlatChem 2019, 17 100130; [5] M. Motola et al., Nanoscale 2019, 11, 23126; [6] H. Simunkova et al., Ms in preparation.

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Graphene-Directed Zinc-MOF Sulfidation for Flexible Solid-State Supercapacitors with High Practical Energy Density

Electrochemical energy storage requires high-energy, high-power, mechanically flexible devices that remain competitive when realistic metrics are applied. Transition-metal-based electrodes, including metal sulfides, offer rich redox chemistry, but typically underperform in devices because of insulating interfaces, particle coarsening, and sluggish charge transport. Here, we employ graphene acid (GA) for the directed sulfidation of ZIF-8 crystals toward a seamless ZnS/GA architecture. Zn-carboxylate coordination unlocks ZnS redox activity, while interfacial bonding suppresses aggregation and insulating sulfur-rich species. This prevents GA restacking and affords a mesoporous, higher-surface-area architecture with improved proton access and fast charge transport, confirmed by scanning electrochemical microscopy (SECM). These properties enable effective operation without heavy metallic foam current collectors, yielding superior full-electrode-mass metrics (including current collector mass) relative to prior systems. A ZnS/GA||GA asymmetric solid-state supercapacitor with a PVA-H₂SO₄ gel electrolyte and an ultrathin graphite-foil current collector operates at 2.0 V. It achieves 27.6 Wh/kg at 2.1 kW/kg with 92% retention after 5000 cycles and stable performance under extreme bending. This approach offers a versatile route to overcome metal sulfide limitations and unlock their redox properties for flexible energy storage.

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In Situ Modification of Bacterial Nanocellulose Membranes for Alkaline Fuel Cell Applications

Alkaline fuel cells (AFCs) are promising energy-conversion systems as they allow the use of non-precious metal catalysts. However, their wider implementation requires further improvement of several key components, including catalysts and anion exchange membranes (AEMs). Developing AEMs that combine adequate performance with sustainability therefore remains an important research challenge. Bacterial nanocellulose (BnC) is a promising material for AEM development because it is renewable and offers high mechanical strength, a nanofibrous structure and good dimensional stability. However, its low ionic conductivity limits its direct use in AFCs. In this study, BnC-based membranes were modified in situ by adding a quaternisation agent directly to the culture medium during biosynthesis. This approach introduced ion-conducting groups as the BnC network formed. The membranes were characterised using attenuated total reflectance Fourier-transform infrared spectroscopy, X-ray diffraction and Scanning electron microscopy. Their dimensional stability, alkali uptake and ionic conductivity were also evaluated. Spectroscopic analysis confirmed the in situ modification, while scanning electron microscopy showed that the characteristic nanofibrous structure of BnC was retained. The modified membranes exhibited higher ionic conductivity than unmodified and maintained their structural integrity during conductivity measurements. These results indicate that in situ modification during biosynthesis is a promising strategy for preparing ion conductive BnC-based membranes for alkaline fuel cell applications. ACKNOWLEDGEMENTS: The authors acknowledge the financial support of the Slovenian Research and Innovation Agency (grant numbers Z2-60175, J2-50086, N2-0388, P2-0118).

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Intrinsic Peroxide Pathway Engineering in Ni(OH)₂ via Lanthanide Single Atoms for Selective Electrochemical H₂O₂ Production

Electrochemical oxygen reduction to hydrogen peroxide through the two-electron pathway offers a sustainable alternative to the energy-intensive anthraquinone process, yet controlling the intrinsic selectivity of earth-abundant hydroxide catalysts remains challenging. Here, we introduce a lanthanide single-atom engineering strategy to regulate the peroxide pathway in β -Ni(OH)₂ for selective electrochemical H₂O₂ production. Atomically dispersed Ce, Gd, and Yb sites were incorporated into the Ni(OH)₂ framework to perturb the local electronic structure, oxygen-binding environment, and interfacial reaction microenvironment without forming separate lanthanide phases. Rotating ring-disk electrode measurements in O₂-saturated alkaline electrolyte reveal a pronounced lanthanide-dependent modulation of the oxygen reduction pathway. Among the investigated catalysts, Gd-Ni(OH)₂ exhibits the strongest preference for the two-electron route, with an electron-transfer number approaching 2.16, corresponding to an estimated H₂O₂ selectivity of approximately 92%, compared with an electron-transfer number of 2.80 for pristine Ni(OH)₂. The contrasting behaviour of Ce-, Gd-, and Yb-modified samples demonstrates that peroxide selectivity is governed not merely by lanthanide incorporation, but by the specific electronic and coordination perturbations introduced by each isolated metal centre. The lanthanide sites are proposed to regulate *OOH binding and suppress O-O bond cleavage, thereby redirecting oxygen reduction away from the competing four-electron pathway. This work establishes lanthanide single-atom incorporation as a versatile approach for engineering the intrinsic peroxide pathway of transition-metal hydroxides and provides a design framework for developing inexpensive and selective electrocatalysts for decentralized H₂O₂ production.

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Carbon Nanostructures with sp² and sp³ Hybridization for Energy Storage Applications

Carbon materials are widely used as anode materials in lithium-ion batteries due to their good electrical conductivity, chemical stability and ability to reversibly store lithium. Graphite remains the most commonly used anode material, however, the development of novel carbon nanostructures offers opportunities to modify anode properties and their

behavior during long-term electrochemical cycling. The aim of this study is to determine the influence of nanodiamond addition to graphite on the electrochemical properties and cycling stability of anode materials and to assess the potential of composites based on nanodiamond and graphite for application in lithium-ion battery anodes. This study investigates anode materials based on nanodiamond and nanodiamond/graphite composites, with graphite used as a reference material. Combining nanodiamonds, characterized by a carbon structure with a high sp^3 contribution, with rich in sp^2 graphite enables the preparation of materials with different proportions of these carbon structures and allows their influence on electrode properties to be investigated. The materials are used to prepare composite electrodes on copper current collectors, which are subsequently assembled into lithium half-cells with metallic lithium as the counter electrode. The study includes structural and morphological characterization of the materials, together with evaluation of their electrochemical performance during repeated galvanostatic charge and discharge cycling. Particular attention is given to changes occurring within the active electrode material during cell operation. Comparison of the electrodes before and after cycling is used to evaluate their structural stability and identify morphological changes associated with repeated lithium storage and release. This work was supported by the bilateral Polish-Czech project “ sp^2 and sp^3 Hybridized Carbon Nanostructures for Energy Storage Applications” (PAN-24-20).

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Single-Atom Sites Stabilized on Functionalized Metal-Organic Framework for Electrochemical Hydrogenation

The development of efficient catalysts for electrochemical hydrogenation (ECH) requires precise control over active-site distribution and substrate-catalyst interactions. Herein, we present a post-synthetic functionalization strategy for engineering metal-organic frameworks (MOFs) with nitrogen-rich coordination environments. The introduced functional groups facilitate strong metal-support interactions and enable effective regulation of the catalyst's electronic and surface properties. The structural integrity and chemical environment of the functionalized material were systematically examined using X-ray diffraction, Fourier-transform infrared spectroscopy, solid-state ^{13}C NMR, electron microscopy, X-ray absorption spectroscopy, and X-ray photoelectron spectroscopy. These analyses confirm successful framework modification, uniform distribution of the catalytically active species, and strong coordination between the metal centers and nitrogen-containing ligands. Electrochemical measurements demonstrate enhanced hydrogenation activity and product selectivity compared with the unmodified framework. This improvement arises from the synergistic interaction between the active metal centers and their tailored coordination environment, which promotes reactant adsorption and activation while regulating hydrogen adsorption. The modified catalyst also suppresses the competing hydrogen-evolution reaction, thereby improving hydrogen-utilization efficiency. This work demonstrates that post-synthetic MOF functionalization offers a versatile strategy for controlling active-site coordination and catalytic behavior. The findings provide useful guidance for designing selective and efficient electrocatalysts for hydrogenation reactions.

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Broadband-Sensitive Photodetector Based on BiOCl/Bi₂S₃ Heterostructure, Boosted by Boron-Doped Diamond Electrodes

In this paper, the novel P-N junction of bismuth oxychloride (BiOCl) and bismuth sulfide (Bi₂S₃) was synthesized and evaluated in photodetector applications. It was found via DFT modelling that the bandgap of both materials is 2.49 and 1.33 eV, respectively. Experimental studies show slight differences, especially for bismuth oxychloride. Photoelectrical characterization of the device with classic gold electrodes showed that the responsivity towards a wavelength of 629 nm is 8.95 mA/W, while for a wavelength of 940 nm it is 2.77 mA/W. Application of electrodes made out of boron-doped diamond (BDD) allowed for the formation of a P-N-P junction, facilitating charge transfer, due to the formation of additional depletion regions at the interface between Bi₂S₃ and BDD. This significantly improved the responsivity of the

photodetector. For wavelengths of 629 nm and 940 nm, it was found to be 39.34 mA/W and 24.82 mA/W, respectively. Additionally, the specific detectivity of the device with BDD electrodes was improved by one order of magnitude in comparison to that with gold electrodes. This proves that boron-doped diamond is a promising electrode material for application in devices utilizing n-type semiconductors or P-N junctions.

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Nanoconfinement Effect of Ni Nanoclusters in Hierarchical ZSM-5 Zeolites for Enhanced CO₂ Methanation

The catalytic hydrogenation of CO₂ to methane is a promising route for renewable energy storage and carbon utilization. The activity and stability of Ni-based catalysts are strongly influenced by the size and dispersion of active Ni species. In conventional microporous zeolites, Ni particles are mainly located on the external crystal surface, making them susceptible to sintering and deactivation. In this work, hierarchical micro-mesoporous ZSM-5 zeolites were employed as supports for nanoconfined Ni catalysts. The mesoporous network enabled the incorporation of Ni nanoclusters within the zeolite structure, resulting in improved dispersion and stabilization of metallic Ni sites. Structural characterization confirmed that nanoconfinement effectively suppressed particle growth compared with catalysts supported on purely microporous ZSM-5. The nanoconfined catalysts exhibited significantly higher CO₂ methanation activity, particularly in the low-temperature region. Enhanced catalytic performance is attributed to improved Ni dispersion, reduced sintering, and increased stability of active sites provided by confinement within the mesoporous system. These results demonstrate that nanoconfinement in hierarchical zeolites is an effective strategy for designing highly active and stable catalysts for sustainable CO₂ valorisation. **ACKNOWLEDGEMENTS:** This work was supported by the Technology Agency of the Czech Republic (TS01030146), the Czech Science Foundation (25-16545S), and the Research Infrastructure NanoEnviCz funded by the Ministry of Education, Youth and Sports of the Czech Republic (No. LM2023066).

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Synergistic MoSe₂/Nb₂C Heterojunction with Hierarchical Architecture for High-Performance Solar Hydrogen Evolution

Development of an efficient solar-driven catalyst for hydrogen (H₂) production is crucial for addressing global energy demands. Transition metal dichalcogenides (TMDs) and two-dimensional (2D) materials, especially MXenes, are getting a lot of interest because they have outstanding electronic and catalytic properties. A simple one-step hydrothermal method was used to fabricate nanocomposites such as MoSe₂/Nb₂C (X) (where X = 5, 10, 15, 20%), and they were characterized using different sophisticated analytical methods. Photocatalytic H₂ production experiments were conducted in a methanol-water solution under visible light, demonstrating that the MoSe₂/Nb₂C 10 % heterostructure exhibits superior activity compared with bare Nb₂C, MoSe₂ and other composites. The better photocatalytic performance of MoSe₂/Nb₂C occurs because electrons can move between the MoSe₂ and Nb₂C layers, which helps create more electron-hole pairs. The MoSe₂/Nb₂C 10 % composite achieved the highest H₂ evolution rate, which is attributed to enhanced interfacial electron transfer and reduced recombination. Electrochemical impedance spectroscopy (EIS) and photoluminescence (PL) studies confirmed improved charge-separation kinetics. This work highlights the potential of 2D MoSe₂/Nb₂C as a high-performance, cost-effective photocatalyst for renewable H₂ production, providing insights into the design of advanced MXene-based hybrid materials for solar energy conversion.

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Scalable Fabrication of Electroconductive MXene-based Electrospun Nanofibrous Networks for Wearable Electronics

Electrospinning is a cost-effective technique for producing nanofibers with high surface area and interconnected porosity. Incorporating nanoparticles provides additional functionality but increases process complexity and makes optimisation of spinning conditions more challenging. The aim of this study was to develop an industrially scalable electrospinning process for the inclusion of MXenes into a poly(ethylene oxide) (PEO) dispersion using a needle-less electrospinning, and thus, fabricate a stable high-capacitance MXene-incorporated fibrous network for wearable electronic applications, i.e., sensors, energy harvesting and storage systems, real-time monitoring of healthcare, personal thermal management, etc. Herein, the influence of electrospinning dispersion on the morphological, structural, chemical, and functional features of newly prepared PEO/MXene nanocomposites was evaluated using Scanning Electron Microscopy (SEM), Fourier Transform Infrared spectroscopy (FTIR) and the four-probe electrical resistivity technique. The obtained SEM and FTIR results showed the successful preparation of the nanofibrous net, in which the form and concentration of MXenes influenced the conductivity and viscosity of the dispersions and, consequently, the morphology of the electrospun net. PEO/MXene nanocomposites exhibited sufficient electrical conductivity through the formation of electrically connected pathways while preserving the intrinsic advantages of electrospun PEO mats, including flexibility, low weight, high porosity, and suitability for wearable electronics. ACKNOWLEDGEMENTS: The results leading to this work were funded by the Slovenian Research and Innovation Agency (ARIS) in the frame of research projects no. J2-50087, Z2-60175 and BI-VB/25-27-022, and a program group for Textile Chemistry and Advanced Textile Materials, P2-0118.

