2025
NANOCON®

ABSTRACTS

17th International Conference on Nanomaterials - Research & Application

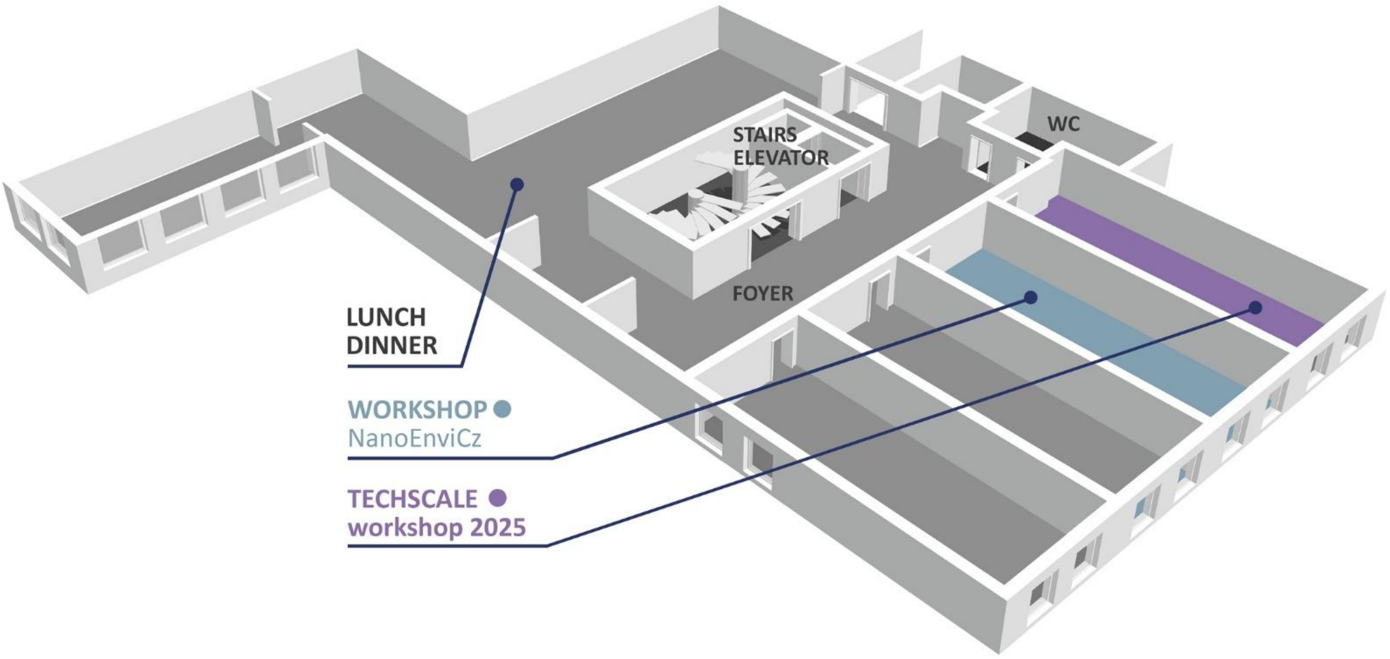
October 15 - 17, 2025
Orea Congress Hotel Brno, Czech Republic, EU

NANOCON

Tanger
RCPTM Regional Centre of Advanced Technologies and Materials
CATRIN Czech Advanced Technology and Research Institute
CSNML

FLOORPLAN

FIRST FLOOR

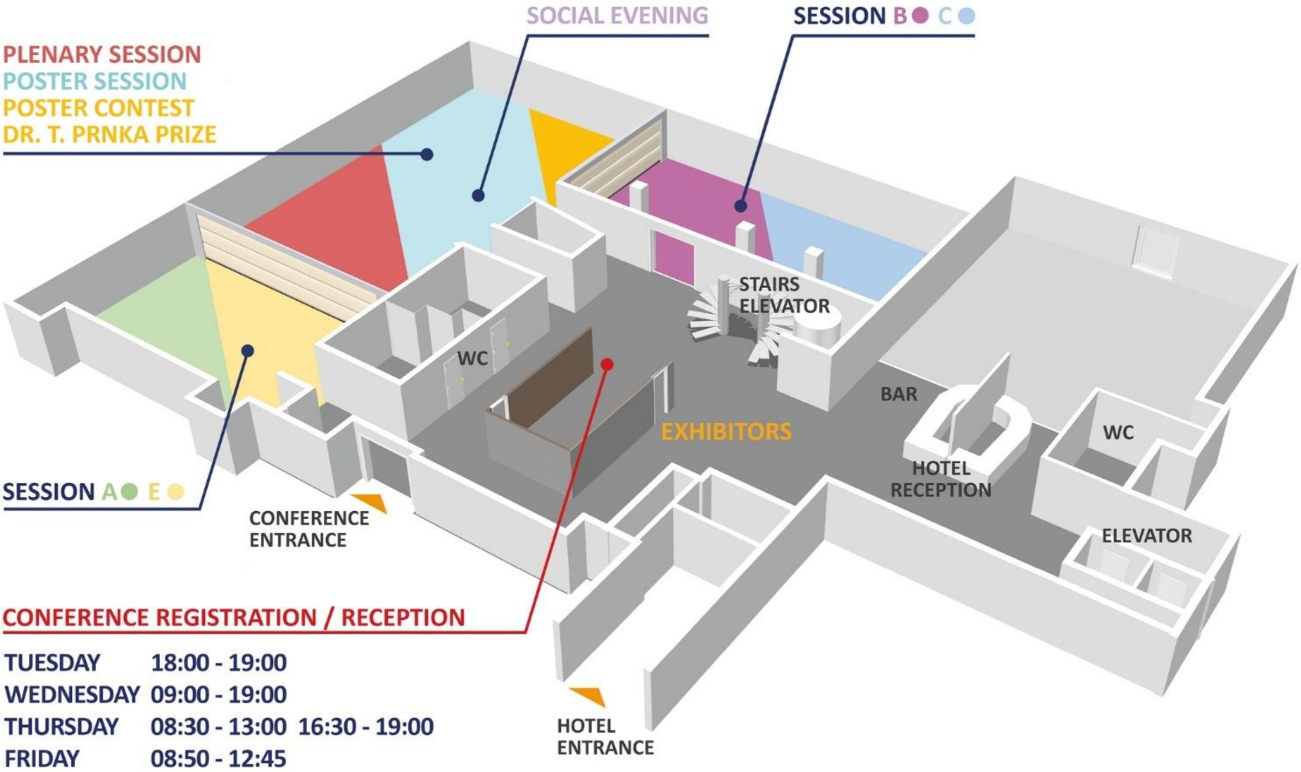


LUNCH
DINNER

WORKSHOP ●
NanoEnviCz

TECHSCALE ●
workshop 2025

GROUND FLOOR



SOCIAL EVENING

SESSION B ● C ●

PLENARY SESSION
POSTER SESSION
POSTER CONTEST
DR. T. PRNKA PRIZE

SESSION A ● E ●

CONFERENCE REGISTRATION / RECEPTION

TUESDAY	18:00 - 19:00	
WEDNESDAY	09:00 - 19:00	
THURSDAY	08:30 - 13:00	16:30 - 19:00
FRIDAY	08:50 - 12:45	

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

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NANOCON 2025 - Abstracts
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Welcome from the Chairlady

For the seventeenth time it is my great pleasure to welcome you on behalf of the organizing and program committees to the NANOCON 2025 international scientific conference. It is focused on the latest advancements, current challenges and future prospects of advanced nanomaterials and nanotechnology, which continue to revolutionize industries and our lives with its novel properties and wide-spanning applications. This three-day event, which is attended by **three hundred participants from more than thirty countries**, offers a rich blend of speeches, poster presentations, workshops, and opportunities for networking, learning and discussions.

All **three key-note speeches** prove enormous breakthroughs made during last years in nanotechnology and material science. The opening plenary talk of **Professor Jesús Santamaría Ramiro** from the University of Zaragoza and the Nanoscience and Materials Institute of Aragon (INMA) will outline novel therapeutic nanoparticles capable of fighting cancer and ways to deliver them to the tumour. The next key-note speaker - **Professor Peter Wick** from the Swiss Federal Laboratories for Materials Science and Technology – EMPA & ETH, will focus his plenary talk not only on innovating low dimensional materials and their promising potential for health applications, but also to the comprehensive assessment of their safety profiles. **Prof. Rainer Hillenbrand** from nanoscience research centre CIC nanoGUNE in San Sebastian in his plenary lecture (on Thursday, Oct. 17, 9.00-9.45) will turn our attention to scattering-type scanning near-field optical microscopy (s-SNOM) and its versatility through application examples, including nanoscale mapping of chemical composition and structural properties.

I hope that also **next 85 lectures and 150 posters** dedicated to preparation of nanoparticles, characterization of their properties, applications of nanomaterials and nanotechnology in various industries and sectors, like energy, electronics, construction, textile industries, nanomedicine or environmental protection, will attract your attention.
On Thursday Oct. 16 afternoon you are invited also to the TECHSCALE **workshop** (13.30-17.10.) and NanoEnviCz workshop (14.00-16.00).

And I believe that you will also be interested in the **offer of scientific technologies, equipment or nanomaterials** to be presented in the conference stands by several producers and suppliers.

On behalf of the organisers – the conference company Tanger and the Czech Society for New Materials and Technology and the Czech Advanced Technology and Research Institute (CATRIN)/the Palacky University Olomouc – I wish you pleasant and inspiring time spent at the NANOCON´25.

Sincerely,

Jiřina Shrbená Váňová
Chairlady of the Program Committee of NANOCON´25

CONFERENCE SCHEDULE

Time	TUESDAY, Oct 14	WEDNESDAY, October 15	THURSDAY, October 16	FRIDAY, October 17
8:00			REGISTRATION 8:30 - 13:00, 16:30 - 19:00	REGISTRATION 8:50 - 12:45
9:00		REGISTRATION 9:00 - 19:00	**PLENARY SESSION** (9:00 - 9:45) **B** (9:45 - 10:45) **C** (9:45 - 10:45)	**E** (9:00 - 10:45) **B** (9:00 - 10:45)
10:00		**CONFERENCE OPENING (10:15)** **PLENARY SESSION** (10:30 - 12:00)	COFFEE BREAK 10:45 - 11:05	COFFEE BREAK 10:45 - 11:00
11:00			**E** (11:05 - 13:05) **B** (11:05 - 13:05)	**E** (11:00 - 12:45) **B** (11:00 - 12:45)
12:00		LUNCH 11:30 - 13:30	LUNCH 12:00 - 14:00	**CONFERENCE FINAL CEREMONY** **Best Lecture Award (12:50)** LUNCH 12:00 - 14:00
13:00		**A** (13:00 - 14:45) **C** (13:00 - 14:45)	**TECHSCALE workshop 2025** (First floor) (13:30 - 17:10)	
14:00		COFFEE BREAK 14:45 - 15:05	**NanoEnviCz workshop** (First floor) (14:00 - 16:00)	
15:00		**A** (15:05 - 16:50) **C** (15:05 - 16:50)		
16:00		COFFEE BREAK 16:50 - 17:10	COFFEE BREAK 16:30 - 17:00	
17:00		**A** (17:10 - 18:55) **C** (17:10 - 18:55)	**POSTER SESSION** (17:00 - 19:00)	
18:00	REGISTRATION 18:00 - 19:00			
19:00		BREAK	**BEST POSTER CONTEST (19:00)** DINNER 19:00 - 22:00	
20:00		SOCIAL EVENING - hotel restaurant 20:00 - 23:00		

PLENARY SESSION

SESSION A

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

Preparation of Nanomaterials / 2D Materials / Nanacatalysis

Preparation of Nanomaterials / Physics of Surfaces

Preparation of Nanomaterials / Nanocomposites / Nanoenergy / Nanosensing

Preparation of Nanomaterials / Nanoelectronics / Nanoalloys

SESSION B

INDUSTRIAL AND ENVIRONMENTAL APPLICATIONS OF NANOMATERIALS

Environmental Applications

Industrial Applications

Industrial Applications / Standardization

SESSION C

BIONANOTECHNOLOGY, NANOMATERIALS IN MEDICINE

Bio Applications / Nanomedicine

Bio Applications / Biosensing

Bio Aplications / Nanotoxicity / Nanosafety

Bio Applications / Nanomedicine

SESSION E

ADVANCED METHODS OF PREPARATION AND CHARACTERIZATION OF NANOMATERIALS

Nanocharacterization - Metrology

Nanocharacterization - Technics

Nanocharacterization - Techniques

TECHSCALE WORKSHOP 2025

WORKSHOP NANOENVICZ

POSTER SESSION A

Nanocomposites

Nanoelectronics

2D Nanostructures

Films / Layers

Magnetic, Metal and Oxidic Nanomaterials & Other Nanostructures

POSTER SESSION B

Industrial Applications - Nanofibres, Thin Films, Layers, Catalysis

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

Environmental Applications

POSTER SESSION C

Nanomedicine: Diagnostics and Therapy

Nanomedicine: Diagnostics and Therapy / Drug Delivery Systems / Targeted Therapy

Nanomedicine: Biosensing

Nanomedicine: Tissue Engineering and Implants / Wound Healing

Microbiology and Others

POSTER SESSION D

Health, Toxicity, Environmental Challenges, Safety

POSTER SESSION E

Advanced Methods of Preparation and Characterization of Nanomaterials

Advanced Methods Of Preparation And Characterization Of Nanomaterials: Films / Nanolayeres / Membranes / Nanofibres / Nanocomposites

Metrology / Progress in STM / AFM Applications

PLENARY SESSION

Chairman, Chairlady

Prof. Dr. Radek ZBORIL	Palacký University in Olomouc, CATRIN-RCPTM, Czech Republic, EU
M.Sc. Jirina SHRBENA	Inova Pro Ltd., Prague, Czech Republic, EU

RAMIRO Jesús Santamaría ***University of Zaragoza, INMA, Zaragoza, Spain, EU***

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

Beyond Chemotherapy. Novel Therapeutic Nanoparticles and Ways to Deliver Them to the Tumor ***PS1***

Cancer continues to be a major health issue, with 20 million new cases diagnosed worldwide every year. In response, a wide variety of therapies have been developed, including Chemotherapy, Radiotherapy, Surgery, Immunotherapy, Precision Medicine and Hormone Therapy, among others. In spite of this, cancer continues to cause around 10 million deaths annually and this is expected to rise to 13 million by 2030. Nanomedicine was expected to change radically this scenario, and indeed hundreds of novel nanoparticles (NPs) with exciting antitumor properties have been reported. However, 30 years after the first nano-enabled drug (DoxilTM) was approved in 1995, nanomedicine has not reached its expectations, largely due to a simple fact: less than 1% of the nanoparticles injected systemically reach the tumor. This causes two main problems. First, nanomedicines not reaching the tumor cause unwanted off target effects in other organs. Second, if the dose reaching the tumor is not sufficient, cancer cells survive and treatment resistances arise, leading to failure of therapy. In our laboratory we aim to develop solutions to the above problems by i) developing catalysts and other therapeutic nanoparticles that provide new ways to fight cancer, from starvation therapy (targeting key tumor molecules such as glucose or key amino acids) to the in situ generation of toxic molecules (reactive oxygen species or prodrug activation using bio-orthogonal chemistry); and by ii) developing ways to deliver the catalyst selectively (or at least preferentially) to the tumor. This is also a formidable challenge, since current methods that rely on the EPR effect or even targeted delivery present a very low delivery efficiency. For this reason, we investigate so-called Trojan Horse delivery strategies, based on extracellular vesicles. In this talk we will present some recent developments of our laboratory1-8 that create therapeutic opportunities using NPs capable of hyperthermia or of enabling catalytic therapies. Methods to load these particles in extracellular vesicles without disrupting their membrane properties will also be discussed. REFERENCES: [1] Sancho-Albero et al. Nature Catalysis 2, 864-72, (2019); [2] Sancho-Albero et al. Nature Protocols 16, 131-63, (2021); [3] J.I. Garcia-Peiro et al. Angew. Chem. Int., e202424037, (2025); [4] J. Bonet-Aleta et al., Small, 2412355, (2025); [5] Sancho-Albero et al. J. Extracellular Vesicles 11:e12193 (2022); [6] Bonet-Aleta et al. Chemical Science, 13, 8307-20, (2022); [7] Rubio-Ruiz et al. Nano Letters, 23, 804-11, (2023); [8] Bonet-Aleta et al. Nano Letters, 24, 4091-4100, (2024).

Collaboration: ***Department of Chemical and Environmental Engineering Universidad de Zaragoza Campus Rio Ebro, Zaragoza, Spain; Networking Research Center on Bioengineering, Biomaterials and Nanomedicine (CIBER-BBN), Madrid, Spain; Instituto de Investigación Sanitaria de Aragón (IISA), Zaragoza, Spain***

WICK Peter ***Empa & ETH Zurich, St. Gallen, Switzerland***

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

Innovating Low Dimensional Materials for Health Applications: Balancing Performance and Safety ***PS2***

Two-dimensional (2D) materials have garnered significant attention since the groundbreaking isolation of gra-phene in 2004, owing to their unique physicochemical properties and broad application potential. Beyond their roles in electronics and energy storage, emerging research highlights the promising use of 2D materi-als—such as graphene, transition metal dichalcogenides (TMDs), and hexagonal boron nitride—as innovative platforms for antimicrobial and anticancer therapies. Their high surface area, tunable reactivity, and ability to interact with biological systems at the molecular level make them ideal candidates for next-generation bio-medical applications. However, the rapid development and increasing utilization of these materials call for a comprehensive as-sessment of their safety profiles, particularly in biological and environmental contexts. The Graphene Flagship project (2013-2023), played a pivotal role in evaluating the potential hazards associated with graphene-based and other 2D materials. It also addressed the structure-activity-relationship and explored green chemistry ap-proaches to ensure safe and sustainable production. This talk synthesizes key findings and insights from the Graphene Flagship and beyond, with a particular focus on the biomedical potential of 2D materials and the critical steps needed to translate their capabilities into safe, effective clinical solutions.

HILLENBRAND Rainer ***CIC nanoGUNE, San Sebastian, Spain, EU***

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

Optical Near-field Nanoscopy ***PS3***

By recording the radiation scattered by a laser-illuminated atomic force microscope tip, imaging and spectroscopy with nanoscale spatial resolution can be achieved in the broad spectral range from visible to infrared to terahertz frequencies [1]. This talk will discuss the basics of scattering-type scanning near-field optical microscopy (s-SNOM) and its versatility through application examples, including nanoscale mapping of chemical composition, structural properties, and electrical conductivity. [1] Hillenbrand, Abate, Liu, Chen, Basov, Visible-to-THz near-field nanoscopy, Nat. Rev. Matter. 10, 285 (2025)

SESSION A - E

SESSION A

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

Chairmen

Prof. Dr. Eduard HULICIUS	Institute of Physics of the CAS, Czech Republic, EU
Assoc. Prof. Dr. Martin KALBAC	J. Heyrovsky Institute of Physical Chemistry of the CAS, Czech Republic, EU

Preparation of Nanomaterials /2D Materials / Nanacatalysis

ZHOU Yazhou ***VSB - Technical University of Ostrava, Ostrava, Czech Republic, EU***

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

Single-Atom Catalysts: Unveiling Synthesis Strategies and Catalytic Potential *A1*

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 value. 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. 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.

SZROEDER Paweł ***Kazimierz Wielki University, Bydgoszcz, Poland, EU***

Acceptor and Donor-doped Carbon Nanotubes as Electrocatalysts for ORR, HER and OER *A2*

Pristine carbon nanotubes have relatively weak electrocatalytic activity. On the other hand, due to the symmetry of the π-electron bands, nanotubes can be doped either donor or acceptor to optimize the kinetics of heterogeneous electron transfer. In this report, we focus on analyzing the effects of acceptor (boron), donor (nitrogen) doping and covalent functionalization of nanotubes with -OH group on the electrocatalysis of cathodic oxygen reduction (ORR) and hydrogen evolution reaction (HER), as well as anodic oxygen evolution reaction (OER). Simulations based on the Gerischer-Marcus model show that acceptor doping shifts the onset of ORR and HER reactions to more negative potentials. At the same time, acceptor doping contributes to increasing the efficiency of the anodic OER by lowering its overpotential. On the other hand, donor doping enhances the kinetics of ORR and HER, while suppressing the OER reaction. We also show that covalent functionalization with an -OH group produces an effect analogous to acceptor doping. We present experimental data obtained in alkaline media, which confirm the predictions of the Gerischer-Marcus model. The results presented outline a strategy for preparing electrode materials containing nanotubes in such applications as water splitting, fuel cells and metal-air batteries. Acknowledgments: 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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Collaboration: ***Linköping University, Laboratory of Organic Electronics, Department of Science and Technology, SE-60174 Norrköping, Sweden***

VAŠÍČEK Michal *Institute of Physics of the CAS, Praha, Czech Republic, EU*

Pathways to Enhancing Optical and Dispersive Properties of Silicon Quantum Dots via Thermal and Radical Hydrosilylation *A3*

Silicon quantum dots (SiQDs) are a promising class of nanomaterials for light-emitting devices and biomedical applications due to their low toxicity and size- and surface-tunable photoluminescence. However, developing precise protocols for their surface termination, ensuring colloidal stability and optical performance, remains challenging.(1) Typical strategies include hydrosilylation, where alkenes covalently attach to SiQD surface via high-temperature or radical initiation. These procedures are highly sensitive to factors such as SiQD quality, size, and surface oxidation, and are limited by a narrow range of usable solvents. Especially in polar, and aqueous, environments, standardized protocols are still underdeveloped.

In this work, we present an optimization study of thermal and radical hydrosilylation in SiQDs synthesized via low-pressure non-thermal plasma in three size fractions (2.5, 4.0, and 5.5 nm) to achieve size-tunable photoluminescence, enhanced photoluminescence quantum yield (PLQY) and colloidal stability in solvents of varying polarity.(2) Specifically, 1-dodecene and undecenoic acid/undecenol were chosen for non-polar and polar terminations, respectively. Reaction parameters such as temperature, duration, and mixture composition were systematically varied. Competitive PLQYs close to 20 % for both non-polar and polar environments were reached. Thus, surface modification of SiQDs critically depends on the type of ligand and requires precise reaction control, but it enables tailored optical and dispersive properties for targeted applications, particularly in polar solvents, which are crucial for many biological and energy-related uses. REFERENCES: [1] Matejka, F. et al., Scalable and Bright: Unlocking Functional Silicon Quantum Dots with Near-Unity Internal Quantum Yield through Universal Plasma-Driven Engineering, 2025, submitted; [2] Galar P., et al., Engineering the Thermal and Energy-Storage Properties in Quantum Dots Using Dominant Faceting: The Case Study of Silicon, ACS Nano 2025.

Co-authors: ***MATĚJKA Filip, GALÁŘ Pavel, KŮSOVÁ Kateřina***

LAZAR Petr *Palacký University Olomouc, CATRIN, Olomouc, Czech Republic, EU*

Solvent Controlled Generation of Spin Active Polarons in Fluorographene under UV Light Irradiation *A4*

Polarons and excitons belong to a class of extensively studied quasiparticles but their interaction with the local environment has been overlooked so far. We present an unexpected phenomenon of solvent-induced generation of polaronic spin active states in a 2D material fluorographene under UV light. Continuous wave X-band electron paramagnetic resonance (EPR) spectroscopy experiments reveal a massive increase in the EPR signal for fluorographene dispersed in acetone under UV-light irradiation, while the system did not show any significant signal in dark conditions and without the solvent. This phenomenon is solvent-specific, the generation of spin-active states is robust in acetone, moderate in benzene, and absent in cyclohexane.The patterns appear due to the generation of transient magnetic photoexcited states of a polaronic character. Our ab initio calculations demonstrate that polarons are formed at the radical sites in fluorographene and interact strongly with acetone molecules in their vicinity. The solvent-tuneable polaron formation with the use of UV light and an easily accessible 2D nanomaterial open up a wide range of future applications, ranging from molecular sensing to magneto-optical devices.

Co-authors: ***HRUBÝ Vítězslav, MEDVEĎ Miroslav, OTYEPKA Michal***

PETRÉNY Roland ***Budapest University of Technology and Economics, Budapest, Hungary, EU***

Hierarchical Carbon Fiber-carbon Nanotube Reinforcement for Tunable Rheological, Thermal, and Conductivity Properties in PA12 Additive Manufacturing Filaments *A5*

Additive manufacturing of fiber reinforced PA12 composites offers a path to lightweight, high performance components, but is often hindered by the challenging flow and thermal characteristics of PA12. During filament extrusion, precise control of diameter is achieved by stretching the still molten filament, in which melt strength is of particular importance. We demonstrated that increasing the fiber content form 10 to 20 wt% led to filament breakage due to low melt strength, unless reinforced with at least 0.5 vol% CNT. Integrating CNTs not only prevented streching-induced breakage at higher fiber content but also produced filaments with more uniform cross sections and significantly enhanced printability. The filaments reinforced with 10-20 wt% chopped carbon fiber (CF) achieved exceptional extensional alignment during extrusion—over 80 % of fibers lied within 10° of the flow direction. Introducing 0.5 vol % multi wall carbon nanotubes (CNT) further sharpened this orientation (peak at 0-5°) by increasing extensional viscosity. With this highly aligned structure, the fillers formed continuous, end to end conductive pathways that reduced inter fiber contact resistance. This was reflected in that the electrical conductivity of the CF reinforced composites increased by an order of magnitude with CNT addition. Thermomechanical analysis showed that carbon nanotubes also have a beneficial effect on dimensional stability, which is of particular importance for 3D printing: the addition of CNTs flattened the Tg and minimized both pre- and post-Tg expansion. These results highlight that multiscale reinforcement—combining chopped carbon fibers with CNTs—was key to achieving enhanced orientation, improved conductivity, and filament processability in PA12-based composites for high-performance additive manufacturing.

FATIMA Mahvish ***Qassim University, Buraidah, Saudi Arabia***

Highly Flexible Electrically Conductive Porous Electrodes Embedded With Carbon Based Fillers *A6*

Now a days studies are focused on the development of conductive polymer composites (CPCs) as well as intrinsically conductive polymers (ICPs) [1]. Certain fillers like carbon fiber, carbon black and graphite may also be added to increase the electrical conductivity of polymers [2]. However, nonflexible and rigid composites have many drawbacks such as limited deformation, brittleness, reduced comfort, limit mobility and difficulty in processing. In our study, we generated polymer aerogels with expanded graphite through freeze-drying and thermal annealing, achieving excellent electromagnetic interference shielding. We used various methods to test and characterize the porous electrode embedded with expanded graphite. A Scanning Electron Microscope (SEM) used to analyze the surface, while Energy-Dispersive X-ray (EDX) and X-ray Diffraction (XRD) determined the elemental composition. The prepared samples of composites were then characterized for the electrical conductivity, EMI shielding and mechanical performance. The conductive expanded graphites having 12% particles showed better results as compared to the others.

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Preparation of Nanomaterials / Physics of Surfaces

REZEK Bohuslav ***Czech Technical University in Prague, Prague, Czech Republic, EU***

Effect of ZnO Surfaces on Charging and Photoluminescence of CsPbBr Nanocrystals *A7*

Perovskites are optically active materials with high light-absorption coefficients, intrinsic defect tolerance, and size-tunable optoelectronic properties. Zinc oxide (ZnO) is a direct bandgap semiconductor that has gained significant importance in optical, electrical, and optoelectronic applications. Prior works indicate that increased photoluminescence yield and electron transport may be achieved when these material are merged in composite systems [Journal of Luminescence 239 (2021) 118396]. In this work, we studied the structural and electronic properties of heterostructures made of thin layers of CsPbBr3 (CPB) nanocrystals prepared from solutions on different ZnO substrates: 0001-Zn face and 0001-O face with polar surfaces, 1010 and 1120 with non-polar surfaces. The material structure was characterized by scanning electron microscopy (SEM) in the secondary (SE) and backscattered (BSE) electron mode. Nanocomposite work function (WF) and time-resolved surface photovoltage (SPV) were studied by scanning Kelvin Probe (SKP) in the dark and under a solar simulator or UV illumination. Confocal photoluminescence (PL) micro-spectroscopy was used to characterize PL emission spectra and their spatial maps. Depending on ZnO surface orientation and polarity, SEM shows cubic grains or planar nanoisland of CPB. WF of CPB in the dark also depends on type of ZnO substrate. It is correlated with PL maps and red shift in PL spectra. The PL shift may be caused by quantum confinement effects and/or change of crystalline phase in CPB nanocrystals, which is controlled by ZnO surface arrangement, chemistry, and polarity. SPV is significant under solar simulator illumination and positive for all the samples, where the least pronounced effect is from CPB on the Zn face surface. The results thus provide guidelines for hybrid nanoscintillator designs. ACKNOWLEDGEMENTS: 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 under the work package VP 27 (Renewable energy resources and distributed energy systems).

Co-authors: ***KULIČEK Jaroslav, HOSTINSKÝ Tomáš, BURYI Maksym***

Collaboration: ***Institute of Plasma Physics, Czech Academy of Sciences, Prague, Czech Republic, EU***

PŘIBYL Roman — *Institute of Scientific Instruments of the CAS, Brno, Czech Republic, EU*

Development of Thin Films for VUV Applications *A8*

Vacuum ultraviolet (VUV) light holds excellent potential for various advanced applications, including VUV lasers for atomic cooling and ultra-precise length measurements using interferometry. However, most conventional materials exhibit strong absorption in the VUV range, which limits their use in optical systems operating at these wavelengths. In this study, we investigate various fluoride-based thin films deposited via (plasma-assisted) electron-beam vacuum evaporation. These materials exhibit wide band gaps and low absorption in the VUV spectral region, making them excellent candidates for high-reflectivity and high-transparency multilayer optical coatings designed for VUV optics. The deposited thin films demonstrate surface roughness on the order of a few nanometers and exhibit short autocorrelation lengths, which are beneficial for minimizing scattering and maintaining optical performance in multilayer systems. ACKNOWLEDGMENT: This work was supported by the Technology Agency of the Czech Republic within the framework of the National Centres of Competence Programme (project No. TN02000020), and by the project Quantum Engineering and Nanotechnology (No. CZ.02.01.01/00/22_008/0004649), co-funded by the European Union and the Czech Academy of Sciences (RVO: 68081731). The CzechNanoLab project LM2023051 funded by MEYS CR is gratefully acknowledged for the financial support of the measurements at CEITEC Nano Research Infrastructure. This research was also supported by the project LM2023039 funded by MEYS CR.

Co-authors: ***FRANTA Daniel, OULEHLA Jindřich, VOHÁNKA Jiří, POKORNÝ Pavel, MIKEL Břetislav***

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Central European Institute of Technology, Brno University of Technology, Brno, Czech Republic, EU

KYLIÁN Ondřej — *Charles University, Prague, Czech Republic, EU*

Plasma-Assisted Fabrication of Porous Heterogeneous Metal/metal Oxide Coatings *A9*

Porous nanomaterials are essential for a wide range of modern technologies due to their high specific surface area. While single-material systems have been extensively studied in the past decades, bi-material nanostructures are nowadays attracting increasing interest, as these materials may offer improved performance or new functionality. This work introduces and investigates a novel and versatile strategy for the solvent-free synthesis of two-component metal/metal-oxide (Me/MeO) nanoparticle-based coatings, which combines a magnetron-based gas aggregation source for nanoparticle synthesis with conventional magnetron sputtering. Using a Ta2O5/plasmonic metal system as a model, we demonstrate that this technique can produce highly porous Me/MeO nanomaterials with various architectures tailored by the deposition protocol. First, a sequential deposition strategy enables the formation of either MeO nanoparticle films decorated with metal nanostructures or sandwich structures with alternating layers of MeO nanoparticles and plasmonic nanostructures. Alternatively, a simultaneous co-deposition process results in porous films composed of MeO nanoparticles randomly decorated with metal nanostructures. A key advantage of our method is the ability to precisely control the size/number of metal nanostructures in the coatings simply by varying the relative deposition rates of the MeO and Me components. This time- and cost-effective method provides a valuable pathway for fabricating Me/MeO nanomaterials with custom-tailored properties, paving the way for applications in advanced photocatalysis, sensing, biodetection and other emerging fields. ACKNOWLEDGEMENTS: This work was supported by the grant GAČR 25-14402L from the Grant Agency of the Czech Republic.

Co-authors: ***PAVLOVIĆ Max, HANUŠ Jan, PROCHÁZKA MArek***

PŘIKRYL Jan — *University of Pardubice, CEMNAT, Pardubice, Czech Republic, EU*

Phase Change Materials for Nanophotonics *A10*

The rapid development of artificial intelligence (AI) necessitates new demands on device engineering. Research focuses on methods to enhance hardware energy efficiency and increase computational speed. Current computational resources are far from optimal or natural for effective machine learning (ML), neural networks (NNs), and AI. Existing concepts include in-memory computing, analog computing, photonic and electro-optic computational cores, and the utilization of phase-change materials (PCMs) for synaptic weights. The application of these concepts promises increased speed, parallelism, and reduced energy consumption. Their combined use is expected to yield order-of-magnitude improvements in both aspects, resulting in positive synergy. The integration of PCM-based components potentially enables the implementation of all aforementioned concepts, individually or concurrently within a single device. Our work focused on the characterization of selected PCMs in a state close to the material's condition inside an operational component. The switching of active PCMs inside a device is achieved with a short pulse of laser light or an electrical current. It was observed that, in some cases, the properties of the thin material layer significantly differ from those of as-deposited and annealed materials. A critical question is whether and how such differences in physical properties may influence the development and design of specific photonic components. Based on the values obtained from the characterization of PCM thin films prepared via various methods, photonic components were modeled. The impact of deviations in physical properties will be discussed. ACKNOWLEDGEMENTS: This work was supported by the Czech Science Foundation (23-07574S) and the Ministry of Education, Youth, and Sports (LM2023037).