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Diamond for Semiconductor Industry: Process Development of Linear Antenna Microwave Plasma CVD on 12 Inch Silicon Substrates

Scaling chemical vapor deposition (CVD) of diamond thin films from traditional substrates ($\varnothing 2-4$ inches) to sizes >6 inches remains a significant technological challenge. Maintaining sufficiently uniform microwave plasma conditions, substrate temperature, nucleation density, and growth rate over areas spanning several tens of centimeters requires careful optimization. Simultaneously, large-area intrinsic and boron-doped diamond films are increasingly demanded for advanced electronic, sensing, and electrochemical applications. Diamond research group in Prague has undergone a continuous scale-up over more than two decades. Initial diamond deposition was established in 2002 on 2 inch substrates (focused plasma in ellipsoid resonator), followed by expansion to a 4 inch deposition area in 2008 (linear antenna plasma). Building on these experiences, and in close collaboration with company scia Systems GmbH, a proof-of-concept demonstration of diamond deposition on 12 inch (30 cm) silicon substrates was successfully achieved in 2026. Our first attempts for large-area deposition revealed pronounced spatial variations in diamond growth and identified several technological limitations, including non-uniform seeding, substrate heating variations, plasma asymmetry, and linear antenna degradation. The knowledge gained from these systematic experimental studies guided subsequent optimization of substrate preparation, deposition conditions, and sequential substrate rotation during the diamond growth. Following process optimization, intrinsic and boron-doped polycrystalline diamond films with thickness of $>1 \mu\text{m}$ were grown on 12 inch Si substrate. Thickness mapping across the entire 30 cm substrate revealed a smooth and approximately axisymmetric profile. Radial thickness variation was below 10% within the central 5 inch-diameter region. Scanning electron microscopy revealed continuous faceted polycrystalline grains and Raman spectroscopy confirmed the characteristic diamond peak $\sim 1332 \text{ cm}^{-1}$ across the wafer. Such proof-of-concept experiments demonstrate significant progress toward wafer-scale diamond deposition using a linear-antenna distributed microwave plasma source and establish a technological basis for further optimization of both intrinsic and boron-doped diamond films. Current efforts are focused on the development of large-area boron-doped diamond electrodes for sensing, electrochemical applications and high-power electronic devices.

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From Hydrothermal Synthesis to MechanoATRP: Tailoring BaTiO₃ Particle Structure and Morphology

Barium titanate (BaTiO₃) nanoparticles are a promising material to be utilized in mechanically induced atom transfer radical polymerization (mechano-ATRP) due to their ferroelectric and piezoelectric properties. These particles are used in mechano-ATRP to facilitate the initiation and propagation of the polymerization. This is achieved by applying mechanical stimuli, such as ultrasound, to a mixture of monomer with suitable particles. The hydrothermal method is widely used for the synthesis of fine and uniform BaTiO₃ powders in a single step. Furthermore, this method is more energy-efficient and works with safer solvents compared to solid-state synthesis and sol-gel methods, respectively. Nevertheless, balancing the synthesis conditions and the properties of the final powder remains a challenge. This work explores the hydrothermal synthesis of BaTiO₃ nanoparticles with multiple varying parameters, allowing for different particle formations. The morphology, crystal structure, and phase composition of the synthesized particles were analysed employing scanning electron microscopy and X-ray diffraction methods. The most significant factor influencing the final properties of the BaTiO₃ powders was the OH⁻ ion concentration. A lower OH⁻ concentration led to the formation of finer, less pure powders, while a higher OH⁻ concentration produced larger particles with no or a minimal amount of by-products. The ratio between precursors had an impact on the tetragonality of the synthesized particles. Interestingly, the highest mechanoATRP activity was observed for the finer, high-surface-area nanopowders, while highly tetragonal particles with a pronounced local ferroelectric response were inactive. These results indicate that mechanoredox performance is not governed by tetragonality or piezoelectric response alone, but is strongly influenced by particle size, accessible surface area, and local structural characteristics.

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Environmental Applications

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Effect of Foaming Intensity on Sorption of Organic Contaminants in Geopolymer Materials

Due to their hierarchical porosity and chemical properties, foamed geopolymer composites represent promising inorganic sorbents for environmental applications. This work focuses on a systematic evaluation of the effect of varying foaming intensities on the structure and sorption behaviour toward model organic contaminants. The geopolymers were prepared with varying aluminium powder contents and two different fillers, which allowed for control of the ratio of macro- to mesoporous structures while preserving micropores in the matrix. Characterization includes the determination of open porosity and pore structure using optical microscopy. Sorption properties are investigated in batch tests with an emphasis on sorption screening. The study focuses on identifying the relationship between the degree of foaming, the availability of active surface sites and effect of pH changes in solution, with the aim of contributing to the optimization of geopolymer sorbents for the removal of organic pollutants from the aquatic environment.

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Effect of Different Types of Surfactants (SDS, Dolapix) on Electrodeposited NiFe Coatings for Alkaline Water Electrolysis

Nickel-iron (NiFe) electrocatalysts are promising low-cost alternatives to noble-metal-based catalysts for hydrogen

production by alkaline water electrolysis. Their catalytic performance is strongly influenced by the composition and morphology of the deposited coating. In this work, the effect of two surfactants, sodium dodecyl sulfate (SDS) and Dolapix CE64 (DPIX), on NiFe coatings electrodeposited on nickel foam was investigated. NiFe coatings were prepared on nickel foam at current densities of 8, 12 and 16 A·dm⁻². Their morphology and elemental composition were characterized by scanning electron microscopy (SEM) coupled with energy-dispersive X-ray spectroscopy (EDX). The electrochemical performance of the prepared electrodes was evaluated by load measurements in a zero-gap alkaline electrolyzer equipped with an anion-selective membrane. The results showed that both the surfactant type and deposition current density significantly affected the Ni/Fe ratio and surface morphology of the coatings. Increasing the current density promoted Fe incorporation, with the most pronounced effect observed for DPIX-containing coatings, where the Ni content decreased from approximately 56 wt.% to 17 wt.%, while the Fe content increased to approximately 53 wt.%. All NiFe-coated electrodes exhibited better performance than uncoated nickel foam. The most pronounced improvement was observed for DPIX-containing electrodes, for which the electrolyzer performance improved with increasing deposition current density. In contrast, SDS-containing coatings showed no significant dependence on deposition current density. The results demonstrate that surfactant selection, particularly the use of DPIX, is an effective approach to controlling the composition and morphology of NiFe coatings and improving their performance in zero-gap alkaline water electrolysis.

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Full-Scale Application of Sulfidated Nanoscale Zero-Valent Iron in a Chlorinated Ethene-Contaminated Aquifer: Long-Term Performance and Transformation

Surface modification of nanoscale zero-valent iron (nZVI) with low-valent sulfur compounds is a promising approach for groundwater remediation. Although several field studies of sulfidated nZVI (S-nZVI) have been reported, experience with its full-scale implementation remains limited. Here, we evaluated the field-scale performance and transformation of S-nZVI in one of the largest full-scale applications reported to date, involving the injection of 150 kg of commercial S-nZVI (NANO FER 25DS, NANO IRON, Czech Republic) into an aquifer heavily contaminated with chlorinated hydrocarbons (CHCs). The material was pressure-injected into permanent wells as an aqueous suspension (~3 g/L). Trichloroethylene was the dominant contaminant, reaching concentrations of up to 10 mg/L. S-nZVI application increased pH, decreased redox potential, and promoted the formation of gaseous CHC degradation products, including ethane, ethene, and acetylene. Groundwater monitoring showed a decrease in total CHC concentrations for up to six months in highly contaminated deeper horizons. Dehalogenation biomarkers (16S rRNA, vcrA, DHC-RT, Dsb, EtnC, and EtnE) were also monitored. A decrease in their abundance coincided with increased total iron concentrations, particularly in the subsurface gravel aquifer at 8 m b.g.l. and in clayey sands at 13-17 m b.g.l. XRD analysis of recovered solids revealed S-nZVI transformation products after 11 months, with trebeurdenite as the dominant mineral. These findings demonstrate the applicability of S-nZVI for full-scale in situ treatment while highlighting the interactions between geochemical changes, nanomaterial transformation, and microbial dehalogenation processes under real aquifer conditions.

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Novel Biochar-Cyclodextrin Polymer Composites for PFAS Removal from Aqueous Environments

Per- and polyfluoroalkyl substances (PFAS) are persistent, mobile environmental contaminants that pose significant risks to human health and ecosystems, driving the need for effective and affordable removal technologies. This study presents the development of novel biochar-cyclodextrin (CD) polymer composites as cost-effective adsorbents for PFAS removal from aqueous environments. The main objective was to reduce the amount of CD polymer required in the adsorbent system, thereby lowering material costs while maintaining or improving adsorption performance. Several biochar-based composites, varying in biochar type and proportion, were synthesized and evaluated against pristine CD polymer. Based on these preliminary adsorption results, one composite was selected for more comprehensive characterization. Detailed kinetic and isotherm experiments were conducted to elucidate the adsorption behavior and underlying mechanisms of

PFAS uptake. Additionally, the effects of water composition and dissolved organic matter were investigated to assess the material's performance under environmentally relevant conditions. Notably, the selected biochar-CD composite exhibited adsorption properties that, in some cases, exceeded those of the pure cyclodextrin polymer. These findings demonstrate the strong potential of biochar-cyclodextrin composites as low-cost, high-performance adsorbents for PFAS remediation in water treatment applications.

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Ti-Al-C MAX Phases Prepared Using Waste Sources of Aluminum and Carbon

MAX phases are ternary layered carbide or nitride compounds that combine the properties of metals and ceramics offering a broad range of technological applications. Ti-Al-C based MAX phases belong to the most often studied. This work focuses on the preparation of Ti-Al-C based MAX phases using TiC, food packaging material as a source of aluminum and commercial titanium. The first part focuses on the synthesis of titanium carbide (TiC) in molten salt at 1250 °C using Ti powder and an ecofriendly alternative carbon source prepared by carbonizing spent Yerba Mate waste. In the second step, as-prepared TiC and aluminum from food packaging were used to synthesize the MAX phase. The main goal was the utilization of secondary sources of aluminum and carbon for the synthesis of high-tech material, significantly increasing the sustainability of the entire process. The influence of the annealing temperature, ball milling duration, single-stage versus two-stage grinding, and sample compaction on the resulting phase purity was monitored. Individual samples were subsequently characterized using X-ray powder diffraction analysis (XRD) and scanning electron microscopy (SEM). Experimental results showed that the sample with the lowest impurity content was prepared by single-phase grinding for 120 min, followed by annealing at 1300 °C for 90 minutes.

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Evaluation of the Self-Cleaning Effect of Carbon-Doped g-C₃N₄ Coatings on Surfaces

The ability of building material surfaces to clean themselves significantly lowers long-term maintenance costs of structures. Self-cleaning behaviour can arise from hydrophobicity, photocatalysis, or their combination. This study concentrates on the photocatalytic route. We prepared white cement paste specimens whose surfaces were coated with carbon-doped g-C₃N₄. Carbon doping was chosen because it narrows the band gap of g-C₃N₄ and improves the separation of photogenerated charge carriers, thereby increasing photocatalytic activity under visible light. The self-cleaning efficiency of the modified surfaces was assessed by two complementary standard methods: the Rhodamine B degradation test according to UNI 11259 and the measurement of water contact angle according to ČSN ISO 27448. Despite the different physical principles of the two techniques, both confirmed a marked self-cleaning effect of the carbon-doped g-C₃N₄ layers. Moreover, the contact-angle results supported the applicability of the Rhodamine B method even for the light-yellowish coatings typical of these materials.

ACKNOWLEDGEMENT: This research was supported by the Czech Science Foundation under the project 24-10949S, while the infrastructure has been utilized in the frame of project No. CZ.02.01.01/00/22_008/0004631 Materials and technologies for sustainable development within the Jan Amos Komenský Operational Program financed by the European Union and from the state budget of the Czech Republic.

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Framework Integrity of MOF-Based Adsorbents in Natural Waters: Influence of Material Design and Post-Adsorption Processing

Metal-organic frameworks (MOFs) have attracted considerable attention as adsorbents because of their high porosity and tunable chemistry. In this study, we examined how different material design strategies, including metal-node substitution, composite formation, synthesis route, and post-adsorption processing, influence framework structural stability under realistic groundwater conditions. A series of ZIF-8- and UiO-66-nanoparticle-based materials was evaluated before and after exposure to naturally contaminated groundwater. The results showed that Ni-substituted ZIF-8 sample retained its crystalline structure better than pristine ZIF-8, despite the low level of Ni incorporation. Similarly, GAC-supported ZIF-8 composites synthesized in methanol preserved their crystallinity after adsorption, whereas PVA-based composites underwent pronounced structural degradation. For UiO-66, the post-adsorption drying procedure also proved important, with gradual drying at room temperature preserving the framework more effectively than oven drying. Despite these differences in structural stability, the selected MOF materials maintained high adsorption efficiencies toward both radionuclides (Lu and Tb) and oxoanions (arsenate and phosphate), exceeding 90% in all cases. Presented results show that framework stability is determined not only by the intrinsic chemistry of the MOF but also by the way the material is synthesized, processed, and integrated into composite systems. The study highlights the importance of considering structural stability alongside adsorption performance when designing MOF-based adsorbents for operation in realistic aqueous environments. ACKNOWLEDGEMENT: This research was supported by the Science Fund of the Republic of Serbia, Grant No. 7282, Project title "Design of radioactive magnetic nanoconstructs for tumour therapy by synergy of nanobrachytherapy and magnetic hyperthermia" - RADIOMAG.

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Iron Nanoparticles as Sacrificial Templates in Cellulose-Based Porous Carbon for Ethinylestradiol Adsorption

The occurrence of endocrine-disrupting compounds in aquatic environments has become a growing environmental concern due to their persistence and biological activity at trace concentrations. Among these contaminants, ethinylestradiol (EE2), a synthetic estrogen widely used in oral contraceptives, poses a significant risk to aquatic organisms and water quality [1]. In this work, porous carbon adsorbents for EE2 removal from aquatic environment were prepared from renewable microcrystalline cellulose using an ice-templating approach followed by carbonization [2]. To enhance pore development, a ferrous salt was incorporated into the cellulose suspension prior to freeze-casting. During subsequent thermal treatment, iron-containing nanoparticles were formed within the carbon matrix. These nanoparticles acted as sacrificial templates and were subsequently removed by leaching with diluted hydrochloric acid followed by washing with demineralized water, resulting in increased porosity and surface accessibility of the carbon material. Moreover, acid leaching wash away any species that could be released into aqueous environment during EE2 adsorption. The prepared porous carbons were characterized in terms of their morphology, textural properties, and chemical composition. The influence of iron-assisted templating and acid leaching on pore formation was evaluated. The adsorption performance of the materials toward ethinylestradiol in aqueous solutions was investigated to assess their potential for water treatment applications. The results demonstrate that the combination of ice-templating and iron-assisted pore generation provides an effective route for producing highly porous carbon materials from sustainable biomass precursors. The developed adsorbents show promise for the removal of endocrine-disrupting pollutants from water and contribute to the development of environmentally friendly remediation technologies. [1] N. Leroux, S. Baekelandt, J.-B. Robert, L. Burattin, C. Keime, C. Gérard, P. Kestemont: Assessment of the effects of estetrol and 17 α -ethinylestradiol on zebrafish (*Danio rerio*) metamorphosis: a morphological and transcriptomic approach. *Environmental Pollution* 376 (2025) 126423 [2] M. P. Chavhan, A. Kryeziu, S. Ganguly, J. Parmentier: Monolithic metal-based/porous carbon nanocomposites made from dissolved cellulose for use in electrochemical capacitor. *Green Carbon* 2 (2024) 109-117.

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Thin Films of Ni and Co mixed metal oxides via Ozone-based Atomic Layer Deposition for Bifunctional Alkaline Water Splitting

Robust and earth-abundant electrocatalysts based on earth-abundant elements are essential for advancing alkaline water electrolysis. In this work, ozone-assisted Atomic Layer Deposition (ALD) was employed to synthesize NiO_x , CoO_x , and mixed NiCoO_x thin films for bifunctional electrocatalytic water splitting applications. Using nickelocene and cobaltocene precursors with ozone as oxidant, conformal coatings were deposited on planar substrates as well as three-dimensional nickel foam (NF) and stainless-steel (SS) mesh electrodes. The influence of catalyst composition and substrate architecture on electrochemical performance was investigated in 1.0 M KOH. Mixed NiCoO_x coatings deposited on SS mesh exhibited enhanced oxygen evolution reaction (OER) activity, achieving an overpotential of 310 mV at 10 mA cm^{-2} and a Tafel slope of 46 mV dec^{-1} . In contrast, deposition on NF promoted hydrogen evolution reaction (HER) performance, showing a low onset overpotential of 230 mV together with improved charge-transfer kinetics. These results demonstrate the potential of ozone-based ALD for the controlled fabrication of conformal mixed-metal oxide electrocatalysts on complex 3D substrates and highlight the role of substrate engineering in tuning bifunctional catalytic activity for alkaline water electrolysis.

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Plasma-Reduced Graphene Oxide/Nanofiber Composite Membranes for Advanced Water Purification

Water source pollution poses an ecological and health problem, necessitating the development of new and effective filtration materials. This study focuses on the fabrication, plasma modification, and characterization of composite membranes based on polymeric nanofibers and plasma-reduced graphene oxide (rGO) for the removal of various water contaminants. Polyamide (PA6) nanofibers were deposited onto a DCSBD plasma-pretreated polypropylene non-woven fabric using electrospinning. The rGO was fabricated by atmospheric-pressure DCSBD plasma-triggered reduction of graphene oxide (GO) papers in a nitrogen atmosphere, followed by nitrogen plasma functionalization using a DCSBD linear APPJ to enhance its adsorption capabilities. The prepared materials were assembled into three types of membranes: PA6 nanofibers without rGO, rGO-containing membranes, and membranes containing nitrogen-functionalized rGO (N-rGO) which were subsequently tested for filtration of selected organic and heavy metals pollutants. Filtration efficiency was evaluated using UV-Vis spectrophotometry, HPLC-MS, and ICP-MS. The results demonstrated higher pollutant removal efficiency for rGO-based membranes compared with nanofiber-only membranes. N-functionalization (amines and amides together with formation of oxygen functionalities) further enhanced pollutant removal under selected conditions; however, its effect depended on the specific pollutant and solution pH. Separate adsorption experiments with rGO were also performed at different pH values. The results confirmed the ability of rGO to adsorb the tested pollutants depending on pollutant type and solution pH. The observed trends were consistent with the filtration results, indicating a significant contribution of rGO adsorption to the overall pollutant removal process.

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Chemical and Thermal Stability of Antibiotic-Humic Complexes

Soils are known by their self-cleaning ability based on the complexation of organic matter with different pollutants and "locking" of them in the matter. Key constituents of soil organic matter are humic substances which are (due to their unique structure) able to immobilize different pollutants in stable complexes resulted in a reduced leachability in soil solution and their input into surface and ground water and plant uptake. These properties of humic substances can be utilized not only in soil systems but also e.g. for water cleaning or waste treatment. In the last decades, pharmaceuticals have been extensively used in large quantities which resulted in their input in environmental systems from their production, industries, hospitals and households, wastewater used in irrigation, and sewage sludges from municipal wastewater treatment plants. In this contribution, sulfathiazole and tetracycline as representants of widely used antibiotics which can be found in ecosystems. The paper deals with the complexation ability of humic substance for these antibiotics and their leachability (chemical stability) connected with their bio-availability and biotoxicity. Simultaneously, obtained results will served as a background for the humic application as the aid for a keeping of health environmental systems. The stability of formed complexes were assessed also by means thermogravimetry where parameters of thermal decomposition will be correlated with antibiotic leachability and potential relationships between chemical and thermal stabilities were investigated and discussed.

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Smart Polysaccharide-Derived Hydrogels for Sustainable Removal of Pharmaceutical Residues from Aqueous Environments

Antibiotic residues persistently contaminate aquatic environments, posing significant ecological and public health risks. This study presents the development of innovative hybrid materials combining natural polysaccharides with inorganic clay fillers, demonstrating high surface activity and functional versatility for the simultaneous specific adsorption of pharmaceutical residues from polluted waters. Using natural polysaccharides such as chitosan, alginate, and agarose was obtained a stable three-dimensional hydrogel with high water-retention capacity (>90%) and tunable porosity. Incorporation of mineral clay such as Montmorillonites and Laponite, enhanced the mechanical stability, specific surface area, and density of active adsorption sites. The nanostructured hydrogels exhibited strong affinity toward antibiotics such as tetracycline, ciprofloxacin and sulfadimethoxin, through multiple interaction mechanisms, including electrostatic attraction, hydrogen bonding, and π - π interactions between the antibiotic molecules and the functional groups present in the polymer-clay network. Physicochemical characterization demonstrated adsorption capacities ranging from 100 to 450 mg/g for tetracycline, 80-250 mg/g for ciprofloxacin and 50-180 mg/g for sulfadimethoxine, depending on the crosslinking degree and functionalization strategy, while removal efficiencies reached up to 85% under optimized pH and adsorbent dosage conditions. Adsorption kinetics followed a pseudo-second-order model, indicating chemisorption as the dominant mechanism. The synergistic combination of biopolymers and inorganic nanomaterials provides promising hybrid matrices for environmental decontamination. ACKNOWLEDGMENTS: This work was carried out through the PN 23.06 Core Program - ChemNewDeal, project no. PN 23.06.01.01-AQUAMAT, and within CCCDI - UEFISCDI, project no. PN-IV-P7-7.1-PED-2024-1277-SafeBioChain.

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HALEŠ Petr**Brno University of Technology, Brno,
Czech Republic****What We Do in the Biochar Research: Bacterial Life in the Pores**

Biochar is a porous, carbon-rich material that can be used as a soil amendment improving soil properties. However, the high temperatures used during pyrolysis produce a sterile material with a limited impact on soil biological processes. Therefore, this study evaluated the feasibility of enriching biochar with plant growth-promoting rhizobacteria (PGPR) to develop a biologically active product with potential applications in sustainable agriculture. Four commercial biochar samples (Carbohran, Novocarbo, Bio-Pflanzenkohle, and Zera) and the bacterial strain *Azotobacter vinelandii* CCM 289 were used in this study. The materials were characterized in terms of their organic and inorganic content (TGA), inorganic elemental composition of aqueous extracts (ICP-OES), and physicochemical properties (pH and electrical conductivity). Two biochar colonization approaches (post-cultivation and co-cultivation) were compared, while bacterial viability was assessed by flow cytometry. The hydrogel samples were rheologically characterized and subsequently freeze-dried to obtain a stable and easily handled material. The experimental part of the study was based on a 92-day pot experiment with maize (*Zea mays*), in which freeze-dried PGPR carriers were applied to soil. After the cultivation experiment, plant growth parameters (plant height, biomass, and ear number) as well as soil physicochemical and microbiological properties were evaluated. Microbial properties were assessed using cultivation-based assays and BIOLOG EcoPlate™ analysis, while PGP activity was evaluated. The results showed that the combination of biochar and PGPR supported microbial activity, contributed to soil pH stabilization, and demonstrated the potential of biochar as a carrier containing beneficial microorganisms. These findings may support the development of environmentally friendly biofertilizers.

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HLAVÁČKOVÁ Barbora**Brno University of Technology, Brno,
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Soil respiration is a key indicator of soil quality and the soil microbial activity, and it plays a significant role in the global carbon cycle. The rates of carbon dioxide release and oxygen consumption depend on organic matter availability, soil structure, and environmental conditions, particularly temperature and moisture. This study focuses on optimizing respirometric measurements using the OxiTop®-IDS system, evaluating the effect of selected experimental conditions (temperature, soil moisture) and the application of bioinoculants containing plant-growth-promoting rhizobacteria (PGPR) on soil respiration rate. The rhizobacterial strain *Azotobacter vinelandii* CCM 289 was used to prepare all application forms of the bioinoculants (bacterial culture in PBS, alginate gel with presence and absence of bacterial culture and biochar, and freeze-dried equivalent of previous bioinoculants). The results confirmed that soil respiration is strongly influenced by changes in temperature and soil moisture. All applied soil conditioners led to a significant increase in the respiration rate of the used model soil. The OxiTop®-IDS system demonstrated high reliability and sensitivity in monitoring microbial activity in soil. These findings indicate that soil respiration using this method provide a suitable and effective tool for assessing the soil functional state as well as for evaluating the effectiveness of soil amendments. This work was supported by the Czech Science Foundation of the Czech Republic (grant number: GA23-06757S) and NATO Science for Peace and Security Programme (project Nr. G6296).

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CALDERÓN-ARMIJO Natalia**Universidad de Chile, Santiago, Chile****Electrospun Functional Nanofibers Incorporating Magnetite Nanoparticles for the Removal of Pesticides from Water**

The presence of pesticide residues in water is an important environmental concern, motivating the development of efficient materials for their removal. In this work, electrospun functional nanofibers were developed for the removal of pesticide contaminants from aqueous media by combining magnetite (Fe_3O_4) nanoparticles with β -cyclodextrin (β -CD) in a poly(vinyl alcohol) (PVA)-based fibrous matrix. The material design combines magnetic functionality with the ability of β -CD to interact with organic molecules, aiming to develop a multifunctional material for environmental remediation. A core-shell architecture was investigated, consisting of a Fe_3O_4 -containing PVA core and a PVA/ β -CD-based shell. Citric acid was incorporated into the polymeric formulation to improve the aqueous stability of the PVA-based material after thermal

treatment. The influence of solution composition and electrospinning conditions on fiber formation was investigated, and the resulting materials were characterized by electron microscopy and magnetic measurements. The materials were evaluated for the removal of selected pesticides from aqueous media, including linuron and pirimethanil. Preliminary experiments showed removal efficiencies of approximately 75% for linuron and 65% for pirimethanil. These results highlight the potential of electrospun nanofibrous materials combining Fe_3O_4 nanoparticles and β -CD as multifunctional materials for the removal of organic contaminants from water and for environmental remediation applications.

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POSTER SESSION C

Nanomedicine: Diagnostics and Therapy / Drug Delivery Systems / Targeted Therapy / Tissue Engineering and Implants

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Toward Integrated Microfluidic Point-of-Care Diagnostics: Optimization and Stabilization of a LAMP Mastermix

Rapid and reliable point-of-care molecular diagnostics require innovative technologies enabling fully integrated and portable testing. Our long-term goal is the development of a microfluidic diagnostic platform combining magnetic particle-based nucleic acid isolation, LAMP amplification, and on-chip detection. Since successful integration of LAMP into such a platform requires a robust and stable reaction mixture, the aim of this study was to optimize and stabilize a LAMP mastermix through the systematic evaluation of reaction additives. Initially, seven reaction additives were evaluated individually to assess their effect on LAMP performance. Each additive was tested at five different concentrations across a temperature gradient. Based on the screening results, the additives were classified as amplification enhancers or protective/stabilizing additives. Subsequently, the combination of the two most effective enhancers, betaine and formamide, was optimized, and sugar-based stabilizers were incorporated into the optimized formulation to improve mastermix stability while maintaining its performance. Betaine exhibited the strongest enhancing effect, and its combination with formamide further improved the amplification efficiency of the LAMP assay. The incorporation of trehalose and sucrose increased mastermix stability, while both sugars demonstrated quantification performance. The combination of amplification enhancers and sugar-based stabilizers resulted in a LAMP formulation with improved amplification efficiency and stability. The optimized LAMP mastermix represents an important component for the future implementation of integrated microfluidic point-of-care diagnostic systems. **ACKNOWLEDGEMENTS:** This work was supported by the NaCeBiVet project (No. TN02000017) and the Internal Grant Agency of Mendel University in Brno (IGA26-AF-IP-045).