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Anodic Oxides Functionalization by In-situ Self-assembly for Defect Engineered Memristors *A11*

The behavior of anodic memristors grown on ultra-thin Hf superimposed on Ta films is studied. Concomitant anodization of these metals leads to self-assembled nanoscale oxide columns formation, through an electrical version of Rayleigh-Taylor effect. This is due to ionic currents preferring the less resistive paths, enhancing the growth of the corresponding oxide. Oxide resistivities and structures, transport numbers, Pilling-Bedworth ratios are all considered as determining factors for the anodization process of superimposed systems producing defect engineered oxides. The boundary between Hf and Ta oxides influences the conductive pathways required for the memristive effect, thus being most relevant for fabrication of highly stable and forming-free memristors. The use of superimposed films with gradient but complementary thicknesses allows investigating the ideal Hf/Ta ratios for which the best memristive behavior is obtained. Controlled O vacancies generation is a critical factor in switching uniformity and reproducibility. Therefore, oxide “fingers” formation is a promising electrochemical approach towards defect-engineered memristors. Further investigation of the composite oxide formation, particularly in Hf/Ta superimposed system, is topical. Until now, such systems were not recognized in the literature for the ReRAM applications. This is highly promising since both memory and electrical characteristics are improved by the forming-free nature of the memristors with filaments mediated by oxide nanostructuring.

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Transition-Metal-Based Electrochromic Materials: from Complex Synthesis to Functional Thin Films *A12*

Electrochromic materials are defined as substances that undergo reversibly change color under an applied voltage and are at the forefront of research in smart technologies, including energy-efficient windows[1], flexible electronics[2], and dynamic military camouflage[3]. One promising direction in this field involves the use of materials that incorporate transition metals, known for their diverse electronic properties and ability to support reversible redox processes. In this study, we present a novel class of electrochromic thin films deposited onto ITO coated electrodes. Obtained materials exhibit clear and reversible color changes in response to electrical signals, with performance characteristics that can be tuned through the selection of molecular components. The most efficient systems demonstrated fast switching behavior, strong optical contrast, and good long-term stability under repeated cycling. Electrochemical and optical measurements confirmed that the color changes arise from coupled electronic changes in both the metal centers and the surrounding molecular framework. The study highlights the potential of transition-metal complexes as versatile components in the design of durable and efficient electrochromic coatings for practical applications. REFERENCES: [1] Cannavale, Alessandro, et al. "Smart electrochromic windows to enhance building energy efficiency and visual comfort." Energies 13.6 (2020): 1449; [2] Li, Wanzhong, et al. "Progress and challenges in flexible electrochromic devices." Solar Energy Materials and Solar Cells 240 (2022): 111709; [3] Lin, Kaiwen, et al. "A multicolored polymer for dynamic military camouflage electrochromic devices." Solar Energy Materials and Solar Cells 278 (2024): 113180.

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Advanced Protective Systems Based on Natural Fibers and Nanomaterials *A13*

The pursuit of technologies aimed at protecting human life has grown substantially in response to increased exposure to a wide range of threats. Among the emerging strategies, the functionalization of natural fibers with nanomaterials (NPs) stands out as a promising approach for developing advanced fibrous structures with enhanced properties. Metal oxide NPs, in particular, are known for their ability to neutralize harmful agents while simultaneously imparting additional functionalities to fibers, all without significantly increasing their weight. Natural fibers have attracted growing interest as sustainable, biodegradable, and cost-effective alternatives to synthetic materials, due to their abundance and low environmental impact. However, a major challenge in the functionalization of textile substrates with nanomaterials lies in the weak adhesion of nanoparticles to the fiber surfaces. Therefore, effective techniques to improve nanoparticle immobilization are critically needed. Electrospinning emerges as a powerful method for this purpose. By producing fibers at the nanoscale and depositing them onto textile substrates, electrospinning not only enhances the anchoring of nanoparticles but also increases the specific surface area and filtration efficiency of the final material. In this study, various natural fibers and biopolymers were functionalized with metal oxide NPs (CaO, MgO, SiO_2, TiO_2, and CeO_2) using straightforward and environmentally friendly methods. The resulting materials were extensively characterized, and their functional properties were systematically assessed.

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Preparation of Nanomaterials / Nanocomposites /Nanoenergy / Nanosensing

STEHLÍK Štěpán ***Institute of Physics of the CAS, Prague, Czech Republic, EU***

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

Origin Matters; Fingerprints in Nanodiamonds from Different Synthetic Methods *A14*

Nanodiamonds (NDs) represent a versatile class of carbon nanomaterials whose properties are strongly determined by their synthetic origin. In this lecture, I will compare two archetypal types of nanodiamonds: detonation nanodiamonds (DNDs) and nanodiamonds obtained by high-pressure high-temperature synthesis (HPHT NDs). Despite their similar crystalline cores, their history of formation leaves distinct fingerprints in size distribution, defect structure, and ultimately in their physico-chemical behavior. A particular focus will be devoted to hydrogenated surfaces, which provide a unique platform to study fundamental differences between DNDs and HPHT NDs. Our recent results reveal that hydrogenation leads to strikingly different electronic and interfacial properties depending on the ND origin. These variations manifest in electronic properties, wettability, and adsorption characteristics, underlining the importance of the synthetic route as a hidden variable in surface-related phenomena. As a complementary topic, phonon confinement effects in ultrasmall diamond nanoparticles will be discussed, with emphasis on how vibrational spectra encode particle size and structural order. Together, these insights highlight that "origin matters": DNDs and HPHT NDs, while often treated interchangeably, represent distinct materials classes with specific opportunities for tailoring surface reactivity and functionality. Understanding and exploiting these fingerprints is essential for rational design of nanodiamond-based interfaces in sensing, biomedicine, and energy-related applications.

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Optoelectronic Properties of Mg and Zn doped CsPbBr2 On Aluminum Oxide *A15*

Two material perovskites and aluminum oxide (Al2O3) are considered for integration into a composite structure aimed at enabling efficient and ultrafast radiation conversion in scintillator detectors. Perovskites are optically active compounds known for their high light absorption, intrinsic defect tolerance, and tunable optoelectronic properties that depend on crystal size. Al2O3, a chemically stable and optically transparent ceramic, is a good electrical insulator with excellent thermal stability, making it an important material in optical, electrical, and optoelectronic applications. Previous studies have shown that using aluminum oxide as an insulating substrate in composite structures can enhance film stability, preserve photoluminescence efficiency, and facilitate charge transport by providing a smooth, inert, and non-conductive foundation [Milan Palei et al., Robust and Bright Photoluminescence from Colloidal Nanocrystal / Al_2O_3 Composite Films via ALD, arXiv:2004.11634 (2020)]. In this study, we investigate the structural and electronic characteristics of nanocomposites composed of $CsPbBr_3$ (CPB) nanocrystals deposited on Al2O3 substrate. CPB was doped by different concentrations of Mg (0.5-5 mol) and Zn (1 mol) to slow absorption of water. Structural analysis was performed using scanning electron microscopy (SEM) in both secondary electron (SE) and backscattered electron (BSE) modes. The work function (WF) and time-resolved surface and spatial-resolved photovoltage (SPV) of the nanocomposites were examined via scanning Kelvin Probe (SKP), in the dark conditions as well as under illumination with a solar simulator and UV light. Confocal photoluminescence (PL) micro-spectroscopy was employed to analyze PL emission spectra and generate spatially resolved PL maps. SEM images and PL maps revealed Mg and Zn concentration-dependent variations in CPB nanocrystal distribution, morphology, and aggregation. SEM analysis suggests that perovskite layers with higher Mg concentration are thicker than those with lower Mg content, Photoluminescence measurements showed that the highest PL intensity occurred for 1Zn:5Mg, with slight peak shifts and Kelvin probe revealed unstable, sometimes negative apparent work functions for certain Mg/Zn doping levels. These findings highlight how Zn/Mg doping and the use of a nonconductive Al_2O_3 substrate influence the optical performance, stability, and surface potential behavior of $CsPbBr_3$ nanocrystals, offering insights for optimizing perovskite-based optoelectronic devices. ACKNOWLEDGEMENTS: Authors gratefully acknowledge the financial support from the Czech Science Foundation Project No. 24-12872S and the program "Strategy AV 21" of the Czech Academy of Sciences, specifically work package VP 27 (Renewable energy resources and distributed energy systems).

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Electrostatic and Hydrophobic Contributions to Interactions Between Surfactants and Pure and Nitrogen-Doped Nanodiamonds *A17*

Nanodiamonds (NDs) are promising carbon nanomaterials for biomedical, sensing, and adsorption applications, yet their deployment is limited by a poor understanding of their adsorption and colloidal properties and stability in challenging environments. Here, we systematically investigate the interfacial interactions between four ND types—detonation nanodiamonds (DNDs, nitrogen-rich) and high-pressure high-temperature (HPHT) nanodiamonds (pure), each with positive or negative zeta potential—and a series of cationic and anionic surfactants with increasing alkyl chain length (3 to 16). Zeta potential measurements, Fourier-transform infrared (FTIR) spectroscopy, and transmission electron microscopy (TEM) were employed to monitor surface charge modulation, surfactant adsorption, and aggregation states, respectively. Our results show that ND composition and surface charge polarity strongly influence surfactant adsorption and colloidal stability of ND-surfactant complexes. Short-chain surfactants interact weakly, whereas longer-chain analogues promote stronger hydrophobic interactions and micelle-related effects, leading to pronounced modifications in zeta potential and dispersion state. Comparative analysis reveals distinct interaction pathways between DNDs and HPHT NDs, with nitrogen content contributing to differences in surfactant binding and aggregation behavior. This work establishes the combined roles of electrostatic and hydrophobic forces in governing ND-surfactant interfacial assembly. The insights provide a mechanistic basis for designing stable ND dispersions, thereby advancing their rational integration into diverse nanomaterial and biomedical applications.

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Electrochemical Synthesis, Characterization and Application of Matrixless Metal Nanoparticles *A18*

These days nanotechnology is a crucial research field for all areas of humans' activity, from medicine and cosmetology through electronics and photonics to catalysis e.g. in chemicals production, environment protection or oil industry [1]. In our research we are focused on the development of the novel route of synthesis of metal nanoparticles in aqueous systems (reffered to as matrixless nanoparticles), numerical modelling of their formation and investigation of their potential applications. Nanoparticles are generated in the process of electro-dissolution of metal electrodes in deionized water without any additives apart from dissolved atmospheric carbon dioxide which acts as a source of counterions for generated metal cations. With this approach we were able to obtain silver [2], copper and gold nanoparticles of a high stability (reaching several years in the case of AgNPs). The synthesis conditions such as duration (from several hours to days) and applied potential were strongly dependent on the chosen metal while the common factors crucial for the synthesis efficiency were: lower temperature ca. 10 - 15 °C due to higher CO2 solubility and presence of the atmospheric molecular oxygen facilitating the initialization of the electrochemical dissolution of metal electrodes. So far the colloids of silver nanoparticles have been examined as growth biostimulants for lettuce (Lactusa sativa L. var. capitata). References: 1. S. Thota, D. C. Crans; Metal nanoparticles. Synthesis and Applications in Pharmaceutical Sciences, Wiley - VCH, Germany 2018 2. M. Adamowska, et al. Molecules, 27, 2592, (2022)

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Anodic Titanium-Tungsten Memristors with Analog Volatile Switching *A19*

A titanium-tungsten (Ti-W) thin film library with a compositional spread 3-20 at.% W was fabricated utilizing a combinatorial approach and anodized to investigate volatile analog memristive switching. The combinatorial methodology allows for high-throughput screening across a wide compositional range, which is advantageous for identifying optimal alloy composition, while minimizing variability due to fabrication conditions. This is valuable for the investigation of memristive systems, where even slight compositional differences influence the device´s performance. Tested devices demonstrated consistent analog switching with stable endurance up to 10^4 cycles. HRS/LRS ratio reached values up to 10^7 in certain compositions. Furthermore, the presence of multi-level switching makes them a great candidate for high-density data storage applications. Switching behavior is uniform across the compositional range, showing analog volatile characteristics. The absence of an abrupt SET/RESET transitions suggests and interfacial switching mechanism rather than a filamentary one. Future work will focus on analyzing the structural origins of the observed behavior to optimize device performance and stability.

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POWAŁA Filip *University of Warsaw, Warsaw, Poland, EU*

Block Copolymer Thin Film Laser Annealing Aided With Machine Learning Algorithm *A19*

Block copolymer (BCP) self-assembly offers a flexible means to fabricate nanoscale patterns with potential application to photonics, electronics, and high-performance materials. Nonetheless, unambiguous, rapid, and reconfigurable management of BCP morphology remains a significant challenge due to the complex interplay between thermodynamic and kinetic factors. In this work, we describe a new platform that integrates laser-induced local thermal gradients, machine learning (ML) algorithms, and lab-on-chip microfluidics to tune BCP self-assembly under real-time conditions. Our method employs a programmable laser array to impose spatially resolved heat distributions within a microfluidic chip that is filled with solutions of BCPs. The local heat inputs are adaptively adjusted real time under feedback provided by a convolutional neural network that is trained to recognize and predict morphologies of BCPs under different conditions. The closed-loop feedback enables adaptive optimization of laser parameters to direct the process of self-assembly to desired structural end-states within minutes rather than hours. We demonstrate formation of sharp lamellar and cylindrical domains with orientation and periodicity that can be controlled, and that the system can be rendered receptive to disturbances or alterations to the pattern in-situ. The hybrid approach offers a highly flexible, scalable, and rapid method of directing BCP ordering that will allow new paths to fabricating nanostructure materials on demand.

Preparation of Nanomaterials / Nanoelectronics / Nanoalloys

MURAS Kacper *Adam Mickiewicz University, Poznań, Poland, EU*

On-substrate Polyazomethine Synthesis for High-performance Electrochromic Device *A20*

Electrochromic devices, which operate based on materials that change color in response to electrical stimuli, require active layers that are not only reliable but also simple to fabricate and easily scalable. In this study, we report a straightforward on-substrate synthesis of a poly(triphenylamino azomethine) electrochromic polymer directly on a conductive substrate (ITO). The polymer film was obtained via thermal polycondensation of two complementary monomers: an electron-rich diamine and a dialdehyde bearing electroactive triphenylamine units. Both monomers were deposited by spray coating, and the resulting “spray-and-bake” method facilitated the formation of uniform films without the need for solubilizing side chains or complex purification steps. The polymer demonstrated reversible color transitions from yellow to purple and blue upon oxidation, with coloration and bleaching times of approximately 3.3 and 1.2 seconds, respectively. These characteristics were confirmed by spectroelectrochemical analysis and cyclic voltammetry. The polymer layer was successfully integrated into a sandwich-type electrochromic device, which retained stable performance over repeated switching cycles. Importantly, the method proved scalable: devices with an area of up to 100 cm^2 exhibited similar electrochromic properties, underlining the potential of this approach for use in smart windows and display technologies. Overall, this work demonstrates that in situ polycondensation of azomethines is a viable and efficient strategy for fabricating functional, scalable electrochromic coatings with minimal processing and material waste.

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Polymerization Strategies for Naphthalene Diimide Electrochromic Systems: Electropolymerization and Photoinitiated Approaches *A21*

A novel electrochromic monomer based on a naphthalene diimide (NDI) core with polymerizable styrene pendant groups was synthesized and explored using two polymerization strategies: photopolymerization and electropolymerization. In the photopolymerization pathway, UV-induced radical polymerization produced uniform crosslinked films. These materials exhibited reversible electrochromic behavior, transitioning from transparent (monomer) or slightly yellow (polymer) to red-brown and green upon stepwise electrochemical reduction of the NDI unit to its radical anion and dianion states. An electrochromic device fabricated using the photopolymerized film demonstrated excellent cycling stability over 500 redox cycles, with switching times of 18 seconds for coloration and 6 seconds for bleaching. These results highlight the effectiveness of photopolymerized NDI-based polymers in achieving robust and responsive electrochromic performance. In parallel, electropolymerization of the same NDI-based monomer was conducted to produce redox-active films via electrochemical deposition. While both methods yielded electrochromically active materials, preliminary observations indicate notable differences in film morphology, electrochemical behavior, and switching dynamics depending on the polymerization route. This study presents a comparative approach to electrochromic material development, emphasizing how the method of polymerizationcan influence the functional properties of NDI-based systems. The findings support the versatility of the NDI scaffold and offer insights into tuning electrochromic performance via synthetic strategy.

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Optimization of Nanostructured Free-Form Optical Fibers Supporting Three Weakly-Coupled Spatial Modes Using Dense and Convolutional Neural Networks *A22*

The continuously increasing need to transfer enormous amounts of data forces scientists and engineers to constantly improve multiplexing technologies and develop new types of optical fibers. One of the promising solutions of great potential are free-form nanostructured fibers. Instead of conventional fabrication methods, such as the Modified Chemical Vapor Deposition (MCVD), one can fabricate a fiber which core consists of thousands of glass rods of nanometric diameters. Two or more types of rods are stacked in a predefined pattern and drawn to obtain a fiber of an arbitrary refractive index distribution. Therefore, one can obtain fibers of optical properties impossible to achieve using other fabrication techniques. Our project aims to determine the best possible structures of few-mode optical fibers using neural networks of different kinds. Using the Generative Inverse Design Networks (GIDNs) framework [1], we studied optimization of the three-mode fibers composed of two types of glass rods: pure SiO2 and SiO2 with 5% of GeO2. We compared the dense neural network, which usage has been reported recently [2], with a convolutional neural network, which we applied for the first time for the free-form fibers optimization. We observed that convolutional network outperformed the dense one just after first GIDNs cycle, nevertheless both managed to achieve high modes separations above 1.9•10-3. ACKNOWLEDGMENTS: This work was supported by the National Science Center, Poland [grant number MAESTRO 14, UMO-2022/46/A/ST7/00238]. REFERENCES: [1] C. Chen and G.X. Gu, Adv. Sci. 7, 1902607 (2020); [2] M. Napiorkowski et al., Eng. Appl. Artif. Intell. 133, 107955 (2024).

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Metal-Organic Framework-Based Magnetic Composite: A Multifunctional Platform for Cancer Therapy *A23*

Cancer remains one of the leading causes of death worldwide, driving the need for innovative treatment and diagnostic strategies.[1] The combination of iron oxide nanoparticles (IONPs) with metal-organic frameworks (MOFs) has emerged as a new approach for developing multifunctional platforms to overcome these limitations.[2] Among various MOFs, zeolitic imidazolate framework-8 (ZIF-8), a zinc-based MOF with a sodalite-like structure, has gained interest due to its high porosity, pH-responsiveness, degradability, and biocompatibility.[3] ZIF-8 has been widely explored for drug delivery, and its porous structure allows for high drug loading and controlled release, particularly in acidic tumour environment.[4] Incorporating IONPs into ZIF-8 to form a core-shell nanocomposite (IONPs@ZIF-8) enhances the system's functionality by integrating the magnetic properties of IONPs with the structural and chemical advantages of ZIF-8.[5] The magnetic core enables external magnetic field-guided targeting and imaging capabilities, while the ZIF-8 shell provides a protective matrix for drug encapsulation and pH-responsiveness release. In this study, we report the synthesis and characterization of IONPs@ZIF-8 composites using IONPs coated with cetyltrimethylammonium bromide (CTAB).[6] The resulting composites showed a cubic morphology of ~200 nm, and their magnetic properties were thoroughly studied by superconducting quantum interface device (SQUID), AC magnetometry, magnetic resonance imaging (MRI), and magnetic particle imaging (MPI). The results showed that the emerging porous materials preserved their magnetic heating capacity of the cores, exhibiting high specific absorption rates (SAR) under AMF, making them suitable for MHT. In addition, their magnetic relaxivity and MPI signal response demonstrated strong contrast capabilities, confirming their dual potential for MRI and MPI-based imaging. Given these multifunctional properties, the composites were subsequently investigated as magnetically responsive drug delivery systems in vitro. The ability of the aforementioned composites to enable AMF-triggered drug release was evaluated using immortalized glioblastoma cells. Using doxorubicin (Doxo) as a chemotherapeutic drug, the system demonstrated reproducibility, high-efficiency drug loading, and significantly enhanced cancer cell mortality upon AMF exposure. These findings highlight IONPs@ZIF-8 nanocomposites as a multifunctional nanoplatform combining imaging capabilities with magnetically triggered drug release. ACKNOWLEDGEMENTS: HeatNMOF | 2020 This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No. 860942. REFERENCES: [1] J. Shi, et al. Nat. Rev. Cancer, 2017, 17, 20-37; [2] R. Bian, et al. Biomater Sci 2015, 3, 1270-1278; [3] K.S. Park, et al. Proc. Natl. Acad. Scu. U S A, 2006, 103, 10186-10191; [4] C. Carrillo-Carrion, et al. Angew. Chem. 2019, 131, 7152-7156; [5] H. Gavilan, et al., Chem. Soc. Rev. 2021, 50, 11614-11667; [6] Y. Li, et al., J.Am.Chem.Soc. 2021, 143, 5182-5190.

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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, EU
Prof. Dr. Miroslav ČERNÍK	Technical University of Liberec, Czech Republic, EU
Prof. Dr. Miloslav PEKAŘ	Brno University of Technology, Czech Republic, EU
Dr. Jan MACÁK	CEITEC BUT / University of Pardubice, Czech Republic, EU

Environmental Applications

WACŁAWEK Stanisław ***Technical University of Liberec, Liberec, Czech Republic, EU***

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

Hybrid Supramolecular Nanomaterials for Selective Water Decontamination *B1*

Water contamination remains one of the most pressing global challenges of the 21st century. Despite the availability of various treatment technologies, their selectivity often falls short, leading to inefficient removal of specific pollutants. Cyclodextrins (CDs), a class of supramolecular compounds known for their unique host-guest chemistry, offer a promising solution. Their ability to selectively encapsulate target contaminants while discriminating against other water matrix constituents makes them highly attractive for advanced water treatment applications. Building on this concept, our research has explored the potential of cyclodextrin-based materials (CDMs) integrated with reactive components to develop hybrid systems capable of both selective adsorption and degradation of pollutants. In 2020, we demonstrated that β-cyclodextrin-modified nano zero-valent iron (nZVI) could selectively enhance the reductive transformation of contaminants, using 4-nitrophenol as a model compound. This study validated the hypothesis that CD-functionalized nZVI improves reaction selectivity, paving the way for further advancements. To increase the material's stability and reactivity, we subsequently designed a polymer network incorporating nZVI, which not only enhanced selectivity but also prolonged the material's lifetime. This next-generation hybrid system successfully reduced sulfamethoxazole—an antibiotic known for its persistence in aquatic environments. A detailed investigation into the reduction mechanism and the toxicity of transformation products further confirmed the material's efficacy and safety. Building upon these findings, we synthesized carboxymethyl-β-cyclodextrin-functionalized nZVI, identified as the most promising candidate for future research. This novel hybrid material exhibited exceptional selectivity and efficiency in the adsorption and removal of perfluorinated compounds, a class of highly persistent pollutants of significant environmental concern. This is the first report of low-temperature reduction of perfluorooctanoate anion by iron-based compounds. Looking ahead, our work will continue to harness the vast potential of supramolecular chemistry to design next-generation cyclodextrin-based hybrid materials. By fine-tuning host-guest interactions and incorporating reactive functionalities, we aim to develop highly selective and efficient systems for the targeted degradation of persistent organic pollutants from contaminated water sources.

DESHMUKH Megha

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

Design and Development of Metal-Based Electrocatalysts for Water splitting *B2*

Electrocatalytic water splitting offers a sustainable and efficient pathway for producing high-purity hydrogen, yet its practical implementation is often limited by the sluggish kinetics of the oxygen evolution reaction (OER). To address this challenge, the development of highly active, cost-effective, and durable electrocatalysts based on earth-abundant transition metals is essential. In this study, we present a strategy for enhancing OER performance by coordinating transition metal ions onto functionalized carbon-based nanostructures. The resulting electrocatalyst exhibits excellent OER activity in alkaline media, characterized by a low overpotential at industrially relevant current densities and a small Tafel slope—outperforming many state-of-the-art catalysts reported to date. When applied in a two-electrode water splitting system, the catalyst demonstrates outstanding long-term operational stability and low cell voltage requirements, maintaining efficient hydrogen and oxygen production over extended periods. This work highlights a promising design approach for advancing the next generation of transition metal-based electrocatalysts for scalable and sustainable water electrolysis.

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REINA Giacomo

EMPA, St. Gallen, Switzerland

Nitrogen Doped Graphene Acid as Photoactive Antiviral and Antibacterial Agent *B3*

Antibiotic resistance is a critical global health threat, with the World Health Organization warning of a looming crisis as common infections become increasingly untreatable. An estimated 4.95 million deaths annually are linked to antibiotic-resistant pathogens, and projections suggest that effective antibiotics could be exhausted by 2050. This underscores the urgent need for alternative antimicrobial strategies. This study presents a novel, metal-free, light-activated antimicrobial coating based on nitrogen-doped graphene acid (NGA), a graphene derivative with excellent chemical stability and colloidal properties. Embedded in a polyvinyl alcohol matrix cross-linked with 1,4-boronic acid, the resulting carbon-polymer composite exhibits both photothermal and photodynamic activity under near-infrared (NIR) light. Upon NIR irradiation, the coating generates localized heat and reactive oxygen species (ROS), effectively neutralizing a wide range of bacterial and viral pathogens. It shows strong efficacy against clinically relevant strains such as Staphylococcus aureus and Pseudomonas aeruginosa, while maintaining performance over multiple cycles and exhibiting no cytotoxicity to skin cells. Additional benefits include strong adhesion and wettability. Compared to existing coatings, the NGA-based system offers superior biocompatibility, reusability, and environmental safety. This is a great example of a fully metal-free, NIR-activatable antimicrobial coating with proven antibacterial and antiviral capabilities. Its potential applications span wound care, medical devices, and public health surfaces, offering a promising tool in combating antimicrobial resistance.

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University of Minho, Guimaraes, Portugal, EU

Unlocking the Potential of Electrospun Nanofibers: Advanced Biopolymeric Membranes for Biomedical and Environmental Applications *B4*

Electrospinning has emerged as a versatile and scalable technique for the fabrication of nanostructured membranes with unique morphological and functional properties. This method enables the production of micro and nanofibers membranes from a wide range of biopolymers, including polycaprolactone (PCL), polyhydroxyalkanoates (PHA), polyvinyl alcohol (PVA), chitosan, and alginate, either as single materials or blended systems. The high surface area-to-volume ratio and tunable porosity of electrospun membranes make them ideal candidates for advanced applications requiring controlled permeability, bioactivity, and mechanical performance. Functionalization strategies, such as the incorporation of nanoparticles (TiO2, MgO, ZnO), allow for enhanced antimicrobial, photocatalytic, and mechanical properties. Moreover, the encapsulation of natural extracts or photosensitisers within the fibrous matrix enables multifunctional behaviours, such as localized photodynamic therapy and controlled release of bioactive compounds. These electrospun biopolymer-based membranes have demonstrated significant potential across diverse application areas. In environmental engineering, they are being explored as high-efficiency filters for wastewater treatment and air purification systems, including protective face masks. In the biomedical field, their tunable biodegradability, non-toxicity, and capacity for bioactive loading make them suitable for wound dressings, localised drug delivery systems, hernia protection meshes, and other tissue-engineering applications. Ongoing research focuses on optimising fibre morphology, interfacial interactions with nanoparticles, and production methods, aiming to meet the demands of next-generation sustainable and multifunctional materials. Electrospinning thus stands out as a key technology for developing innovative biopolymer-based fibrous structures tailored for high-performance and eco-friendly solutions.

Collaboration: ***Centre of Textile Science and Technology - 2C2T, Portugal, EU***

USMAN Yasir ***Palacký University, Olomouc, Czech Republic, EU***

Cu nanostructures incorporated in PVDF electrospun fibers *B5*

Electrospun poly(vinylidene fluoride) (PVDF) nanofibers were functionalized with copper (Cu) nanostructures synthesized in dimethylformamide (DMF) via a reflux-assisted process. To suppress Cu nanostructure oxidation and ensure stability, 5% PVDF was introduced during the synthesis. The final spinning solutions were prepared with 13% PVDF dissolved in a mixture of DMF/acetone (1:1). As a result of this approach, controlled tuning of Cu content in the final fibers was reached. Optical characterization (UV-Vis and fluorescence) confirmed the successful formation of Cu nanostructures, while scanning electron microscopy (SEM) revealed uniform fiber morphology with improved fineness upon Cu nanostructure incorporation. Results of X-ray diffraction (XRD) gave evidence of β-phase PVDF content as well as provided peaks of crystalline Cu, suggesting nanostructure-induced nucleation. FTIR (Fourier Transform Infrared absorption) spectroscopy confirmed that β-phase proportion remained relatively unchanged. On the contrary, dielectric characterization demonstrated a significant augmentation in permittivity with Cu content increase, attributed mainly to interfacial polarization and space-charge effects. Beyond improved dielectric response, the integration of Cu nanostructures into PVDF holds strong promise for multifunctional applications, where the inherent piezoelectricity of PVDF can be exploited for biosensing and stimulation, while Cu nanostructures impart antibacterial functionality and optical sensing. Therefore, these multifunctional fibers represent a versatile platform for next-generation wearable sensors, wound-healing scaffolds, and antimicrobial piezoelectric devices.

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SOUSA Rui P. C. L. ***University of Minho, Braga, Portugal, EU***

A New Approach for Hybrid Bioresorbable Hernia Meshes: Combination of 3d Printing With Chitosan Electrospun Nanofibers *B6*

Hernia repair is one of the most common surgical procedures worldwide, with more than 20 million hernia surgeries worldwide every year. Fibrous mesh structures are used in most repair procedures, aiming to reinforce tissue and support the hernia treatment process. However, commercial hernia meshes continues to present challenges, including inflammation, infection, and poor tissue integration. The development of multifunctional, bioresorbable, and biocompatible meshes is being studied to offer new possibilities to hernia repair and to improve patient outcomes. This study explores the combination of 3D printing and electrospinning for the development of new hybrid hernia meshes. This preliminary approach combines a polylactic acid (PLA) 3D-printed architecture with an auto-adherent electrospun nanofibrous layer based on the biopolymer Chitosan (Ch). PLA was selected for its mechanical stability, biodegradability, and ease of processing, providing a robust structural scaffold suitable for preliminary approaches. Ch nanofibers offer excellent biocompatibility, antimicrobial properties, and a biomimetic interface that supports cellular adhesion and tissue integration. The hybrid architecture can balance mechanical strength and biological performance, ensuring adequate support during healing while promoting regeneration. The innovative scaffolds were characterized to evaluate their structural, thermal, and mechanical properties, besides their morphology and antibacterial activity. This dual-fabrication strategy can be a versatile platform for next-generation hernia meshes with tunable features tailored to clinical needs. Future work will involve in vitro biocompatibility and cytotoxicity evaluation, and the functionalization of the Ch formulation to further enhance regenerative performance.

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MATLAK Teresa *AGH University of Krakow, Kraków, Poland, EU*

Facile and Green Synthesis of Antibacterial Nanocolloids Involving Ag Nanoparticles, Tannic Acid and Metal Ions (Fe3+, Cu2+) ***B7***

The formation of bacterial biofilms is one of the key factor of chronic infections. Furthermore, the global crisis of antibiotic resistance requires the searching for novel alternative therapeutic approaches in this regard. Metallic nanoparticles combined with catalytically active metal ions are of particular interest, as they exhibit unique unknown effects opening up new possibilities in therapeutic applications (for example: anti-cancer, anti-oxidant and antimicrobial strategies). In this study facile and eco-friendly synthesis of Ag nanoparticles using tannic acid (TA) as reducing and stabilizing agent was carried out. Then, Fe(III) or Cu(II) ions were coordinated with TA modifying the metallic surface of the resulting nanoparticles and forming novel metal-organic hybrid nanostructures (Ag@TA_Fe(III) and Ag@TA_Cu(II), respectively). Firstly, materials were characterized in terms of their stability by UV-ViS spectroscopy, while hydrodynamic diameters, and Zeta potential was analyzed by DLS method. TEM analysis provided insights into the morphology and precise diameter of the particles. Then, antibacterial activity was tested in vitro on two selected Gram-(-) and Gram-(+) bacteria strains (E. coli, B. paramycoides). Additionally, a comparative study on the catalytic activity of the synthesized materials was carried out involving antioxidant activity and •OH generation. Presented herein preliminary results are promising and envision various potential applications in biomedical sector. However, further research is needed, in particular, in terms of more precise investigation focused on the explanation of catalytic and biological activities (i.e., redox reactivity, antibacterial mode of action, cytotoxicity in vitro and in vivo). ACKNOWLEDGEMENTS: This work was supported from the subsidy of the Ministry of Science and Higher Education for the AGH University in Kraków (Project No 16.16.160.557, B-506, Teresa Matlak) and the National Science Center project OPUS-22 (2021/43/B/ST4/02833).

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Industrial Applications

GHOSH Indrajit *VSB - Technical University of Ostrava, Ostrava, Czech Republic, EU*

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

Photoredox Catalysis with One or Two Photons & an Electron Transfer ***B8***

"Chemical synthesis with light", commonly known as photo(redox) catalysis, has experienced a resurgence in synthetic chemistry and has become a valuable tool for synthesizing high-value chemicals in both academic and industrial settings. In this lecture, I will explore the design and development of photoredox catalytic systems that efficiently harness,1 effectively transduce,2 regulate,3 or completely transfer4 the energy of visible-light photons for synthetic transformations. These systems facilitate the activation of very stable chemical bonds or the simultaneous activation of two chemical bonds for synthetic transformations, enabling, in some cases, the insertion of a heteroarene into carbon-heteroatom bonds.