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Biocompatibility Evaluation of Mg-Whitlockite-Containing Electrospun Polyhydroxybutyrate Nanofibers for Bone Regeneration

Polyhydroxybutyrate (PHB) is a naturally occurring, biodegradable polyester with potential use as a scaffold material in bone tissue engineering. Here, we used electrospun nanofibrous PHB (3% w/v) scaffolds with incorporated 1, 3, 10, or 30% (w/t) Mg-Whitlockite (w/t), a magnesium-substituted calcium phosphate mineral that may enhance bone regeneration properties of the scaffolds by promoting cell proliferation and adhesion. SaOS-2 osteoblast-like cells were grown on the tested materials or exposed to 24-h material extracts for 1, 3, and 7 days to evaluate potential toxicity of direct material-cell contact as well as of material leachates. Cell metabolic activity and proliferation were assessed by MTS and PicoGreen assays, cell morphology and viability were evaluated by light microscopy and Live/Dead staining using fluorescence and confocal microscopes. Cells exposed to extracts of all PHB-Mg materials maintained metabolic activity and proliferation, with no observed cytotoxic effects. Although 10% Mg-Whitlockite caused a statistically significant decrease in metabolic activity, cell viability remained $\geq 80\%$, which is above the ISO 10993-5 cytotoxicity threshold. Direct cultivation on scaffolds resulted in lower initial cell attachment in comparison to tissue culture plastic, however cell numbers increased during cultivation, indicating continued proliferation. Overall PHB scaffolds containing 0-30% Mg-Whitlockite demonstrated good

biocompatibility, supporting their potential as biodegradable materials for bone tissue engineering. The study was funded by the Ministry of Education, Youth and Sports of the Czech Republic, programme Johannes Amos Comenius (Reg. No. CZ.02.01.01/00/22_008/0004562) and by the Czech Science Foundation (GAČR Weave programme, Project No 26-23142L).

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Evaluating Nanoparticle-Induced Changes in outer Cell membrane Mechanics: An AFM Study and Data Analysis

The rapid development of nanotechnology is bringing nanomaterials, such as nanodiamonds (NDs) and silica nanoparticles (SiO₂ NPs), closer to everyday applications in biomedicine and industry. However, their increasing integration into everyday products raises crucial questions about their safety, toxicity, and precise effects on the human body. Since nanoparticle internalization in cells often triggers cytoskeletal reorganization, cellular nano-mechanics and morphology serve as highly sensitive indicators of cellular responses to these materials. In this work, we study alterations in outer NHDF cell membrane topography and elasticity following exposure to NDs and SiO₂ NPs using Atomic Force Microscopy (AFM). Quantitative force spectroscopy is used to map the local Young's modulus of the cell membrane. To efficiently process extensive multi-point force-indentation datasets, we utilize specialized data analysis software that calculates Young's modulus via Hertz/Sneddon mechanics fitting and other parameters, such as adhesion.

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Development and Optimization of Liposomal Systems for Nucleic Acid Encapsulation for Biomedical Applications

Nucleic acids, such as DNA and RNA, are important biomolecules with board applications in biomedicine, particularly in the development of novel therapeutic and diagnostic approaches. However, due to their low stability in biological environments they are rapidly degraded by nucleases. One effective strategy to protect these biomolecules is their encapsulation into nanocarriers, such as liposomes [1; 2]. The aim of this study was to optimize the preparation method of liposomal particles encapsulating plasmid DNA and synthetic oligonucleotides and subsequently evaluate their encapsulation efficiency and stability. The experimental part deals with preparation of liposomes with different lecithin-to-cholesterol rations, followed by the encapsulation of nucleic acids. Prepared particles were characterized using dynamic light scattering and encapsulation efficiency was evaluated by agarose gel electrophoresis. We successfully optimized liposome preparation at reduced reaction volume and achieved high encapsulation efficiency, more than $95,38 \pm 3,94 \%$, for commercially available synthetic oligonucleotides. On the other hand, plasmid DNA exhibited lower encapsulation efficiency, particularly at higher concentrations. These findings provide a solid foundation for further optimization of liposomal delivery systems and their future application in biomedical research and therapeutic development. REFERENCES: [1] Cullis, P. R., & Hope, M. J. (2017). Lipid nanoparticle systems for enabling gene therapies. *Molecular Therapy*, 25(7), 1467-1475; [2] Kulkarni, J.A., Witzigmann, D., Thomson, S.B. et al. The current landscape of nucleic acid therapeutics. *Nat. Nanotechnol.* 16, 630-643 (2021). <https://doi.org/10.1038/s41565-021-00898-0>.

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Engineering Manganese-Substituted Maghemite Nanoflowers for Bimodal Cancer Therapy via Hyperthermia and Radionuclide Delivery

This study reports the development and characterization of manganese-substituted maghemite nanoflowers (Mn_xFe_{2-x}O₃) engineered as a multifunctional platform for synergistic cancer treatment combining magnetic hyperthermia and nanobrachytherapy. Synthesized via a controlled polyol route, nanoparticles with varying manganese content maintained

a spinel-type lattice, while structural analysis confirmed successful Mn²⁺ incorporation. Surface functionalization with 1-hydroxyethylidene-1,1-diphosphonic acid (HEDP) ensured colloidal stability and enabled high-yield radiolabeling (>98%) using therapeutic radionuclide ¹⁷⁷Lu. Calorimetric measurements showed enhanced magnetic heat generation at moderate manganese substitution levels. The radiolabeled nanoconstructs demonstrated excellent stability in human serum, high protein-binding affinity, and favorable pharmacokinetic profiles in animal models. Following intratumoral administration in 4T1 tumor-bearing mice, ¹⁷⁷Lu-labeled nanoflowers exhibited strong localized tumor retention with minimal leakage into healthy tissues. Combined thermo-radiation therapy resulted in significant tumor growth inhibition, showing the highest efficacy in smaller initial tumor volumes. These findings demonstrate the strong potential of manganese-substituted iron oxide nanoflowers as an effective bimodal agent for localized oncological interventions. ACKNOWLEDGEMENT: This research was supported by the Science Fund of the Republic of Serbia, Grant No. 7282, Project title "Design of radioactive magnetic nanoconstructs for tumour therapy by synergy of nanobrachytherapy and magnetic hyperthermia" - RADIOMAG.

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Rational Engineering of Multifunctional Iron- and Manganese-Based Nanostructures for Biomedical Theranostic Applications

Cancer remains the leading cause of global mortality, making early diagnosis and effective localized treatment essential for improving survival. MRI is a cornerstone diagnostic tool for its non-invasive, high-resolution soft-tissue contrast, though its performance relies on contrast agents that enhance tumor differentiation. Manganese ferrite (MnFe₂O₄) nanoparticles are especially promising in this role, offering tunable magnetism, strong biocompatibility, and multimodal imaging-therapy capability in a single platform offering distinct advantages over conventional Gd-based or pure iron oxide contrast agents. Our study aims to establish a structure-property-functional relationship by investigating how Mn substitution/doping in both through compositional tuning (Mn_xFe_{3-x}O₄) and Mn-based core-shell architectures in iron oxide with the role of interfacial layer as a versatile platform strategy for tailoring magnetic properties, MRI relaxometric properties and hyperthermia, for integrated cancer diagnosis and treatment. In Mn_xFe_{3-x}O₄ increasing Mn content shifted particle morphology from faceted octahedra to larger, irregular structures. The MRI relaxivity showed dependence on Mn substitution. Increasing Mn content clearly showed a transition from T₂ dominant ($r_2/r_1 \sim 430$) contrast behaviour to T₁ dominant ($r_2/r_1 \sim 9$) contrast behaviour. While the hyperthermia showed dependence on size of the particles with showing a highest SAR (673.73 W g⁻¹), for Fe rich particles having the smallest size. The particles showed a good biocompatibility along with ROS based therapy in cancer cells. While the Fe₃O₄@MnO₂ core shell particle showed changes in dual T₁/T₂ behaviour with MnO₂ coating acting as a pH responsive layer. Mn substitution offers a practical, single-parameter route to tune a single ferrite platform for divergent theranostic applications, supporting its potential as an MRI-guided, multifunctional nanopatform for cancer diagnosis and therapy.

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Green Synthesis and Mechanistic Anticancer Evaluation of Quercetin-Functionalized Silver Nanoparticles Against Non-Small Cell Lung Carcinoma

Non-small cell lung cancer (NSCLC) remains one of the most lethal malignancies worldwide, characterized by poor prognosis, chemoresistance, and limited durable therapeutic options. Phytochemical-metal nanoconjugates offer an emerging strategy by combining distinct cytotoxic mechanisms within a single nanopatform. We report the green synthesis, physicochemical characterization, and mechanistic anticancer evaluation of quercetin-functionalized silver nanoparticles (AgNPs-Que), designed to combine the cytotoxicity of silver with the oncosuppressive activity of quercetin. AgNPs-Que were synthesized via a solvent-based single-step method using quercetin as the reducing and stabilizing agent, with NaOH-facilitated deprotonation driving Ag⁺ reduction, followed by purification through a 2 kDa dialysis membrane. Characterization by UV-Vis spectrophotometry, FTIR, SEM, DLS, and zeta potential analysis confirmed nanoparticle formation, surface functionalization, and colloidal stability. Cytotoxicity against A549 NSCLC cells assessed by MTT assay yielded a mean IC₅₀ of 16.80 ± 3.31 µg/mL, demonstrating superior potency over free quercetin and bare AgNPs. Live/dead

fluorescence and cell cycle analyses revealed dose-dependent G1 phase arrest linked to p53/p21 axis activation and CDK inhibition. DCFH-DA fluorometry demonstrated intracellular ROS generation, while MitoTracker Red staining showed mitochondrial membrane depolarization, indicating activation of the intrinsic apoptotic pathway, further supported by caspase-3 immunofluorescence imaging. Collectively, AgNPs-Que demonstrate promising anticancer activity through enhanced oxidative stress, cell-cycle arrest, and apoptosis, supporting their potential as a green-synthesized nanotherapeutic strategy for NSCLC and warranting further in vivo investigation.

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Advanced Functionalized Mxene Architectures for Enhanced Electrochemical Detection of Tumor Biomarkers

MXenes are 2D titanium carbide nanomaterials with high conductivity, large surface area, and biocompatibility, making them suitable for (bio)sensing applications. Herein, we present the development of miniaturized electrochemical biosensors based on functionalized MXene nanomaterials as conductive supports for peptide receptors, for fast, sensitive and non-invasive detection of the lung cancer biomarkers, carcinoembryonic antigen (CEA) and epidermal growth factor receptor (EGFR) in saliva. Titanium carbide MXenes were synthesized by selective etching of MAX phase precursors with LiF/HCl, followed by DMSO-assisted delamination, and then functionalization with amino groups using APTES. The functionalized conductive MXene flakes were deposited on screen-printed electrodes (SPEs), providing enhanced conductivity and support for covalent binding of ferrocenyl-labeled peptide receptors. Successful synthesis and delamination were confirmed by SEM, revealing characteristic accordion morphology and 5-20 μm flake dimensions, alongside TGA and Raman spectroscopy, while FTIR confirmed functionalization through characteristic amino and silanization bands. The electrocatalytic performance of the MXene-modified electrodes was evaluated using voltammetry and electrochemical impedance spectroscopy. CV studies showed that MXene deposition increased the electroactive surface area from 0.1256 cm^2 (bare SPE) to $0.159 \pm 0.012 \text{ cm}^2$, and to $0.223 \pm 0.019 \text{ cm}^2$ upon amino-functionalization. Ferrocenyl-labeled peptide receptors were immobilized on MXene-NH₂/SPE via sulfo-SMCC assisted covalent binding, and comparisons with adsorption and glutaraldehyde crosslinking confirmed more homogeneous surface coverage for covalent methods. Further work focuses on optimizing peptide immobilization and evaluating biosensor response towards biomarker detection. ACKNOWLEDGEMENTS: This work was supported by the Ministry of Research, Innovation and Digitization, CNCS/CCCDI-UEFISCDI, through projects PN-IV-P2-2.1-TE-2023-1281, MXEPEPMIN and by Core Program PN 23.06.01.01. AQUAMAT.

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Synthesis, Characterization, and Evaluation of Positively and Negatively Modified Nanoparticles for Nucleic Acid Separation

Surface-functionalized magnetic nanoparticles (MNPs) are promising materials for nucleic acid separation due to their tunable surface properties and magnetic responsiveness. In this study, silica-coated MNPs were functionalized with polycations, including chitosan and poly-L-lysine, to enhance their interaction with nucleic acids. The physicochemical, surface, and magnetic properties of the modified nanoparticles were investigated and related to their nucleic acid binding and separation performance. The functionalized nanoparticles demonstrated significantly improved RNA extraction compared with unmodified silica-coated MNPs, with chitosan modification providing the highest separation efficiency. The results demonstrate the potential of polycation-functionalized MNPs for efficient nucleic acid separation and their further application in biomedical and diagnostic technologies [1,2].

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Application of Microscopic Analysis of Crystal Structures and Nanomaterials in Clinical Medicine

Microscopic techniques using bright-field and polarized light can be suitable for the analysis of crystal structures and nanomaterials. Moreover, suitable markers for the selective and sensitive diagnosis of serious diseases are still being sought. In addition, these procedures are applied in clinical laboratory medicine. The aim of this work was to analyze samples of solid biominerals and nanomaterials using microscopic and spectroscopic methods. Biological samples were evaluated by microscopic analysis combined with image analysis. Furthermore, individual types of solid calculi were identified by advanced FTIR spectroscopic analysis. Using automated microscopic analysis followed by image analysis, an average of 55,474 microscopic analyses per year were performed between 2015 and 2026. The main groups of identified crystals were oxalates (on average 1,772 per year), uric acid (on average 522 per year), phosphates (on average 364 per year), and urates (on average 17 per year). In addition, approximately 250-350 highly specialized spectroscopic examinations of calculi are carried out each year. Within this group, various forms of oxalates predominate. Modern spectroscopic methods allow minimal sample preparation. The obtained data are mathematically processed and can serve as a very important basis for establishing a diagnosis.

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Microencapsulated Iron for Sustained Release: Biochemical Analysis of Iron Status Dynamics

Anaemia affects approximately 9 % of adults aged 20-59 years, 12.5 % of those aged 60 and older, and more than 20 % of the population above 85 years. Treatment of sideropenic anaemia requires elimination of the underlying cause together with iron substitution sufficient to restore both haemoglobin and ferritin. Oral Fe^{2+} salts remain the first-line treatment, and although their uptake is further enhanced by concomitant ascorbic acid, their use is frequently limited by gastrointestinal effects such as nausea, epigastric fullness, diarrhoea and constipation. Additionally, in malabsorption, intolerance, severe losses or when rapid correction is required, parenteral Fe^{3+} -carbohydrate complexes are employed to bypass both intestinal absorption and hepcidin-mediated blockade of ferroportin. Microencapsulated preparations have therefore been proposed to circumvent these limitations, but human data are scarce. In this study, serum iron kinetics were characterised over 600 min after a single oral dose (60 mg/d) of a microencapsulated iron formulation in three non-anaemic volunteers aged 25 to 59 years spanning a wide range of iron stores (ferritin 9.3 to 136.2 $\mu\text{g/l}$). Serum was sampled at 0, 60, 120, 240, 360, 480 and 600 min and analysed in triplicate by graphite-furnace atomic absorption spectrometry alongside automated clinical chemistry. The magnitude of the response was inversely related to baseline iron status. The iron-depleted subject (ferritin 9.3 $\mu\text{g/l}$, transferrin saturation 8.5 %, sTfR 0.92 mg/l) showed a 4.4-fold rise from 6.8 to 29.8 $\mu\text{mol/l}$ peaking at 240 min and remaining 2.7-fold above baseline at 600 min. The intermediate subject a 1.9-fold rise peaking at 480 min, whereas the iron-replete subject showed no net absorption. Ferritin rose from 9.3 to 13.2 $\mu\text{g/l}$ in the iron-depleted subject, while transferrin remained unchanged throughout. Thus, such microencapsulated preparations can

improve bioavailability.

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Iron-Based Nanozymes Targeting PANoptosome-Mediated PANoptosis for Myocardial Ischemia-Reperfusion Injury Therapy

The extensive crosstalk among pyroptosis, apoptosis, and necroptosis limits the efficacy of therapies targeting only one pathway. Here, we show that Prussian blue (PB) nanoparticles act as multi-target PANoptosis inhibitors by binding key PANoptosome components including RIPK1, ZBP1, and AIM2 through multimodal interactions, thereby concurrently suppressing pyroptosis, apoptosis, and necroptosis in myocardial ischemia-reperfusion injury (MIRI). Platelet membrane-coated PB nanoparticles (PB@PM) exhibit enhanced cardiac targeting and efficiently alleviate MIRI-induced cardiac dysfunction, adverse ventricular remodeling, and cardiomyocyte hypertrophy. Mechanistically, PB@PM disrupt PANoptosome assembly, scavenge reactive oxygen species, improve mitochondrial function, and restore immune-inflammatory homeostasis. By integrating single nucleus transcriptomics of human heart samples, molecular dynamics simulations, transcriptomics, medical imaging, and molecular validation, we systematically decipher the therapeutic mechanisms of PB-based PANoptosis inhibition. This study establishes an integrative multi-omics framework for exploring PANoptosis in cardiovascular diseases and provides a promising nanotherapeutic strategy for MIRI treatment.

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Alternative Nanofibrous Membranes for Lateral Flow Assay

The work deals with the study of nanofibrous membranes as alternative protein carriers in the lateral flow test (LFA), which is based on the immunochromatographic principle. The topic of the work has significant application potential, especially in the field of rapid diagnostics. Today, LFA is used not only in medical diagnostics but also in food safety testing and environmental analysis. Despite the many advantages they offer, their weakness remains limited sensitivity, which often does not allow reliable detection of very low concentrations of analytes. Currently, research in this field focuses on increasing the sensitivity of tests, both by modifying the labelling of detection molecules and by modifying the carrier membrane. The aim of the work is to compare the binding of model proteins on a conventional membrane (nitrocellulose) and several types of nanofibrous membrane (e.g., polyvinylidene difluoride, PVDF) and to verify the influence of the nanofibrous material on the sensitivity of detection of the bound protein. For comparison of membranes, the conditions of protein immobilisation were optimised and the functionality of the designed model system was experimentally verified. The results include the binding efficiency of albumin and ovalbumin proteins and their binding capacity to membranes using analytical methods and instrumental techniques (BCA test, dot blotting, AFM and FTIR). The results also allow us to assess the influence of the material structure on the binding capacity and detection sensitivity. The detection limit achieved for the bound protein was in the order of nanogrammes per microlitre, thus reducing the detection limit for nanofibrous membranes compared to the standard NC membrane. The results confirmed the potential of the nanofibrous PVDF materials in increasing the sensitivity of LFA tests.

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Ultrathin ALD Coatings for Enhanced Biocompatibility of Titanium-Based Biomaterials

TiO₂ surfaces, especially TiO₂ nanotube (TNT) layers with 15 nm diameters grown by anodization [1] on Ti foils and frequently used TiAlV, are excellent biocompatible materials [2,3]. We demonstrate that ultrathin ALD coatings of TiO₂ [2-

4], ZrO₂, V₂O₅ [5], and TiN significantly affect cell adhesion and proliferation on TNT layers, Ti foils, and Ti alloys. For osteoblasts on amorphous and crystalline TNTs, crystalline 5c ZrO₂ TNT15 exhibited the most favorable effect on cell growth and cytoskeleton development after 48 h. In contrast, 5c V₂O₅ coatings showed cell growth comparable to uncoated TNT15, with expected cytotoxicity on larger TNT30 and TNT100. In parallel, an overall decrease in surface roughness was observed with increasing nanotube diameter and added coatings. TiN ALD coatings showed that when TiN layers were deposited with a sufficient thickness to remain chemically stable, their unique surface chemistry and high mechanical stability provided improved surfaces for osteoblast growth. Overall, ultrathin ALD coatings hold strong promise for enhancing biocompatibility in biomedical applications. REFERENCES: [1] Park et al. Small, 6, 666 -671, 2009; [2] Capek et al. ACS Applied Materials & Interfaces 16, no. 5, 5627-5636, 2024; [3] Sepúlveda et al. Front. Bioeng. Biotechnol. 12:1515810, 2024; [4] Motola et al. ACS Appl. Bio Mater., 3, 6447-6456, 2020; [5] Baishya and Bacova et al. ACS Appl. Mater. Interfaces, 17, 1, 739-749, 2025.

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Composition-Dependent Thermal Stabilization of Functional PVA Nanoyarns for Biomedical and Electronic Applications

Functional nanofibrous yarns combine the high surface area and flexibility of electrospun materials with the processability of continuous fibrous assemblies, making them promising candidates for biomedical constructs and flexible electronic devices. However, practical use requires sufficient mechanical integrity while preserving a formulation suitable for functional additives. This work investigates the effect of thermal stabilization on the tensile behavior of AC-electrospun poly(vinyl alcohol) (PVA) nanoyarns containing PEDOT and graphene. Five 10 wt% PVA formulations were evaluated: neat PVA, PVA with PEDOT, PVA with graphene, and two PVA formulations containing both functional additives. Stabilization was performed by heating the yarns from 85 to 125 °C over 4 h. Tensile testing assessed the changes in strength, stiffness, and elongation at break induced by the treatment. The results demonstrate that thermal stabilization does not produce a universal improvement in mechanical properties; instead, its effect depends strongly on composition. PEDOT yarns generally exhibited greater strength and stiffness than neat PVA or graphene-only formulations, although this reinforcement was commonly accompanied by reduced elongation. Graphene alone did not consistently improve tensile performance. Importantly, the combined PEDOT-graphene formulations showed a composition-dependent interaction with thermal stabilization: one mixed formulation lost strength and stiffness after treatment, whereas the formulation with higher functional-additive contents displayed clear post-stabilization strengthening and stiffening. This favorable response was accompanied by lower extensibility, indicating a controllable shift in the strength-ductility balance. These findings show that thermal stabilization can be used as a formulation-sensitive tool to tailor functional PVA nanoyarns. Such control is relevant for biomedical fibrous structures requiring reliable handling and structural integrity, as well as for conductive yarn-based components in flexible or wearable electronics.

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Nanomedicine: Biosensing

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Multifunctional Nanomaterial-Based Electrochemical Aptasensors for Antibiotic Residue Detection in Meat- A Step Forward in Food Safety and AMR Control

The increasing need for safety in healthcare, water resources, and the food supply chain represents a major public health challenge. Excessive antibiotic use in animal husbandry contributes to antimicrobial resistance (AMR) causing an estimated

4.95 million deaths annually worldwide, and to residues in meat products exceeding regulatory limits, while waterborne pathogens and chemical contaminants continue to threaten public health. Electrochemical aptasensors offer a compelling alternative to conventional analytical methods by combining aptamer selectivity with nanomaterial-based signal amplification. In this paper, we present the development of two independent aptasensor platforms based on innovative nanomaterials, Fullerenol (Apt-FL/SPE) for tetracycline detection, and MXene (Apt-MXene-AuNP/SPE) for penicillin detection fabricated on screen-printed electrodes (SPE) and evaluated in meat (pork, chicken, and beef) matrices. The sensing interfaces exploit the hydroxyl-rich functionalization of Fullerenol and the high conductivity of MXene to enable stable covalent immobilization of specific aptamers. Analytical performances were evaluated using EIS, SWV, and DPV. The Apt-FL-Glu/SPE achieved a sensitivity of $299.4 \Omega \text{ dec}^{-1}$ (range 0.05-45 nM, LOD 0.01 nM) for tetracycline detection, while Apt-MXene-AuNP/SPE reached $390.35 \Omega \text{ dec}^{-1}$ ($R^2 = 0.9864$) (range 3 nM-15 μM , LOD 8.6 nM) for penicillin. Overall, the systems we have developed provide versatile platforms capable of detecting drug residues for food safety monitoring, and their portability, sensitivity, and adaptability make them strong candidates for real-time applications that can contribute to improving quality of life and public health.

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Enhanced Ascorbic Acid Sensing via Structural Optimization of ZnO Nanostructures

The development of highly sensitive and selective sensing materials for the detection of biologically active molecules remains one of the key challenges in modern nanomaterials science and sensor electronics. Among various semiconductor materials, zinc oxide (ZnO) has attracted considerable attention due to its wide band gap, high chemical stability, large specific surface area, and biocompatibility [1]. These properties make ZnO a promising platform for the design of next-generation electrochemical sensors [2]. In the present study, the sensitivity of nanostructured ZnO toward ascorbic acid (AA) in a neutral medium has been investigated. Ascorbic acid plays a crucial role in biological processes as a powerful antioxidant and participates in numerous metabolic reactions. Accurate monitoring of its concentration is essential for medical diagnostics, pharmaceuticals, and the food industry. ZnO nanostructures were synthesized via thermal decomposition of a zinc acetate solution in ethanol, followed by the formation of a fine-dispersed powder. The synthesis was carried out at 250 °C, after which a portion of the samples was subjected to additional annealing at 450 °C. This approach enabled control over the degree of crystallinity and the concentration of defect states, which are critical factors governing the sensing properties of the material. Morphological characterization using scanning and transmission electron microscopy revealed that the synthesized structures consist of dense ensembles of one-dimensional nanorods with lengths of approximately 200-500 nm and diameters of about 20-40 nm. Such morphology provides a high specific surface area and a large number of active adsorption sites, thereby enhancing the electrochemical response. The structural properties of the samples were confirmed by X-ray diffraction and Raman spectroscopy. The material was found to crystallize in the hexagonal wurtzite structure. After thermal treatment, a significant narrowing of diffraction peaks and an increase in their intensity were observed, indicating improved crystallinity and a reduced concentration of structural defects. The electrochemical properties of ZnO were investigated by cyclic voltammetry in a phosphate buffer solution at pH = 7.0. A ZnO nanoparticle-modified glassy carbon electrode was used as the working electrode. It was established that increasing the scan rate leads to a rise in both anodic and cathodic currents, indicating a diffusion-controlled electrochemical process. The obtained results demonstrate that nanostructured ZnO exhibits high electrocatalytic activity toward ascorbic acid. A significant role is played by the developed porous morphology and the presence of surface defect states, which act as active adsorption sites and facilitate charge transfer at the electrode-electrolyte interface. Thus, the proposed synthesis approach enables the fabrication of an efficient material for non-enzymatic electrochemical sensors. High sensitivity, stability, and the ability to operate in a physiologically neutral medium make the developed system promising for biomedical analysis and the monitoring of antioxidants in real samples. REFERENCES: [1] I.M. Maafa, Biosensors 15, 61 (2025); [2] D.B.Tolubayeva, L.V. Gritsenko, Y.Y. Kedruk, M.B. Aitzhanov, R.R. Nemkayeva, K.A.Abdullin, Biosensors 13, 793 (2023).

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DISHA Disha***Institute of Physical Chemistry PAS, Warsaw,
Poland*****Biowaste-Derived Carbon Dots Integrated with Metal-Organic Frameworks for Printable Biosensing Platform**

Biosensing devices play a crucial role in diverse fields such as disease diagnosis, pharmaceutical research, and the identification of pathogens and contaminants in biological samples. Notably, electrochemical biosensors dominate the market due to their broad applicability in healthcare and environmental monitoring. Combining the nanomaterials, characterized by high surface area, excellent conductivity, and tunable properties, further improves sensor performance by enhancing sensitivity, selectivity, and reproducibility. In this study, carbon dots derived from citrus peel biowaste (BWCDs) are integrated with metal-organic frameworks (MOFs) where BWCDs provide rich surface functionality, while MOFs contribute highly porous and adjustable architectures that facilitate effective antibody immobilization. The resulting BWCD-MOF heterostructures are structurally and compositionally characterized and optimized to be formulated into a printable ink for biosensor fabrication. Finally, in order to enhance the performance of the biosensors a technique, viz scanning electrochemical microscopy is explored to lower the limits of detection for tumor necrosis factor- α (TNF- α), an important pro-inflammatory cytokine linked to early diagnosis and progression of diseases such as Alzheimer's disease, sepsis, and cancer.

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Early detection of cancer is a key prerequisite for successful treatment and improved patient prognosis within the framework of personalized medicine. Conventional laboratory methods tend to be time-consuming and costly, which opens the door to the development of highly sensitive, rapid, and selective biosensors. This work focuses on the development and testing of an immunosensor designed for the *in vitro* detection of carcinoembryonic antigen (CEA) in model fluids. The active layer of the biosensor was fabricated from polyacrylonitrile (PAN) nanofibers prepared by electrostatic spinning. The nanofiber support was subsequently reduced and functionalized by covalently binding an anti-CEA monoclonal antibody. Successful immobilization of the protein on the nanofiber surface was verified by Fourier-transform infrared (FTIR) spectroscopy through the identification of a characteristic peptide bond. The interaction of the functionalized carrier with the CEA antigen in a buffered solution was evaluated using two methods: by fluorescence following excitation with UV light (254 nm) on a transilluminator, and spectrophotometrically by measuring absorbance at 280 nm. The results demonstrated an inverse relationship between the carrier's luminescence intensity and the CEA concentration, as well as an increase in absorbance with increasing amounts of bound antigen. The prepared bionanosensor reliably detected CEA over a wide concentration range from 0.025 to 25 ng/ml. The proposed system represents a promising platform for use in laboratory immunodiagnosics, oncological screening, and monitoring the efficacy of anticancer therapy.