Furthermore, I will discuss the applications of visible-light photoredox catalysis for general C(sp2)-(hetero)atom cross-coupling reactions involving nickel and visible light. The adaptive and dynamic nature of the catalytic system referred to as AD-HoC allows for the straightforward categorization of various classes of nucleophiles in cross-coupling reactions.5 This adaptability has been synthetically demonstrated in nine distinct bond-forming reactions, including C(sp2)-S, Se, N, P, B, O, C(sp3, sp2, sp), Si, and Cl bonds, with hundreds of synthetic examples produced under predictable reaction conditions. The catalytic reaction centre(s) and conditions differ from one another by the added nucleophile, or if required, a commercially available, inexpensive amine base. ACKNOWLEDGMENTS: Financial support from the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) under grant TRR 325-444632635 is gratefully acknowledged. REFERENCES: [1] I. Ghosh, T. Ghosh, J.I. Bardagi, B. König, Science 346 (2014) 725-728; [2] I. Ghosh, R.S. Shaikh, B. König, Angew. Chem. Int. Ed. 56 (2017) 8544-8549; [3] I. Ghosh, B. König, Angew. Chem. Int. Ed. 55 (2016) 7676-7679; [4] I. Ghosh, J. Khamrai, A. Savateev, N. Shlapakov, M. Antonietti, B. König, Science 365 (2019) 360-366; [5] I. Ghosh, N. Shlapakov, T.A. Karl, J. Düker, M. Nikitin, J.V. Burykina, V.P. Ananikov, B. König, Nature 619 (2023) 87-93.

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Effect of Size and Shape of Palladium Nanoparticles on Electrocatalytic Hydrogen Evolution Reaction *B9*

Platinum group metals such as Pt, Ru, Pd, Ir, etc., have superior performance for various catalytic applications [1]. However, due to their scarcity, efforts were being made to reduce the mass/load or even replace them with other metals. Some colloidal approaches are very suitable for the synthesis of noble metals in various sizes and shapes [2]. Using polar protic media, e.g. alcohols, ammonia, or water, it is possible to develop a direct micelle approach to produce Pd nanoparticles (NPs) located inside the micelles, that is, surrounded by hydrophobic parts of surfactant. The Pd growth is controlled by a stabilizer through its chemical adsorption to hydrophobic metallic surface [3]. In this case, the morphology of the Pd NPs can be controlled with greater freedom [4,5], making this technique particularly promising. Using a direct micelle approach, nanoclusters of Pd can grow into Pd NPs with a certain shape by controlling the relative growth rates of different facets. The overall redistribution of the growth kinetics of different facets can be altered by the change in the surface energy of a certain facet. The free energy of a facet can be affected through the selective chemical adsorption between the metallic surface and negatively charged species (so-called “capping agent”). Thus, the final shape of Pd NP is determined by the facet on which crystal growth has the lowest rate. Pd NPs can be used as a model system to study the interactions between H2 and specific Pd surfaces [6]. Electrochemical means have been demonstrated to be one of the best options to study these interplays, however for electrocatalytic applications, it is important to choose the right substrates. Carbon papers and titania nanotube layers decorated with noble metals including Pd proved to be highly efficient in electrocatalysis [7,8]. In the present work Pd NPs were uniformly loaded on Vulcan carbon powder (~20wt.%) for the electrochemical hydrogen cycling. By post-mortem characterizations it was revealed that their shape and size remained very stable after all electrochemical experiments. Pd NPs with sizes ranging from 15 to 34 nm and shape of nanocubes (NCs) were synthesized by a direct micelle approach. They were characterized in detail by a whole range of analytical techniques [9]. Hydrogen sorption capacity in the Pd NCs, with the H:Pd molar ratio increasing from 0.55 to 0.68 as the particles size increased from 5 to 20 nm [10]. A range of Pd nanoobjects in the form of regular NCs, concave NCs and octahedrons with average size of approximately 19 nm were synthesized too [11]. Their interactions with H atoms were investigated via electrochemical means to quantify the H absorption properties and the HER/HOR kinetics dependency on the particle size and shape. Our findings not only provide an effective approach to understanding the catalytic performance of Pd NPs but also demonstrate their great future potential in large-scale clean H2 generation technologies. REFERENCES: [1] Huang, Z. F. et al. Adv. Energy Mat. 7 (2017) 1700544; [2] Semagina, N., et al., App. Catal. A: General, 280 (2005) 141-147; [3] Saldan, I., et al. J Mat. Sci. 50 (2015) 2337; [4] Lim, B., et al. Adv. Funct. Mater. 19 (2009) 189; [5] Zhang, H., et al. Acc. Chem. Res. 46 (2013) 1783; [6] Li, G., et al. Nature Mat. 13 (2014) 802; [7] Bawab, B. & Macak, J. M., et al., Electrochim. Acta 429 (2022) 141044; [8] Bawab, B. & Macak, J. M., et al., Chem. Eng. Journal 482 (2024) 148959; [9] Saldan, I., Moumaneix, L., Umer, M., et al. Small 19 (2025) 2408788; [10] Viola, A., Saldan, I., Ngoipala, A. et al. In preparation; [11] Saldan, I., Schott, C., Gubanova, E., et al. In preparation.

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Nickel-Catalyzed Reductive Hydrolysis of Nitriles to Alcohols *B10*

Nitriles are an abundant class of compounds that are widely used as versatile feedstocks to produce various chemicals including pharmaceuticals, and agrochemicals as well as materials. We report Ni-catalyzed reductive hydrolysis of nitriles to alcohols in the presence of molecular hydrogen. This conversion likely occurs in a domino reaction sequence that first involves the hydrogenation of nitrile to primary imine, then the hydrolysis of imine, and subsequent deamination to the aldehyde, which is finally hydrogenated to the desired alcohol. Crucial for this reductive hydrolysis process is the commercially available triphos-ligated Ni-complex that enables highly efficient and selective transformation of aromatic, heterocyclic, and aliphatic nitriles including fatty nitriles to prepare functionalized primary alcohols. Further, the synthetic applicability of this Ni-based protocol is presented for the selective conversion of nitrile to alcoholic group in structurally diverse and complex drug molecules as well as agrochemicals. The resulting products, alcohols are indispensable chemicals commonly used in organic synthesis and life sciences as well as material and energy technologies.

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Iron Single-Atom Catalyst on Nitrogen-Doped Graphene Acid: Unlocking a Green Route from HMF to DFF *B11*

The sustainable conversion of biomass-derived platform chemicals into high-value products is a key challenge in green chemistry and an essential component of a circular economy. 5-Hydroxymethylfurfural (HMF) is a versatile biobased intermediate that can be selectively oxidized to 2,5-diformylfuran (DFF), a valuable precursor for bioplastics, pharmaceuticals, and fine chemicals. Achieving high selectivity and efficiency in HMF oxidation using non-noble metal catalysts remains challenging. In this work, we report an iron-based single-atom catalyst supported on nitrogen-doped graphene acid (FeNGA) that mimics enzyme-like behavior to enable highly efficient and selective HMF oxidation under mild conditions. FeNGA was synthesized via fluorographite exfoliation, nitrogen doping, oxidation, and Fe(III) coordination, and characterized using X-ray absorption spectroscopy, X-ray photoelectron spectroscopy, and electron microscopy to confirm atomic dispersion and iron oxidation states. The catalyst achieved complete HMF conversion with approximately 93% selectivity toward DFF. Mechanistic studies reveal a redox cycling pathway involving Fe^{3+}/Fe^{2+} species, which synergistically interact with the nitrogen-doped graphene acid support to stabilize active sites and promote efficient oxygen activation. FeNGA exhibits superior turnover frequency compared to previously reported non-noble metal catalysts and maintains excellent reusability over multiple cycles without aggregation or deactivation. These results demonstrate that FeNGA is a highly promising candidate for sustainable, large-scale biomass valorization, offering an effective strategy for the green production of biobased chemicals.

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COSTA Sofia *University of Minho, Portugal, Portugal, EU*

Algae-inspired Nanofibers: Electrospinning of Seaweed Compounds for Advanced Fibrous Structures *B12*

Electrospinning has attracted increasing attention due to their exceptional versatility, performance, customization and scalability, offering great potential for various areas. Those include biomedical sector, personal protective equipment, food packaging, environmental applications, among others. Electrospun membranes exhibit outstanding characteristics, like large surface area-to-volume ratio, high porosity with interconnectivity, flexibility, ability to incorporate and release several bioactive agents, vast surface functionalization, biocompatibility, and biodegradability, which makes electrospinning a powerful technology for the development of the next-generation materials for several industrial domains. More than ever, the search for sustainable materials to produce micro- and nanofiber membranes is a priority across academic research and industry. In this context, seaweed stands out as a renewable source of several biopolymers (alginate, carrageenan, etc) and bioactive compounds with distinct functionalities. Aligned with this, the atypical proliferation and accumulation of some marine seaweed species in coastal areas represents a threat for both ecosystems and humans. Since this biomass is discarded in landfills or left to accumulate on beaches, valorisation strategies of these algae wastes should be a priority instead of its disposal, following the circular economy concept. Therefore, this work aimed to use four brown macroalgae species harvested from various locations in Portugal, Laminaria ochroleuca, Sargassum muticum, Saccorhiza polyschides and Rugulopteryx okamurae, to extract sodium alginate (SA), using sustainable methodologies. The species with the highest extraction yield was selected for the extraction of bioactive compounds. Finally, electrospun nanofibers were produced using the extracted SA blended with PVA, and functionalized with the extracted bioactive compounds to develop bioactive membranes.

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ARUMUGAM Veerakumar ***Nanyang Technological University, Singapore, Singapore***

Exploring PCM-Filled Core-Sheath Fibers for Winter Clothing and Optimizing their Mass Percentage for Thermal Regulation *B13*

Dynamic heat storage and release in clothing is essential for maintaining thermal balance and ensuring the comfort, safety, and well-being of individuals in various environmental conditions. By effectively managing heat transfer between the body and the environment, clothing helps support the body's natural thermoregulatory mechanisms and enhances overall comfort and performance. Hence, this study aims to investigate how Phase Change Material (PCM) filled core-sheath staple fibers in ring-spun polyester yarn influences thermoregulation and heat storing properties of the resulting fabric. This study also involves investigating various levels of PCM staple fibers mass percentage (5%, 10%, 15% and 30%) within the fabric to determine the optimal amount that maximizes fabric's ability to regulate body temperature by absorbing, storing, and releasing heat as needed. The results show that fabrics contain fibers filled with PCM exhibits altered temperature profiles compared to fabrics without PCM, with potential delays in both heating and cooling phases due to the absorption and release of heat by the PCM materials. The findings show that the addition of PCM fibers to some extent up to15% to the fabric leads to a progressive decrease in the rate of heat absorption and release and temperature rise or reduction. Fabric with 15% PCM fibers content exhibits several desirable thermal properties including lowest thermal conductivity, highest thermal resistance, thermal effusivity and Far Infrared (FIR) Emissivity among all other fabrics. Fabric with 15% PCM fiber content yields a higher output than fabric with 30% PCM fiber content, despite having lower PCM content. In addition, the fabric results were validated by developing composite plates with different concentrations of PCM-filled staple fibers. Like fabric, composites with 15% PCM-filled staple fibers exhibited the lowest rate of heat absorption and heat loss, making them ideal for cold environments. Overall, this study has the potential to advance our knowledge of thermal regulation in winter clothing, leading to the development of next-generation fabrics with improved performance, comfort, and sustainability.

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Industrial Applications/Standardization

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

Commercialising Advanced Materials - Lessons Learned on Commercialising Nanomaterials *B14*

For nearly two decades nanomaterials were viewed as the top end of innovation and investment. In the early days of nanotechnology development we have seen billions invested by companies and governments alike. The nature of investing into and commercialising of a horizontal technology made us face some difficulties as well as opened up some amazing avenues for development. Newly coined term “advanced materials” is now growing in use and is following the footsteps of nanomaterials - or does it? We examine a wealth of knowledge in the field of commercialisation of nanomaterials and advanced materials.

ŽENKA Jan ***University of Ostrava, Ostrava, Czech Republic, EU***

Barriers in Industrial Application of Nanotechnologies at Firm Level *B15*

Drawing on the canonical TAM-TOE (Technology Acceptance Model-Technology Organization Environment) framework of technology adoption, we aim to propose a comprehensive list of factors affecting nanotechnologies acceptance and industrial application at firm level. Despite substantial existing conceptualization and empirical evidence on intra-firm factors of technology acceptance, two groups of antecendent factors are underexplored: i. individual-level sociodemographic, contextual and socio-cultural factors that affect decisions of particular managers and ii. regional-level factors, including the technological, organizational and geographic proximity that constrain and enable various paths of industrial path development and also dominant barriers of innovation collaboration at regional level. Individual, firm and regional level factors will be integrated into a single explanatory framework of nanotechnologies industrial application.

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Thermal and Rheological Characterisation of PLA Composites Containing Lignocellulosic Additives *B16*

This study examines the rheological and thermal properties of polylactic acid (PLA)-based biocomposites reinforced with three types of lignocellulosic fillers: bamboo, pine, and cork. Pure PLA was tested as a reference. The filaments underwent a standardised preparation process involving grinding into granules, drying to remove moisture, remelting, and then being injection moulded into uniform, disc-shaped specimens. The study primarily focused on evaluating melt-state rheological behaviour using a rotational rheometer at 210 °C. Frequency sweeps were performed to determine key viscoelastic parameters, such as storage modulus, complex viscosity, and phase angle. To gain further insight into molecular organisation and filler-matrix interactions, the data were analysed using Cole-Cole and van Gurp-Palmen diagrams. These graphical tools enabled the identification of relaxation dynamics, network formation, and compatibility effects induced by different fillers. Complementary thermal analysis techniques were employed to evaluate thermal transitions and decomposition behaviour, including differential scanning calorimetry and thermogravimetric analysis. The fillers were shown to influence crystallisation kinetics; pine exhibited the most pronounced nucleating effect, and cork enhanced both rheological structuring and thermal stability. Overall, these results demonstrate that the type of lignocellulosic filler plays a critical role in defining the structural and functional characteristics of the filled PLA. This work contributes developing environmentally sustainable materials for thermoplastic processing and additive manufacturing applications.

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Promising Properties of $CsPbI_3$ QDs Photovoltaics *B17*

All-inorganic cesium lead iodide ($CsPbI_3$) quantum dots (QDs) are emerging as promising candidates for high-performance photovoltaics. This is attributed to their optimal bandgap (~1.75 eV), high photoluminescence quantum yield (PLQY), intrinsic defect tolerance, solution processability, and ability to maintain the desirable black perovskite phase at room temperature. In this study, $CsPbI_3$ QDs were synthesized via the hot injection method, yielding well-dispersed nanocrystals, as confirmed by transmission electron microscopy and X-ray diffraction confirmed the single-phase character of the product and its perovskite structure. Optical characterizations, including absorption spectra, photoluminescence, and PLQY measurements, reveal strong red emission with high quantum efficiency, highlighting their potential in light-harvesting applications. Despite limited long-term stability, these initial results demonstrate the promising optoelectronic properties of $CsPbI_3$ QDs, providing a baseline for future optimization and stabilization efforts.

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SHRIVASTAV Vishal ***Palacký University Olomouc, RCPTM, CATRIN, Olomouc, Czech Republic, EU***

Conducting Metal Organic Frameworks Structures as an Anode Materials for Potassium Ion Batteries *B18*

In this work, we present a novel two-dimensional conductive metal-organic framework (MOF) as a high-performance anode material for potassium-ion batteries (PIBs). Unlike conventional bismuth-based materials such as Bi-BDC and Bi-BTC, which suffer from poor electrical conductivity and limited rate performance, Bi-HHTP leverages a π-conjugated HHTP ligand framework that provides intrinsic conductivity and structural robustness. Structural analysis confirmed the successful formation of the Bi-HHTP framework, and electrochemical testing in 4M KFSI/DME electrolyte revealed superior performance metrics. Cyclic voltammetry confirmed a reversible alloying reaction between Bi and K^+, and galvanostatic charge-discharge tests demonstrated an initial discharge capacity of 1500 mAh/g at 50 mA/g. The material retained 600 mAh/g at a high current density of 1 A/g and exhibited excellent long-term cycling stability over 1400 cycles. In contrast to bulk Bi powder, which showed rapid capacity fading, the 2D Bi-HHTP structure effectively buffered volume changes and maintained structural integrity throughout extended cycling. Our findings pave the way for the rational design of multifunctional MOFs for next-generation energy storage systems.¶

KHANDELWAL Mahima ***Palacký University Olomouc, RCPTM, CATRIN, Olomouc, Czech Republic, EU***

Interfacial Engineering of In-situ Grown 2D Layered Double Hydroxide on Functionalized Graphene for High-Performance Supercapacitor *B19*

Two-dimensional (2D) layered double hydroxides (LDH) have gained significant attention as electrode material due to their high electrochemical redox activity, high theoretical capacitance, tunable micro-structure, as their interlayer anions can adjust their layered structure and functionality through ion exchange, making them ideal for supercapacitor (SC) applications. However, their poor conductivity, and low stability results in poor rate capability, which remains a significant bottleneck for SC applications. In order to overcome these issues, we developed the strong interfacial interactions between the 2D nickel manganese LDH and functionalized graphene containing carboxylic groups (LDH-FG), taking place at the atomically thin interfaces. As a result, the 2D LDH-FG heterostructure exhibited 41 and 51 % improved capacitance compared with the pristine 2D LDH and when hybridized with non-functionalized graphene, respectively in a three-electrode open cell using 3 M KOH aqueous electrolyte. Furthermore, the assembled hybrid supercapacitor (HSC) full cell device using LDH-FG as a positive electrode and porous carbon as a negative electrode, allowed to achieve the voltage window upto 1.6 V in aqueous electrolyte. The HSC device exhibited exceptionally high gravimetric (64.7 Wh/kg at 0.5 kW/kg) and volumetric energy densities (70.7 Wh/L at 0.54 kW/L) with long term cycling stability (90% capacitance retention after 9000 cycles). The combined superior gravimetric and volumetric characteristics outperformed the state-of-the-art advanced electrode materials. These advancements in 2D LDH materials with improved structural and electrochemical properties could significantly enhance supercapacitor performance, leading to dramatic improvements in sustainable energy storage technology.

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SESSION C

BIONANOTECHNOLOGY, NANOMATERIALS IN MEDICINE

Chairmen

Prof. Dr. Anton FOJTÍK	Czech Technical University in Prague, Czech Republic, EU
Prof. Dr. Jiří HOMOLA	Institute of Photonics and Electronics of the CAS, Czech Republic, EU
Prof. Dr. Bohuslav REZEK	Czech Technical University in Prague, Czech Republic, EU

Bio Applications / Nanomedicine

GIORDANI Silvia ***Dublin City University, Dublin, Ireland, EU***

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

Engineering Carbon Nanoparticles for Biomedical Applications *C1*

Carbon nano-onions (CNOs)—multi-layered fullerenes composed of concentric sp^2-hybridized carbon shells—are emerging as promising nanocarriers for targeted drug delivery due to their cellular uptake, low toxicity, and high surface functionalization capacity. Our group has developed a reliable method for synthesizing pure, monodisperse CNOs and functionalizing their surfaces with receptor-targeting and imaging units. These modified CNOs demonstrate high photostability in aqueous media and selective uptake by cancer cells without significant cytotoxicity. We employed supramolecular functionalization using a hyaluronic acid-phospholipid (HA-DMPE) conjugate to target CD44-overexpressing cancer cells and improve nanocarrier solubility. HA-DMPE-functionalized CNOs showed enhanced cellular uptake and viability in CD44+ human breast cancer cells compared to CD44- ovarian cancer cells. In vivo zebrafish studies confirmed strong biocompatibility throughout development. We further loaded the CNOs with gemcitabine-derived prodrugs, achieving potent cytotoxic effects against pancreatic adenocarcinoma cells. In parallel, doped BN-CNOs were functionalized with HA-DMPE for pH-triggered delivery of doxorubicin (DOX). This system showed superior uptake and anticancer activity in MDA-MB-231, MDA-MB-468, and MCF-7 breast cancer cells compared to free DOX and Caelyx®, and significantly reduced cardiotoxicity in AC16 human cardiomyocytes. These results demonstrate the potential of CNO-based systems as safe, effective platforms for targeted cancer therapy and highlight their promise in advancing nanomedicine.

STRNADOVÁ Kateřina ***Technical University of Liberec, Liberec, Czech Republic, EU***

Physical Principles of Crosslinking of Water-Soluble Polymers for Tissue Engineering *C2*

The physical principles of crosslinking water-soluble polymers offer innovative pathways to creating hydrogels. Overall, hydrogels have very specific properties, that closely mimic the mechanical properties of native tissues. Moreover, the high-water content of hydrogels supports better nutrient supply, metabolites' disposal and is also beneficial for drug delivery systems. Unlike chemical crosslinking, physical crosslinking methods avoid cytotoxic reagents, enhancing biocompatibility and applicability for tissue engineering applications. It can be stated, that by physical crosslinking we produce highly pure scaffolds without any additional undesired chemicals. The polymers polyvinylalcohol (PVA) and gelatin (GEL) were chosen as representatives of water-soluble natural (GEL) and synthetic (PVA) polymers for these experiments. The polymers were electrospun by NanospiderTM and further irradiated by β-electrons (Microtron MT25, NPI CAS, doses of 50 and 100 kGy). The morphology of the fibers was evaluated prior and after irradiation by the scanning electron microcopy, followed by the stereological evaluation of the fiber diameter. The irradiated fibrous materials were further examined in the means of water-solubility and cytotoxicity according to the ISO 10993. This research contributes to the advancement of tissue engineering in the field of hydrogels, a field poised to revolutionize medical treatments by enabling the development of sustainable, biocompatible tissue replacements. ACKNOWLEDGEMENTS: This research is funded by the project SGS-2025-4519 of Technical University of Liberec.

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Coating of Metalloproteins Peptides Conjugates on Different Medical Implants to Avoid from Hospital Acquired Infections *C3*

In recent years, the incidence of postoperative infections has been increasing due to the use of artificial implants. Bacterial resistance is a challenging limitation in the treatment of infections. Thus, the development of antimicrobial implants in orthopedic with proven antimicrobial activity are developed in present research. The antibacterial activity was achieved by a novel conjugate (Silver@AMP) of Silver and antimicrobial peptides (AMP). At first green synthesis approach used to develop the Silver nanoparticles. Then, AMP were obtained from Bellamya bengalensis, a fresh water snail. Subsequently, their conjugates were prepared. The physicochemical characterization of the nanocomposites were characterize by UV-Visible spectroscopy, Zetasizer. TEM (HITACHI H-800) Fourier transmission electron microscopy (FTIR) etc. Antimicrobial assessment of MXene@AMP composite was performed by Resazurin microtitre assay method (REMA). Secondly, three implants (pure titanium, stainless steel and polyethylene) were selected to grow the biofilm on their surfaces. The coating was analyzed under confocal microscopy.

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Light-Controllable Nanozyme-Based Enzyme-Mimicking Microneedle Platform for Combating Skin Subdermal Infections and Inflammation *C4*

Over the past decades, the escalating problem of antimicrobial resistance (AMR) has kept challenging the clinical treatments for infectious diseases. The evolution of antimicrobial-resistant bacteria has limited the antibiotic options and increased the complexity in treating the infections. Nowadays, one of the main strategies in fighting AMR is to develop alternative treatments to antibiotics preventing resistance. Reactive oxygen species (ROS) based treatments, as one of the most promising antibiotic-free strategies, have gained increasing attention in the field. ROS, a class of highly reactive molecules, ideally can induce direct damage to the pathogens through lipid, protein, and/or DNA oxidation. Within this framework, nanomaterials that present catalytic activities, like naturally occurring enzymes that can mediate ROS generation and scavenging, are being explored. Here we reported three different nanoyzmes (Vanadium Carbide MXenes, Molybdenum Boride MBenes, and Borophene) synthesised with green chemistry that can mimic Peroxidase-like and/or Catalase-like activities. These enzyme-mimicking activities show their potential to be utilised for antibacterial and/or anti-inflammatory applications. Due to the high light-responsive property of nanozymes, the light enhancement can help to increase the effectiveness of nanozymes while also providing a more controllable dual- or multi-enzyme mimic activities to overcome potential resistance development. For this study, we also combined nanozymes with microneedles, aiming to provide a more precise transdermal drug delivery to treat skin subdermal infections where the antimicrobial-resistant drug usually effect. In this project, we introduced light-tunable nanozyme-based microneedles to provide a transdermal treatment that can fight the bacteria while controlling the inflammation.

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Biological Properties of $Ti_3C_2T_x$ MXenes in Advancing Targeted Photothermal Therapy for Melanoma *C5*

The biological properties of 2D nanomaterials MXenes are strongly influenced by flake size, surface functionalization, and concentration. Titanium carbide MXene ($Ti_3C_2T_x$) has high photothermal conversion and good stability in biological solutions, making it a new perspective option for biomedical applications such as photothermal therapy (PTT). Melanoma is a highly aggressive metastatic tumor that requires very precisely targeted treatment. Melanoma is a highly aggressive metastatic tumor that requires very precisely targeted treatment. For this purpose, MXene flakes as a photosensitizer can be essential. Our study systematically evaluates the relationship between MXene flake size and biological effects using a multi-assay approach for investigating cell viability, apoptosis, and proliferation, genotoxicity, and immunomodulatory potential. The study compared dose dependence (6.25, 25, and 100 µg/mL) in different coincubation times (4h, 24h, 72h). $Ti_3C_2T_x$ flakes modified with polydopamine and targeted antibodies demonstrate exceptional photothermal efficiency under NIR-I laser (808nm) irradiation. Testing various irradiation modes from 2 to 4 W and from 10 to 50 Hz, during 5 or 10 min, reveals a direct correlation between temperature increase and MXene concentration, with 50 µg/mL achieving 47.8°C - sufficient for selective melanoma cell ablation. Targeted antibody functionalization enhances specificity, minimizing off-target effects. These findings elucidate the structure-function relationships critical for optimizing MXene-based platforms, highlighting their potential for precise, safe, and effective PTT in oncology. ACKNOWLEDGEMENTS: The Latvian Council of Science (LCS) Project (Grant lzp-2024/1-0135).

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Determination of Crystalline, Rigid Amorphous, and Mobile Amorphous Fractions in Electrospun Poly(ε-Caprolactone) Nanofibers Using Modulated Differential Scanning Calorimetry *C6*

Electrospun poly(ε-caprolactone) (PCL) nanofibers are promising materials for biomedical applications due to their biocompatibility and biodegradability. PCL is a semicrystalline polymer, and its functional properties are strongly influenced by its crystalline-amorphous morphology. While the crystalline and amorphous domains are commonly distinguished, recent studies on multiphase polymers suggest that the amorphous region can be further subdivided into rigid and mobile fractions. The so-called rigid amorphous phase (RAP) is typically located near the crystallite boundaries, where chain mobility is significantly restricted, while the mobile amorphous phase (MAP) retains high segmental mobility. In this study, we applied modulated differential scanning calorimetry (MDSC) to quantify the crystalline, RAP, and MAP fractions in electrospun PCL nanofibers. Although the three-phase model is known in filled polymers, its application to nanofibrous systems has not been explored so far. Nanofibers were prepared from 16 wt% PCL solution in chloroform:ethanol (8:2 wt), and multiple MDSC runs confirmed the reproducibility of phase separation. The crystalline fraction appeared as the most dominant phase, while both amorphous fractions were also clearly distinguishable. The phase proportions exhibited only minor variation across repeated measurements, supporting the robustness and reproducibility of the method. Since degradation behavior depends strongly on amorphous mobility, this approach may aid in designing resorbable nanofibrous scaffolds with tailored properties.

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Bio Applications / Biosensing

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

Biosensors: From Glucose to Nanoworld *C7*

The traditional focus of biosensors is detection of glucose in diabetic patients. The single use devices are being replaced by continuously measuring wearable systems providing improved performance and user comfort. Our experience from monitoring glucose in sweat will be reported. However, biosensors are developed for many other analytes. One of the drivers is the detection of very low concentrations of biomarkers. In many critical situations, even a few molecules of toxins can be harmful, individual pathogenic microbes initiate infectious disease, and traces of cancer markers indicate the beginning of malignant transformation. From the suitable approaches, single-molecule immunochemical sensors and assays provide the detection of individual analyte molecules reaching the ultimate sensitivity in analytical chemistry [1]. Immunosensors are being developed to enhance the sensing capabilities, lower limits of detection and provide point-of-care mode of use with short analysis times. The promising approaches recently initiated in our laboratory include digital affinity sensing - single-molecule assays (or better single-analyte to include also viruses, bacteria and cells), combination of optical and electrochemical transduction, and inorganic nanocrystals for either luminescent labelling (quantum dots, photon up-conversion nanoparticles) or catalytic (Prussian blue nanoparticles) signal enhancement [2]. Furthermore, advanced nanotools based on scanning probe microscopies allowed us to touch and interface individual cells using nanomechanical transducers, in combination with microelectrode arrays and fluorescence [3]. This provides detailed information on the physiological state of patients-derived cells, allows to model disease progress at the cellular level and optimize personalized medication. In conclusion, the combination of biosensors with new tools and materials and tools resulting from nanobiotechnology studies allowed this field to direct new horizons. REFERENCES: [1] Farka, Z; Mickert, MJ; Pastucha, M; Mikušová, Z; Skládal, P; Gorris, HH. Advances in optical single-molecule detection: en route to supersensitive bioaffinity assays. Angew. Chem. Int. Ed. 59 (2020) 10746; [2] Farka, Z.; Juřík, T.; Kovář, D.; Trnková, L.; Skládal, P. Nanoparticle-based immunochemical biosensors and assays: Recent advances and challenges. Chem. Rev. 117 (2017), 9973; [3] Caluori, G.; Přibyl, J.; Pešl, M.; Jelínková, S.; Rotrekl, V.; Skládal, P.; Raiteri, R. Non-invasive electromechanical cell-based biosensors for improved investigation of 3D cardiac models. Biosens. Bioelectron. 124 (2019) 129.

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Fluorescence Lifetime-based Carbon Dot Nanosensor for Broad-range Intracellular pH Imaging *C8*

Accurate mapping of pH at the nanoscale with high spatial and temporal resolution is essential for understanding many physiological and pathological processes. However, current fluorescence lifetime-based pH nanosensors are often challenging to synthesize and are limited by poor biocompatibility, a narrow pH range, and stability issues. In this work, we present a simple one-step synthesis of biocompatible, water-dispersible carbon dots (CDs) from Rhodamine B, yielding a robust pH nanosensor with excellent performance. These CDs exhibit a stable, pseudo-linear fluorescence lifetime response across an exceptionally broad pH range (1-11), enabled by pH-dependent modulation of their electronic states. Using fluorescence lifetime imaging microscopy (FLIM), we demonstrate their intracellular localization to lysosomes in human skin fibroblasts and the ability to quantitatively track inhibitor-induced pH changes. This approach offers a powerful platform for real-time, calibration-free monitoring of pH dynamics in live cells, with broad potential applications in biomedical and cellular research.

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Crossbar Memsensor Based on Anodic TiO2 for Dopamine Detection *C9*

Memristors are metal/insulator/metal (MIM) devices capable of retaining and recalling their resistance through an applied electric field, allowing them to remember past memory states. This resistive switching behavior can arise from oxygen vacancy migration or interfacial effects, such as Schottky barrier modulation. TiO_2 is a common material for MIM architectures due to its wide bandgap, high dielectric constant, and natural tendency for oxygen vacancy formation. In particular, anodically grown TiO_2 layers offer self-rectifying properties, which help suppress sneak-path currents in crossbar arrays, making them attractive for sensing applications. Besides memory storage, memristors are gaining traction in neuromorphic computing, as their conductance alters in response to electrical stimuli, which closely resembles biological synaptic plasticity. This behavior enables them to process and store information analogous to the synapses in the brain. For this reason, dopamine, a key neuromodulator in biological systems, plays a crucial role in strengthening or weakening synaptic connections during learning processes. In this work, a $Ti/TiO_2/Pt$ memristive sensor was developed for the selective detection of dopamine.The device was fabricated by sputtering a Ti layer as the bottom electrode (BE), followed by anodization to form the active insulating TiO_2 layer (AIL). To complete the MIM structure a Pt top electrode (TE) was sputtered lastly. Various concentrations of dopamine solution were drop-cast directly onto the exposed oxide surface. During the electrical measurements, the BE was biased while the TE was grounded. The recorded I-U sweeps showed a dopamine concentration-dependent resistance increase, suggesting that dopamine adsorption or partial charge transfer affects the conductive pathways within the oxide layer, responsible for the resistive switching behavior. The results highlight the potential of the memsensor for neurotransmitter detection and suggest future applications in neuromorphic computing. Further surface and structural characterization are ongoing to interpret the sensing mechanism and assess the device’s stability.

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Advanced Nanoparticle-Based Labels for Sensitive Detection of Biomarkers in Lateral Flow Immunoassays *C10*

Lateral flow immunoassays (LFIAs) are widely used analytical tools that offer straightforward and cost-effective detection of clinical biomarkers. However, conventional LFIAs utilizing gold nanoparticle-based labels are often limited to qualitative results and may lack the sensitivity to detect low-abundance analytes. One strategy to overcome these limitations is to replace the labels with advanced nanomaterials. Recently, labels based on photon-upconversion nanoparticles (UCNPs) have emerged as particularly promising due to their anti-Stokes emission, reducing background interference from naturally occurring fluorophores. In this study, we developed and optimized an LFIA using a piezo-driven low-volume dispenser for precise antibody deposition. Subsequently, we evaluated the performance of five different nanoparticle-based labels: gold nanoparticles, gold nanoshells, and three types of UCNPs varying in size, dopant composition, and surface chemistry. The best-performing labels, gold nanoshells and polyacrylic acid-coated UCNPs, were then used to detect human serum albumin (HSA) and prostate-specific antigen (PSA) in spiked urine and serum, respectively. For HSA analysis in urine, the developed LFIA achieved a limit of detection (LOD) of 150 pg/mL using gold nanoshells and 63 pg/mL with polyacrylic acid-coated UCNPs. For PSA detection in serum, the LODs were 39 and 34 pg/mL for gold nanoshells and UCNPs, respectively. Nevertheless, PSA detection using UCNPs exhibited a significantly stronger correlation with the reference values (82-119% recovery), as gold nanoshells tended to aggregate in serum. These findings highlight the potential of UCNP-based labels to enhance LFIA sensitivity and enable precise quantitation of analytes in clinical diagnostics.

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Aptamer-Based Switchable Aggregates of Gold Nanoparticles for Ultrasensitive Detection of Prostate Cancer Biomarkers ***C11***

Cancer remains a leading cause of global mortality, with Prostate Cancer (PCa) ranking as the fourth most common cancer in men. Early diagnosis is one of the most important factors in determining its prognosis, and it is feasible especially for its possible recurrences. Sensitive detection of tumour-specific biomarkers, especially in liquid biopsies or directly in the bloodstream, has the potential to improve significantly our diagnostic capability. I will discuss about triggerable nanostructures based on oligonucleotides / (ultrasmall) gold nanoparticles (NPs) architectures, which selectively disassemble in the presence of the biomarker of interest thanks to an aptamer forming a section of one of the oligonucleotides, partially paired to a complementary sequence. Their optimization are based also on in-silico determination of the aptamer interactions with the protein of interest. We demonstrated this scheme for the case of Prostate Specific Membrane Antigen (PSMA), also derived from exosomes, and of Prostate Specific Antigen (PSA). We tested the disassembly of the systems by diameter and count rate measurements in dynamic light scattering (DLS), and by inspection of its plasmon resonance shift. We found appreciable differences upon addition of the recognized biomarker down to the sub-picomolar range in the first case and to the femtomolar range in the second one. I will moreover discuss the analysis of the DLS data, the electromagnetic coupling amongst the NPs, and most importantly the performed experiments and the further requirements for in-vivo diagnostic applications especially of the PSA-sensitive system, based on renal-excretable 4-nm ultrasmall NPs.

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From Atomic Design to Cellular Response: Decoding the Bioactivity of Single-Atom Nanomaterials ***C12***

Single-atom nanomaterials (SAMs) represent a new frontier in nanobiotechnology, offering atomic precision in catalytic and biomedical functionalities. In recent years, they have gained increasing attention along three rapidly expanding research axes in biomedicine: anticancer therapy, antibacterial/antimicrobial applications, and modulation of redox homeostasis in inflammatory or neurodegenerative conditions. Despite this progress, a fundamental understanding of how the atomic structure of SAMs governs biological outcomes remains largely elusive. In our work, we present a comprehensive investigation into the structure-activity relationships of atomically dispersed metals anchored on nitrogen-doped graphene acid (NGA), a highly tunable 2D platform. By controlling metal identity and coordination at the atomic level, our aim is to mechanistically dissect cellular responses—ranging from immune activation to cancer cell death and bacterial inhibition. Furthermore, given the rapid rise of SAMs in catalytic and biomedical fields, we emphasize the need for comprehensive evaluation of their biological interactions and safety profiles. Together, this work outlines a framework for guiding the rational and safe-by-design development of SAMs for future biomedical use. ACKNOWLEDGMENTS: The work is supported from European Regional Development Fund - Project “Excellence in Regenerative Medicine” (CZ.02.01.01/00/22_008/0004562) and with the financial support of the European Union under the REFRESH - Research Excellence For Region Sustainability and High-tech Industries project number CZ.10.03.01/00/22_003/0000048 via the Operational Programme Just Transition.

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Bio Aplications / Nanotoxicity / Nanosafety

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

Assessing Nanoparticle Toxicity Using In Vitro Models: Quick Methods vs. Complex Approaches *C13*

Understanding the toxicity of nanoparticles (NPs) is essential for developing safer-by-design advanced materials. Toxicity testing typically begins with cytotoxicity assays, followed by assessments of oxidative stress, genotoxicity, and inflammation; each requiring careful consideration of potential assay interference. High-throughput methods, including reporter cell lines, can offer efficient screening. We employed the ToxTracker assay, a panel of GFP-tagged reporters for key stress pathways, to evaluate the (geno)toxicity of 33 metal and metal oxide NPs, as well as quantum dots. Most NPs activated oxidative stress reporters, while fewer triggered DNA damage responses. While ToxTracker enables rapid profiling of reactive NPs, it does not capture secondary genotoxicity driven by inflammation. Co-culture models can be a solution for such assessments. Additionally, conventional submerged exposure may not reflect physiological conditions of the lung. Air-liquid interface (ALI) exposure offers a more relevant model but remains technically challenging. For long-term endpoints such as malignant transformation, extended exposure is required, followed by transformation assays to assess phenotypic changes like loss of contact inhibition and anchorage-independent growth. Omics approaches including transcriptomics, proteomics, and metabolomics provide broad mechanistic insights but generate complex datasets that may pose analytical challenges. Recently, phenomics has emerged as a complementary approach, using Cell Painting to capture high-dimensional morphological profiles via fluorescent staining of cellular compartments. This image-based method complements molecular assays and may advance nanosafety assessment.

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The Application of Antimicrobial Nanoparticles and Mesenchymal Stem Cells for Skin Wound Healing *C14*

The biological mechanisms in wounded skin after the application of mesenchymal stem cells (MSCs) and nanoparticles (NPs) (Ag, ZnO), either alone or combined, were studied in mice, with the aim of determining the optimal approach to accelerate the healing process. This combined treatment should be associated with the production of molecules supporting the healing process and antimicrobial activity. The samples were collected seven days after injury. When compared with untreated wounded mice (controls), the combined (MSCs+NPs) treatment induced the expression of Sprr2b, a gene encoding small proline-rich protein 2B, involved in keratinocyte differentiation, the response to tissue injury, and inflammation. Pathways associated with keratinocyte differentiation were also affected. Ag NP treatment (alone or combined) modulated DNA methylation changes in genes involved in desmosome organization. The percentage of activated regulatory macrophages at the wound site was increased by MSC-alone and Ag-alone treatments, while the production of nitric oxide, an inflammatory marker, by stimulated macrophages was decreased by application of both MSC/Ag alone and MSCs+Ag. Ag induced the expression of Col1, encoding collagen-1, at the injury site. The results of the MSC and NP treatment of skin wounds (alone or combined) suggest an induction of processes accelerating the proliferative phase of healing. Thus, MSC-NP interactions are a key factor affecting global mRNA expression changes in the wound. Supported by grant No. 21-17720S from the Czech Science Foundation. Data processing was supported by the Strategy AV21 program: AI: Artificial Intelligence for Science and Society.

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Impact of Polystyrene Nanoplastic on Autism-Like Behaviour in Zebrafish *C15*

Abstract: Nanoplastics are an emerging environmental concern, with an increasing evidence highlighting their potential impact on neurodevelopmental impairments such as Autism Spectrum Disorder (ASD). The purpose of this study was to evaluate the impact of Polystyrene (PS) nanoplastics with different surface charges—positive and negative—on autism-like behavior, using zebrafish (Danio rerio) larvae, as a model for studying neurodevelopmental disorders. Zebrafish larvae were exposed to PS nanoplastics at two different concentrations of 100 µg/L and 500 µg/L. Autism-related behaviors were analyzed through basic locomotor activity and sensory processing assessments, considering the travelled distance and epileptic-like motor pattern in light/dark transition. The results revealed a significant concentration-dependent reduction in locomotor activity, evaluated by the distance travelled in light/dark transition. Notably, at the higher concentration (500 µg/L), negatively charged PS nanoplastics induced greater behavioral dysregulation, including erratic movements and hyperactivity under sensory stimulation (light-dark transitions), suggesting sensory processing impairments. PS nanoplastics uptake analysis indicated a significant higher uptake at lower concentration for both positive and negative charges. Moreover, at the same concentration, negatively charged nanoplastics exhibited significantly higher internalization for both experimental concentrations, particularly at 100 µg/L. These findings underscore the role of nanoplastics' physicochemical properties in modulating neurobehavioral outcomes and raise concern over their potential contribution to neurodevelopmental disorders. Further studies are warranted to explore long-term effects and underlying mechanisms. ACKNOWLEDGEMENT: This paper received support from the project "FIS-2023-00527- CUP C53C24001400001" funded by department of chamical sciences, university of Padova, Italy.

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Differential Response of Haematococcus Pluvialis to Silver Nanoparticles: Role of Inoculum Type in Astaxanthin Accumulation *C16*

Silver nanoparticles (AgNPs) have been extensively investigated for their biostimulatory or toxic effects on microalgae. However, the influence of the inoculum's developmental stage on astaxanthin biosynthesis in the microalga Haematococcus pluvialis remains largely unexplored. This study aimed to assess the effects of AgNPs on biomass and astaxanthin production in Haematococcus pluvialis by comparing cultures initiated with two distinct inoculum types: green vegetative cells and aplanospores. Experimental cultures were exposed to silver nanoparticles of 40 and 60 nm, each applied at five concentrations (from 0.01 to 1.0 mg/L). Biomass and astaxanthin content were quantified to evaluate the metabolic responses induced by AgNPs exposure. Both inoculum types exhibited a similar response profile: exposure to 40 nm AgNPs did not induce astaxanthin synthesis at any tested concentration. When astaxanthin was determined in the aplanospore stage, the green-cell inoculum showed inhibited accumulation at all concentrations, with over a 20% reduction, while the aplanospore inoculum maintained control levels. For 60 nm AgNPs, final astaxanthin content in Haematococcus pluvialis cultures with green motile cell inoculum increased by 8.7-13.3%, mainly at higher concentrations. With the aplanospore inoculum, red-stage astaxanthin increased by 50-80% at all concentrations. A slight reduction in biomass was observed in green-cell cultures treated with 40 nm AgNPs, while aplanospore-based cultures maintained more stable biomass growth. The results underline the critical role of the inoculum's developmental stage in modulating the metabolic response of Haematococcus pluvialis to AgNPs and provide a foundation for optimizing astaxanthin yield through nanoparticle-assisted cultivation strategies. This research was supported by a grant of NARD, project 24.80012.7007.08 SE.

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Green Synthesis of Gold Nanoparticles Using Aromatic Amino Acids: Physico-Chemical Characterization and Cytotoxicity Tests *C17*

Gold nanoparticles exhibit unique optical and electronic properties, which can be utilised in a variety of applications, from electronics to nano-bio-medicine. Changes in precursor concentrations tune size, shape, surface chemistry and charge of the resulting nanostructures. Chemical synthesis of nanoparticles often relies on the use of toxic chemicals as reducing and stabilising agents. On the contrary, green synthesis is a chemical method that uses safe and often cheap chemicals. Nowadays, there is an urgent demand for sustainability and environmental friendliness of synthetic protocols, especially in the field of bio-applications of nanomaterials. It is known for many years that amino acids can play the key role as both, reducing and stabilising agents in gold nanoparticle formation; moreover, they are biocompatible and biodegradable. Nevertheless, synthetic parameters still require optimization such as for instance: concentration changes and mutual ratios of reactants, physical and chemical conditions of the synthesis. In this work we synthesised gold nanoparticles (AuNPs) via four different aromatic amino acids (Tyr, Trp, Phe. and His), under several different temperatures. AuNPs were then characterised by means of UV-Vis absorption spectroscopy, DLS (dynamic light scattering), ELS (electrophoretic light scattering, TEM (transmissive electron microscopy) and FT-IR (Fourier transform infrared spectroscopy) . The as-prepared AuNPs possessed LSPR (localised surface plasmon resonance(peak located at ~520 - 540 nm and manifested themselves by sizes of 10 - 30 nm in diameter. The dialysed samples were tested and their cytotoxic effect evaluated on MCF-7 and BJ cell lines (Calcein-AM fluorescence assay). Significant differences in cell viability were found in AuNPs synthesised by tyrosine and phenylalanine (Tyr@AuNPs and Phe@AuNPs): Phe@AuNPs exhibited cytotoxic effect in both cell lines, whereas Tyr@AuNPs were selectively cytotoxic only to MCF-7. We presume that the different oxidation products of Tyr and Phe, resulting from AuNPs formation, serving as AuNPs capping agents, are causing the difference in cytotoxicity. However, further research must be conducted. The authors acknowledge the financial support by Internal Grant Agency (project no. IGA_PrF_2025_007).

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Quantitative Biodistribution Imaging of Gd-Labeled Nanoparticles with Preclinical MRI *C18*

Magnetic resonance imaging (MRI) is a powerful tool for studying nanoparticle biodistribution in vivo, but conventional approaches usually rely on qualitative assessment from T1-, T2-, or T2*-weighted images. These methods provide only indirect estimates of nanoparticle concentration and are sensitive to motion artifacts. We present a new quantitative MRI methodology for evaluating biodistribution of gadolinium-labeled nanoparticles in small animals. The method is based on T1 mapping and designed to be robust against respiratory and potentially also cardiac motion, ensuring reliable longitudinal measurements of nanoparticle concentrations. The approach was tested in six tumor-bearing mice (BALB/c, 4T1 tumor), each imaged at five fixed time points within 48 hours after intravenous administration of gadolinium-labeled lipid nanoparticles carrying ellipticine, or, as a reference, the standard contrast agent Gadovist. Our results demonstrate reproducible T1 quantification in the tumor, kidney, liver, and spleen, enabling direct and quantitative analysis of nanoparticle accumulation and clearance over time. This methodology represents a robust, noninvasive strategy for assessing nanoparticle biodistribution and may facilitate the preclinical development of novel nanomedicine therapies.

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Bio Applications / Nanomedicine

KUZELOVA KOSTAKOVA Eva **Technical University of Liberec, Liberec, Czech Republic, EU**

Biodegradable AC Electrospun Nanofibrous Yarns: Technology, Modifications, Postprocess Treatment and Properties for Surgical Sutures *C19*

Nanofibrous materials have potential in medical applications. The application of nanofibrous yarns as medical fibers, involving sutures, has been suggested to enhance the quality of the repair. However, due to a lack of robustness of the current fabrication methods, continuous nanofibrous filaments cannot be manufactured and scaled up in industrial settings and are not currently available for clinical use. To solve this problem, we have developed an effective method that enables the manufacture of electrospun yarns of two classes (100% nanofibrous yarns and composite yarns with nanofibrous shells), with the potential to be applied as surgical sutures. Presentation of production technologies via videos, process and material parameters of nanofibre yarn production by AC electrospinning, including possible modifications and post-process treatments such as braiding or surface treatment of nanofibres in yarns, represents the versatility of these materials, mainly by detailed scanning electron microscope images. In particular, the focus is on applications as surgical suture threads, and related to this, the basic properties and evaluation procedures of these nanofibrous threads or composite threads with nanofibers are presented.

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ŘÍHOVÁ Martina **Brno University of Technology, CEITEC, Brno, Czech Republic, EU**

Centrifugally Spun Natural Fibers with Zinc Oxide Nanoparticles: A Novel Therapeutic Strategy for Acne Vulgaris *C20*

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/antiviral aktivity [1,2]. Electrospinning is a well-known technique for the nanofiber synthesis from a solution using high electrostatic field. However, this technique still has some shortcomings, such as a low production rate and requires a high voltage. Centrifugal spinning works only on centrifugal force, which is robust in terms of yield, and thus eliminates the above-mentioned shortcomings [3,4]. The fibers based on gums blended with other polymers can be shaped and modified according to the targeted application. Recently, new approaches to the use of polymeric fibers have also shown potential for cosmetic and dermatological applications. In general, different types of creams, hydrogels and films are often being limited by their application, e.g. due to easy contamination over time and prevention of skin ventilation [5]. In contrast, fibrous materials possess unique characteristics, including high porosity, a large specific surface area, and good breathability, making them ideal carriers for cosmetic and dermatologic application. Combining fibers with ZnO NPs creates a synergistic effect that holds great promise for the effective treatment of Acne vulgaris [6]. In this study, biomedically approved ZnO NPs with distinct diameter were used as the active therapeutic modality to treat acne-causing pathogens. For the first time, we show the utilization of ZnO NPs that were evenly distributed within centrifugally spun fiber carriers. Upon application on the skin, ZnO NPs can sustainably release and have profound antibacterial activity at lower therapeutic concentrations. Fibers were made using innovative centrifugal spinning procedure from natural polymers - gum arabic and pullulan - that are known for their biocompatibility. Different amount of ZnO NPs (from 0.03 to 4.5 wt.% related to the dry mass) was added into the spinning polymer solution, either in a form of a dry powder or as a dispersion containing NPs and isopropyl myristate. The resulting fibers were subsequently characterized for morphology and presence of ZnO NPs by Scanning Electron Microscopy and Energy-Dispersive X-ray fluorescence spectrometry. The materials were thoroughly assessed for their antibacterial activity against Cutibacterium acnes and Staphylococcus epidermidis, which are major opportunistic pathogens causing acne. The combination of two types of nanomaterials, namely active nanoparticles and fiber carriers, proved to be very promising and bear a great potential for the treatment of these diseases [6,7]. REFERENCES: [1] R. Balkrishnan et al., Predictors of healthcare outcomes and costs related to medication use in patients with acne in the United States, Clin. Ther. 77(2006), 251-255; [2] A. Sirelkhatim et al., Review on zinc oxide nanoparticles: Antibacterial activity and toxicity mechanism, Nano-Micro Lett. 7(2015), 219-242; [3] M. Rihova et al., Water-born 3D nanofiber mats using cost-effective centrifugal spinning: comparison with electrospinning process: A complex study, J. Appl Polym Sci. 168 2021), e49975; [4] S. Padron et al., Experimental study of nanofiber production through forcespinning, J. Appl. Phys., 113(2013), 024318; [5] M. Rihova et al., The centrifugal spinning of vitamin doped natural gum fibers for skin regeneration, Carbohydr. Polym. 294(2022), 119792; [6] M. Rihova et al., Biopolymeric fibers prepared by centrifugal spinning blended with ZnO nanoparticles for the treatment of Acne vulgaris, Appl. Mater. 37(2024), 102151; [7] M. Rihova et al., Centrifugally spun and ZnO-infiltrated PVA fibers with antibacterial activity for treatment of Acne vulgaris, J. Control. Release 383, 113777.

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BAISHYA Kaushik *University of Pardubice, Pardubice, Czech Republic, EU*

Ultrathin TiO2 ALD Coatings Strongly Enhance Biological Response of Biomedical Materials *C21*

TiO2 surfaces are in general recognized as excellent biocompatible materials, owing to their low cytotoxicity, high stability, antibacterial properties, and wetting ability. Among various TiO2 nanostructured surfaces that show very good cell interactions (various cell types) and osseointegration, self-organized TiO2 nanotube (TNT) layers, grown by anodization of Ti, have emerged as extremely suitable substrates. Numerous papers showed also that anodization is a very viable tool for nanostructuring of various biomedical alloys, including frequently used TiAlV [1,2]. A pioneering work demonstrated that TNT layers with diameter of 15 nm are the most suitable for the growth of various cells [3]. In this presentation, we will demonstrate that ultrathin coatings of TiO2 [1,2,4,5], ZrO2, and V2O5 [6] can significantly increase the cell proliferation and adhesion on various TiO2 surfaces, including anodized ones. Last, but not least, black form of TNT layers (i.e. with significant content of Ti3+ states) was investigated for cell proliferation in comparison to classical TNT layers [7]. REFERENCES: [1] J. Capek, M. Sepúlveda, J. Bacova, J. Rodriguez-Pereira, R. Zazpe, V. Cicmancova, P. Nyvltova, J. Handl, P. Knotek, K. Baishya, H. Sopha, L. Smid, T. Rousar, J.M. Macak. ACS Applied Materials & Interfaces 16, no. 5, 2024: 5627-5636; [2] M. Sepúlveda, J. Capek, K. Baishya, J. Rodriguez-Pereira, J. Bacova, Š. Jelínková, R. Zazpe, H. Sopha, T. Rousar, J.M. Macak. Front. Bioeng. Biotechnol. 12:1515810, 2024; [3] J. Park, S. Bauer, K.A. Schlegel, F.W. Neukam, K. Der Von Mark, P. Schmuki. Small, 6, 666 -671, 2009; [4] M. Motola, J. Capek, R. Zazpe, J. Bacova, L. Hromadko, L. Bruckova, S. Ng, J. Handl, Z. Spotz, P. Knotek, K. Baishya, P. Majtnerova, J. Prikryl, H. Sopha, T. Rousar, J.M. Macak. ACS Appl. Bio Mater., 3, 6447-6456, 2020; [5] K. Baishya, K. Vrchovecká, M. Alijani, J. Rodriguez-Pereira, S.M. Thalluri, M.P. Goldbergová, J. Přibyl, J.M. Macak. Applied Surface Science Advances 18, 100459, 2023. [6] K. Baishya, J. Bacova, B. A. Chimali, J. Capek, J. Michalicka, G. Gautier, B. Le Borgne, T. Rousar, J. M Macak. ACS Appl. Mater. Interfaces, 17, 1, 739-749, 2025. [7] H. Sopha, J Bacova, K Baishya, M Sepúlveda, J Rodriguez-Pereira, J Capek, L Hromadko, R. Zazpe, S.M. Thalluri, J.Mistrik, P. Knotek, T. Rousar, J.M. Macak. Surface and Coatings Technology, 462, 129504, 2023.

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FÉROVÁ Marta *University of Ostrava, Ostrava, Czech Republic, EU*

Biosynthesis of ZnO Nanoparticles Using an Invasive Plant and the Effect of Oxygen Vacancies on its Properties *C22*

In this study, we report a biosynthesis of ZnO nanoparticles using a leaf extract from Reynoutria bohemica, an invasive plant species abundant in Central Europe. The phytochemicals present in the extract served as reducing and stabilizing agents, enabling the formation of ZnO particles upon thermal treatment. Optimization of reaction conditions revealed that calcination at ≥300 °C is essential for the formation of phase-pure wurtzite-structured ZnO. The resulting particles exhibited a pyramidal particles decorated with nanocrystallites. The sizes of the prepared nanoparticles reached hydrodynamic diameters ranging from 48 to 128 nm depending on the calcination temperature. Compared to conventionally synthesized ZnO, the biosynthesized materials showed a pronounced red-shift in the optical absorption edge (~540 nm), along with intense green photoluminescence centered around 595 nm. These features are attributed to the presence of oxygen vacancies within the ZnO lattice, which was supported by density functional theory (DFT) calculations. Moreover, the isoelectric points of biosynthesized ZnO were significantly shifted towards more acidic values (pH 2.7-4.0), suggesting altered surface chemistry and enhanced colloidal stability. This work highlights the potential of invasive biomass as a sustainable precursor for advanced oxide materials and underlines the role of defect engineering in tuning the functional properties of ZnO. 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. MŠMT ČR 8X23021 Multifunkční hybridy na bázi ZnO pro sanaci odpadních vod, ČR - SR - Srbsko projektu LERCO Evropské unie CZ.10.03.01/00/22_003/0000003.

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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, EU

SESSION E

ADVANCED METHODS OF PREPARATION AND CHARACTERIZATION OF NANOMATERIALS

Chairmen

Dr. Petr KLAPETEK	Czech Metrology Institute, Czech Republic, EU
Dr. Oldřich SCHNEEWEISS	Institute of Physics of Materials of the CAS, Czech Republic, EU
Dr. Michael SOLAR	Czech Technical University in Prague, Czech Republic, EU

Nanocharacterization - Metrology

GIANNAZZO Filippo ***Consiglio Nacionale delle Ricerche, Catania, Italy, EU***

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

Electrical Scanning Probe Microscopy of 2D Materials and Their Heterostructures with Wide-Bandgap Semiconductors for Advanced Electronics *E1*

Two-dimensional (2D) materials, including graphene and semiconducting transition metal dichalcogenides (TMDs) like MoS2, attracted huge research interests in the last 20 years, owing to their outstanding electronic properties. Wide-bandgap semiconductors (WBG), including silicon carbide (4H-SiC) and group-III Nitrides (GaN, AlN and their alloys), are nowadays the materials of choice in energy efficient power conversion, high frequency electronics and optoelectronics. The integration of these two classes of materials is currently the object of investigation by several academic and industrial teams, with the double aim to address key issues of SiC and GaN technologies and to demonstrate advanced or novel device functionalities, including UV photodetectors, quantum devices, high frequency (THz) transistors, and logic devices able to operate under extreme environments [1,2]. This talk will provide an overview of recent developments and open challenges in this field. Scalable top-down and bottom-up preparation strategies of 2D materials and their heterostructures with WBG will be illustrated [3,4]. Extensive investigation of their structural, chemical, optical and electrical properties by multiscale correlative characterizations (SPM, Raman/PL spectroscopy, atomic resolution electron microscopies) will be presented, with a special focus on nanoscale resolution electrical SPM (i.e. C-AFM and KPFM) providing crucial information on the morphology, surface potential and local current injection of the differently prepared 2D/WBG heterojunctions [5]. Furthermore, perspective device applications based on these material systems will be discussed. ACKNOWLEDGEMENTS: This work was supported, in part, by MUR in the framework of the PRIN2022 project “2DIntegratE” (2022RHRZN2). REFERENCES: [1] F. Giannazzo, et al., Mat. Sci. Semicon. Proc. 174, 108220 (2024); [2] F. Giannazzo, et al., ACS Appl. Electron. Mater., 1, 2342 (2019); [3] F. Giannazzo, et al., Appl. Surf. Sci 631, 157513 (2023); [4] S. E. Panasci, et al., Adv. Funct. Mater. 35, 2414532 (2025); [5] F. Giannazzo, et al., Nanomaterials 10, 803 (2020).

UKRAINTSEV Egor ***Czech Technical University in Prague, Prague, Czech Republic, EU***

Photothermal Cantilever Excitation for Non-contact Measurements of Co Nanodots on ZnO Surfaces *E2*

In this work the stable non-contact non-resonant AFM method, which is based on our US12253539B2 patent, was implemented using photothermal cantilever excitation on the Drive AFM (Nanosurf). This implementation is based on the possibility of reversing the feedback gain sign combined with measurements with negative setpoint. Such implementation allows stable measurements in both imaging and spectroscopy modes in static, dynamic and WaveMode regimes. Usage of short WaveMode cantilevers and thermally induced cantilever oscillations allow fast and reliable measurements of weakly attached objects, maintaining the attractive interaction between the tip and the sample. This method was applied to study the surface polarity-driven assembly of Co nanodots on polar (Zn-face (0001), O-face $(000\bar{1})$), and non-polar ($(10\bar{1}0)$ and $(11\bar{2}0)$) ZnO surfaces. All ZnO surfaces cause assembly of Co nanodots into ~ 10 nm weakly attached randomly distributed nanodots with ~ 0.1% surface coverage. Circular dichroism measurements show that Co nanodots on the O-face ZnO surface exhibit a stronger CD signal with 90° symmetry, whereas Co nanodots on the Zn-face ZnO surface result in a weaker CD response with 180° symmetry. This unexpected result has led us to further investigate the underlying mechanisms - to what degree they are related to the different geometry and crystalline phase of Co nanodots or to physical effects such as spin-orbit coupling. Theoretical simulations show the impact of surface dipole electric field orientation and magnitude and surface chemistry on the Co nanodots assembly. The results thus also show a way for controlling the assembly of Co nanodots for diverse nanomagnetism based applications such as spin controlled molecular interfaces.

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MAJCHRZYCKI Łukasz ***Poznan University of Technology, Poznan, Poland, EU***

Adhesion Measurements of Thin Films at the Nanoscale *E3*

The tribological properties of the surfaces are crucial due to the high wear cost of the working surfaces. Thus, a lot of effort is made to limit the friction and adhesion forces and surface wear as a result. Especially in the field of nano- and micromechanical systems, where the application of fluid lubricants is limited, other strategies, like thin film coatings, are highly expected [1]. In this work, we present the influence of the loading force and the loading rate, on the adhesion force between the atomic force microscopy tip and the thin film coatings as silanes, thiols and graphene oxide (GO) single-layered flakes. Since adhesion can significantly contribute to friction at the nanoscale [2], limiting adhesive forces is a key point in reducing the wear of nano-coatings. The theoretical models of thermal activation, such as the Bell-Evans (BE) and Dudko-Hummer-Szabo (DHS) models, have been adapted to the results. Fitting parameters as the dissociation rate constant, the distance between the bound state and the transition state, as well as the free-energy of activation, have been calculated. ACKNOWLEDGEMENTS: This work was supported by the National Science Centre in Poland under Project No. 2020/37/B/ST8/02023. REFERENCES: [1] M. Weiss, Ł. Majchrzycki, E. Borkowska, M. Cichomski, A. Ptak, Tribology International, 2021, 162, 107133; [2] G. A. Tomlinson (1929). The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science, 1929, 7(46) 905-939.

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HAVLÍČEK Štěpán-Adam ***Pragolab s.r.o., Prague, Czech Republic, EU***

***** COMMERCIAL PRESENTATION *****

Introduction of NEW SEMPLOR SEM Analysis - Quick and Easy *E4*

Efficient and accessible characterization of nanomaterials is essential for both research and industrial applications. The SEMPLOR scanning electron microscope has been designed to provide high-quality imaging and analysis while maintaining a user-friendly and streamlined workflow. Its compact design, intuitive operation, and fast acquisition make SEM analysis available to a broader range of users, from academic laboratories to production environments. This contribution demonstrates how SEMPLOR enables quick and easy imaging and elemental analysis of diverse nanomaterials without compromising precision or reliability.

SAPRE Atharva ***Institute of Physics of the CAS, Prague, Czech Republic, EU***

Investigating the Thin Film Growth of [Ni(HVanox)2] by Microscopic and Spectroscopic Techniques *E5*

Thin films of transition metal complexes are widely studied for their tunable properties in optoelectronics, sensing, and molecular electronics. Surface roughness plays a crucial role in determining their functional performance by increasing surface area and enabling unique interactions. Controlled fabrication of films with tailored roughness has therefore become essential for understanding and optimizing film growth mechanisms and enhancing the overall efficiency of these materials in various applications. In this work we investigate the controlled deposition and structural growth of thin films of the nickel(II) complex, [Ni(HVanox)2], derived from o-vanillin oxime (H2vanox = o-vanillin oxime). Low-pressure experiments to prepare thin films were conducted at temperatures between 120-150°C to optimize the deposition rate for uniform films. Thin films of increasing thickness (16-336 nm) have been prepared on various substrates and were characterized in detail using microscopic and spectroscopic methods: scanning electron microscopy (SEM), atomic force microscopy (AFM) and transmission electron microscopy (TEM). These revealed a rough surface with a dense arrangement of elongated, rod and needle-like nanocrystals with random orientation. AFM images revealed the surface with a high degree of roughness, varying with different thicknesses. Microscopic characterization also helped us to understand the growth mechanism of the film by observing a seeding layer, which grows in parallel to the surface of the substrate, upon which long needles or grass-like crystals grow perpendicular to the substrate. X-ray photoelectron spectroscopy (XPS) was used to confirm the elemental composition of the films along with the square-planar environment around the Ni(II) center. XRD data revealed the phase purity of the thin films, with additional Rietveld refinement of the XRD data leading to refined lattice parameters which are in good agreement with the structure of [Ni(Hvanox)2]. ACKNOWLEDGEMENTS: This work was supported by the Czech Science Foundation (GAčR grant number: 23-05878S) and the OP-JAK project financed by European Structural and Investment Funds and the Czech Ministry of Education, Youth and Sports (Project No. SENDISO - CZ.02.01.01/00/22_008/0004596).

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NOVOTNÝ Dušan ***Measurement Technic Moravia Ltd., Zastavka, Czech Republic, EU***

***** COMMERCIAL PRESENTATION *****

Breaking Limits: Infrared Microscopy with Submicrometer Lateral Resolution *E6*

Optical photothermal infrared (O-PTIR) microscopy overcomes the classical infrared diffraction limit by probing photothermal responses with a visible beam, yielding FT-IR-quality spectra at sub-micron resolution. We present the mIRage-LS platform, a sub-500 nm multimodal microscope that unifies O-PTIR spectroscopy, simultaneous Raman scattering, and co-located fluorescence, and introduces a high-speed widefield O-PTIR modality powered by fluorescence-detected photothermal IR (FL-PTIR). In a counter-propagating configuration—IR pumping from below and visible probing from above—the system achieves <500 nm IR and Raman spatial resolution (demonstrated down to ~280 nm on periodic diatom structures) with FT-IR-like spectral fidelity and minimal scattering artifacts. Widefield FL-PTIR acquires up to 262,144 pixels per snapshot over 65 µm × 65 µm fields (130 nm sampling), enabling single-wavenumber chemical images in seconds, hyperspectral arrays in minutes, and dynamic imaging up to 5 frames s^{-1}, all with simultaneous widefield fluorescence. The platform supports non-contact reflection or transmission on glass or CaF2, live-cell studies with water/oil immersion objectives, and automated detection and chemical identification of particles (featurefindIR) for microplastics and contaminants. Application examples span life sciences and materials: fluorescence-guided targeting with label-free IR structural readouts in cells; simultaneous IR+Raman confirmation on polymers; and artifact-free spectra for 3–30 µm microplastics. By combining molecular specificity, speed and sub-diffraction IR resolution in a single instrument, mIRage-LS advances nanoscale chemical imaging for nanotechnology research and industrial analysis.

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OZLIMAN Yasemin ***Ege University, Izmir, Turkey***

Preparation Strategies and Multifunctional Applications of Cellulose-Based Aerogels in Energy and Environmental Fields *E7*

Aerogel is a type of material with an expanded three-dimensional network structure, assembled by consistent polymer molecules. Organic aerogels have gained attention in recent years as environmentally friendly materials due to their high porosity, low density, and similar characteristics. With the increasing interest, bio-based aerogels are regarded as key materials for sustainable studies due to their renewable sources, and biocompatible structures. In this study, the synthesis methods of cellulose-based aerogels, the structural properties of the obtained materials, and their applications are discussed. In aerogel production, cellulosic materials are generally converted via the sol-gel method and various drying techniques are applied. The pore size and structures of the produced bio-based aerogels vary depending on the precursor, synthesis method, and drying technique. To increase their mechanical strength, crosslinkers and/or hybrid structures are used, and various modifications are made. The produced bio-based find a broad spectrum of applications. Those with low density can be used as supercapacitor materials. Additionally, they are recognized efficient materials in absorption and also adsorption. As a result, bio-based aerogels have a potential that can be evaluated for the development of sustainable material technologies. Thanks to their eco-friendly characteristics and advantageous properties, they hold great potential in various fields including energy storage, CO_2 capture, and electromagnetic shielding. Future studies will focus on improving their properties and enabling industrial-scale production.