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POSTER SESSION D

Health, Toxicity, Environmental Challenges, Safety

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Integrated Assessment of ZnO Nanoparticle Toxicity in *Limnospira Platensis*

The extensive use of zinc oxide nanoparticles (ZnONPs) has increased their release into aquatic environments, highlighting the need for integrated approaches to nanotoxicity assessment that combine nanoparticle characterization with biological responses. Cyanobacteria are valuable model organisms because changes in photosynthetic pigments and primary metabolism provide sensitive indicators of cellular stress. The effects of ZnONPs (≤ 50 nm, Sigma-Aldrich) on *Limnospira platensis* were evaluated. Prior to application, nanoparticle suspensions were ultrasonicated in deionized water for 20 min. Cultures were exposed to ZnONPs ($40\text{--}100\text{ mg L}^{-1}$) during the lag and exponential growth phases. Nanoparticle behavior was characterized by monitoring zinc ion release in a model medium over seven days and colloidal stability by zeta potential measurements. Under highly alkaline cultivation conditions, ZnONPs exhibited extremely low zinc ion release while maintaining high colloidal stability, evidenced by a consistently negative zeta potential. Biological responses were assessed using biomass, total protein, phycocyanin, and malondialdehyde (MDA) as toxicity endpoints. ZnONPs induced concentration-dependent responses. Biomass decreased by 20–58%, total protein by 18–29%, phycocyanin was almost completely depleted at the highest concentrations, and MDA increased markedly, indicating oxidative stress. Similar response patterns were observed in both growth phases, although their magnitude depended on the developmental stage. The results demonstrate that phycocyanin is a highly sensitive biomarker of ZnONP-induced stress. Integrating nanoparticle physicochemical characterization with multiple physiological and oxidative stress biomarkers provides a more reliable assessment of nanoparticle toxicity than any single endpoint.

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Batch Data Analysis of Mechanical Properties of Cells Interacting With Nanoparticles

By atomic force microscopy (AFM) it is possible to indirectly measure one of the markers of living cells' condition - the rigidity of their outer membrane. To obtain the Young modules, which represent membrane rigidity, we need to analyse AFM data, which can be done using many commercial software packages. However, commercial software often does not support real batch data processing, and in almost every case, they act like a black box without any options to fully control the correction processes on the data. Therefore, we are developing a Python-based tool to analyse AFM data, which will be open-source. It provides all the necessary steps in data analysis, like baseline corrections, removing bad-measured points from the dataset and calculating Young modules (with both Sneddon and Hertz models). This gives us full control over all steps of the data analysis and gives us the ability to process the whole measured dataframe at once. We utilize this evolving tool to assess the cytotoxicity of nanoparticles in human cells. Analyzing membrane mechanical changes during nanoparticle uptake provides valuable insights into the role of the protein corona in nano-bio interactions.

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Hematological Effects of Zinc Oxide Nanoparticles and Arthrospira platensis Polysaccharide Powder: Evidence from Acute and Subchronic Rat Models

Background. Zinc oxide nanoparticles (ZnO NPs) are widely used in biomedical, pharmaceutical, cosmetic, and industrial applications, increasing the risk of biological exposure. Together with the growing prevalence of polysaccharide powder derived from the cyanobacterium *Arthrospira platensis* (PSS), these contaminants may adversely affect hematopoietic homeostasis through oxidative stress and inflammatory mechanisms. **Objective.** To investigate the effects of ZnO NPs, PSS, and their combined exposure on erythrocyte and platelet indices in rats under acute and subchronic experimental conditions. **Materials and Methods.** Forty-eight male Wistar rats (90-120 g) were randomly assigned to acute and subchronic exposure cohorts. Each cohort comprised four groups ($n = 6$): control, PSS, ZnO NPs, and ZnO NP + PSS. Test substances were administered orally with feed. Acute exposure consisted of a single dose of 2000 mg/kg followed by a 14-day observation period, whereas subchronic exposure involved daily administration of 250 mg/kg for 14 days. Hematological assessment included erythrocyte and platelet indices. **Results.** Exposure to ZnO NPs, PSS, and their combination significantly altered hematological parameters. RBC counts increased in all treated groups compared with controls, with the highest values observed in the ZnO NP group during acute exposure and in the PSS group during subchronic exposure. Mean corpuscular volume (MCV) decreased in all experimental groups, indicating a tendency toward microcytosis. RDW-CV and RDW-SD remained below control values, suggesting reduced variability in erythrocyte size. During subchronic exposure, platelet count (PLT), plateletcrit (PCT), mean platelet volume (MPV), and platelet large cell ratio (P-LCR) increased, particularly in the PSS and ZnO NP groups, indicating enhanced thrombopoiesis and platelet activation. **Conclusions.** ZnO nanoparticles and PSS induce adaptive remodeling of erythrocyte and platelet compartments. Combined exposure produced the most pronounced hematological changes, suggesting potential synergistic interactions between these environmental contaminants.

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Effects of Zinc Oxide Nanoparticles, Polysaccharide, and Their Combination on Leukocyte and Lymphocyte Parameters in Rats under Acute and Chronic Experimental Conditions

Introduction. Zinc oxide nanoparticles (ZnO NPs) are widely used in science, medicine, and industry. Due to their selective toxicity and increasing industrial application, investigation of their toxic effects is essential because of the associated risks of environmental contamination and human exposure. **Objective.** To evaluate the effects of ZnO nanoparticles, polysaccharide (PSS), and their combination on leukocyte and lymphocyte morphology and counts in rats under acute and chronic experimental conditions. **Materials and Methods.** Forty-eight male Wistar rats (90-120 g) were randomly assigned to acute and chronic exposure groups. Each group comprised four subgroups ($n = 6$): control, PSS, ZnO NPs, and ZnO NPs + PSS. Test substances were administered orally as powders mixed with feed. Acute exposure consisted of a single dose of 2000 mg/kg followed by a 14-day observation period, whereas chronic exposure involved daily administration of 250 mg/kg for 14 days. Hematological evaluation included analysis of leukocyte and lymphocyte parameters. **Results.** Exposure to ZnO NPs, PSS, and their combination induced significant changes in the leukocyte profile. Leukocytosis was observed in most animals, while marked leukocytosis in some groups indicated intoxication, acute inflammation, or extensive tissue damage. Increased lymphocyte percentages suggested enhanced immune activity. Relative lymphopenia was associated with elevated granulocyte levels, a hallmark of acute inflammatory responses. Increased absolute counts of monocytes and eosinophils indicated activation of phagocytic processes. **Conclusions.** Acute cytotoxic effects were observed in the ZnO and PSS groups, whereas the ZnO NPs + PSS combination demonstrated a protective effect. Activation of phagocytosis was also detected. Was founded 26NARD-1A005

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Morphofunctional Response of the Small Intestine to Oral Exposure to Zinc Oxide Nanoparticles in Rats

Background: Zinc oxide nanoparticles (ZnO NPs) are increasingly used in food applications, raising concerns about their effects on the gastrointestinal barrier. The small intestine is a primary site of contact with ingested nanoparticles and may be vulnerable to structural alterations. Objective: To evaluate the morphofunctional response of the small intestine to oral exposure to ZnO NPs administered alone or with PSS in Wistar rats. Materials and Methods: Forty-eight male rats (90-120 g) were divided into acute and subacute exposure cohorts. Each cohort included four groups (n = 6): control, PSS, ZnO NPs, and ZnO NPs + PSS. Test substances were mixed with powdered chow. Acute exposure consisted of a single dose of 2000 mg/kg followed by 14 days of observation, whereas subacute exposure involved daily administration of 250 mg/kg for 14 days. Small-intestinal samples were examined histologically and morphometrically. Villus architecture, epithelial integrity, enterocyte proliferation, goblet cells, lymphoid infiltration, and mast-cell activity were assessed. Results: Preliminary observations indicate exposure-dependent changes in the intestinal mucosa, including reduced enterocyte height, focal epithelial desquamation, villus deformation or fusion, and impaired epithelial renewal. Increased lymphocytic infiltration and mast-cell activation suggested a local inflammatory and adaptive response. Changes appeared more pronounced after repeated exposure and in the ZnO NPs + PSS group. Conclusions: Oral exposure to ZnO NPs may disturb intestinal epithelial homeostasis and activate local immune mechanisms. Final quantitative analysis will determine their magnitude and statistical significance. ACKNOWLEDGEMENT: This research was supported by the Armenian-Moldovan bilateral research project No. 26NARD-1A005 on nanoparticle safety.

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Study of PVDF Nanomembrane Fragmentation Under UV Radiation

Polyvinylidene fluoride (PVDF) is a polymer belonging to the fluoropolymer family. It is characterized by high thermal and chemical resistance, piezoelectric properties, and good mechanical strength. PVDF is widely used as a filtration layer in respirators. This experiment investigated the effects of ultraviolet radiation (UV) on a PVDF membrane and the formation of particles released during the degradation process. The samples were exposed to UV radiation with a wavelength of 365 nm for a duration of one week in a specially designed photoreactor. Subsequently, the PVDF membrane was characterized using an ATR-FTIR method. Particles released during the degradation process were analyzed by DLS and SEM method coupled with EDS for elemental analysis. ATR-FTIR analysis confirmed the presence of characteristic PVDF absorption bands, however, no clear evidence of material degradation was observed after one week of UV exposure. In contrast, SEM analysis revealed the presence of released particles with irregular morphology, which were likely the result of fragmentation of the PVDF membrane. Subsequent TEM analysis confirmed the SEM findings. DLS analysis showed the highest abundance of particles with an average hydrodynamic diameter of 91 nm. The results suggest that improper disposal of PVDF membrane waste may lead to the release of membrane fragments into the environment, potentially causing adverse environmental impacts.

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Differential Effects of α - and γ -Fe₂O₃ Nanoparticles on Root Growth, their Anatomical Structure, Nanoparticles Intracellular Localization, and Elemental Homeostasis in Arabidopsis Thaliana

The rapid development of technology and industry has resulted in an increasing presence of nanoparticles in the environment. While they may pose potential ecological risks, they are also widely applied in medicine as drug delivery systems and in agriculture as innovative nanofertilizers. In recent years, particular attention has been given to the use of nanomaterials to enhance plant nutrient use efficiency. Iron is an essential microelement required for proper plant growth and development, playing a crucial role in processes such as photosynthesis and cellular respiration. The aim of this study was to investigate whether iron oxide nanoparticles (in form of α - and γ -Fe₂O₃), differing in size and morphology, exhibit differences in bioavailability and interactions with plant cells. We analyzed the impact of nanoparticle type and concentration on root growth, root anatomical traits, intracellular localization of nanoparticles performed by transmission

electron microscopy and concentration of nanoparticles within roots and leaves, and the content of other microelements in plant tissues by ICP-MS measurements. The zeta potential and tendency to aggregation of α - and γ -Fe₂O₃ nanoparticles in water and MS plant culture medium were also investigated. The experiments were conducted using the model plant *Arabidopsis thaliana* in a hydroponic culture. The results contribute to a better understanding of the relationship between the physicochemical properties of α - and γ -iron oxide nanoparticles and their biological effects on plants. This knowledge is essential for environmental risk assessment and for evaluating the potential application of iron nanoparticles as advanced nanofertilizers.

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POSTER SESSION E

Advanced Methods of Preparation and Characterization of Nanomaterials

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Comparative Study of Nanoscale Kinetic Friction in Different Friction Pairs

Utilizing an atomic force microscope operated in lateral force mode, we probe dry kinetic friction across various friction pairs, including Si, Si₃N₄, and diamond tips against different types of surfaces, including: silane nanocoatings [1], single graphene oxide (SGO) [2], and thiol SAMs. We analyze friction as a function of multiple variables: velocity, load, and temperature. Our results demonstrate that the same dry friction mechanisms (adhesive friction and stick-slip) govern energy dissipation across all surface pairs. However, the dependence of friction on sliding velocity differs quantitatively among the surface pairs. Rebinding effects are observed for all systems at low loads and low sliding velocities. Increasing the normal load above 4-6 nN suppresses rebinding for velocities greater than 10 $\mu\text{m/s}$. The friction-velocity dependence is non-monotonic: the friction force initially increases with sliding velocity, consistent with stick-slip behavior, then decreases rapidly reaching a minimum, and subsequently increases again [1]. This minimum is nearly imperceptible for thiol pairs, whereas it occurs at higher velocities for SGO (200-400 $\mu\text{m/s}$) than for silane nanocoatings (200-250 $\mu\text{m/s}$). The temperature of the system modifies these trends. The friction minimum (200-400 $\mu\text{m/s}$) corresponds to the most favorable operating conditions for minimizing friction. Under these conditions and at normal loads of 4-6 nN, SGO exhibits friction forces below 0.3 nN and silane nanocoatings approximately 1 nN. Harnessing these insights may enable custom development of protective nanocoatings, effectively limiting the destructive impact of friction. ACKNOWLEDGEMENTS: This work was supported by the National Science Centre in Poland under Project No. 2020/37/B/ST8/02023. REFERENCES: [1] Weiss, M. et al., 2021, Tribology International, 162, 107133; [2] Weiss, M. et al., 2025, Tribology International, 201, 110203. Corresponding authors: marek.weiss@put.poznan.pl; arkadiusz.ptak@put.poznan.pl

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Quantum Algorithms for PDEs on IBM Hardware

Solving partial differential equations (PDEs) is central to modeling physical systems, but classical numerical methods scale poorly with problem size and dimensionality. Quantum algorithms offer potential speedups by encoding solutions in quantum states. This work implements a quantum algorithm on IBM's quantum computers and quantum computer simulators to solve different kinds of PDEs and compares it against a classical solver in terms of accuracy, convergence, and resource scaling (qubits/circuit depth vs. classical compute cost). We discuss the outlook for practical quantum advantage in scientific computing.