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Nanocharacterization - Technics

FRIÁK Martin *Institute of Physics of Materials of the CAS, Brno, Czech Republic, EU*

Combined Theoretical and Experimental Study of Miscibility of Sn in LaNi5 *E8*

The LaNi5 compound is considered a promising candidate for future hydrogen-storage applications. Some of its properties have not been sufficiently studied so far and some critically important data is missing. In particular, there is a miscibility gap when substituting Ni atoms by Sn atoms in LaNi5. We have employed quantum-mechanical calculations implementing the density functional theory (DFT) within the generalized gradient approximation (GGA) to determine the ground-state structural, electronic, thermodynamic, and vibrational properties of several substituted La(Ni,Sn)5 phases. Our computational cell containing 48 atoms allowed for simulating different Sn/Ni ratios as well as different configurations of substituting Sn atoms. Our results indicate that there is a miscibility gap which is quite independent of the temperature. Our theoretical study was complemented by experiments which found a similar miscibility gap, too. Acknowledgments 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 Komensky Operational Program financed by the European Union and from the state budget of the Czech Republic. The authors acknowledge the Ministry of Education, Youth and Sports of the Czech Republic for the financial support of large research infrastructures 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 and project CZ.02.01.01/00/22_008/0004572.

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AGARWAL Akanksha *Institute of Physics of the CAS, Prague, Czech Republic, EU*

Study of Trion-exciton Dynamics in CVD-Grown MoS2 Flake for Advanced Optoelectronics *E9*

Two-dimensional transition metal dichalcogenides (TMDs) have emerged as promising materials for next-generation electronic and optoelectronic devices. Among these, monolayer molybdenum disulfide (MoS2) stands out due to its direct bandgap (~1.9 eV) that enables intense visible-range photoluminescence, making it ideal for advanced optoelectronic applications. In this study, MoS2 films were synthesized on Si/SiO2 substrates using a single-step chemical vapor deposition (CVD) process. The number of layers in the as-grown MoS2 films was determined via the peak energy difference (Δ) between the in-plane (E2g) and out-of-plane (A1g) Raman phonon modes, verified by atomic force microscopy (AFM) imaging. Comprehensive photoluminescence (PL) analysis reveals systematic layer-dependent optical properties that correlate well with Raman characterization. The overall excitonic peak exhibits a continuous red-shift of ~0.04 eV with increasing layer number, attributed to quantum confinement effects and enhanced interlayer screening. Quantitative spectral deconvolution under appropriate fitting constraints demonstrates that trion binding energies systematically decrease with increasing layer number, indicating modified interactions in few-layer systems. Importantly, we observe a layer-dependent inverse relationship between trion binding energy and electron density. Our findings establish a fundamental understanding of layer-controlled excitonic emission in CVD-grown MoS2, demonstrating that trion formation and stability can be precisely tuned through structural optimization. These results reveal that layer-tunable trion dynamics provide critical insights into many-body excitonic interactions and offer essential design guidelines for developing structurally-engineered MoS2-based photodetectors, light-emitting devices, and quantum photonic applications with tailored excitonic properties.

MARCHIONI Marianne ***Izon Science Europe SAS, Lyon, France, EU***

***** COMMERCIAL PRESENTATION *****

Nanoparticles: Scale-Up Purification and Single-particle Characterization *E10*

Reproducible efficient isolation and characterisation is the foundation of various aspects of nanoparticles research and development. Izon Science has led the way in developing products, instruments, and services aimed at the Nanoparticles isolation whether for fundamental research, diagnostic, or therapeutic purposes, supported by nanoparticles characterization of size, concentration, and zeta potential on a single-particle levels using Tunable Resistive Pulse Sensing (TRPS) technology. With our size-exclusion chromatography qEV columns, we have pushed isolate purity further than ever before, improving significantly contaminant depletion in the nanoparticles-enriched volumes. Added to that their ease to use and rapidity of the process, high generated yields, gentle isolation, and scalability, which make the columns the adequate choice for most applications.

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BERECOVÁ Valentína ***Institute of Physics of Materials of the CAS, Brno, Czech Republic, EU***

Exploring Spin Disorder in Ferrimagnetic Iron Oxides Using Standard DFT and Advanced Computational Methods *E11*

Iron oxide nanoparticles are extensively explored for applications in biomedicine, data storage, and spintronic devices, owing to their magnetic behavior and tunable size-dependent properties. While bulk magnetite and maghemite are ferrimagnetic, this long-range magnetic order often diminishes at the nanoscale. The loss of symmetry, reduced coordination environments, and altered bond lengths and angles—particularly in ultrasmall particles with high surface-to-volume ratios—introduce structural and electronic distortions. As a result, the formation of magnetically disordered surface layers has been widely reported by both experimental and computational studies. Configurations involving spin flips at the surface reduce the net magnetic moment and may correspond to metastable, energetically accessible states. Interestingly, magnetic disorder has also been associated with enhanced T_1 relaxation times in MRI, pointing to a potential connection between local spin structure and biomedical functionality. This study focuses on the electronic structure of bulk and ultra-small nanoscale iron oxide models exhibiting spin-flipped arrangements, evaluated using standard semi(local) density functional theory (DFT) methods and selective approaches beyond standard DFT. A range of exchange-correlation functionals is employed to examine how spin disorder affects key electronic properties such as band structure, band gap width or potential in-gap states. Additionally, machine learning techniques will be explored as a comparative tool to identify the possible spin-flipping phenomena. Altogether the findings aim to identify the most suitable theoretical framework for describing these systems and to support the future design of applications based on their electronic properties.

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Plasma Polymerized Polyimide Films for the Development of Electrochemical Sensors *E12*

The demand for advanced chemical and biosensing platforms has driven the development of tailored nanostructured surfaces and functional thin films capable of selective and sensitive interaction with a wide range of target analytes, including biomolecules, explosives, and chemical warfare agents. Among various surface engineering methods, low-temperature plasma processes have emerged as powerful tools for nano-engineering and precise surface functionalization. In this work, we report the development of a novel, flexible electrochemical sensor based on laser-induced graphene (LIG) fabricated on plasma-polymerized polyimide films. The fabrication process begins with the deposition of thin polyimide films via magnetron sputtering, a Physical Vapor Deposition (PVD) technique where highly energetic ions sputter the polyimide target (Kapton). The bombardment of energetic species results in the fragmentation of the polyimide structure which is then deposited on the substrate and results in its polymerization. These stable plasma polymer films serve as the precursor layer for laser-induced graphene formation, a single-step, maskless technique performed under ambient conditions. The laser photolysis process converts the polymeric surface into a porous, three-dimensional graphene-like structure, leveraging the localized thermal and photochemical effects of laser irradiation. This approach offers several key advantages over conventional graphene synthesis methods: it is scalable, solvent-free, cost-effective, and compatible with flexible substrates. The deposition of polyimide (Kapton) thin films and its laser ablation were verified using various analytical methods including FTIR, SEM and Raman analysis. The FTIR results proved the presence of characteristic bonds consistent with the polyimide Kapton and results from SEM and Raman proved the formation of graphitic/graphenic structures after the process of LIG. These films were found to be stable after the process of LIG which open opportunity to use this method for the preparation of electrochemical sensors. Overall, this work highlights the integration of magnetron-sputtered polyimide films with laser-induced graphene conversion as a promising strategy for the fabrication of next-generation, flexible sensing devices. The combination of plasma-assisted thin-film engineering with laser-based nano structuring provides a versatile and efficient route toward the development of advanced electrochemical sensors for environmental monitoring, security, and defense applications.

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***** COMMERCIAL PRESENTATION *****

IR-SNOM Nanoscopy Combined with Confocal Raman Imaging: Theory and Examples *E13*

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 seam¬lessly 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 polymer, graphene transistor and Metal Organic Framework (MOF) research.

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Raman-Active Nanocomposites with Functionalized Clay: Synthesis and Analysis *E14*

Developing functional nanocomposites that can non-invasively monitor material structure is an important area of modern materials science. Clay nanofillers are of particular interest because they can serve as well-dispersed structural fillers and as carriers for embedded analytical markers after intended chemical modification. This study presents nanocomposites containing functionalized clay with integrated Raman-active alkyne functionalities. These nanocomposites allow for local spectroscopic analyses without destroying the sample or requiring special preparation. The nanocomposites were prepared by melt extrusion to ensure uniform phase distribution in a polystyrene matrix. Raman spectroscopy confirmed the effective incorporation and preservation of alkyne functionalities; the spectra demonstrated distinct peaks in the spectral silent region. This region is typically free from interfering signals, which allows for the precise detection of these functional markers and confirms their stability within the nanocomposite structure. Additional thermal analysis using thermogravimetric analysis (TGA) and differential scanning calorimetry (DSC) was carried out to evaluate the thermal stability and structural transitions of the nanocomposites. These methods corroborated the Raman findings, revealing the modified clay's good stability and measurable influence on the polymer matrix's thermal behavior. These results suggest that these materials are suitable for use in intelligent condition monitoring systems, such as polymer packaging, sensor coatings, and adaptive composites for engineering applications. ACKNOWLEDGEMENTS: We want to express our gratitude for the financial support provided by the LIT Institute of Technology at Johannes Kepler University Linz, project number: LIT-2022-11-SEE-123.

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Nanocharacterization - Techniques

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Single-Atom Engineering 1D Nanoreactor for Electrochemical Hydrogen Evolution *E15*

Rapid depletion of fossil fuels, the energy crisis, and environmental pollution are the most pressing issues today and in the future. Focusing on alternative green energies is highly desirable and critically important. Among these, green hydrogen production using catalysts from water represents a revolution in the energy sector. Hydrogen evolution driven by the high atom utilization of atomically dispersed single-atom catalysts (SACs) is a hot topic, offering advantages over conventional catalysts. However, most SACs suffer from low specific and intrinsic activity, poor stability at high current densities, and limited durability. One-dimensional boron nitride nanotubes (1D-BNNTs), containing vacant defects and alternative B/N moieties, are considered promising support materials due to their attractive properties, which facilitate strong anchoring sites for single atoms. The intercalated PtRu single atoms (SAs)/nanoclusters (NCs) in multiwalled BNNTs (PtRu SAs/NCs@BNNT) enhance intrinsic activity through the combination of dual active sites (PtRu) and significantly lower the overpotential to only 93.5 mV at a high current density of -1000 mA cm-2 in an acidic medium, compared to commercial Pt/C (199.6 mV at -1000 mA cm-2). This 1D PtRu SAs/NCs@BNNT catalyst demonstrates outstanding hydrogen evolution performance, with a high turnover frequency (TOF) of 61.34 $H2\ S^{-1}$ at 0.1 V, substantially outperforming reported catalysts.

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Structure Compatibility Calculation: Computational Determination of Preferred Out-of-Plane and In-Plane Orientation for Two-Phase Crystalline System *E16*

Characterization of the interface between two crystalline phases can be quickly and easily performed by structure compatibility calculation (SCC), a geometric method determining the preferred out-of-plane (OP) and in-plane (IP) crystallographic orientation. The overlaps of atoms from two parallel crystallographic planes (e.g. substrate and thin film plane) are counted for each rotation step of one plane relative to the other, and the average number of these overlaps calculated after 360° rotation quantifies the OP orientation of a given pair of crystallographic planes. The higher the average number of overlaps, the more preferred the OP orientation. The IP orientation is then determined by rotation angles corresponding to global or local maxima of the overlaps. The usefulness and practicality of this method is demonstrated by determining the preferred orientations of various thin films on different substrates. The eight following substrate/film systems were examined: Si/ZnO, C/ZnO, MgO/ZnO, SrTiO3/ZnO, Al2MgO4/ZnO, Si/AlN, Ni/BN, and GaN/FeN. The experimentally determined preferred orientations of these systems (obtained from the literature) agree very well with the preferred orientations determined for these systems by the SCC method. Additionally, the selection of elements for OP orientation determination did not affect the agreement with experimental data. This research was supported by The Ministry of Education, Youth and Sports of the Czech Republic from the SGS projects SP2024/041 and SP2025/029.

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Modern Approach to Study Suspensions for the Creation of Porous Zirconia Nanoceramics *E17*

Porous zirconia ceramics could be used in large number of applications, such as artificial cortical bones, zirconia filters for hot gas filtration or supporting material for catalysts.The presented work deals with the analysis of suspensions from two types of zirconium oxide nanopowder and two types of reagents (Disperbyk and Dolapix) suitable for the creation of porous ceramics. In the work, a secondary material - micro methyl cellulose (MMC) was used as a combustion additive, and the stability and rheological behaviour of suspensions with increasing MMC content was observed. Thanks to the stability analysis, which proved to be a fast complementary analysis to conventional rheological measurements, the behaviour of the suspensions was predicted even before forming ceramics body, specifically by slip casting. Stability analysis on LUMiSizer analytical centrifuge is a unique approach to obtain a stability of suspension and to assessment of sedimentation or agglomeration of particles thanks to the scanning of transmission profiles during set up time. MCC proved to be a suitable stabilizer of suspension and successfully prevented separation of solid particles from matrix. The microstructure analysis confirmed the influence of MMC on the pore content as well as the applicability of a unique stability analysis for predicting the possibility of porous ceramic body formation.

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Finite Difference Time-Domain Investigation of the Plasmonic Effect in Spion-Decorated Gold Nanorods *E18*

Plasmonic nanoparticles are characterized by the occurrence of the Localized Surface Plasmon Resonance (LSPR) effect, which happens when illuminating the nanoparticle with the light of a specific wavelength (and is dependent on the size, shape, and material of the plasmonic nanoparticle) which causes conduction band electrons to oscillate collectively in a spatially confined manner. One of the materials with particularly good plasmonic properties is gold, which is simultaneously valued for its biocompatibility. Another material that exhibits valuable properties for biomedical applications is iron oxide, particularly in the form of superparamagnetic iron oxide nanoparticles (SPIONs). As demonstrated by Rizvi et al. (2022) [1], it is possible to coat gold nanorods with iron oxide nanoparticles and use magnetic field to control the orientation distribution of the nanorods. Using finite difference time-domain method, a study was conducted on the electromagnetic field distribution and heat flux values for systems with ordered, and randomly oriented gold nanorods, illuminated with non-polarized light and with light of different polarization angles. Distributions of x, y, and z components of electric field, as well as heat flux values, were obtained and compared for various configurations and conditions. The results indicate that heat flux is affected by the alignment and can be increased or decreased, depending on the polarization. ACKNOWLEDGEMENTS: Research project supported by program „Excellence initiative - research university” for the AGH University of Krakow. REFERENCES: [1] RIZWI Mehedi H. et al., Magnetic Alignment for Plasmonic Control of Gold Nanorods Coated with Iron Oxide Nanoparticles, Advanced Materials, 2022.

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Interaction Between Perovskite CsPbBr3 and Zno Surfaces (Non-Polar) Studied by DFT *E19*

Studying the interaction between $CsPbBr_3$ (CPB) perovskite and various ZnO surfaces is crucial for understanding how structural, electronic, and optical properties - such as bandgap, charge transport, and binding energy - are influenced by ZnO surface polarity and ligand presence, which directly impacts the design of efficient optoelectronic devices like scintillators and solar cells. Oleic acid (OA) and oleylamine (OAm) ligands are commonly employed to enhance the stability of CPB nanocrystals, to passivate surface defects and thus to improve photoluminescence efficiency and carrier lifetime, and to tune electronic properties. This study presents a detailed structural, electronic and optical analysis of interaction between semiconductor CPB perovskite and ZnO surfaces using DFT formalism. The impact of surface structure of polar (Zn-face ("0001"), O-face $(000\bar{1})$), and non-polar ($(10\bar{1}0)$ and $(11\bar{2}0)$) ZnO surfaces and the impact of OA and OAm ligand presence on CPB properties is investigated. The bandgap, HOMO-LUMO, the electron density distribution, the density of states, projected density of states, the charge transport and binding energy of the proposed system are analyzed. The optoelectronic properties of CPB with and without OA and OAm ligands are studied to understand the contribution of each component towards the applications of this work including scintillators and solar cells.

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The Influence of Temperature, Velocity and Load on Nanoscale Friction *E20*

This work refers to the studies of the nanoscale friction mechanisms. The atomic force microscope becomes one of the major tools for studying phenomenon of friction [1, 2]. The occurrence of various friction mechanisms and the fact that friction force depends on the chemical composition of the friction pair and on numerous variables, for example: loading force, sliding velocity, roughness, contact elasticity, temperature, humidity, renders the experiment and data analysis an intriguing and demanding task. The main goal of presented research was to study the influence of temperature, velocity and load on friction mechanisms, particularly adhesive friction and stick-slip, for robust silicon nitride AFM tip versus trichloro(3,3,3-trifluoropropyl)silane hydrophobic functional nanocoating - a nanolayer studied in one of our previous articles [1]. In contrast, here we are focusing on the influence of temperature on friction for aforementioned friction pair. Data recorded for a very wide range of sliding velocities (10-4 000 µm/s) show a significant decrease in friction force with increasing temperature. 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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The Influence of Nanoplastics Surface Charge on the Formation of Protein Corona and the Subsequent Sorption of Pb2+ and Cd2+ Ions *E21*

Micro and nanoplastics (NPs) are considered as emerging contaminants. When enter in human body they interact with proteins results in the formation of the protein corona, which significantly influences the properties of the particles, e.g,. the sorption capacity. In this study, we investigated the formation of protein corona on negatively and positively charged polystyrene (PS) NPs (PS-NPs) and their subsequent effects on the sorption of Pb2+ and Cd2+ metal ions. Both positively and negatively charged NPs exhibited almost similar protein corona compositions, regardless of their surface charge with the exception for glycoprotein, which showed a statistically higher adsorption on negatively charged particles. Lead acetate trihydrate and Cadmium nitrate tetrahydrate salts were mixed individually with the 1 mg/L positively and negatively charged PS-NPs to reach a final concentration of 500µg/L for 4 days. In MQ water without protein corona, there was no significant adsorption of Cd2+ and Pb2+ on both negatively and positively charged PS-NPs. In human serum over 72 hours, positively charged PS-NPs associated with Pb2+ and Cd2+, leading to a reduction in concentration from 100% to 85.9% and from 100% to 92.3% for these metals in the media, respectively. In the presence of negatively charged particles, Pb2+ concentration decreased to 83%, while Cd2+concentration unexpectedly increased to 110.4%. Our results showed that the presence of protein corona significantly influences the sorption capacity of the particles for metals. Moreover, Pb2+ consistently showed higher adsorption than cadmium (Cd2+), indicating a metal-specific affinity towards PS-NPs, after the formation of the protein corona. ACKNOWLEDGMENT: This paper was funded by PhD funding budget of Department of Chemical Sciences, University of Padova, Italy.

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TECHSCALE WORKSHOP 2025

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OTYEPKA Michal ***Palacky University Olomouc, CATRIN, Olomouc, Czech Republic, EU***

From Sheet to Site: Graphene Platforms for Single-Atom Mastery *TE3*

The isolation of a single graphene sheet transformed the field of nanomaterials and unlocked entirely new research directions. While graphene exhibits extraordinary electronic mobility, mechanical strength, and thermal conductivity, its full potential in sensing, biointerfaces, and catalysis can only be realized through deliberate tailoring of its surface chemistry. Covalent graphene functionalization modulates electronic structure, magnetism, and interfacial behavior, but graphene is difficult to functionalize directly. We bypassed the graphene chemical inert nature by chemistry of fluorographene (FG). FG is readily obtained from commercially available graphite fluoride and reacts under mild and well controlled conditions. This chemistry unlocks a broad library of graphene derivatives that emerge as discrete nanoflakes with well-defined chemical functions.1 These materials already power diverse applications that span supercapacitor electrodes,2,3 Li-ion4 and LiS5 batteries, chemical sensing,6,7 and catalysis.8-11 A representative example is graphene acid,12 which operates as a metal free catalyst for alcohol oxidation with excellent efficiency. These functional single sheet platforms are also ideal anchors for isolated metal species.8 Cyanographene, bearing nitrile groups, captures copper at the level of single atoms in mixed valence states and delivers outstanding activity in dioxygen driven transformations, including oxidative amine coupling and the selective activation of benzylic C-H bonds that lead to valuable pharmaceutical intermediates.10 To further control the coordination environment, we created a graphene support that carries 1,10-phenanthroline-5-amine units; this installs well defined chelating pockets that allow rational and selective placement of transition metals. Building on this platform, copper sites remain atomically dispersed and exhibit strong performance in benchmark cross coupling chemistry.13 FG chemistry transforms an inert sheet into a programmable site, converting graphene into a modular platform for precise single atom control and extending its reach across catalysis, electronics, energy storage, and sensing. The work was supported from ERDF/ESF project TECHSCALE (No. CZ.02.01.01/00/22_008/0004587) www.techscale.cz

Collaboration: ***IT4Innovations National Supercomputing Center, VSB - Technical University of Ostrava, Ostrava-Poruba, Czech Republic, EU***

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Nanorobotics: Towards Nanoarchitectonics and Single Atom Engineering for Biomedicine and Environmental Remediation *TE4*

Single-atom nanorobotics represent a groundbreaking advancement in the fight against environmental pollution and health challenges. These nanoscale devices are engineered to target critical issues such as the removal of nanoplastics from aquatic environments and the eradication of resilient biofilms that compromise medical treatments and device performance. Leveraging their precise atomic-scale designs, single-atom nanorobots disrupt biofilm structures to enhance therapeutic outcomes and adsorb micro- and nanoplastics to mitigate water pollution. This discussion explores the innovative architectures and mechanisms of single-atom nanorobots, emphasizing their potential to revolutionize biomedical and environmental fields. Key advancements include their role in delivering highly targeted therapies, boosting antibiotic efficiency, and capturing harmful plastic particles from ecosystems. The paper provides an in-depth analysis of their current capabilities, emerging applications, and the challenges of scaling these technologies for sustainable global impact.

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Low-dimensional and Single-Atom Materials for Advanced Biomedical and Chemical Technologies *TE5*

Low-dimensional chemistry is an emerging field in materials science that enables precise control over the dimensionality, structure, and surface functionalization of nanomaterials, while also facilitating the entrapment of single metal species to achieve exceptional properties. These advancements have broad applications in medicine, catalysis, energy, and environmental technologies. In this talk, we will explore specific aspects of 2D graphene chemistry, beginning with fluorographene, which serves as a starting point for synthesizing a diverse range of 2D materials. The exceptional utility of well-defined graphene derivatives, such as graphene acid and cyanographene, will be showcased for developing advanced antimicrobial agents that address bacterial resistance. These findings will be contextualized with the antimicrobial properties of silver nanoparticles, alongside a discussion of bacterial resistance mechanisms against these nanomaterials. Moving beyond carbon-based systems and nanomedicine, the application of cost-effective Cu/Fe-based catalysts for sustainable chemical technologies will be highlighted. The remarkable properties of pyramidal 0D plasmonic CuFeS2 nanoparticles will be demonstrated in the context of fast and selective nitroarene reduction under visible light. Similarly, the catalytic efficiency of 1D Fe/Fe-O nanowires embedded in a silica matrix will be explored through their application in the hydrogenation of nitriles to amines. Finally, the general strategy for synthesis of single atom catalysts (SACs) with 2D graphene-like and 0D carbon-dot supports will be explored and diverse applications of SACs in organic synthesis will be delivered. The work was supported from ERDF/ESF project TECHSCALE (No. CZ.02.01.01/00/22_008/0004587) www.techscale.cz

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From Atoms to Applications: Advancing Sustainable Catalysis with 2D Zeolites *TE6*

Sustainable catalysis can be achieved through the understanding, tuning, and utilization of atomic-level species stabilized on carefully designed supports. One promising approach involves two-dimensional (2D) zeolitic materials, engineered with abundant surface silanol groups that provide versatile platforms for immobilizing and stabilizing catalysts at the single-atom or nanoparticle scale.[1] By coupling advanced synthesis with cutting-edge structural tools - such as high-resolution scanning transmission electron microscopy and correlative SEM-AFM imaging - it is possible to achieve precise control over catalyst structure and function. Here, we demonstrate that downsized palladium catalysts supported on 2D zeolites outperform traditional systems in selective hydrogenation, combining high activity and selectivity with reduced precious-metal demand.[2] We further present the by-design incorporation of various metal nanoparticles into zeolite matrices via the novel ADOR approach, which enables the post-synthetic modification of germanosilicates through controlled disassembly into layered precursors. Building on this concept, we extend the design principle to reactions such as the Tsuji-Trost allylic alkylation - long dominated by homogeneous catalysis - now made feasible with recyclable heterogeneous catalysts. Similarly, defect-engineering strategies applied to rare-earth-modified platinum systems reveal new pathways to tune selectivity in cinnamaldehyde hydrogenation, an industrially important and challenging reaction. This presentation will illustrate a pipeline that integrates synthesis, advanced characterization, and catalytic applications to deliver the novel scalable and sustainable catalytic technologies. REFERENCES: [1] A. Li, Y. Zhang, C.J. Heard, K. Gołąbek, X. Ju, J. Čejka, M. Mazur, Encapsulating Metal Nanoparticles into a Layered Zeolite Precursor with Surface Silanol Nests Enhances Sintering Resistance**, Angew. Chemie Int. Ed. 62 (2023) e202213361. https://doi.org/https://doi.org/10.1002/anie.202213361; [2] J. Xie, J. Přech, M. Kubů, M. Mazur, J. Čejka, Subnanometric palladium zeolite catalysts improve selectivity in alkyne semihydrogenation, Catal. Today. 460 (2025) 115479. https://doi.org/https://doi.org/10.1016/j.cattod.2025.115479.

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Single Atom Engineering for Catalysis and Energy Storage *TE7*

Functional low-dimensional materials with judicious molecular and single-atom engineering may unlock versatile platforms for high-performance electrochemical energy storage and efficient, earth-abundant catalysis. In the first part of the talk I will discuss about how tailored graphene derivatives and organic architectures can push the limits of batteries and supercapacitors with the aid of single metal ions. The second part highlights catalytic applications that exploit materials of such design, which are key to decreasing the energy and environmental footprint of the chemicals industry. An aminoacid-anchored graphene acid organocatalyst outperforms homogeneous acids for solvent-free valorization of waste organics and for biofuel production. Embedding earth abundant transition metal atoms in such graphene derivatives affords redox-switchable mixed-valence catalysts that efficiently drive aerobic oxidative transformations of lower-value molecules to key chemicals for the pharmaceutical and polymer industry. These studies demonstrate how molecularly functionalized materials and metal-carbon seamless architectures can deliver advances in catalysis for low energy organic transformations and electrochemical energy storage technologies.

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Smart alloy-enabled flexible zinc-halide battery with high corrosion-resistance *TE8*

Over thirty years after their commercialization, lithium-ion batteries remain the most widely adopted cell technology. However, concerns around safety and the growing demand for lithium-based systems have led to challenges in sourcing raw materials and ensuring safe, stable components. This has driven the search for alternative battery chemistries that rely on more abundant resources while offering sustainable, cost-effective, and high-performance energy storage. Zinc-ion batteries are gaining attention as a promising alternative due to their use of inexpensive, widely available materials and water-based electrolytes. Among these, halide-based cathodes stand out for their potential to achieve high energy density through multi-electron transfer redox processes. Nonetheless, halide ion diffusion often accelerates zinc corrosion, which severely limits long-term cycling stability. In this study, we address this challenge by employing a Ni-Ti shape-memory alloy as the zinc anode substrate, leveraging its naturally formed TiO_2 passivating layer to enhance corrosion resistance. The resulting zinc-iodine battery demonstrates exceptional cycling durability, achieving up to 20,000 cycles. The underlying corrosion-resistant mechanisms were clarified using both in-situ and ex-situ spectro-electrochemical characterizations, which contributed dually through Ni-Ti alloy and the preferred crystal orientation of zinc deposition. Furthermore, a flexible pouch-cell prototype was fabricated, showcasing excellent mechanical flexibility and shape programmability activated by temperature, highlighting the system's potential for next-generation wearable devices.

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Development of Cascade Reactions Using Synergistic Catalysis *TE9*

Cascade reactions are processes in which several consecutive transformation steps take place within a single reaction system without the isolation of intermediates. This strategy significantly enhances the efficiency of synthesis, shortens the number of steps, reduces solvent consumption and waste generation, and simultaneously provides access to complex molecules from simple starting materials. In the last decade, synergistic catalysis has been successfully applied in cascade reactions. Synergistic catalysis is defined as a process in which two catalysts and two catalytic cycles work in concert to form new bond(s). Among other strategies, the beneficial approach involves combining a chiral organocatalyst with an achiral transition-metal complex. The organocatalyst is responsible for asymmetric induction, thereby eliminating the need for expensive and hard-to-obtain chiral ligands. Our goal is the development of synergistically catalyzed cascade reactions, in which enamine/imine activation or Bronsted activation is combined with transition metal catalysis. Next, our goal is to synthesize suitably modified organocatalysts that can be immobilized on a solid support and subsequently used in synergistically catalyzed cascade reactions. The immobilization of organocatalysts allows their easy separation from the reaction mixture and subsequent reuse. This approach reduces their application costs and generally facilitates the study and development of new cascade reactions.

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Single-atom-based co-catalysts for photocatalytic hydrogen production ***TE10***

Photocatalysis offers a promising route to diversify future energy sources by directly converting sunlight into hydrogen and other valuable products. Central to achieving high activity and selectivity is the integration of metal-based co-catalysts, which accelerate charge separation, enhance interfacial redox kinetics, and suppress recombination losses. Among them, single-atom co-catalysts (SACs) have emerged as a new frontier: they maximize atom utilization and create unique, well-defined reaction sites that outperform conventional nanoparticles or clusters. This contribution will highlight our recent advances in SAC-modified photocatalysts based on TiO2, g-C3N4, and perovskite-derived materials, where atomically dispersed metals enabled dual functional action—not only high-efficiency hydrogen production but also selective oxidation of alcohols into value-added products. Particular emphasis will be placed on how isolated atoms tune the electronic structure of the semiconductor, modulate charge-transfer pathways, and provide distinct adsorption and activation sites. Despite these advantages, important challenges remain, including the long-term stability of SACs, precise control over their coordination environment, and the theoretical description of their mechanistic role in complex photocatalytic reactions. By combining experimental insights with computational modelling, recent studies shed light on how SACs lower activation barriers and direct selectivity in hydrogen evolution, and alcohol oxidation. Together, these results underline the pivotal role of single-atom co-catalysts in advancing the design of next-generation photocatalysts for sustainable hydrogen production and chemical transformations. The work was supported from ERDF/ESF project TECHSCALE (No. CZ.02.01.01/00/22_008/0004587) www.techscale.cz

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HOŠEK Jiří *Palacký University Olomouc, RCPTM, CATRIN, Olomouc, Czech Republic, EU*

SEM-FIB: Advanced Technique for Materials Characterization *W1*

Scanning Electron Microscopy with Focused Ion Beam (SEM-FIB) is an advanced analytical technique that combines the high-resolution imaging capabilities of a Scanning Electron Microscope with the precise milling and manipulation features of a Focused Ion Beam. This dual-beam approach provides detailed insights into morphology, topography, and composition at the nanoscale, while also enabling site-specific sample modification. The integration of these two powerful techniques makes SEM-FIB a crucial tool for correlative and multi-modal characterization. The Focused Ion Beam allows for precise cross-sectioning and preparation of electron-transparent lamellae for subsequent Transmission Electron Microscopy (TEM). This functionality, combined with comprehensive compositional studies via Energy Dispersive X-ray Spectroscopy (EDS) mapping, enables simultaneous structural and chemical characterization of samples. These combined functionalities make SEM-FIB highly versatile and applicable across diverse fields, including nanomaterials science, microelectronics, catalysis, and life sciences. It is an indispensable technique for advanced research and material characterization. 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 and the Internal Student Grant Agency of the Palacký University in Olomouc, Czech Republic (IGA_LF_2025_001).

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RÖSSNEROVÁ Andrea *Institute of Experimental Medicine of the CAS, Prague, Czech Republic, EU*

Molecular Insights Into Occupational and Non-occupational Exposure to Engineered Nanoparticles *W2*

Nanoparticles (NPs) have become an important part of everyday life during the last years. Aside from their undoubted benefits, questions regarding the risk of inhalation exposure to human health, and/or genome still need to be addressed. Despite these facts, human biomonitoring studies relevant to the consequences of the chronic and acute exposure to NPs on the molecular processes in cells as well as health effects are still rare. The Czech biomonitoring research plays the dominant role in this field due to the systematic sampling of the chronically and acutely exposed groups during the nanocomposite materials processing in research phase and/or in their application. During the last years, effects of NPs exposure on the molecular mechanisms by cytogenetic, epigenetic and transcriptomic markers have been studied in the group of nanoparticles research workers as well as volunteers with exposure simulated that in stomatology. Overview of the most crucial results published during the years 2019-2025 in collaboration with partners from other institutions will be presented during the NanoEnviCz workshop 2025. This complex research was supported by the Czech Science Foundation (grants #18-02079S and #22-08358S), by the Cooperation program (207041-3) of Charles University and by the research infrastructures EATRIS-CZ (MEYS #LM2023053) and NanoEnviCz: (MEYS #LM2023066).

ŠŤASTNÝ Martin ***Institute of Inorganic Chemistry of the CAS, Husinec-Řež, Czech Republic, EU***

Application of HPLC-DAD for Monitoring the Degradation of Organic Pollutants in Aqueous Systems *W3*

The Research Infrastructure NanoEnvi-Cz provides unique access to advanced analytical tools for environmental and nanotechnology-related research. Within this framework, the Institute of Inorganic Chemistry offers the HPLC-DAD UltiMate 3000 system as a robust platform for monitoring the degradation of organic pollutants in aqueous matrices. The developed chromatographic methods enable precise quantification of a wide range of contaminants, including pesticides, pharmaceuticals, and endocrine-disrupting compounds, as well as the detection of selected degradation products. Our analytical approach is closely coupled with catalytic studies, allowing the investigation of both adsorption and catalytic transformations under dark conditions, and photocatalytic processes under UV or simulated solar irradiation. Although the system does not include mass spectrometric detection, the optimized HPLC-DAD protocols are readily transferable to LC-MS platforms, facilitating in-depth structural elucidation of degradation products where required. The combination of advanced separation methods with catalytic and photocatalytic testing highlights the versatility of this infrastructure for research on water decontamination. These capabilities are available to potential users of NanoEnvi-Cz, supporting studies on the fate of organic pollutants, the performance of novel catalytic materials, and the development of environmentally relevant degradation pathways. 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.

ŘEZANKA Michal ***Technical University of Liberec, Liberec, Czech Republic, EU***

Utilization of NanoEnviCz Instrumentation for Cyclodextrin-Based Nanomaterials in Micropollutant Removal *W4*

The increasing occurrence of pharmaceutical residues and other persistent micropollutants in aquatic environments poses a major challenge for conventional wastewater treatment technologies. Cyclodextrin-based nanomaterials offer a promising strategy to address this issue, as their unique supramolecular cavities enable efficient host-guest interactions with a wide range of organic contaminants. At the Technical University of Liberec, within the NanoEnviCz research infrastructure, we develop and characterize advanced cyclodextrin-functionalized nanomaterials designed for the adsorptive removal of environmentally relevant pollutants. Comprehensive characterization using NanoEnviCz instrumentation, including NMR spectroscopy, BET, FTIR, and HRMS, has revealed key insights into molecular inclusion, and structure-function relationships. These results highlight the potential of cyclodextrin-based nanomaterials as scalable, high-performance adsorbents for advanced water purification and environmental remediation. The author 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.

KORMUNDA Martin ***J. E. Purkyne university, Ústí nad Labem, Czech Republic, EU***

X-ray photoelectron spectroscopy in NanoEnviCZ facility *W5*

The large research infrastructure NanoEnviCZ offers XPS at two partner workplaces. Both instruments are regularly upgraded according to user requirements. The utilization of infrastructure support for XPS at the UJEP workplace will be shown. The instrument has undergone significant evolution since its first start up in 2007, when the original configuration was equipped only with an achromatic dual Al/Mg X-ray tube SPECS XR 50, a hemispherical analyzer SPECS PHOIBOS 100, and a single-channel electron detector. But a second (experimental) chamber was already connected to the XPS. Gradually, the detector was replaced with a 5-channel one and an ion gun with MW ionization TECTRA was added to the experimental chamber. Then a second bigger sample loader with a magazine for 4 holders was added. Further improvements consisted in the installation of a SPECS FOSUS 500 monochromator with an X-ray tube and compensation source from ProNanoEnviCZII. The last improvement added programmable control of the sample manipulator and the possibility of using Ar clusters for surface engineering. Even this device is not enough to satisfy the growing demands of NanoEnviCZ users, and therefore a new Thermo Nexsa G2 device with significantly higher capacity will be installed in January 2026, while simultaneously improving the quality of measurements. It is supported by ProNanoEnviCZIII. Results obtained on materials based on CeOx, CrCN, AlCrSiN, ZnO, PVDF, and similar will be shown. Here, surface XPS has proven to be key for the analysis of catalytic systems and for assessing the condition of surfaces. XPS measurements can be performed on virtually all materials that can be placed in a vacuum, including nano and micro fibers and powder catalysts. Results obtained on nanofibrous materials from polymers modified by the addition of active compounds, for example with Br or CeOx, and/or surface-treated with plasma will be shown. Research was financially supported by the Ministry of Education, Youth, and Sports of the Czech Republic under Project No. LM2023066.

SAZAMA Petr ***J. Heyrovský Institute of Physical Chemistry of the CAS, Prague, Czech Republic, EU***

Environmental Catalysis for a Sustainable Future: Research Highlights from the NanoEnviCz Infrastructure ***W6***

This presentation will showcase research conducted within the NanoEnviCz infrastructure, focusing on environmental catalysis as a tool to address urgent global challenges. The work aims to support cleaner air, safer water, and sustainable energy production while reducing the environmental impact of industrial processes. Environmental catalysis plays a pivotal role in tackling both ecological and industrial issues related to pollution and sustainability. As a cornerstone of green chemistry, it enables the reduction of harmful emissions, enhances energy efficiency, and promotes cleaner production technologies. A particularly critical challenge is the reduction of greenhouse gases, especially carbon dioxide (CO_2), arising from energy production, transportation, and industrial activities. Catalytic systems are being developed to not only decrease CO_2 emissions but also to utilize it as a feedstock. Advanced catalysts enable the conversion of CO_2 into fuels such as methanol or hydrocarbons, as well as into value-added chemicals, thereby contributing to circular and sustainable carbon management. Catalysis is also indispensable in the field of sustainable energy, offering pathways to cleaner alternatives to fossil fuels. Particularly important is catalytic biomass conversion, which enables the production of biofuels and thus reduces dependence on non-renewable energy sources. Each of these research areas will be illustrated in the presentation through case studies of projects carried out within the NanoEnviCz infrastructure. The author acknowledges financial support from the Ministry of Education, Youth, and Sports of the Czech Republic under Project No. LM2023066 (VVI NanoEnviCz).

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POSTER SESSION (A - E)

POSTER SESSION A

Nanocomposites

VARGA Marián ***Institute of Electrical Engineering, SAS, Bratislava, Slovakia, EU***

Self-standing Ga2O3/diamond Photodetector: Optical Response and UV Selectivity *PA1*

The development of solar-blind ultraviolet (UV) photodetectors for wavelengths below 280 nm remains a key challenge in the field of modern optoelectronics. Materials with bandgaps >4.4 eV (e.g. AlxGa1-xN, Ga2O3 and diamond) are recognized as suitable for deep UV detection, but single crystalline forms are often costly and limited in size. However, when polycrystalline, these films provide a lower cost, tuneable platform with versatile processing routes. In this work, we present self-standing Ga2O3/diamond p-n heterojunction photodetectors fabricated from Si-doped Ga2O3 (n-type) and B-doped diamond (p-type) polycrystalline films. The optical response of prepared photodetectors was characterized under UV and VIS illumination from both the diamond and Ga2O3 sides. The measured I-V characteristics confirm p-n behaviour, and the photocurrents exceeded the dark current up to 2 orders of magnitude. The photodetectors exhibit pronounced solar-blind selectivity: the UV/visible rejection ratio, defined as the responsivity ratio (R232/R400 at 232 nm vs. 400 nm), exceeds values of 1,700 when illuminated from the diamond side and approx. 300 when illuminated from the Ga2O3 side (R250/R400 at 250 nm vs. 400 nm). These results clearly demonstrate that low-cost polycrystalline Ga2O3/diamond heterojunctions are a promising route to highly selective deep UV photodetection. M.V. acknowledges support from the project IM-2023-87 funded by the Slovak Academy of Sciences via the programme IMPULZ 2023. F.G. and M.Ť. acknowledge the support by the Slovak Academy of Sciences (SAS-TUBITAK/JRP/2024/1107.C/COPS), bilateral project no. CAS-SAS-2024-08 (SAV 25-11) and EU recovery and resilience plan (09I05-03-V02-00030).

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Photoluminescence properties of IIa (111) single-crystalline diamond epitaxially overgrown with Si-doped diamond film *PA2*

In this study, we present the temperature- and excitation wavelength-dependent Raman and photoluminescence (PL) properties of single-crystalline diamond (SCD) substrate (IIa (111) with low nitrogen content from EDP Japan), which was epitaxially overgrown with a thin diamond layer containing silicon-vacancy (SiV) centres. Raman and PL spectra were measured at four different excitation wavelengths: 405, 488, 532 and 633 nm. Temperature-dependent measurements (from 5 K to 500 K) were performed to investigate the effect of temperature on the PL of NV and SiV colour centres, as well as on the diamond Raman peak characteristics and stress-induced phenomena. The measurements revealed three PL peaks, corresponding to the NV0 (575 nm), NV- (638 nm) and SiV (738 nm) centres. For all PL peaks a red-shift of about 3 nm was observed with increasing temperature. However, the intensity of SiV and NV decreases significantly with increasing temperature. On the other hand, at low temperatures (5 - 75 K), the splitting of the SiV PL peak was observed for the excitation wavelengths of 405, 488, and 532 nm. This work was supported by the Slovak Research and Development Agency (project # APVV-23-0361). 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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CVD Diamond Growth from Detonation Soot: Nucleation Density, Morphology, and SiV Photoluminescence *PA3*

Optically active diamond is a key platform for bio-, opto-, and quantum technologies. Recent progress in the CVD technology enables wafer-scale growth with tunable properties, yet the quality is highly sensitive to the seeding step. Beyond nucleation density, recent work indicates that seed-crystal quality and shape can influence both film growth and color-center performance. Here, we ask whether inexpensive detonation soot (DS) can substitute for purified single-digit detonation nanodiamond (DND) as a seeding agent, and what impact - if any - this substitution has on CVD film morphology and the photoluminescence (PL) of silicon-vacancy (SiV) centers. DS was produced by detonation of a Composition B charge (40% TNT/60% RDX) in an ice shell and cleaned only with HCl to remove metallic residues. Aqueous DS was prepared by probe sonication and used either as (i) the full dispersion, or (ii) the supernatant after centrifugation (16,000 rcf, 1 h). For comparison, Si substrates were also seeded with a standard nucleation colloid of well-purified single-digit DND. All seeding layers and dispersions were analyzed by SEM; the dispersions by DLS, ζ-potential and FTIR. Diamond films were deposited in a focused microwave plasma reactor at 760 °C for 5–480 min and characterized by SEM, Raman spectroscopy, and PL with emphasis on SiV emission. For all three seeding types (*DND*, *DS full*, *DS supernatant*) we observe comparable nucleation densities and successful diamond growth. Within the explored parameter space, film morphology and SiV PL characteristics show no detectable degradation when DS-based seeds are used. These results demonstrate that minimally processed DS offers as a cost-effective seeding alternative for the CVD diamond growth, without compromising SiV-center optical response.

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MOSIŃSKA Lidia ***Kazimierz Wielki University, Bydgoszcz, Poland, EU***

Undoped Diamond Films for Transducer Applications *PA4*

Diamond is a material of major importance for sensor technologies due to its chemical stability, hardness, wide band gap and biocompatibility. Nanocrystalline diamond (NCD) films are attractive, since they combine the intrinsic properties of diamond with a large surface area and tunable electronic behavior depending on surface termination. Unlike boron- or nitrogen-doped layers, which may introduce defects and reduce stability, undoped NCD films preserve structural quality and reproducible surface chemistry suitable for functionalization. Undoped nanodiamond layers were synthesized by hot-filament chemical vapor deposition (HF-CVD) on quartz substrates. Quartz provides transparency, dielectric stability and compatibility with microfabrication processes, which is advantageous for sensor integration. Structural characterization with Raman spectroscopy and scanning electron microscopy confirmed nanocrystalline films with minimal sp^2 carbon admixture. Surface functionalization with hydrogen or oxygen was applied to tailor electronic properties. Hydrogen termination induces p-type surface conductivity through transfer doping, while oxygen termination maintains insulating behavior. These modifications are directly related to sensor performance. The obtained layers are proposed as a transducer for solid-gate field-effect transistors (SGFETs) and gas sensors. In SGFET structures, hydrogen-terminated nanodiamond enables sensitivity to ionic and biochemical changes, supporting bio- and chemo-sensitive devices. In gas sensing, oxygen-terminated surfaces provide selectivity, reproducibility and resistance to harsh conditions. The combination of nanocrystalline morphology, controlled functionalization and chemical robustness supports the use of these layers in multifunctional sensors. ACKNOWLEDGEMENTS: The work was performed in the frame of MNSW Poland Regional Excellence Initiative no. RID/SP/0048/2024/01 project.

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DOLEŽAL Zdeněk ***Institute of Physics of the CAS, Prague, Czech Republic, EU***

Temperature-Dependent Photoluminescence of Si-V Centers in Diamond MEMS Structures *PA5*

This study investigates nanocrystalline diamond (NCD)-based MEMS structures incorporating silicon-vacancy (Si-V) centers. The combination of device design, the physical properties of diamond, and the optical characteristics of Si-V centers demonstrates strong potential for non-contact optical thermometry and strain sensing. Structures were fabricated using lithography and microwave plasma-enhanced chemical vapor deposition (CVD). Scanning electron microscopy (SEM) analysis confirmed the uniform thickness and nanocrystalline morphology of the diamond films. Raman spectroscopy revealed spatial variations in the diamond peak position across the MEMS structures, indicating non-uniform mechanical strain within the NCD layer. Photoluminescence (PL) spectroscopy showed a dominant, sharp zero-phonon line (ZPL) at 738 nm, characteristic for negatively charged $(Si\text{-}V)^-$ centers. The ZPL position and FWHM exhibited a linear dependence on temperature over the measured range, during heating and cooling process. These results confirm the sensitivity of Si-V centers to local strain and temperature variations. The work contributes to the growing understanding of Si-V centers in diamond and supports their future integration into quantum technologies, sensing platforms, and photonic devices.

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BRUDER Nicolas ***University of Fribourg - Adolphe Merkle Institute, Fribourg, Switzerland***

Disordered Diamond-Like Structures from Colloidal Building Blocks *PA6*

Photonic crystals are periodic structures able to control the propagation of light, preventing photon transport in ay way analogous to electron behaviour in semiconductors. Among these, the cubic diamond structure is notable for exhibiting a complete photonic bandgap [1][2]. This makes cubic diamond an attractive candidate for photonic materials, motivating extensive research into its fabrication [3]. A promising approach involves DNA-mediated self-assembly of deformed tetrameric colloids. The four-patch geometry of these colloids prevents the formation of the hexagonal diamond, which lacks a bandgap, while enabling binding to four nearest neighbours, thereby producing a cubic diamond lattice [4]. Beyond perfect crystals, there is growing interest in introducing controlled disorder to achieve strong photon localization, also known as Anderson localization [5]. Sajeev John proposed realizing such states by embedding long-range order into disordered systems [6]. In contrast, this project investigates disorder introduced into an initially ordered cubic diamond crystal. The colloidal self-assembly route allows tuning of disorder by adjusting colloid deformation, patch protrusion, and rotational flexibility. Additionally, mixing slightly different particle shapes provides another mechanism to construct diamond-like structures with tailored disorder, while preserving long-range photonic properties.

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Cu(I)/Cu(II) Single Atoms Over N-Doped Graphene Acid for Electrocatalytic Nitrate Reduction to Ammonia *PA7*

The escalating global demand for energy continues to drive a significant increase in greenhouse gas emissions, a concern highlighted at the 27th Conference of the Parties, which underscored the urgent need for coordinated action toward sustainable energy systems and carbon mitigation technologies. Among the most energy-intensive industrial processes is the Haber-Bosch method for ammonia synthesis, which accounts for a substantial share of anthropogenic CO2 emissions. Given ammonia's critical role as a nitrogen source in fertilizers, identifying alternative, low-emission synthesis routes is vital for ensuring long-term food security. In this study, we present a sustainable approach to ammonia production via electrocatalytic nitrate reduction, leveraging nitrate ions commonly present in wastewater as a nitrogen source. Our method utilizes Single Atom Catalysts (SACs), engineered by immobilizing individual copper atoms onto functionalized graphene supports. Specifically, we synthesize Cu(I)/Cu(II) mixed-valence species stabilized on nitrogen-doped graphene acid. The functional groups within the graphene lattice play a dual role: enhancing metal atom stabilization and promoting in situ reduction of Cu(II) to catalytically active Cu(I) centers. During electrocatalysis, Cu(I) sites facilitate proton adsorption and activation (forming H*ads), while Cu(II) sites coordinate with nitrate ions. The proximity of these two sites enables the transfer of H*ads to bound nitrate, promoting its stepwise reduction to ammonia. This dual-site mechanism not only offers a low-carbon route for ammonia electrosynthesis but also contributes to wastewater remediation by converting nitrate pollutants into valuable chemical products, thereby addressing both environmental and agricultural challenges.

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COETZEE Divan — *Technical University of Liberec, Liberec, Czech Republic, EU*

Advancing Electrospun Polymer-Graphite Composites: Strategies for Improved Performance *PA8*

This study examined the spinnability of expanded graphite mixed with PVB, PCL, and PLA polymers using AC electrospinning. Expanded graphite was ultrasonicated to reduce its porosity and was successfully incorporated at concentrations of up to 30% in PVA, 20% in PVB, and 10% in PCL. Although electrical resistivity decreased slightly with higher graphite loading, the improvement in conductivity was limited due to the material's high porosity. Mechanical properties measured along the fibre direction showed only minimal enhancement. The study suggests that to achieve better performance, the material should be axially compressed to increase density, which would improve conductive networks through enhanced particle-to-particle contact and increase the axial load-bearing capacity.

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Influence of Multi-Step Process Parameters on the Porosity of Iron-Doped, Cellulose-Based Porous Carbon Monoliths *PA9*

Cellulose-based porous carbon monoliths have attracted significant interest as sustainable materials for applications in catalysis, adsorption, and energy storage. However, preparation of these porous carbon monoliths from microcrystalline cellulose powder requires a multi-step procedure based on ice-templating effect [1] where each individual step influences total pore volume and pore size distribution of prepared monoliths. This work investigates the impact of individual steps within this multi-step preparation procedure on the porosity characteristics—specific pore volume, specific surface area, and pore size distribution—of iron-doped, cellulose-based carbon monoliths. Microcrystalline cellulose was dissolved in precooled aqueous NaOH solution and mixed with saturated $FeSO_4$ solution. The resulting mixture was poured into molds and subjected to controlled freezing, (preceded by pre-heating at 85 °C for varying durations in selected samples), regeneration, washing, drying and pyrolysis. By systematically varying each process parameter from pre-heating to pyrolysis, this study aims to elucidate their individual and combined effects on the resulting porous structure. The findings contribute to a deeper understanding of the controllable synthesis of tailored porous carbon monoliths from renewable precursors, offering pathways to optimize their textural properties for specific applications. [1] 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

MÁCA František — *Institute of Physics of the CAS, Prague, Czech Republic, EU*

Stability and Magnetic Ordering Near the Antiphase Boundary in Ni2MnGa *PA10*

Antiphase boundaries (APBs) are planar crystallographic defects that play an important role in strengthening Ni-based alloys, and their sensitivity to alloy composition offers a flexible tuning parameter for alloy design. Thermal APBs in magnetic shape memory alloys affect magnetic coercivity through magnetic domain wall(DW) pinning. Magnetic force microscopy (MFM) and Lorentz transmission electron microscopy (TEM) studies of Ni2MnGa have shown a clear difference between signals generated by a thermally induced APB and by a single magnetic DW. A change of sign of the out-of-plane component of magnetic flux (Bz) measured across the interface is a signature of APB in an in-plane magnetized sample, whereasa simple but much stronger peak of Bz indicates a single DW. We combine experimental and theoretical (ab initio) methods to analyze the stability and magnetic ordering near the antiphase boundary in Ni2MnGa with L21 ordering. Ab initio electronic structure calculations based on density functional theory are used to investigate the magnetic ordering in a structure simulating APB's in cubic austenite.The total energy calculations indicate that at the antiphase boundary the ferromagnetic ordering changes its orientation in the opposite direction.This sudden change in magnetization highlights the APB's,which are then readily visible by magnetic force microscopy. We find that single APB's,when close together, tend to attract each other and form thicker antiphase boundary complexes. The APB region with lowest ground state energy was used as an input of a magnetostatic calculationas implemented in Quantum ATK atomistic simulation software.This continuum model was used to predict magnetic contrast at length scales comparable to the MFM observation.

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NGHIEM Xuan Duc — *Brno University of Technology, CEITEC, Brno, Czech Republic, EU*

Evaluating the Influence of Synthesis Procedures and Electrochemical Activation on Rgo-Cuo Nanocomposites Towards Histamine Detection *PA11*

Histamine is a biogenic amine commonly found in fermented foods and fish products. High histamine intake can lead to histamine poisoning, resulting in an array of health consequences, and in severe cases, fatal outcomes. Hence, the detection of histamine in food is of great importance. Electrochemical sensors based on nanomaterials are a great candidate for this purpose. In this study, rGO-CuO nanocomposites were employed, and the impacts of synthesis procedures and electrochemical activation on these nanocomposites towards histamine were investigated. More specifically, rGO-CuO was synthesized by two different approaches, namely in situ and ex situ. Secondly, the physicochemical characterization of the nanomaterials was implemented by Scanning Electron Microscopy and X-ray Diffraction. Lastly, the electrochemical performance of glassy carbon electrodes modified by the nanocomposites was evaluated by Cyclic Voltammetry and Differential Pulse Voltammetry in the presence of histamine. The results indicated that the nanocomposites from the two synthesis approaches had different morphologies, resulting in two distinct electrochemical behaviours towards histamine. Furthermore, the electrochemical activation led to significant improvements for the nanocomposites from both synthesis approaches, with the electrode modified with rGO-CuO from the ex situ approach having a better peak current than the bare one and the one modified with rGO-CuO from the in situ approach. ACKNOWLEDGEMENT: This study was supported by the project CEITEC VUT-J-25-8756, Brno University of Technology.

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Inter-lanthanide Perovskites LaYO3 Doped with Yb3+/Tm3+ *PA12*

Inter-lanthanide perovskites exhibit interesting magnetic and optical properties. The intensity of photoluminescence (PL) emission can be influenced by the composition of the host matrix and is characterized by sharp spectral peaks from their 4f electron transitions [1, 2]. The aim of this work was to prepare selected perovskites with host matrix LaYO3 doped with ≈1 at. % Yb3+ and various concentration of Tm3+ ions (≈0; 0,02; 0,1; 0,5; 1 and 2 at. %). Perovskites were prepared by combustion synthesis and were studied their physic-chemical properties, with a focus on optical properties. In addition to the impact of the chemical composition of perovskites on the resulting properties, attention was paid to revealing the dependence of Tm3+ ion concentration on upconversion (PL) emissions. The samples were characterized in terms of their chemical composition (EDX microanalysis), crystallites size (SEM), their crystallographic structure (XRD analysis), diffuse reflectance spectra (UV-Vis-NIR spectroscopy), and steady-state and time-resolved PL emission spectra measured at the pumping wavelength of λ ≈ 977 nm. In the perovskites, was observed the near-infrared Tm3+: 3F4 → 3H6 (λ ≈ 1.82 µm) PL Stokes and the visible Tm3+: 3H4 → 3H6 (λ ≈ 770 nm), Tm3+: 3F2, 3F3 → 3H6 (λ ≈ 670 nm) and Tm3+: 1G4 → 3H6 (λ ≈ 485 nm) PL anti-Stokes emission. Based on the PL emission spectra and the decay times of Tm3+ electronic transitions, the mechanism of upconversion PL emission was determined.

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Hybrid Nanocomposites Based on Polypropylene (PP) Reinforced with Nano-silica (SiO2) and Graphene Oxide (GO) ***PA13***

In this study, hybrid nanocomposites based on polypropylene (PP) reinforced with nano-silica (SiO2) and graphene oxide (GO) were synthesized and characterized. A melt compounding technique was used to fabricate the nanocomposites with varying contents of SiO2 (1-3 wt%) and GO (0.5-1 wt%). The thermal, mechanical, and morphological properties of the nanocomposites were evaluated using TGA, DSC, tensile testing, XRD, and SEM. Results showed significant improvements in thermal stability and tensile strength due to the synergistic effects of GO and SiO2, making the material a potential candidate for high-performance applications.

Nanoelectronics

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Porphyrine Memristors ***PA14***

In our ongoing computational work we are in the progress of rational designing the porphyrine-based molecular device that is capable of controllable and repeatable switching between at least two states. Both states are to be stable without the impulse - external electric field, that only mediates switching between them ("writing"). Further, these states would have different characteristics, that would allow the states to be distinguished, or "reading". Porphyrines can host a variety of metals that would allow the molecule to exist in alternate spin states - singlet or triplet. We aim to utilize these different multiplicity states of metal porphyrines as states to switch between, rendering the molecule different total and spin resolved conductivity, depending on the state. Such a device would serve as a prototype for future applications in nanoelectronics as molecular memory-storage element, for example. ACKNOWLEDGEMENTS: We acknowledge the support of Czech Science Foundation, project 25-158875 for this work.

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Study of the Structure and Fabrication Possibility of a Nanosheet Metal-Dielectric-Semiconductor Transistor on a Graphene Base ***PA15***

The rapid evolution of nanoelectronics underscores the need for innovative field-effect transistor (FET) architectures that deliver enhanced performance and enable further miniaturization. This study investigates the design and fabrication potential of a multilayer nanosheet metal-dielectric-semiconductor (MDS) transistor, utilizing semiconducting graphene layers deposited on a silicon substrate and incorporating gold source and drain regions. The graphene layers form contacts with both the upper and lower surfaces of the gold electrodes, resulting in a multilayered gate and channel structure. This configuration allows the gate to fully enclose the channel, thereby improving electrostatic control and optimizing transistor performance parameters. A comprehensive technological modeling process was conducted to define the fabrication sequence, yielding a structure composed of vertically stacked graphene channels encapsulated by silicon dioxide and polycrystalline silicon. Additionally, the study explores a cost-effective and scalable method for depositing graphene layers. This approach involves exfoliating graphite into particles containing varying numbers of graphene layers, which are then dispersed in a liquid medium. Using sharp-edged, blade-shaped probes, these particles are selectively transferred onto the substrate surface, enabling the formation of graphene layers with controlled thickness and dimensions. The findings demonstrate that the proposed structure and fabrication method can facilitate the development of compact, high-speed MDS transistors and significantly broaden the practical applications of graphene in nano-electronic devices.

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Acoustofluidic Focusing of PS@Ag: Towards Continuously Renewable SERS Substrate *PA16*

Acoustic forces enable contactless and selective manipulation of particles within microchannels, allowing precise control over their distribution and flow dynamics. This work presents the development of a glass microfluidic chip with an integrated piezoelectric element, designed for the continuous handling of functionalized polystyrene microparticles using acoustofluidic principles. The core innovation lies in the design and implementation of a system that facilitates controlled mixing of the sample with these microparticles, followed by their spatial concentration in a dedicated detection zone. As part of the system development, substantial effort was devoted to optimizing the synthesis and surface functionalization of polystyrene microparticles with silver nanostructures (PS@Ag), intended for future use as SERS-active carriers. Although surface-enhanced Raman spectroscopy (SERS) detection is not yet implemented, this study establishes the groundwork by demonstrating the feasibility of continuous particle focusing and transport within the microfluidic platform. The presented device represents a crucial step toward the realization of an automated, flow-through analytical system, with the potential for future integration with separation techniques and real-time, SERS-based chemical analysis. ACKNOWLEDGEMENT: This work was supported by the Czech Science Foundation (Grant No. 25-16617S). Additional support was provided by the ATEBIO project (ID CZ.02.01.01/00/23_020/0008535) funded by the European Union, and by institutional support RVO 68081715 from the Institute of Analytical Chemistry of the CAS (Czech Republic).

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Suppressing Noise in Quantum Computing of Electronic Structure of Crystals *PA17*

Quantum computing is currently emerging as a new computational technology for solving complex computational problems. Current quantum computers are unfortunately too noisy to provide sufficient accuracy, and quantum-classical hybrid algorithms emerged as a solution. Variational Quantum Algorithms are currently showing promising results at overcoming noise introduced by current level of quantum hardware. Variational Quantum Deflation (VQD) has gained significant attention when computing spectrum of eigenvalues in quantum chemistry and solid-state physics. Noise in VQD calculations performed on the current noisy quantum computers, or their simulators, can be partly suppressed by methods available in the Qiskit Python package provided by the IBM company. In our study, several of these error suppression and mitigation methods have been tested and our results offer rather unique comparison in the case of calculations of the electronic structure of crystals when the performance is sensitive to the actual point in the reciprocal space. ACKNOWLEDGEMENTS: Financial supports from the Czech Academy of Science are gratefully acknowledged, in particular the Praemium Academiae awarded to MF, and the Strategy AV21 (the program "AI: Artificial Intelligence for Science and Society"). The authors further acknowledge financial supports from (i) The Ministry of Education, Youth and Sports via the INTER-EXCELLENCE II program, sub-program INTER-COST, in particular the project No. LUC25028, and (ii) the Quantum Innovation Centre providing us the access to the IBM quantum computers. 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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Fe-Doped Hexagonal Boron Nitride Nanotubes: A First-Principles Study of Vibrational and Electronic Properties ***PA18***

This theoretical study extends our previous calculations on Fe-doped hexagonal boron nitride (h-BN). We investigated the structural and thermoelectric properties of h-BN nanotubes when Fe atoms are introduced by substitution into the B sites. The objective is to evaluate the stability of the doped materials, their potential for harmful gas sensing, and their suitability for hydrogen-related applications through optimization of vibrational (IR and Raman) properties. Calculations were performed on a (2 × 1 × 1) supercell using the SCF-LCAO-DFT-B3LYP approach implemented in the CRYSTAL17 program. The h-BN nanotubes were constructed from 2D hexagonal BN sheets, and doping configurations with one and two Fe atoms were considered. The obtained nanotubes exhibit semiconducting behavior. IR and Raman analyses reveal the active vibrational modes of (9,0) and (10,0) BN nanotubes, consistent with results from both the primitive and supercells. These findings support the feasibility of Fe-doped h-BN nanotubes for sensing and energy applications.

2D Nanostructures

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Effect of Exfoliation Conditions on the Photocatalytic Properties of Graphitic Carbon Nitride Investigated by Electrochemical Impedance Spectroscopy ***PA19***

Graphitic carbon nitride (GCN) is a promising material in the field of photocatalysis. Mott-Schottky analysis and electrochemical impedance spectroscopy (EIS) were used to investigate the electronic structure and charge transfer properties of exfoliated GCN. The conduction band potential was measured by Mott-Schottky measurement and charge transfer kinetics were studied from Nyquist plots constructed from EIS measurements. Results from electrochemical measurements suggest, that exfoliation can be used to modify the electronic structure of GCN and potentially improve its photocatalytic properties.

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Non-Linear Magneto-Optical Properties of Quazi-2D Electron Gas in Periodically Modulated GaAs Nanostructures ***PA20***

Beyond their technological impact, 2D electron systems in semiconductor heterostructures provide a versatile platform for studying quantum many-body effects [1, 2]. A key feature is the ability to modulate the electron density into quasi-2D or 1D arrays, leading to rich physics. In a perpendicular magnetic field with a periodic superlattice, a 2D electron gas (EG) exhibits the fractal Hofstadter spectrum due to quantum interference [3, 4]. Embedding such systems in photon cavities (PCs) allows tunable control over electronic and material properties in chemistry [5], physics [6], and materials science [7]. The high polarizability and mobility of EGs in GaAs make them ideal for exploring strong coupling with far-infrared photons [8]. We have modeled a change in spin configuration in a 2D square array of quantum dots (QD) and rings (QR) subjected to a transverse magnetic field. The system is placed in a cylindrical far-infrared photon cavity with a circularly symmetric mode. Our simulations show that spin ordering in each QD or QR can be controlled by the electron-photon coupling strength and photon energy. Electron-electron interactions are treated within a spin-density functional framework, while para- and diamagnetic electron-photon couplings are handled using a configuration interaction approach in a truncated many-body Fock space. Without external pulses, spin reordering is reflected in the orbital magnetization of the rings and can be suppressed at strong coupling. Dynamical simulations reveal spin fluctuations when the system is excited via a time-dependent coupling scheme that enhances the diamagnetic interaction [10]. REFERENCES: [1] P. Kumbhakar, J. S. Jayan, A. S. Madhavikutty, P. Sreeram, A. Saritha, T. Ito, C. S. Tiwary, iScience 2023, 26, 106671; [2] T. Ando, A. B. Fowler, F. Stern, Rev. Mod. Phys. 1982, 54, 437; [3] D. R. Hofstadter, Phys. Rev. B 1976, 14, 2239; [4] M. Mansoury, V. Mughnetsyan, A.

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Magnetotransport in a Rashba-Coupled Two-Dimensional Electron Gas in a Chain of Planar Quantum Rings ***PA21***

The magnetotransport and magnetooptical properties of an electron gas in a quasi-1D chain of planar quantum rings have been studied. The system was subjected to a homogeneous magnetic field directed perpendicularly to the plane of the structure. An analytic function for the external modulation potential is proposed to model the periodic motion of electrons in one direction and the quantized motion in the transverse direction of the structure. The basis vectors in the Hilbert space are chosen so that they capture both the symmetry and the periodicity of the system. The interaction between electrons is modeled in the Hartree approximation. The Rashba spin orbit interaction is also discussed. The computed electronic band structure as a function of the magnetic field reveals a high degeneracy in the spectrum of the system for specific values of magnetic field. The degeneracy is expressed as nodes in the energy minibands and has its signature in all the physical quantities discussed in the work. As a consequence, the orbital magnetization, and the longitudinal component of the magneto-conductance tensor exhibit oscillatory behavior which is sensitive to the Rashba coupling strength. For the transverse component of the conductance tensor plotted versus magnetic field induction, we observe a ladder-like behavior reminiscent of the quantum Hall effect. However, a detailed examination shows that the reason for such a behavior is the mini-band nodes. Additionally, we have calculated the magneto-absorption of the system within the dipole approximation. The absorption coefficient as a function of incident photon energy for two perpendicular photon polarizations and various magnetic field strengths has been analyzed.

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Films/Layers

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Fast and Selective Detection of H_2S Using Nanostructured Zinc Stannate Thin Films ***PA22***

The reliable detection of hydrogen sulfide (H_2S) at low concentrations is vital due to its toxicity and health hazards. In this work, we developed zinc stannate (Zn_2SnO_4, ZTO) thin films via a sol-gel spin coating process to serve as efficient H_2S gas sensors. The fabricated films, predominantly composed of Zn_2SnO_4 with a small fraction of ZnO, exhibited nanorods and hexagonal surface structures that significantly enhanced their sensing ability. Comprehensive structural and compositional analyses confirmed the crystalline quality and chemical purity of the films. Gas sensing tests revealed strong selectivity toward H_2S over other interfering gases. Notably, the sensors demonstrated a rapid response time of 10 seconds and recovery within 24 seconds when exposed to 7 ppm H_2S at an optimal operating temperature of 200 °C. The sensing behavior is explained through an adsorption-desorption mechanism, with intrinsic oxygen vacancies playing a crucial role in enhancing reactivity. These findings highlight the potential of nanostructured ZTO thin films as promising candidates for highly sensitive, selective, and fast-response hydrogen sulfide (H_2S) gas sensors.