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Top-Down Fabrication of GaN Nanowires Using Nanosphere Lithography

Nanosphere lithography (NSL) is a versatile and well-known method, which is suitable for fabrication nanostructures over a large area. NSL is commonly used to fabricate an array of ordered triangular nanostructures, which originates from deposited metal material onto the interstices between the closely packed spheres. However, the fabrication of disk array with the same arrangement as a sphere monolayer is rarely documented. The aim of this work is to develop a reliable Top-

down approach for manufacture of the disk array and subsequential plasma etching to create gallium nitride nanowires. In this work two approaches are considered. The first approach involves deposition of metallic bilayer over the surface covered by the spheres, where one of the metal layers serves as a sacrificial layer. After spheres removal a positive sidewall from the sacrificial material is observed, which is carefully etched out. In the next step a target metal is deposited, which will create a disk of the target metal and the sacrificial layer is completely removed. Second approach utilizes deposition of a sacrificial metal layer onto the interstices between the spheres and shallow etching to create exposed area in the gallium nitride. Then the deposition of the target metal into the etched hole is performed, which will result in a disk in the same place as the original sphere in the monolayer. Residual sacrificial metal is removed, and the sample is etched in the plasma to fabricate nanowires.

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Testing the Performance of Quantum-Computing Harrow-Hassidim-Lloyd Algorithm

Solving systems of linear equations is a common problem encountered across a wide range of scientific or technical applications including computational material science. As the dimension of the system increases, classical algorithms become computationally demanding. Quantum computing introduced new possible approaches to tackle this problem, for example the Harrow-Hassidim-Lloyd (HHL) algorithm, which offers an exponential speed-up under specific assumptions, reducing the complexity to polylogarithmic with respect to the dimension of the problem. Our work provides a review of the previous applications of HHL algorithm, describing its functioning, testing its performance, and outlining its advantages and limitations. Furthermore, we discuss possible extensions of the HHL algorithm and its further fine-tuning. Finally, we demonstrate the algorithm on a simple system of linear equations using Qiskit Python package, where we compare its behavior and results. For this purpose, we use both numerical simulations and real hardware realizations on IBM quantum computers.

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Engineering Metal-Oxide Interfaces for Efficient One-Pot Upgrading of Xylose into C4/C5 Cyclic Ethers

A highly efficient one-pot chemocatalytic strategy for the direct conversion of xylose into value-added C5/C4 cyclic ethers was developed using a novel ZrO₂-modified Ni-Pd catalyst supported on H-β zeolite. The optimized catalyst, Ni₂Pd_{0.5}Zr₁/H-β(25), delivered nearly complete xylose conversion (>99%) while achieving remarkable selectivities of 48.6% toward 2-methyltetrahydrofuran (2-MTHF) and 20.2% toward tetrahydropyran (THP) under relatively mild conditions (200 °C, 1.0 MPa H₂, 2 h). Comprehensive physicochemical characterization revealed that ZrO₂ incorporation generated abundant oxygen vacancies, strengthened hydrogen activation, and enhanced metal dispersion, creating highly active multifunctional catalytic sites for sequential hydrogenation and hydrodeoxygenation. Furthermore, in situ diffuse reflectance infrared Fourier transform spectroscopy (DRIFTS) employing furfural and furfuryl alcohol as probe molecules uncovered favorable adsorption configurations and strong electronic interactions at the Ni-Pd-ZrO₂ interfaces, providing direct evidence for the origin of the enhanced catalytic performance. Time-resolved experiments and substrate-dependent investigations further unraveled the reaction network, identified the key intermediates, and clarified the synergistic roles of the metallic and acidic active sites. Notably, the catalyst exhibited outstanding structural stability and catalytic durability, maintaining high activity and selectivity over repeated recycling tests with only negligible performance loss. These findings establish a robust structure-activity relationship and offer valuable design principles for engineering multifunctional catalysts capable of the selective upgrading of renewable biomass into high-value bio-based chemicals.

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Water Interactions in Materials Modelling: Assessing Density Functionals and Machine-Learned Models

Nanoparticles possess high surface-to-volume ratio, making their properties particularly sensitive to interactions with surrounding environment. Water or hydroxyl groups are often present under experimental conditions and may influence structural stability, chemical reactivity and surface-related processes through hydrogen bonding and cooperative molecular interactions. Their reliable description is therefore essential for realistic simulations of nanoscale materials. Accurate electronic-structure methods, such as coupled-cluster approaches, can accurately describe water interactions, but their computational cost limits their application for systems containing tens or hundreds of atoms. Simulations of solid materials therefore commonly rely on more computationally affordable density-functional approximations. However, functionals used for solids may not reproduce the balance between hydrogen bonding and dispersion interactions that determines the relative stability of different water configurations. In this work, selected semilocal and dispersion-corrected density functionals commonly used in solid-state modelling are assessed using representative arrangements of H₂O molecules and hydroxyl groups. The comparison focuses on binding energies, geometries, hydrogen bonding and the relative stability of competing configurations. The results are also compared with machine-learned models. This approach allows us to evaluate whether computationally affordable functionals can reliably describe water interactions for future large-scale simulations of nanoparticles and related material systems. ACKNOWLEDGEMENTS: This work was supported by the Strategy AV21 project „The power of objects: Materiality between past and future“. The support from the Czech Academy of Sciences (the Praemium Academiae awarded to M. Friák at the Institute of Physics of Materials in Brno) is also acknowledged.

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Development of an Electrochemical Protocol for Quality Assessment of Biowaste-Derived Carbon Paste Electrodes

The demand for sustainable and cost-effective electrochemical platforms has driven the exploration of biowaste-derived carbon materials. Within the "UP-S! - Upcycling Biowaste into Nanomaterials" project realised by undergraduate students at Gdańsk Tech, carbon materials obtained from pyrolyzed agricultural and marine wastes, such as cabbage and fish scales, were utilized to fabricate carbon paste electrodes (CPEs). These electrodes are of particular interest due to their low fabrication cost, simple preparation and ease of surface modification. CPEs may find their application in water quality assessment, environmental monitoring, food safety control and point-of-care diagnostics[1]. Carbon pastes were prepared by pyrolyzing waste fish scales and cabbage, followed by ball-milling and mixing with binders including mineral oil or Nafion. This study aimed to establish a reproducible electrochemical evaluation method that can be applied to biowaste-derived CPEs. To ensure a reproducible active surface, a specific electrode preparation protocol was employed, involving surface polishing with aluminum oxide, followed by rinsing with organic solvents and ultrasonic cleaning. Cyclic Voltammetry (CV) was subsequently used to evaluate the electrochemical properties. The measurements were performed in a standard three-electrode configuration using a hexacyanoferrate redox probe, alongside a platinum counter electrode and a silver/silver chloride reference electrode. As a result, a preparation and measurement method has been established. This protocol will be further applied to systematically evaluate the prepared biowaste-derived CPEs. REFERENCES: [1]Tajik S, Beitollahi H, Nejad FG, Safaei M, Zhang K, Van Le Q, Varma RS, Jang HW, Shokouhimehr M. Developments and applications of nanomaterial-based carbon paste electrodes. RSC Adv. 2020 Jun 4;10(36):21561-21581. doi: 10.1039/d0ra03672b. PMID: 35518767; PMCID: PMC9054518. ACKNOWLEDGEMENT: The work is financially supported by the Ministry of Science and Higher Education within the project SKN/SP/658313/2026.

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Advanced Methods of Preparation and Characterization of Nanomaterials: Films / Nanolayeres / Membranes / Nanofibres / Nanocomposites

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Solvothermal Synthesis and Characterization of a Molybdenum-based Metal-Organic Coordination Material for Electrochemical Biosensing

Metal-organic coordination materials are promising electrode modifiers for electrochemical biosensing due to their tunable structure and possibility of introducing functional groups for subsequent bioconjugation. In this study, the effect of organic linker functionalization on the morphology and electrochemical properties of molybdenum-based coordination materials was investigated. Mo-H₂BDC and Mo-NH₂-BDC materials were synthesized solvothermally from sodium molybdate using terephthalic acid (H₂BDC) and 2-aminoterephthalic acid (NH₂-BDC), respectively. FTIR spectroscopy indicated coordination of carboxylate groups with molybdenum species and confirmed the presence of amino groups in Mo-NH₂-BDC. SEM analysis revealed a pronounced effect of the linker on material morphology. Mo-H₂BDC formed rod-like structures with lengths of 3-7 μm, whereas Mo-NH₂-BDC formed flower-like assemblies composed of interconnected nanoscale structures. Electrochemical characterization using a ferri/ferrocyanide redox probe showed differences in interfacial charge transfer between the two materials. Mo-NH₂-BDC exhibited charge-transfer resistance of 696-793 Ω compared with 761-937 Ω for Mo-H₂BDC, while differences in anodic peak currents were less pronounced. The results demonstrate that amino functionalization of the terephthalate linker influences the morphology and interfacial electrochemical behavior of Mo-based coordination materials. In addition, the amino groups present in Mo-NH₂-BDC provide potential sites for subsequent bioreceptor immobilization, supporting further investigation of this material as an electrode interface for electrochemical biosensing.

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Evolution of CVD strategies for Transition Metal Carbides Growth

Low dimensional transition metal carbides (TMCs) are attractive functional materials due to their high electrical conductivity, thermal stability and chemical resistance. In particular, bottom up CVD synthesis offers a route toward bare carbide structures without the surface terminations typically introduced during wet chemical synthesis of MXenes. In the current work, we present the evolution of CVD strategies for different carbide systems, from well-established Mo₂C as a reference system to other materials, such as vanadium carbide and chromium carbides. The application of Cu-assisted Mo₂C growth methods to other transition metals is not straightforward because of differences in Cu-transition metal interactions, and therefore modifications of the growth configuration are required. For vanadium, the Cu/V configuration requires particular consideration because of the high affinity of metallic vanadium toward oxygen. Similarly to other CVD-based syntheses, methane concentration and temperature strongly influence the growth process and final material morphology. Ongoing research on chromium carbides provides promising results and indicates that modification of the metal stacking configuration may be a useful strategy for extending this approach to other members of the TMC family; however, further studies are required. ACKNOWLEDGEMENTS: P. S. W. and A. G. acknowledge financial support from the National Science Centre, Poland (NCN) under the SONATA grant no. 2024/55/D/ST11/02285. A. B. and M. Z. acknowledge the European Union's Horizon Europe research and innovation programme under Grant Agreement No. 101087143 (Electron Beam Emergent Additive Manufacturing, EBEAM).

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BARRAQUE Facundo

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Integration of Exfoliated g-C₃N₄ and MOFs: Building Towards Optical and Photocatalytic Applications

For photocatalytic applications, capturing pollutants is only half the challenge; efficient platforms must also concentrate them towards accessible catalytic sites. This limitation motivates the integration of complementary materials, combining the photocatalytic activity of two-dimensional semiconductors with the porosity of metal-organic frameworks (MOF). Here, we explore the controlled integration of eg-C₃N₄ and MOF as a first step toward multifunctional, supported and film-based architectures. Bulk g-C₃N₄ was synthesized and exfoliated at 550 C and two different times (30, 60 min), followed by their characterization using N₂ adsorption to determine the surface area, which increased when extending the exfoliation time. The values found were 131 m²/g and 208 m²/g, respectively. The exfoliated g-C₃N₄ was also characterized by XRD and DLS. To optimize the integration of g-C₃N₄ with MOF, bulk and exfoliated g-C₃N₄ dispersion stability tests were conducted. The preliminary results showed that both exfoliated samples present better dispersion properties than the bulk material in DMA and DMF solvents after 3 h, while methanol (also a common solvent for MOF preparation) allows only partial dispersibility. In parallel, suitable MOF were prepared by solvothermal synthesis, characterized in terms of their surface area and selected according to their compatibility with the 2D semiconductor and potential for interfacial integration. Establishing structure-function correlations will provide design guidelines for the development of immobilized eg-C₃N₄/MOF architectures with potential applications in optical sensing and photocatalytic pollutant degradation.

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Doping With Nanodiamonds: A Universal Strategy for Enhancing the Functional Properties of Advanced Materials

Nanodiamonds (ND) combine a chemically robust sp³ carbon core with a rich, tunable surface chemistry, making them attractive not as standalone materials but as functional dopants capable of modifying the properties of already established material systems [1]. Incorporating ND into a host matrix introduces additional charge-trapping centres, surface functional groups, and structural defects that translate into measurable changes in electrical, optical, electrochemical, and surface behaviour, without requiring the redesign of the host material itself. ND doping is a universal modification strategy applicable across diverse classes of materials already used for sensing applications. Depending on the host system, ND incorporation has been shown to alter charge-transport and trap-state dynamics, shift characteristic electronic parameters, and modify surface wettability and electrochemical activity relative to undoped counterparts. Across these systems, the common denominator is that ND acts as a multifunctional dopant, broadening the operating range and application potential of materials that are already widely used, rather than introducing an entirely new material platform [2,3]. The aim is to consolidate these observations into a coherent framework describing how nanodiamond doping enhances the functional properties - electrical, optical, electrochemical, and surface-related - of diverse host materials. The novelty of this approach lies in treating ND not as a competing sensing material, but as a universal, cross-platform modifier that extends the functionality and application range of established materials. **ACKNOWLEDGEMENTS:** The work was performed in the frame of MNSW Poland Regional Excellence Initiative no. RID/SP/0048/2024/01 project. **REFERENCES:** [1] Mochalin, V.N., et al., The properties and applications of nanodiamonds. *Nature Nanotechnology*, 2012. 7(1): p. 11-23; [2] Kromka, A., et al., Nanocrystalline diamond films for sensing applications. *Physica Status Solidi (a)*, 2009. 206(9): p. 2035-2040; [3] Pleskov, Y.V., *Electrochemistry of diamond: a review*. *Russian Journal of Electrochemistry*, 2002.