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Exploration of Methane Concentration Effects on Boron-Doped Diamond Film Quality: Morphological Changes ***PA23***

Boron-doped diamond (BDD) thin films have emerged as multifunctional materials for advanced electronics due to their exceptional properties. When combined with gallium oxide (Ga_2O_3), a new class of heterostructures emerges that influences the complementary advantages of both materials, especially as next-generation power electronic (as p type) and optoelectronic devices (as n type). In this study, BDD films were synthesized on p-type silicon substrates using a microwave plasma-enhanced chemical vapor deposition system across a broad range of methane concentrations (1.5 % - 18 %) while maintaining a constant boron-to-carbon (B/C) ratio of 2000 ppm. Structural and physicochemical characterization using scanning electron microscopy, Raman spectroscopy, X-ray diffraction, and optical emission spectroscopy showed a distinct morphological evolution from microcrystalline diamond (1.5 % - 9% CH4) to nanocrystalline diamond (12 % - 15 % CH4), and further to two-dimensional needle-like pointed diamond structures at the highest methane concentration (18 %). The Hall effect analysis confirmed an enhancement in electrical conductivity with increasing methane content. Concurrently, Kelvin probe force microscopy measurements indicated a tunable work function ranging from 5.45 eV (1.5 % CH4) to 4.1 eV (18 % CH4). As a proof-of-concept application, the as-grown BDD films were employed as multifunctional electrodes (n type) in microplasma display devices. BDD synthesized at 18% CH4 exhibited the lowest breakdown voltage (370 V) and the highest current density (36 mA cm-2), highlighting the strong influence of methane concentration on charge transport and optoelectronic performance. Furthermore, these findings provide an understanding of BDD tailoring via gas-phase chemistry and open a new avenue for underlining the significant potential of Ga_2O_3/BDD heterostructures for high-performance power electronics.

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Structural and morphological nature of Ti-Si layers ***PA24***

The structure and morphology of binary Ti-Si thin films were studied. Ti-Si surface alloys were deposited by electron beam. The Si content was controlled by the evaporation rate of Ti and Si targets. The structure was investigated by X-ray diffraction (XRD) and the morphology and surface roughness were measured by atomic force microscopy (AFM). The results show that the morphology and surface roughness reflect the structural evolution. The crystalline nature of Ti-Si thin films tends to nanocrystalline form. Higher amounts of Si resulted in an amorphous structure with a smoothed surface morphology and the lowest roughness.

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Magnetic, Metal and Oxidic Nanomaterials & Other Nanostructures

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Inkjet-Printed Magnetoelectric Nanoparticles: Deposition and Characterization ***PA25***

The combination of inkjet-printing method and optical lithography was used to deposit multilayer sensing structure. Key advantages of inkjet printing include low material consumption, a quick transition from design to finished product, and low production costs. This is why this technology is increasingly used in the production of electronic circuits and devices. In contrast, metal sputtering in conjunction with optical lithography enables high-resolution patterning with excellent dimensional control and process repeatability, which are critical for the reliable fabrication of microscale features in microelectronic devices. In this research, we present the formulation of an ink, including the synthesis of magnetoelectric nanoparticles (MENPs) and the preparation of a stable dispersion suitable for inkjet printing. Furthermore, we demonstrate the design, fabrication, and characterization of deposited magnetoelectric layers. MENPs are highly promising materials in the fields of nanotechnology, biomedicine, and spintronics due to their unique ability to interconvert electric and magnetic fields at the nanometer scale. The MENP-based ink was inkjet-printed onto both rigid and flexible substrates, and the resulting layers were characterized in terms of homogeneity, thickness, and particle distribution, considering different printing resolutions and numbers of overprinted layers, which are the main parameters that affect the final result. Scanning electron microscopy (SEM), optical microscopy, electrical measurements, and other analytical techniques were employed to evaluate the structural and functional properties of the printed layers. This study provides a comprehensive approach to ink formulation, deposition, and characterization of magnetoelectric nanoparticle layers, offering valuable insights for the development of advanced multifunctional materials and additive techniques.

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C(sp2)-S Cross-Coupling Reactions with Cobalt and Visible Light *PA26*

Cross-coupling reactions are fundamental to modern organic synthesis, enabling the rapid construction of carbon-carbon and carbon-heteroatom bonds. Merging photoredox catalysis with transition-metal catalysis has revolutionized these transformations, as visible light provides a sustainable means to access reactive metal oxidation states under mild conditions. While nickel and copper have been widely exploited in this dual-catalysis paradigm, the potential of cobalt remains largely underexplored. Here we report the first cobalt-mediated metallaphotoredox strategy for C(sp^2)-S cross-coupling under visible-light irradiation. This approach enables the efficient coupling of diverse (hetero)aryl bromides, including challenging electron-rich substrates, with a broad range of thiol nucleophiles, delivering the corresponding products in yields up to quantitative. The operational simplicity, broad substrate scope, and sustainability of this protocol highlight cobalt as a powerful yet underutilized platform for dual-catalytic cross-coupling.

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Thermally Induced Transformation of the Nickel-Fullerene Hybrid Assembly *PA27*

Metal-fullerene hybrid assemblies represent a specific class of materials exhibiting interesting properties [1, 2], which find their way into electronics [3], medicine [4], catalysis [5] or materials science [6]. However, due to the weak intermolecular interactions that bind the hybrid components together, the integrated assembly is thermodynamically unstable. Destructive processes, such as thermal annealing or ion irradiation, can lead to a change in their structure and consequently their properties. In this work, the thermal stability of several nickel-fullerene complexes was investigated over a wide temperature range. The evolution of the samples was monitored using neutron depth profiling, Rutherford backscattering, micro-Raman spectroscopy and scanning electron microscopy. The results showed that the hybrid films exhibit a specific phase transformation upon heating, which leads to a dramatic change in their structure and culminates in the formation of a new self-assembled material. REFERENCES: [1] J. Vacík et al., Pattern formation induced by co-deposition of Ni and C60 on MgO(100), Journal of Chemical Physics 114 (2001) 9115; [2] V. Lavrentiev et al., Emergent ferromagnetism and interface exchange bias in self-assembled copper-fullerene hybrid nanostructures, Advanced Composites and Hybrid Materials 8 (2025) 287; [3] M.G. Helanderat al., Metal/Fullerene Electrode Structure: Physics and Device Applications, Proc. SPIE 7051, Organic Light Emitting Materials and Devices XII, 70510Z (2 September 2008); [4] J. Vacik et al., Fullerene (C60) - Transitional Metal (Ni) Composites - Structural and biological properties of the thin films, Diamond and Related Materials 19 (2010) 242; [5] U.M. Dzhemilev et. al., Metal complex catalysis in the chemistry of fullerenes, Handbook on Fullerene: Synthesis, Properties and Applications, 2011, Ed. R.F. Verner, C. Benvegnu, 241-312; [6] P.A. Kumar et al., Fabrication and applications of fullerene-based metal nanocomposites: A review, Journal of Materials Research 36 (2021) 114.

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Synthesis of Poly(glycidyl Methacrylate) via Mechano-Atrp Using Barium Titanate and Zinc Oxide Nanoparticles as Active Agents *PA28*

This study focuses on the synthesis of poly(glycidyl methacrylate) (PGMA) using a mechanically controlled atom transfer radical polymerization (mechano-ATRP) activated by barium titanate (BaTiO3) or zinc oxide (ZnO) nanoparticles as piezoelectric agents. Polymerization optimizations were performed with a typical ATRP reaction mixture containing monomer, initiator, ligand, and transition metal. The piezoelectric agents were used at the amounts of 0.5 wt.% for ZnO and 4.5 wt.% for BaTiO3 nanoparticles. The presence of oxygen in the reaction mixture was minimized through argon purging. The mechano-ATRP was carried out in an ultrasonic bath under defined conditions, such as temperature and intensity, for 5 hours. The reaction kinetics were evaluated using proton nuclear magnetic resonance (1H NMR) by calculating monomer conversion over time. The polydispersity index and molar mass of the polymer were determined using gel permeation chromatography (GPC). The aim of this study was to gain control over the mechano-ATRP of PGMA to produce a well-defined polymer with a low polydispersity index, specifically below 1.4, which was successfully achieved. ACKNOWLEDGEMENTS: The authors wish to thank the Czech Science Foundation (25-16538S) for financial support and also gratefully acknowledge the Ministry of Education, Youth and Sports of the Czech Republic - DKRVO (RP/CPS/2024-28/003).

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Mechano-ATRP of N-butyl Acrylate Mediated by Barium Titanate Nanoparticles *PA29*

Mechano-ATRP is newly discovered controlled polymerization technique, where the control of the reaction is provided by piezoactive component. The barium titanate particles were recognized as suitable additive to provide polymer chains with well controlled structure. The barium titanate particles can be obtained in both micro and nano dimensions. This study focuses on the investigation of effect of micro and nano size of barium titanate on the polymerization process of n-butyl acrylate. The reactions conditions including type of catalyst, ligand and piezoactive filler type and concentration were varied. Interestingly, the polymerization occurs only presence of the most active ligand, Me6Tren. ACKNOWLEDGEMENT: The authors wish to thank the Czech Science Foundation (25-16538S) for financial support and also gratefully acknowledge the Ministry of Education, Youth and Sports of the Czech Republic - DKRVO (RP/CPS/2024-28/003).

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Spin Transport and Splitting of Magnons in Altermagnets *PA30*

Altermagnets attract ongoing interest because of their unexpected electronic properties, such as spin splitting of electron bands or various transport properties (anomalous and spin Hall effects). Besides the electronic properties, based on elementary excitations that can be classified using the electron spin as a good quantum number, attention has recently been paid to magnons, where such simple classification is not possible. Nevertheless, magnon-related properties of altermagnets are interesting as well, including the chirality-based splitting of magnon eigenvalues or various transport phenomena induced by temperature gradients. However, systematic description of these magnon-related properties is not available at present. In this contribution, magnons in a simple model of altermagnetism, corresponding to a two-dimensional bilayer, are studied within the classical isotropic Heisenberg Hamiltonian. Particular attention is paid to the splitting of magnon eigenvalues as well as to the spin currents generated by temperature gradients. The obtained results are compared with those related to electrons, namely, with the spin splitting of electron eigenvalues and with the spin currents generated by external electric fields. It is found that the previously developed classification scheme [I. Turek, Physical Review B 106 (2022) 094432] is relevant for both electron-based and magnon-based properties; minor deviations are discussed as well. ACKNOWLEDGEMENT: The work was supported financially by the Czech Science Foundation (grant No. 23-04746S).

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Impact of Non-Sphericity and Exchange Interaction on the Huang-rhys Parameter for Excitons in a Core-Shell Quantum Dot *PA31*

Using the exciton-phonon Fröhlich interaction matrix elements for a core-shell quantum dot (QD), obtained in our earlier work [Comput. Mater. Sci., 246, 113394, 2025], we studied the Huang-Rhys parameter (HRP), which quantifies the strength of exciton-phonon coupling for a specific excitonic state. The phonon confinement effects and strong confinement regime for excitons are considered. The combined effect of the non-sphericity of the quantum dot core and the electron-hole exchange interaction on the exciton Huang-Rhys parameter in a QD with a zinc-blende structure has been studied for the first time. These effects remove the degeneracy of exciton energy levels, creating a fine structure. It is found that the non-sphericity affects only the 1U, -1U, 1L, and -1L exciton states. Calculations for the InP/ZnSe system show that for QDs with prolate and oblate cores, the HRP is larger than in the spherical case. The contribution of quasi-confined phonons to the HRP significantly exceeds that of interface phonons. The HRP also strongly depends on the ratio of light- to heavy-hole effective masses. This work was supported by the HESC of MESCS RA within the framework of the research projects No. 24WS-1C040 and No. 21AG-1C048.

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Optimization of Gma Homopolymerization via Atrp: Impact of Temperature on Polymer Nanostructure and Crosslinking Behavior *PA32*

This study focuses on the optimization of the homopolymerization of glycidyl methacrylate (GMA) using atom transfer radical polymerization (ATRP). Particular attention was paid to the effect of reaction temperature on polymer nanostructure and the tendency of the epoxide ring to undergo undesired crosslinking reactions. Polymerizations were carried out at various temperatures (30-80 °C) while maintaining consistent reaction parameters. Nuclear magnetic resonance (NMR) spectroscopy and gel permeation chromatography (GPC) were used for structural and molecular weight characterization. Results showed that elevated temperatures, particularly above 40 °C, led to increased crosslinking due to epoxy ring opening, which significantly affected the solubility and dispersity of the resulting polymers. The optimal reaction conditions were identified at lower temperatures (30-40 °C), where well-defined polymers with minimal crosslinking and narrow molecular weight distribution were obtained. Prepared polymers have been investigated using scanning electron microscope to see the size of the individual fabricated polymers. These findings highlight the importance of temperature control during ATRP of GMA to preserve epoxide functionality and ensure predictable polymer structure. ACKNOWLEDGEMENT: 2/2 The authors wish to thank the Grant Agency of the Czech Republic (25-16538S) for financial support and also gratefully acknowledge the Ministry of Education, Youth and Sports of the Czech Republic - DKRVO (RP/CPS/2024-28/003).

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POSTER SESSION B

Industrial Applications - Nanofibres, Thin Films, Layers, Catalysis

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Textile Fibers Nanocoated by Doped TiO2 Thin Films for Multifunctional Applications *PB1*

In this work, we report the development of doped or undoped TiO_2 nanocoatings by asymmetric bipolar direct current pulsed sputtering on textile fibers. Low-temperature pulsed sputtering using Ti Target and transition metals was used to create functional nanocoatings on textile fiber surfaces. The phase formation and structural parameters were studied by X-ray diffraction (XRD), XPS and morphological parameters by atomic force microscopy (AFM) and scanning electron microscope (FEG-SEM) and transmission electron microscope (HRTEM). The photocatalytic activity was explored by measuring the hydrophilic/hydrophobic properties and photodegradation of methylene blue and rhodamibe B aqueous dye solution under UV radiation. The experimental results show that the nanocoated textile fibers with doped TiO_2 exhibit hydrophobic, antimicrobial behavior and efficient self-cleaning properties, with a photocatalytic efficiency above 95% and a high degradation kinetics, based on the Angmuir Hinshelwood (L-H) mechanism. Concluding that the nanocoated fibers can be used in several environmental applications. Acknowledgements This research was supported by CARREFOUR group and the Coordination for the Improvement of Higher Education Personnel- Brazil (CAPES)- Finance Code 001, as well as to the National Council for Scientific and Technological Development (CNPq) under projects number 400913/2023 - 2 and 404139/2022 - 1. Further thanks are due to the Graduate Program in Chemical Engineering at the Federal University of Rio Grande do Norte (PPGEQ/ UFRN) for providing technical assistance.

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The Effect of PCL/PLA Blend Nanofibers with Clotrimazole on Candida Albicans Growth *PB2*

Polycaprolactone (PCL) and polyl(actic acid) (PLA) are biocompatible and biodegradable polymers widely used in biomedical applications. This study explores the fabrication and antifungal efficacy of electrospun nanofiber blends of PCL/PLA incorporated with clotrimazole, an imidazole-based antifungal agent, targeting Candida albicans. Nanofibers were produced by needless electrospinning with different clotrimazole concentrations. Morphological analysis using scanning electron microscopy confirmed smooth fiber formation with diameters affected by the clotrimazole content. In vitro antifungal assays were conducted using Candida albicans, assessing fungal growth inhibition through zone of inhibition tests and the effect on growth curve by nanofiber eluate. Results demonstrated that clotrimazole-loaded PCL/PLA nanofibers significantly inhibited Candida albicans growth compared to unloaded controls, with the most pronounced effect observed in nanofiber mats containing the highest dose of clotrimazole (~ 40 µg/ mg). Cytotoxicity assay confirmed biocompatibility of the nanofiber mats to human vaginal keratinocytes. This study highlights the potential of clotrimazole-loaded PCL/PLA nanofibers as a promising platform for localized antifungal therapy, particularly in treating vaginal candidiasis.

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Development and Research of a New Technology for Core-Sheath Nanofiber Yarn Production *PB3*

The aim of this work is the development of a new technology for the production of core-sheath nanofiber yarn based on applying a nanofiber bundle onto a ballooning yarn core in a parallel orientation. In contrast to the currently used perpendicular deposition methods, this concept enables the fibers to be applied at a single point, which is expected to achieve higher cohesion between the nanofiber sheath and the core. An innovative design of a core spinning electrode enabling the passage of the yarn core through the center of the spinning electrode was proposed and manufactured. Several electrode variants, including single-stage and two-stage configurations, were experimentally tested, and their productivity, process stability, and yarn quality were evaluated. The best performance was achieved with a two-stage electrode, where a productivity of 0.35 ± 0.02 g/min was measured at a voltage of 50 kV. Initial experiments confirmed the feasibility of long-term production of core-sheath nanofiber yarn using the proposed technology. However, several areas requiring further optimization were identified, particularly ensuring uniform fiber drying and minimizing defects in the yarn structure. The results indicate that the newly developed technology has significant potential to expand the possibilities of industrial production of nanofiber-based materials and open up new application areas.

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Machine Learning-Driven Prediction and Optimization of Polyether Sulfone (PES) Nanofiber Diameter in Electrospinning Processes *PB4*

The study investigates how electrospinning parameters affect polyether sulfone (PES) nanofiber fiber diameter, specifically for water treatment applications. In order to determine fiber morphology, it employs Response Surface Methodology (RSM) to create correlations between flow rate, tip-to-collector distance, PES concentration, and lithium chloride (LiCl) concentration. To improve the predictive accuracy of fiber diameter estimation based on electrospinning parameters, our implementation builds on this foundation by incorporating machine learning models. A number of models were trained to predict fiber diameter with high precision, including Random Forest (MSE: 5.27, R^2: 0.997), Gradient Boosting (MSE: 10.84, R^2: 0.993), Support Vector Regression (MSE: 29.13, R^2: 0.982), XGBoost (MSE: 1.92, R^2: 0.999), Linear Regression (MSE: 193.16, R^2: 0.881), Lasso Regression (MSE: 216.08, R^2: 0.866), Ridge Regression (MSE: 192.61, R^2: 0.881), Elastic Net Regression (MS2E: 1235.45, R^2: 0.236), and K-Nearest Neighbours (MSE: 0.00067, R^2: 1.000). Linear Regression and XGBoost outperformed the others, producing predictions that were almost flawless. For the specified input parameters, the expected nanofiber diameters ranged from 323.11 nm to 328.24 nm, which closely matched the experimental values. The study demonstrates that real-time parameter optimization is made possible by combining machine learning with electrospinning technology[1], which improves control over nanofiber fabrication. Additionally, experimental confirmation demonstrates that while decreasing fiber diameter decreases water flux, it increases particle removal efficiency. These results demonstrate how data-driven methods can be used to improve membrane design for filtration applications.

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Sustainable Flexible Films Based on Natural Polysaccharides Usable as Nanomaterial Support *PB5*

The global push for eco-friendly and biodegradable alternatives to conventional plastics has intensified interest in natural polymers for sustainable functional materials. In this contribution, we present a robust formulation for highly sustainable, flexible composite films engineered from a synergistic combination of two abundant polysaccharides, carrageenan (CG) and sodium alginate (SA). These abundant biopolymers were selected for their intrinsic film-forming ability, non-toxicity, and biodegradability, offering a green alternative for advanced material design. Using a solvent-casting technique without toxic crosslinkers, we engineered CG-SA composite films with tailored structural and mechanical performance by modulating the CG:SA ratio. A thorough investigation of the films' structural, thermal, optical, surface, and mechanical properties reveals a strong compositional dependence, with the most pronounced synergistic effect observed in mechanical performance. Notably, a CG:SA ratio of 40:60 permits a synergistic molecular interaction between the polysaccharides, enabling a fourfold increase in tensile strength and over twofold improvement in elongation at break compared to films made from single-component systems. Given their biodegradable nature, processability, and mechanical resilience, these films are strong candidates for supporting nanomaterials traditionally implemented in real-world applications such as eco-conscious food packaging using ZnO or nanoclays, in flexible electronics with carbon nanostructures, in wearable sensors employing plasmonic nanoparticles, or in bio-integrated substrates with polymer nanoparticles. This work, thus, contributes to the growing field of green nanomaterial supporting platforms, offering a scalable, non-toxic route aligned with the objectives of sustainable nanotechnology.

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PPB-level Ammonia Sensor Based On Ternary Flexible ZnO/PPy-Ag Thin Film *PB6*

Detection of hurtful and noxious gases has become more and more crucial for the environmental monitoring, manufacturing/monitoring of industrial products and for human health safety. Into this bargain, an innovative ammonia (NH3) gas sensor based on ternary composites of ZnO/PPy-Ag, deposited in ITO-PET thin film was successfully synthesized via photopolymerization process. The chemical structural state and morphology of ZnO/PPy-Ag (0.5 to 3M), PPy-Ag (1M) and ZnO nanofibers samples were fully revealed by Fourier Transform Infrared spectroscopy (FTIR-ATR), RAMAN Spectroscopy and Scanning Electron Microscopy (SEM), confirming its successful fabrication. The electrical conductivity was carried out using the common four probes method. Obviously, the ternary ZnO/PPy-Ag (1M) composites sensor exhibited a highest conductivity of 0.699 S.cm-1 with an extremely low detecting level. Moreover, the composites ternary layers showed an ultra-fast response/recovery time at room temperature and robust operation reproducibility during five cycles. Meanwhile, the experimental results promising an alternative approach for the production of a new ternary materials and a novel insight for high-performance ammonia sensing applications.

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Enhancing Microcrystalline-Diamond Adhesion on Cemented Carbide Cutting Tools Using a Nanocrystalline-Diamond Buffer Layer and High-Temperature Interlayers *PB7*

Diamond coatings provide outstanding hardness and wear resistance for cutting tools, but their deployment on cemented tungsten carbide (WC-Co) is often limited by inadequate adhesion. In an industry-academia collaboration between the Institute of Physics of the Czech Academy of Sciences and SHM, s.r.o., we address this challenge by introducing a thin nanocrystalline-diamond (NCD) buffer to promote the adhesion of subsequently grown microcrystalline-diamond (MCD) coatings. Additionally, two types of interlayers routinely used in industry, TiAlSiN and a SiC-based, were deposited on commercially WC-Co inserts by magnetron sputtering. The NCD buffer was prepared in the linear-antenna microwave plasma CVD system at substrate temperatures as low as 565 °C with a thickness of 0.6-0.8 µm. After that, the MCD coatings were deposited on both interlayers in focused microwave plasma CVD (0.40-0.75 µm on TiAlSiN and 0.61-0.84 µm on SiC-based) with and without NCD buffer layer. Scanning electron microscopy and Raman spectroscopy (sp^3 diamond peak near 1331-1337 cm^{-1}) confirmed diamond crystalline quality and film continuity across conditions. While the low-temperature deposition process (575 °C, 15 h) resulted in good diamond adhesion, the high-temperature deposition (800-860 °C, 15 h) or long-duration growth at low-temperature (100 h, 580-610 °C) exhibited extensive delamination. Samples with SiC-based interlayer showed less peeling than TiAlSiN under otherwise comparable conditions. Overall, employing an NCD buffer markedly improves adhesion, and interlayer selection is critical: the SiC-based interlayer combined with NCD consistently yields more homogeneous coverage with minimal delamination compared to TiAlSiN. These results provide a robust, industrially relevant pathway towards adherent, uniform MCD coatings on carbide tools.

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Intrinsic and Boron-doped Diamonds as Supports for Ultra-small Size-selected Catalytic Clusters *PB8*

Herein, we report a comparative study focused on various microcrystalline and nanostructured diamonds, examining the effects of surface chemistry and doping on the properties of the ultra-small size-selected catalytic clusters. We prepared eight diamond types: hydrogen-terminated intrinsic, oxygen-terminated intrinsic, boron-doped hydrogen-terminated intrinsic, and boron-doped oxygen-terminated diamond films in both microcrystalline and nanocrystalline morphologies. The latter is expected to feature an increased density of grain boundaries. These samples cover a wide range of surface structures and chemical composition, from insulating intrinsic diamonds to conductive boron-doped diamonds. This variability enables control of mechanistic and electronic interactions with other systems. This is particularly relevant for ultra-small, size-selected metallic clusters CuxPdy for catalysis. Vice versa, the clusters' unique electronic structures can further tailor the diamonds' properties through metal-support interactions. These cluster-decorated diamonds were characterized by atomic force microscopy (AFM) and Kelvin probe measurements. On microcrystalline samples, AFM showed a uniform cluster distribution with an average height of ~0.5 nm, confirming effective anchoring of the clusters to the diamond surface and their stability. Kelvin probe measurements revealed a shift to a higher work function (5.5 ± 0.1 eV) after cluster deposition that was to some extent modulated by the type and surface termination of the diamond support. The selected samples were tested in the model oxidative reaction, revealing that their catalytic activity depends on the type of diamond support. In addition to the work function shifts after clusters deposition identified by Kelvin-probe, near-ambient-pressure XPS showed that the dominant C 1s component at ≈285.0 eV corresponds to sp3-hybridized carbon, and the reduction of the oxidation state of the deposited clusters was found to be essential for catalytic activity. The results confirm the existence of unique metal-support interactions improving catalytic activity and selectivity that are governed by adsorption strength and electronic coupling to the reactants.

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Tailored Micro-Mesoporous Ferrierite Catalysts for CO_2 Hydrogenation: Insights into Structural Modification and Activity *PB9*

Synthetic natural gas produced via catalytic hydrogenation of CO_2 to methane represents one of the viable pathways for large-scale and long-term renewable energy storage. An energy-efficient methanation process requires the development of low-temperature and low-pressure catalysts that enable complete conversion of pure CO_2 to methane without the need for recycling. Nickel clusters supported on zeolites belong to active catalysts. However, the microporous zeolites possess a relatively limited capacity for Ni clusters, and their hydrophilic character adversely affects catalytic activity. This study demonstrates how post-synthetic modification of zeolites influences the dispersion of supported Ni clusters and their activity in the selective low-temperature hydrogenation of CO2 with hydrogen to methane, and shows how post-synthetic modification affects the surface hydrophobicity and the stabilization of Ni clusters on the zeolite surface. The optimal structure of Ni particles enables high conversion in the favourable low-temperature region, allowing for efficient CO2 conversion and methane selectivity. ACKNOWLEDGEMENTS: The authors acknowledge the support of the Technology Agency of the Czech Republic (Project No. TS01030146) for this study. Support was provided by the Research Infrastructure NanoEnviCz under Projects No. LM2023066, EF18_046/0015586, and LM2018124, funded by the Ministry of Education, Youth and Sports of the Czech Republic.

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Structure and Magnetic Properties of Fine Fe3Mn3O8 Ferrite Particles *PB10*

Manganese-iron Fe3Mn3O8 ferrite represents an important functional material for as catalytic purposes. In this study, Fe3Mn3O8 ferrite particles were synthesized and investigated with the aim of understanding its structure and magnetic behaviour. As a starting material, a manganese-iron precursor was prepared and its chemical composition verified by SEM/EDX, while X-ray diffraction (XRD) and Mössbauer spectroscopy provided insights into its crystal structure and local environment of iron. The precursor was subsequently annealed in a hydrogen atmosphere to obtain the final ferrite phase. The resulting Mn-Fe ferrite was analysed using the same structural and spectroscopic methods to confirm the transformation and purity of the product. In addition, its magnetic properties were investigated to obtain a comprehensive picture of its structural and magnetic characteristics.

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Bimetallic Nanoparticles on Graphene Support as an Electrocatalyst for Hydrogen Evolution Reaction *PB11*

The development of efficient and stable electrocatalysts for the hydrogen evolution reaction (HER) is crucial for sustainable hydrogen production. This work presents a high-performance catalyst comprising palladium-nickel (PdNi) bimetallic nanoparticles supported on activated carboxylated graphene. The synergistic interplay between the PdNi alloy and the highly conductive, functionalized carbon support was engineered to optimize the adsorption energetics of hydrogen intermediates. Electrochemical evaluation in 0.5 M H_2SO_4 revealed exceptional HER kinetics, as evidenced by a small Tafel slope of 44 mV dec^{-1}, which indicates a rapid Volmer-Heyrovsky reaction mechanism. These results highlight the strategic advantage of utilizing bimetallic alloys on functionalized carbon supports to create cost-effective alternatives to platinum-based catalysts.

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MoO3 Nanorods: A Nanocatalyst Facilitating the Unprecedented Degradation of Methyl Red Dye with Outstanding Efficacy *PB12*

Methyl red is a toxic azo dye widely used in industries such as textile dyeing and paper printing. It exhibits carcinogenic and mutagenic effects, raising serious environmental and health concerns. Conventionally, such dyes are degraded using techniques like photocatalysis, adsorption, electrochemical treatment, biodegradation, Fenton reaction, and ozonation. However, these methods often require complex setups, longer treatment durations, or any external agents like sunlight, ozone, microorganisms, etc. In this study, we present a novel, simple, and highly effective approach for the complete degradation of methyl red using a hydrothermally synthesized orthorhombic MoO_3 nanocatalyst. The addition of a catalyst to the dye solution leads to complete degradation within a short reaction time. The process is remarkably fast and does not require any external agents, including sunlight. Adding 1 mg of MoO_3 to a 10 ml solution of 10 ppm methyl red dye achieved complete degradation within 2 hours at 25 °C, which lowered to 1 hour under UV light or at 50 °C. The degradation process can occur across a broad spectrum of temperatures spanning from 15 °C onwards, thereby facilitating the utilization of MoO3 nanocatalysts across diverse climatic conditions suitable in various regions worldwide. In addition, the catalyst retains its ability to degrade the dye even after the fifth cycle. No reports are available with such a simple and easy degradation mechanism of methyl red dye, suggesting the potential for commercialization of the synthesized catalyst.

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Morphology-Dependent Photocatalytic Performance of TiO_2 Nanostructures: Influence of Crystal Facets, Phase, and Silver Modification ***PB13***

The Nanotechnology industry is growing rapidly, leading to concerns about the potential commercial uses of nanostructures. Nanostructures of titanium dioxide (TiO2) with the shapes of nanofibers (TNFs), nanorods (TNRs), and nanograss (TNGs) were created. The morphology and phase that are formed are greatly influenced by synthetic processes. The anatase phase is present in both TNFs and TNRs. On the other hand, TNGs that crystallise in the rutile phase are produced. Morphology is directly related to the exposed crystal planes. According to XRD measurements, the 101 facet is exposed in anatase nanomaterials (TNFs, TNRs) and the 110 facet is exposed in rutile nanomaterials (TNGs). The photocatalytic properties are greatly influenced by the interaction of morphology, the same most stable facets, and modification with silver. The strongest photoactivity towards the breakdown of rhodamine B (RhB) is exhibited by anatase nanomaterials, particularly those with low crystallinity (TNFs). In contrast, highly crystalline rutile crystals do not demonstrate good photocatalytic performance, neither in UV nor in simulated solar light (SSL). However, by adding metallic silver to the surface and forming a Schottky barrier, the photoactive performance of most materials can be improved. Finally, hydroxyl radicals, superoxide anion radicals, and hole scavengers were used to uncover the mechanisms of photocatalytic breakdown. This study demonstrates that high-performance photocatalysts in UV and SSL may be created by selecting the right morphology (crystal shape), exposing the necessary facets, and altering the chemical composition.

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The Catalyst Within: Deciphering Ni(OH)2 Formation from Ni-MOF During OER ***PB14***

The oxygen evolution reaction (OER) remains a key bottleneck in electrochemical energy storage and conversion. In this work, we present a top-down reconstruction of a Ni-based metal-organic framework (Ni-MOF), built from 1D Ni-(μ3-OH)/(μ2-H2O)-Ni chains and 1,4-ndc linkers, into catalytically active, defect-rich β-Ni(OH)2 nanosheets (~1.5-2.6 nm thick). The catalyst achieves a low overpotential of 300 mV at 10 mA·cm-2, surpassing commercial IrO2. In situ Raman and PXRD reveal pH- and potential-dependent phase transitions, while in situ XAS confirms structural evolution, including Ni-O bond contraction from 2.06 A to 1.89 A, indicative of a dynamic NiOOH-like phase. DFT studies show that exposed Ni2+ centers favor stabilization of OER intermediates via the adsorbed oxygen evolution mechanism (AEM). The catalyst also maintains high activity at elevated temperatures. This work provides mechanistic insights into MOF-to-hydroxide transformation and offers a robust strategy for developing efficient MOF-derived OER electrocatalysts.

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Testing of the Self Cleaning Performance of the Surfaces Modified with g-C3N4 ***PB15***

Self cleaning properties of the surfaces of the building materials represent an important benefit which reduce the operational costs connected to meintanace of the building structures. In principle, the self cleaning phenomenon can be achieved by three effects: i) hydrophobic, ii) photocatalytic, and iii) combination of hydrophobic and photocatalytic effects. In our work we focused on evaluation of self cleaning performance of blocks of pastes made of white cement achieved by photocatalytic effect. The photocatalyst g-C3N4 was applied on the surface of hardened cement pastes and self-cleaning performance of such treated surfaces were evaluated using UNI 11259 ‘Determination of the photocatalytic activity of hidraulic binders - Rodammina test method, and ČSN ISO 27448 ‘ine ceramics (advanced ceramics, advanced technical ceramics) — Test method for self-cleaning performance of semiconducting photocatalytic materials — Measurement of water contact angle'. Although the principle of both methods is different, the results obtained using both methods show that the surfaces covered with g-C3N4 shows significant self-cleaning performance. 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 Komensky Operational Program financed by the European Union and from the state budget of the Czech Republic. The support of the project SGS SP2025/044 is also greatly acknowledged.