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A Quantum-Mechanical Study of the Stability and Materials Properties of Zn₅Sb₄In₂

Intermetallic compounds in the Sb-Zn system exhibit excellent thermoelectric properties, which can be further improved by indium alloying. Accurately describing the underlying In-Sb-Zn ternary phase diagram using CALPHAD modelling method relies on precise input datasets of all constituent phases. Among these, Zn₅Sb₄In₂ represents the sole known ternary compound in the system. This work presents an ab initio study of the ground state of the ternary phase Zn₅Sb₄In₂. Density functional theory (DFT) was employed to evaluate the equilibrium structural parameters, along with its detailed electronic properties and formation energetics. Additionally, the thermodynamic and mechanical stability limits of the system were established. Furthermore, the dynamical stability was investigated by calculating the phonon density of states using the Phonopy package. The electronic calculations of density of states revealed a distinct energy gap at the Fermi level, indicating the semiconducting character of Zn₅Sb₄In₂. This study is a part of the project No. CZ.02.01.01/00/22_008/0004631 Materials and technologies for sustainable development within the Jan Amos Komenský Operational Program financed by the European Union and from the state budget of the Czech Republic. Computational resources were provided by the Ministry of Education, Youth and Sports of the Czech Republic under the Projects e-INFRA CZ (ID:90254) at the IT4Innovations National Supercomputing Center and e-Infrastruktura CZ (e-INFRA LM2018140) at the MetaCentrum as well as CERIT Scientific Cloud, all provided within the program Projects of Large Research, Development and Innovations Infrastructures.

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From Fish-Scale-Derived Biochar to Carbon Paste Electrodes: Theoretical Insights into Electrical Transport

Biochar is a carbon-rich material obtained through pyrolysis or carbonization of biomass, which has attracted increasing interest due to its tunable surface properties, porous structure, and potential applications in electrochemical systems. In recent years, biochar-based materials have been investigated for various electrochemical applications, including energy storage, electrochemical desalination, and sensor development. However, the properties of biochar strongly depend on the precursor material, pyrolysis conditions, and additional processing steps, which determine its structural characteristics and electrical transport behavior. [1] In this work, fish scales are considered as a biomass precursor to produce biochar intended as a conductive component of carbon paste electrodes. The structural features of the obtained carbon material are analyzed based on microscopic and spectroscopic characterization, with particular attention to morphology, particle size, and carbon structure. The influence of biomass origin, pyrolysis conditions, and particle size reduction on the expected performance of biochar-based conductive composites is discussed. A theoretical analysis of electrical transport in a biochar/paraffin composite is presented to assess the potential of fish-scale-derived biochar as a conductive component of carbon paste electrodes. The study combines structural characterization of the obtained biochar by scanning electron microscopy and Raman spectroscopy with a theoretical description of electrical transport in conductive composites. Particular attention is paid to the influence of particle morphology, characteristic particle size, and carbon structure on the expected conductive behavior of the composite. The influence of the conductive phase content on the formation of conductive pathways is also discussed within the framework of conductive composite models. The analysis aims to identify the structural and compositional factors that are expected to govern electrical transport in the composite and to provide a theoretical basis for the further development of biochar-based carbon paste electrodes. [1] Cristiane Kalinke, Paulo R. de Oliveira, Juliano A. Bonacin, Bruno C. Janegitz, Antonio S. Mangrich, Luiz H. Marcolino-Junior, Márcio F. Bergamini; State-of-the-art and perspectives in the use of biochar for electrochemical and electroanalytical applications. Green Chem. 2021; 23 (15): 5272-5301. <https://doi.org/10.1039/d1gc00843a> Acknowledgement: The work is financially supported by the

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Theoretical Investigation of the Electronic Structure and Transport Properties of Ni₂P

Nickel phosphide (Ni₂P) has attracted considerable attention as a multifunctional material for nanoelectronic and catalytic applications owing to its metallic nature and remarkable charge transport characteristics. In this work, the electronic structure and transport properties of hexagonal Ni₂P are systematically investigated using a combination of density functional theory (DFT) and the non-equilibrium Green's function (NEGF) formalism. The electronic structure calculations reveal a metallic behavior characterized by finite electronic states at the Fermi level, arising mainly from the hybridization between Ni-3d and P-3p orbitals. The calculated band structure shows three bands crossing the Fermi level, while the Fermi surface analysis highlights the contribution of these bands to the electronic conduction. To evaluate charge transport under realistic device conditions, Au/Ni₂P/Au junctions with different surface terminations were examined. The results demonstrate that phosphorus-rich (Ni₃P₂) interfaces exhibit higher transmission at the Fermi level than phosphorus-poor (Ni₃P) interfaces because of stronger orbital hybridization across the metal/semiconductor interface. The influence of phosphorus vacancies was also investigated, showing that structural defects reduce the transmission coefficient, with vacancies located inside the spacer producing a more pronounced degradation of the electrical conductance than interfacial defects. These findings establish a direct correlation between the electronic structure, surface termination, and quantum transport characteristics of Ni₂P, highlighting the importance of interface engineering and defect control for optimizing the performance of Ni₂P-based nanoelectronic devices.

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Interpretation of Complex Laurdan TRES Profiles in DPPC Model Membranes

This contribution focuses on the use of fluorescence spectroscopy for the characterization of membrane properties in liposomes prepared from dipalmitoylphosphatidylcholine (DPPC). DPPC is a well-established phospholipid frequently used as a model membrane component, either alone or in combination with other lipids, for the preparation of aqueous vesicular dispersions, including small unilamellar vesicles. Fluorescence-based methods are widely applied to monitor changes in membrane physicochemical properties induced by temperature, membrane composition, dispersion medium, or interactions with external compounds such as lipids, polymers, or biopolymers. Commonly evaluated parameters include membrane microviscosity, fluidity, polarity, and hydration. Among these, membrane hydration is particularly informative, as it reflects both the degree of probe solvation within the membrane environment and the mobility of water molecules involved in local relaxation processes, providing sensitive information on structural and dynamic changes in lipid membranes. Laurdan (1-[6-(dimethylamino)naphtalen-2-yl]dodecan-1-one) is one of the most widely used environment-sensitive fluorescent probes for lipid membrane studies. In steady-state fluorescence measurements, Laurdan emission is commonly evaluated using the generalized polarization parameter, which provides a convenient description of membrane order and hydration. However, this approach may not fully capture complex membrane responses, particularly near phase transitions. Time-resolved emission spectroscopy (TRES) extends Laurdan fluorescence analysis by following the temporal evolution of the emission spectrum during the excited-state lifetime. This approach enables evaluation of spectral relaxation amplitudes, limiting emission positions, and solvent relaxation kinetics. This poster presents the basic principles of Laurdan TRES analysis in DPPC model membranes measured at different temperatures and discusses strategies for interpreting complex time-resolved spectral profiles, particularly in the phase transition region.

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Metrology/Progress in STM/AFM Applications

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A Rigorous Framework for Traceable Indenter Geometry Calibration in Nanoindentation

Instrumented nanoindentation is a widely used technique for determining hardness and elastic modulus at the micro- and nanoscale. Its versatility has enabled applications in materials science, including thin films, polymers, and composites, as well as in fields such as biomedicine, biophysics, and cultural heritage research. The method is based on measuring load and displacement during the penetration of a diamond indenter into a material. Evaluation of mechanical properties requires the tip area function, which is defined by the indenter geometry. Since measurement accuracy strongly depends on the accuracy of the area function, indenter geometry is a major source of uncertainty, particularly at the nanoscale. Consequently, reliable tip calibration is essential for quantitative nanoindentation. Calibration of the tip area function can be performed indirectly using reference samples or directly using microscopy techniques. While the indirect approach is widely supported by instrument manufacturers, the limited availability of certified reference materials restricts traceability. Direct methods, typically based on atomic force microscopy (AFM) or confocal microscopy, determine the complete tip geometry and derive the area function from it. In addition to improving traceability, they provide important geometric parameters such as apex radius and face angles for tip quality assessment. AFM characterization of indenter tips poses specific challenges. In contrast to most samples, the tip lacks a flat reference surface, complicating data processing. Standard AFM preprocessing procedures, including line-mismatch correction, are often unsuitable, leaving only a limited set of applicable evaluation methods. Steep side slopes can affect the feedback loop and generate complex measurement errors. Because the area function is obtained by pixel counting, results are highly sensitive to data defects and global image distortions such as bow and thermal drift. Accurate characterization requires calibration of all three measurement axes, while lateral dimensions are additionally affected by tip convolution. Data-processing methods and user-defined parameters can significantly influence results. Therefore, complex evaluation workflows require rigorous uncertainty assessment and propagation. These choices should be considered part of the calibration procedure and preserved as metadata. This work presents a comprehensive framework for evaluation and uncertainty propagation. The applicability and limitations of conventional uncertainty-propagation methods are analyzed, particularly for nonlinear and complex workflows. Where required, numerical approaches such as Monte Carlo simulations and alternative sampling methods are employed. Uncertainty propagation across the entire traceability chain is also addressed, from AFM calibration to improved nanomechanical measurements, including the management of traceability-related metadata.

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Advancing Bright-Field Optical Microscopy and Slitless Spectroscopy for Single Nanoparticle Imaging and Characterization

The development of advanced optical microscopy methods for single-entity characterization is essential for the qualitative and quantitative analysis of nanomaterials with diverse optical properties.¹ Here, we present two independent optical approaches that enable the characterization of individual nanoparticles by exploiting their light absorption, scattering, or emission. The first approach extends bright-field microscopy for Evaporated Volume Analysis (EVA),² eliminating the coffee-ring effect while enabling the optical detection of 30-100 nm Ag and 50-80 nm Au nanoparticles. To support high-throughput analysis, we developed a convolutional neural network that reliably counts thousands of nanoparticles, even in the presence of background impurities. The second approach targets luminescent nanoparticles using slitless spectroscopy³ for the simultaneous acquisition of spatial and spectral information from individual ~55 nm Er-doped photon-upconversion nanoparticles. A transmission diffraction grating positioned in front of the camera facilitates slitless spectroscopy of hundreds of nanoparticles in a single measurement. Combined with automated data analysis, the method enables rapid characterization of spectral variability with single-particle resolution. Together, these methods expand the capabilities of accessible optical microscopy for the characterization of light-absorbing, scattering, and luminescent nanoparticles. They provide versatile tools for nanoparticle quality assessment and establish a foundation for future

multimodal optical studies. ACKNOWLEDGEMENTS: This work was supported by GA ČR project No. 26-22284S; institutional support RVO: 68081715. REFERENCES: 1 J. Zhou, A. I. Chizhik, S. Chu, D.-Y. Jin, Nature 2020, 579, 41-50; 2 A. Hlaváček, K. Uhrová, J. Weisová, H. Brožková, N. Pizúrová, Anal. Chem. 2025, 97, 2588-2592; 3 A. Hlaváček, K. Uhrová, J. Weisová, J. Křivánková, Anal. Chem. 2023, 95, 12256-12263.

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Optical Microscopy for Integrated Nanoparticle Counting and Slitless Single-Particle Spectroscopy

Comprehensive nanoparticle characterization relies on complementary quantitative and qualitative information describing the properties of a nanoparticle sample. Here, we present an optical microscopy platform that integrates both types of analysis within a single instrument through minimal modifications of the optical setup. Quantitative characterization is achieved by calibration-free absolute nanoparticle counting based on direct imaging of individual nanoparticles. The approach is applicable to both intrinsically luminescent nanoparticles (here photon-upconversion nanoparticles, diameter 66 nm), and intrinsically non-luminescent nanoparticles (here polystyrene nanoparticles, diameter 83 nm), following fluorescent labelling. Its performance is demonstrated by determining the average number of surface carboxyl groups on nanoparticles, providing a straightforward route to quantitative surface characterization.^{1,2} For qualitative characterization, the microscope is readily converted into a slitless spectroscopic system by inserting a diffraction grating into the detection path. This enables acquisition of emission spectra from individual luminescent nanoparticles without substantial modifications of the microscope.^{3,4} Together, absolute nanoparticle counting and single-particle spectroscopy provide complementary information on nanoparticle concentration, surface chemistry, and optical properties. The proposed workflow demonstrates how a single optical device can integrate quantitative and qualitative nanoparticle characterization, offering a versatile and efficient platform for the analysis of functional nanomaterials. ACKNOWLEDGEMENTS: This work was supported by GA ČR project No. 26-22284S; institutional support RVO: 68081715. REFERENCES: [1] H. Brožková, J. Weisová, A. Hlaváček, Langmuir. 2025, 41, 13216-13133; [2] A. Hlaváček, J. Křivánková, H. Brožková, J. Weisová, N. Pizúrová, Anal. Chem. 2022, 94, 14340-14348; [3] A. Hlaváček, K. Uhrová, J. Weisová, H. Brožková, J. Křivánková, Anal. Chem. 2023, 95, 12256-12263; [4] J. Zhou, A. I. Chizhik, S. Chu et al, Nature. 2020, 579, 41-50.

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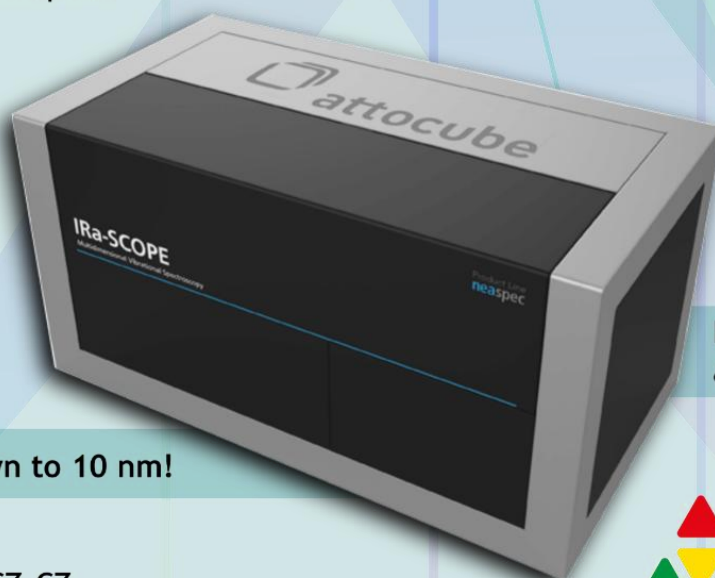
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