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Polymer-supported Nano-catalysts for Carbonylative Transformations *PB16*

Carbonylation reactions play a crucial role in modern organic synthesis, enabling the formation of valuable carbonyl-containing compounds such as amides, esters, acids, and ketones having high relevance in pharmaceuticals, agrochemicals, and fine chemicals. The use of nano-catalysts for carbonylation reactions has earned significant attention due to their unique physicochemical properties, including high surface area, enhanced catalytic activity, tunable reactivity, lower catalyst loadings, greater selectivity, and recyclability, contributing to the development of greener and more sustainable chemical processes. Herein, well-characterized polystyrene-anchored bimetallic palladium-gold (Pd-Au@PS) and monometallic palladium (Pd@PS) nano-catalysts have been demonstrated for executing the challenging carbonylative transformations. The Pd-Au@PS nano-catalyst exhibited outstanding catalytic activity for CO and C1 insertion reactions via significantly outperforming its monometallic counterparts (Pd@PS and Au@PS) for carbonylative synthesis of aryl S-methylthioesters and bis(indolyl)methanes from aryl iodides. In addition, Pd@PS nano-catalyst showcased high efficiency for carbonylative synthesis of 2-aryl benzimidazoles from aryl iodides and aromatic diamines. Overall, this infusion of nano-catalysis with carbonylation strategies represents a transformative advancement in the pursuit of efficient, scalable, and eco-conscious synthetic methodologies.

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Catalytic (de)hydrogenation Reactions: Catalyst Design, Scope and Mechanism *PB17*

Liquid Organic Hydrogen Carriers (LOHCs) such as methanol (12.6% H_2 content) represent an attractive platform for sustainable hydrogen storage, yet challenges arise from its endothermal dehydrogenation (63 kJ/mol) and the risk of CO/CO_2 contamination. Our work focuses on transition-metal-catalyzed (de)hydrogenation and transfer hydrogenation strategies to overcome these limitations. We have established Cp*Ir(III)/bipyridonate systems as efficient catalysts for methanol dehydrogenation via a β-hydride transfer pathway (22.5 kcal/mol), with mechanistic insights revealing spectroscopic detection of transient hydride species and a pH-dependent reversible interconversion between two iridium-hydride states. The catalyst show wide substrate scope in ketone transfer hydrogenation and enable chemoselective reduction of α,β-unsaturated ketones at room temperature, supported by kinetic and isotope effect studies. Building on this, our recent work explores base-metal alternatives, including mechanistic elucidation of Cp*Co(III)-catalyzed quinoline transfer hydrogenation coupled with formic acid dehydrogenation. Furthermore, we demonstrate the design of novel nanocobalt-embedded 3D-COF heterogeneous catalyst, offering recyclability, enhanced chemoselectivity, and applicability in nitroarene reduction with potential for late-stage functionalization of drug-like molecules. Together, these studies advance both the mechanistic understanding and practical implementation of sustainable hydrogen storage and utilization strategies. References: (1) Tetrahedron Green Chem., 2024, 3, 100043 (2) ACS Catalysis 2024, 14, 23, 17556-17570 (3) Coord. Chem. Rev. 2021, 433, 213728 (4) Langmuir 2024, 40, 72-83 (5) Appl. Organometal. Chem. 2018, 32, e4357

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Thermal Stability of g-C3N4 in the Presence of Selected Oxides ***PB18***

Graphitic carbon nitride (g-C3N4) is an intensively studied photocatalyst active in the VIS range of spectra. The most commonly used method for g-C3N4 preparation is the thermal polycondensation of melamine at temperatures in the range of 500-600°C, resulting in the so-called bulk g-C3N4. Such prepared g-C3N4 suffers from low photodegradation activity associated mainly with its low specific surface area and fast e-/h+ recombination. One way to suppress electron-hole recombination is to prepare composite materials in which g-C3N4 is combined with another semiconductor, such as TiO_2, ZnO, and Fe_2O_3. These composites are often prepared from the individual components by their mechanical mixing followed by heat-treatment of the prepared mixture. This paper focuses on the study of the thermal stability of g-C3N4 in the presence of selected oxides. The prepared mixtures of g-C3N4 with the corresponding oxide phase were subjected to simultaneous thermal analysis at temperatures up to 800°C, as well as heating in a muffle furnace at temperatures ranging from 400 to 525°C.

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

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Plasma-Sprayed NiO-YSZ Anodes for Solid Oxide Fuel Cell: Effects of Water- and Ethanol-Based Liquid Feedstocks on Microstructure, Composition, and Electrical Performance. ***PB19***

Solid Oxide Fuel Cells (SOFCs) are a promising clean energy technology, but its widespread adoption is often limited by high operating temperatures and complex fabrication routes. Advanced electrode architectures are critical for enabling lower-temperature operation. In this work, we demonstrate the fabrication of Nickel Oxide-Yttria-Stabilized Zirconia (NiO-YSZ) anodes using a unique hybrid water-argon stabilized plasma torch (WSP-H). This technique offers a high deposition throughput and precise microstructural control, making it ideal for creating efficient SOFC anodes from liquid feedstocks. We present a comparative study of anodes produced from ethanol-based and water-based suspensions/solutions to investigate the solvent's influence on the microstructural and electrical properties of these anodes. Our findings show that ethanol-based feedstock yields a more favourable microstructure, promoting the in situ formation of metallic nickel and creating optimal porosity. These characteristics are directly linked to enhanced electrochemical performance. In contrast, anodes deposited from the water-based feedstock, while exhibiting lower porosity and larger splat morphology, demonstrated significantly superior redox stability, which is crucial for long-term operational durability. This study highlights the critical trade-off between performance and stability, underscoring how feedstock engineering via hybrid plasma spraying is a key strategy for tailoring next-generation SOFC anodes.

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Advancing Perovskite Solar Cell Fabrication through Large-Area Atmospheric Plasma Processing ***PB20***

Conventional silicon-based production methods for modern energy-harvesting systems and electronic devices do not meet the requirements for low-cost fabrication. The commercialization of flexible and printed electronics is expected to rely on rapid and cost-effective roll-to-roll manufacturing, which requires the use of flexible and inexpensive substrates such as PET, PEN, and, more recently, eco-friendly alternatives like nano-paper. For these materials, the fabrication temperature is a critical factor and typically must not exceed 150 °C. Low-temperature plasma, therefore, represents a promising approach to enable the next generation of scalable manufacturing techniques. We present proprietary diffuse coplanar surface barrier discharge (DCSBD) as a large-area plasma source with an exceptionally high-power density of up to 100 $W\cdot cm^{-3}$, capable of generating diffuse, homogeneous, and cold plasma (<70 °C) in open air and in various gases, including nitrogen, argon, and methane [1]. Despite its low operating temperature, the plasma provides sufficient energy to modify the surfaces of nanostructured materials and semiconductors, such as graphene oxide [2], titanium dioxide [3], tin oxide [4], graphitic carbon nitride [5,6], and MXenes [7], by altering their crystallinity, optoelectronic properties, and wettability. Owing to its low temperature and short treatment times (1-10 s), this plasma technology is well-suited for integration into roll-to-roll manufacturing, thereby enhancing the commercial feasibility of flexible and printed electronics. Here, we demonstrate several applications of plasma in the fabrication of perovskite solar cells [8]. These include (i) plasma treatment of indium tin oxide electrodes, serving as a rapid alternative to the extensive chemical pretreatment typically required before depositing conductive films, and (ii) plasma processing of mesoporous titanium dioxide electron transport layers, offering a fast, low-temperature substitute for conventional high-temperature sintering, among others. ACKNOWLEDGEMENTS: Funding for this research was provided by the Ministry of Education, Youth and Sports of the Czech Republic through projects No. 9F23003 and LM2023039.

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Harvesting Low-Grade Heat: Electricity Generation via Aqueous Electrolytes in Nanochannels *PB21*

Currently, the demand for new technologies and materials capable of efficiently converting waste heat into electricity is particularly acute. One promising research direction is the development of low-cost ionic thermoelectric materials based on aqueous electrolyte solutions. In bulk electrolytes, the thermoelectric effect arises from the movement of ions under a temperature gradient (the Soret effect). In nanochannels, where electrical double layers overlap, charge separation becomes more efficient, leading to higher voltages compared to bulk electrolytes. In this work, the thermal diffusion of sodium ions in aqueous electrolytes confined within nanochannels of anodic alumina, silica aerogels, and biopolymer matrices was investigated. The nanochannels were impregnated with aqueous solutions of sodium salts (Na_2SO_4 and NaCl) at concentrations ranging from 10^{-5} M to 1 M. Ion transport was studied using electrochemical impedance spectroscopy and cyclic voltammetry. Applying a temperature gradient to nanoconfined aqueous electrolytes increased the output voltage, due to thermally induced ion transport. For nanoconfined electrolytes, the generated voltage decreased with increasing salt concentration. The significant enhancement of thermovoltage in nanochannels with overlapping electrical double layers highlights nanoconfinement as an effective strategy to improve the efficiency of waste heat-to-electricity conversion in liquid electrolyte-based materials. Furthermore, the feasibility of employing these materials to develop nanochannel-confined Na-based aqueous electrolyte ionic supercapacitors has been demonstrated. ACKNOWLEDGEMENTS: The work was performed within European Union’s Horizon 2020 Research and Innovation Program under TRANSLATE “The Recycling of waste heat through the Application of Nanofluidic ChannelS: Advances in the Conversion of Thermal to Electrical energy” project (Grant agreement: 964251).

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Trailblazing Nanocomposites for Electrochemical Hydrogen Evolution and Methanol Oxidation Reactions *PB22*

Developing efficient and cost-effective bifunctional electrocatalysts is crucial for future renewable energy systems. The production of hydrogen via the dissociation of water molecules, and the oxidation of methanol to produce direct methanol fuel cells are essential for achieving sustainable energy solutions. However, robust electrocatalysts exhibiting high efficiencies and stabilities have not yet been reported. Herein, a novel Pr-doped PtTiP electrocatalyst supported on engineered N-doped multi-walled carbon nanotubes (PrPtTiP/N-MWCNTs) is developed and evaluated for use in the hydrogen evolution reaction (HER) and the methanol oxidation reaction (MOR). For HER in 0.3 M H2SO4 electrolyte, PrPtTiP/N-MWCNT exhibits remarkably low overpotentials of 8.2 and 12.2 mV at 10 and 100 mA cm-2, respectively, outperforming PtP/N-MWCNT and commercial Pt/C catalysts. PrPtTiP/N-MWCNT demonstrates an exceptional electrochemical stability and activity at 50 and 150 mA cm-2. Subsequently, PrPtTiP/N-MWCNT delivers a significantly enhance MOR mass activity of 5.83 A mg-1Pt (i.e., 3.3- and 8.3-fold greater than those of PtP/N-MWCNT and Pt/C, respectively). Moreover, this catalyst displays excellent durability over 10,000 potential cycles and chronoamperometric tests with preserved nanoparticle integrity on the N-MWCNT support. These results position PrPtTiP/N-MWCNT as a promising electrocatalyst for HER and MOR applications in acidic media.

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Water-Driven Synthesis of SnTe Nanoparticles for High-Performance Flexible Solid-State Supercapacitors *PB23*

In this work, we present a novel, environmentally sustainable approach for synthesizing ligand-free Tin Telluride (SnTe) nanoparticles via a hot-injection method using water as a solvent - a significant departure from traditional organic-solvent-based protocols. This green chemistry route enables precise control over nucleation and growth, yielding phase-pure, uniformly distributed SnTe nanoparticles with enhanced pseudocapacitive properties. Comprehensive structural, morphological, and surface analyses confirmed the formation of crystalline SnTe with a porous architecture conducive to ion transport. Electrochemical testing in a three-electrode configuration using 1 M NaClO4 electrolyte revealed a high specific capacitance of 602 F/g and capacitance retention of 89% after 5000 cycles, attributed to a diffusion-controlled pseudocapacitive mechanism. Building upon these results, we fabricated a flexible all-solid-state symmetric supercapacitor (FSSC) using SnTe electrodes on stainless steel and PVA-NaClO4 gel polymer electrolyte. The device delivered an energy density of 17.8 Wh/kg and power density of 3.1 kW/kg, with 96.56% retention over 5000 cycles and excellent mechanical flexibility, retaining 95% capacitance even at a 160° bend. Our findings demonstrate the feasibility of SnTe as a high-performance electrode for flexible energy storage and establish a cost-effective, scalable synthesis route aligned with sustainable materials development.

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Study of Lithium Behavior in All-solid-state Li-S Half-cell Battery *PB24*

The effect of a thin layer of nickel on lithium diffusion, deposited between the solid electrolyte and the cathode, was studied using neutron depth profiling (NDP) in an in situ configuration [xx]. Half-cells consisting of a LIPO solid electrolyte, a MoS2 cathode, and an Au current collector were deposited on a titanium substrate by ion beam sputtering. Selected samples were coated with a thin intermediate layer of nickel between LIPO and MoS2 to study the possible effect on lithium diffusion. Nickel is believed to suppress the shuttle effect in Li-S batteries [xx], but its possible influence on lithium-ion diffusivity is not fully understood. To clarify the effect of nickel, the samples were connected to an electrochemical station and several voltage steps were applied in situ during the NDP measurements. Neutron depth profiling is highly sensitive to the natural isotope 6Li and allows the depth distribution of lithium to be studied with high accuracy. Further analyses were performed using Rutherford backscattering spectroscopy to analyze the depth distribution of other elements. Funding: This work was supported by the Ministry of Education, Youth and Sports (MEYS) CR under the project CZ.02.01.01/00/22_008/0004591.

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Engineered Graphene Cathode for High-Performance Zinc-Ion Capacitors *PB25*

Advancing electrode materials is crucial for enhancing the performance and reliability of next-generation energy storage devices. In this work, we present a one-step synthesis approach to produce nitrogen-doped graphene functionalized with both amine groups. This method simultaneously incorporates nitrogen containing functionalities into the graphene structure. Detailed structural and spectroscopic studies confirm the successful integration of nitrogen and oxygen groups into the graphene framework. These functional groups act as active coordination sites, strengthening the interaction between the electrode and metal ions during charge-discharge cycles. The modified graphene exhibits improved structural features, including higher porosity and enhanced electronic conductivity, leading to better ion diffusion and redox behaviour. Compared to traditional graphene materials, the functionalized nitrogen-doped graphene shows a higher chemical affinity for metal ions, particularly due to the presence of N-functional groups, enabling efficient and reversible ion adsorption/desorption. This study introduces a scalable design strategy for advanced carbon-based electrodes, offering a promising route toward high-performance cathodes for rechargeable batteries and energy storage systems.

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Study of LAGP Coating of PE Separator for Polysulfide Suppression in Li-S Battery System ***PB26***

The use of a thin layer of solid electrolyte on a polyethylene (PE) separator has been tested as a strategy to mitigate the shuttle effect relating to polysulfides in lithium-sulfur (Li-S) batteries and significantly shortens their lifetime. While some solid electrolytes, such as LAGP ($Li_{1+x}Al_xGe_{2-x}(PO_4)_3$), have shown the potential to effectively suppress the shuttle effect, their brittle ceramic nature limits their widespread application, especially in flexible electronics. Coating PE separators with LAGP nanofilms offers a promising solution by combining the mechanical flexibility and thinness of polymer separators with the electrochemical advantages of LAGP due to their NASICON-like structure and high ionic conductivity. In this study, PE separators were coated with LAGP nanofilms by ion sputtering and analyzed using a set of relevant methods: thermal neutron depth profiling (TNDP) was used to investigate the diffusion of lithium ions through the separator, the surface morphology was analyzed using atomic force microscopy (AFM) and scanning electron microscopy (SEM), Raman spectroscopy and X-ray diffraction (XRD) were used for phase identification, and electrochemical impedance spectroscopy (EIS) was used to evaluate the electrochemical performance. The work presents original results that show that the use of PE separators with a thin LAGP layer strongly influences the shuttle effect and thus allows to limit unwanted processes in Li-S batteries.

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Synthesis and Modification of Thin NaSICON Solid Electrolytes Using Ion Beams ***PB27***

Solid electrolytes (SEs) for sodium-based superionic conductor (NaSICON) was first introduced in 1976 and was recognized for their excellent ionic conductivity. Although much effort has been devoted to the development of thin electrolytes for all-solid-state batteries (ASSBs), only a few composites have been successfully prepared as thin solid sodium-based SEs. They are desirable for their reduced electrical resistance, which increases with the SE thickness. Thinning the SEs to a nanometer thickness can significantly increase their ionic conductivity. In this study, the starting NASICON composite was prepared in the form of pellets by the mixed oxide technique using a planetary ball mill and synthesized by the solid-state method at 1300 °C. The obtained pellets were used as a sputtering target in low-energy ion facility to prepare a continuous NASICON nanofilms. To study the effect of ion implantation on electrical properties of NASICON, the prepared films were bombarded with Ni ions of 1.1 MeV at different fluences using a Tandetron accelerator in CANAM infrastructure (NPI Řež). The electrical properties of the synthesized and implanted films were analyzed by electrochemical impedance spectroscopy (EIS). Here, results describing effect of irradiation on NASICON parameters are presented.

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Method for Comparing Catalyst Reactivity and Efficiency by Measuring Changes in the Illumination Intensity of H2 Bubbles During Water Electrolysis ***PB28***

This study provides a description of a simplified, accelerated and economically advantageous method for determining the catalytic activity of carbon compounds based on graphene oxide (GO) and graphitic carbon nitride g-C3N4 during the electrolysis of water. The method proposed in this study for determining the catalytic activity of carbon compounds based on graphene oxide and graphitic carbon nitride is based on measuring the amount of H2 bubbles formed by the process of the dissociation of water on a cathode. The amount of bubbles indicated the efficiency of the catalysts. The principle of the proposed method for determining catalytic activity comprises the measurement of changes in the intensity of the light that illuminates the cathode. Such changes are influenced by the amount of bubbles formed. The experiments confirmed that the nanostructures employed enhanced reactivity and provided support for the photocatalytic reactions involved in the production of hydrogen.

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The Role of Dispersants (SDS, PVP, SLES, and CB) in Modifying the Electrode Properties for the Oxygen Reduction Reaction (ORR), Electrochemical Properties ***PB29***

Dispersants such as SDS, PVP, SLES, and CB play a crucial role in shaping the morphology and availability of active sites on the electrode surface. The aim of this study was to investigate their influence on the efficiency of the oxygen reduction reaction (ORR), which is critical for fuel cells and energy storage systems. Electrodes modified with dispersants were characterized using cyclic voltammetry (CV) and linear sweep voltammetry (LSV) to evaluate changes in electrochemical performance. In addition, heterogeneous electron transfer (HET) kinetics were investigated using ferrocene/ferrocenium and hexacyanoferrate(III)/(II) redox probes, allowing for a deeper understanding of the impact of dispersant type on the electrochemical processes occurring at the electrode surface. Comparative analysis revealed that the choice of dispersant significantly affected the oxygen reduction kinetics, the electrochemically active surface area (ECSA), and the charge transfer resistance.

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Thermally Tunable Hyper-Crosslinked Polymer for Metal-Free Oxygen Reduction Reaction ***PB30***

The oxygen reduction reaction (ORR) plays a central role in electrochemical energy and chemical conversion processes. Through a 2-electron pathway, ORR enables the direct synthesis of hydrogen peroxide (H_2O_2), an attractive and environmentally friendly alternative to traditional oxidants. However, this pathway competes with the 4-electron reduction to water, which often dominates. Carbon-based, metal-free electrocatalysts have emerged as promising materials for tuning ORR selectivity and efficiency. In this study, a hyper-crosslinked polymer with an aminal triazine network (mt-HCP) was thermally treated between 400°C and 800°C to modulate its structural and electronic features. The use of mt-HCP as a starting synthetic platform allows the assembly of novel ORR electrocatalysts through thermal treatment, offering high surface area and well-defined structure. Higher graphitization temperatures improved ORR catalytic activity, but also reduced selectivity for H_2O_2, while lower-temperature materials retained nitrogen-rich polymeric features that favored the 2-electron route. In addition, electrochemical impedance spectroscopy revealed that excessive microporosity in the highly graphitized samples restricted mass transport, promoting full reduction to water. Detailed characterization by nitrogen physisorption, X-ray photoelectron spectroscopy, Raman spectroscopy, X-ray diffraction, nanoscale infrared imaging and electrocatalytic studies by rotating ring-disk electrode analysis and electrochemical impedance spectroscopy, established the clear correlations between materials' morphology and ORR electrocatalytic performance. These results underscore the potential of thermally tunable porous organic polymers for selective ORR electrocatalysis, providing valuable insights into the application of this class of materials for ORR.

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Gallium Nitride-based Heterostructures for Photocatalytic Hydrogen Production *PB31*

The increasing global demand for sustainable energy sources has driven extensive research into photocatalytic water splitting as a clean method for hydrogen production. The development of green hydrogen, produced from renewable energy sources, is a key step in achieving a truly sustainable energy future. Indium gallium nitride (InGaN) is a very attractive material for such applications due to its good chemical stability in both acidic and neutral electrolytes, high absorption coefficient, tunable bandgap, |and high electron mobility. Moreover, InGaN can be prepared in form of various nanostructures like nanorods, nanowires or nanopyramids with a high surface-to-volume ratio, leading to increased light absorption and improved charge carrier transport. In this work, we report on a photocatalytic application of InGaN heterostructures based on different types of 3D nitride heterostructures: self-assembled core-shell InGaN/GaN nanorods prepared at different temperatures on sapphire substrate, top-down etched nanostructures based on thick InGaN layers prepared directly on sapphire, InGaN/GaN MQW structures prepared on 3D GaN surfaces. The structural and optical properties of prepared InGaN/GaN heterostructures were characterized by SEM, photoluminescence, cathodoluminescence and compared with respect to their efficiency of photocatalytic hydrogen generation using a batch photoreactor. Hydrogen was detected as the only product of the photocatalytic decomposition of methanol-water solution. The stability of the photocatalyst was verified by repeated use of the same batch with reproducible results. We show that the photocatalytic activity of InGaN/GaN heterostructures is strongly dependent on the material quality, for example influenced by the temperature of the preparation of the InGaN shell around the GaN core. The heterostructures are required to allow fast separation of photogenerated electrons and holes. We propose different ways of carrier separation for each type of structure and compare their efficiency. This research was funded by MEYS in the frame of CzechNanoLab infrastructure LM2023051.

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Synthesis and Application of Rock-Salt High Entropy Oxides Nanoparticles for Photocatalytic Hydrogen Production *PB32*

Hydrogen has been widely recognized as a potential source of clean energy for the next generation due to its ultra-high energy density and zero emission. However, the conventional methods utilized for hydrogen production (e.g., methane reforming and biogas stream reforming) are accompanied by the releases of greenhouse gases (e.g., CO2) into the environment. Therefore, the photocatalysis of water to produce green hydrogen has been considered as an ideal option from economic and environmental viewpoints. In recent years, the high entropy oxides (HEOx) with five or more cations randomly distributed in the cationic site of the structure have gained growing attention in the area of catalysis/photo,catalysis mostly attributed to highly tuneable optical properties [1, 2]. Moreover, the synergy between multi-element in HEOx provides a diverse range of adsorption and defects sites (e.g., oxygen defects) to facilitate the catalytic process [3, 4]. In this respect, the present work describes the photocatalytic potential of rock-salt HEOx nanoparticles for photocatalytic hydrogen production with visible light. The materials were synthesized via a new and easy-to-implement process combining solid-state high temperature reaction and mechanical ball-milling. A series of HEOx nanoparticles were formed by varying the process conditions and their impact on optical properties and hydrogen production will be discussed. Overall, It was observed that the HEOx NPs exhibited 8-fold higher photocatalytic activity relative to bulk HEOx. REFERENCES: [1] Edalati, P., et al., Photocatalytic hydrogen evolution on a high-entropy oxide. Journal of Materials Chemistry A, 2020. 8(7): p. 3814-3821; [2] Yu, H., et al., Self-Floating Nanoporous High-Entropy Oxides with Tunable Bandgap for Efficient Solar Seawater Desalination. Nano Letters, 2023. 23(22): p. 10554-10562; [3] Akrami, S., et al., Defective high-entropy oxide photocatalyst with high activity for CO 2 conversion; Applied Catalysis B: Environmental, 2022. 303: p. 120896; [4] Gu, K., et al., Defect-rich high-entropy oxide nanosheets for efficient 5-hydroxymethylfurfural electrooxidation. Angewandte Chemie, 2021. 133(37): p. 20415-20420.

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Development of Self-Cleaning Glass for Building Facades Through Nano Surface Structuring ***PB33***

Maintaining the cleanliness of building facades, particularly glass surfaces, imposes significant operational costs and water consumption, especially in high-rise urban environments. This research aims to develop a cost-effective and environmentally friendly self-cleaning glass by engineering its surface at the nano-scale to achieve hydrophobicity. Inspired by natural surfaces such as lotus leaves, the glass is modified through nano-scale surface structuring techniques to repel water and dust without the need for chemical detergents or manual cleaning. The study investigates using nano-scale laser surface structuring followed by chemical surface treatment, to create a water- and dust-repellent surface without the need for chemical detergents or manual cleaning. The hydrophobic performance is characterized by measuring water contact angles, sliding angles, and resistance to fouling. Future work will include studying the impact of the nano-structured surface on optical transmittance and thermal insulation performance, to evaluate its suitability for energy-efficient building design. Additionally, an economic evaluation will be conducted to quantify potential reductions in water usage and maintenance costs, reinforcing the practical value of this approach for sustainable architecture.

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Altering Surface Properties and Composition of the Crushed Glass Waste for Use in Cementitious Composites ***PB34***

The use of fine-grained glass waste as alternative fillers for concrete composites has been recognized as reasonable disposal strategy. However, chemical composition and physical characteristics of glass particles' surface can significantly affect interactions with the binder disrupting the composites microstructure and deteriorating its mechanical strength or improving hydration kinetic. For instance, for soda-lime glass due to the higher alkali mobility than that of silicon and oxygen (network formers), Na or Ca content near the surface may differ from the bulk affecting glass reactivity. The hydrophobic glass surface affects the interaction with water and can influence the early-age concrete, while oxygen-containing functional groups on surface promote hydroxylation. In this study we analyze dry (plasma) and wet (chemicals) treatments of recycled glass particles. The detected changes in surface composition were explained by etching or polymerization of carbon-based surface contaminants or metal ions leaching. The observed findings indicate possibility of glass reactivity altering and will be helpful in the understanding and explanation of calcium-silicate-hydrate formation kinetic and early-age behavior of concrete. ACKNOWLEDGEMENT: The work was supported by the Czech Science Foundation grant no. 23-05500S.

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Investigation of Ground Silicon-Based Waste as Potential Secondary Raw Materials for Civil Construction ***PB35***

Silicon-based glass is a non-biodegradable material and, if not recycled, causes disposal problems. Indeed, landfilled ordinary glass waste, waste from foundries and end-of-life photovoltaic solar panels are harmful to the environment due to danger of leaching. Application of silicon-based waste as partial replacement for natural aggregates and cement for civil construction is recognized as a promising utilization strategy. However, particles size, high concentration of alkaline impurities, presence of heavy atoms, reactive silica etc. in alternative fillers that endanger the calcium-silicate-hydrate formation and deteriorate concrete properties must be carefully considered. In this work we investigate several ground silicon-based waste materials as potential secondary raw materials for cement-based composites. Selected ground materials were characterized by different analytic techniques including electron microscopy, infrared and Raman spectroscopies, the X-ray fluorescence and photoelectron spectroscopies, etc. The found differences in particles structure (amorphous vs crystalline), oxidation state and impurities content in bulk and on surface were considered as important for their use in cementitious composite materials and explanation of the interaction reactions. ACKNOWLEDGEMENT: The work was supported by the Czech Science Foundation project no 23-05500S.

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Optimizing Silanization of Plasma-Activated Float Glass for Enhanced Adhesion and Shear Strength *PB36*

This study investigates methods to improve the shear strength of glass joints by forming a thin layer of (3-aminopropyl)triethoxysilane (APTES) on float glass surfaces using plasma activation. The ambient air plasma was generated at atmospheric pressure with a Diffuse Coplanar Surface Barrier Discharge (DCSBD). APTES introduces polar amine groups to the glass surface, which bond strongly with the epoxy groups present in adhesives. The influence of silanization parameters, such as the plasma activation time and reaction time in the APTES solution, was evaluated using surface wettability, adhesion, and XPS measurements. Our results show that plasma activation significantly increases surface free energy without substantially altering surface elemental composition. Furthermore, plasma treatment more than tripled the peel strength on the tin side of the glass and slightly enhanced shear strength on both sides. Regarding silanization, longer reaction times (~20 h) and plasma exposure times (60 s) resulted in higher water contact angles, indicating successful APTES binding. However, both peel strength and shear strength decreased after silanization, with the shear strength on the air side decreasing almost six-fold. Therefore, further experiments are required to determine whether or not silanization can actually improve the adhesion properties of glass joints.

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Modification of Commercial Polyphenylene Sulfide With Multi-Walled Carbon Nanotubes for Improved Mechanical and Antistatic Performance *PB37*

Polyphenylene sulfide (PPS) is a high-performance thermoplastic widely used in engineering applications due to its excellent chemical resistance, dimensional stability, and flame retardancy. However, its brittleness and intrinsic electrical insulating nature limit its use in multifunctional systems where mechanical flexibility and conductivity are required. In this study, we report the development of PPS-based composites modified with multi-walled carbon nanotubes (MWCNTs) to enhance both mechanical properties and antistatic behavior. A commercially available PPS grade (Fortron FX55T1) was compounded with various concentrations of MWCNTs (0.3-2.0 wt%) using melt extrusion at 315 °C. To improve CNT dispersion within the matrix, polyethylene glycol (PEG 1500) was employed as a processing aid, serving both as a dispersing agent and plasticizer. Among all tested formulations, the composite containing 0.5 wt% MWCNTs exhibited the most balanced property profile. Notably, the elongation at break increased from 42% for neat PPS to 83% for the modified composite, without compromising tensile strength, Young's modulus, or Charpy impact strength. Furthermore, a significant antistatic effect was achieved: the surface resistivity of the optimized composite decreased to the order of $10^7\ \Omega\cdot sq^{-1}$, compared to $>10^{11}\ \Omega\cdot sq^{-1}$ for neat PPS. The applied methodology demonstrates the potential of low-load MWCNT reinforcement in achieving ductile, mechanically robust, and antistatic PPS-based materials, suitable for advanced applications in the automotive, electronics, and industrial sectors.

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Rigorous Analysis of CMOS-compatible Coupler Structures on a Silicon Nitride Photonic Integrated Circuit Platform for Compact Laser Light Engines in the Visible Spectral Region ***PB38***

The rapid expansion of photonic integrated circuits (PICs) has led to significant advancements across various industries, particularly in applications utilizing the visible and near-infrared (NIR) spectrum. Silicon nitride (SiN) has emerged as a promising material for PICs due to its broad spectral range, CMOS compatibility, and low optical losses. However, several challenges remain in optimizing SiN-based devices for visible spectrum applications, especially in terms of compactness and efficiency. In this work, we focus on addressing these challenges by analyzing CMOS-compatible silicon nitride rib waveguides and their performance in two-mode interferometers (TMIs), critical components in laser beam combiners used for augmented reality (AR) and virtual reality (VR) systems. Our study provides a comprehensive wafer-level analysis of the splitting ratios of two-mode interferometers in the visible regime, comparing them to directional couplers under variations in fabrication processes. We explore key factors influencing device performance, including fabrication tolerances, waveguide geometry, and material properties. Numerical simulations are compared with experimental data to assess theoretical predictions against measured results. This comparison highlights critical fabrication aspects that affect splitting ratios, such as etch depth control and rib height variation. Our results show that while simulated data generally align with experimental trends, significant deviations in splitting ratios arise due to imperfections in the fabrication process. Optimized rib waveguide dimensions for visible wavelengths significantly improve the performance of two-mode splitters compared to directional couplers, particularly in the blue region of the spectrum where fabrication tolerances are most critical. These findings offer valuable insights for further refinement of SiN-based photonic components, aiding the development of compact, high-performance devices for visible light applications.

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Environmental Applications

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Plasma-Engineered Graphene Oxide/Nanofiber Composite Membranes for Efficient Water Purification ***PB39***

Water source pollution poses a significant ecological and health problem, necessitating the development of new, effective filtration materials. This study focuses on the fabrication and characterization of composite membranes composed of polymeric nanofibers and plasma-reduced graphene oxide (rGO) for the removal of various water contaminants. The PA6 nanofibers were deposited onto a DCSBD plasma-pretreated polypropylene non-woven fabric, using electrospinning method. The rGO was fabricated by custom DCSBD atmospheric plasma triggered reduction of graphene oxide (GO) papers in a nitrogen atmosphere, followed by DCSBD linear APPJ nitrogen plasma functionalization to enhance its adsorption capacity. The fabricated nanomaterials were then pressed into membranes and tested for the filtration of model contaminants, including rhodamine B dye, selected heavy metals, and pharmaceuticals. The plasma functionalization of rGO was analysed by XPS. Filtration efficiency was evaluated using HPLC-MS, and ICP-MS methods. The results demonstrate that rGO-based membranes exhibit significantly higher contaminant removal efficiency, with further improvements achieved through plasma functionalization of the rGO material. This study confirms that the combination of rGO and polymeric nanofibers represents a promising approach for the development of advanced filtration membranes for water treatment.

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Empowering a Sustainable Future by Biomass Conversion on Single Atom Catalysis ***PB40***

Efforts have traditionally concentrated on the use of organic carbon as bioenergy, to produce chemicals and fuels. In the past decade, technologies have been developed to recover high-value commodities from renewable feedstocks. Simultaneously, innovative heterogeneous catalytic processes have been proposed to produce chemicals that can be immediately reused from the biowaste to facilitate a renewable future. Several biomass conversion techniques based on supported metal catalysts comply with most green chemistry principles, provided that metal particles and supporting materials leach into the reaction medium. Metal-catalyzed biomass conversion reactions including hydrogenation, dehydrogenation, deoxygenation, and oxidation reactions will achieve by multistep conversion in a single pot, maybe in combination with acid/base-catalyzed reactions like hydrolysis and dehydration reactions. Apart from nanoparticle catalysts (NCs) which contain bulk metals, Single Atom catalysts (SACs) expose all metal atoms on the surface with a 100 % metal utilization rate. Current single metal atom catalysts based on carbon supports relay on in plane doping, limiting the interactions with the substrates due to the geometry and interlayer stacking phenomena of the carbon sheets. Therefore, here, Lignocellulosic biomass conversion using SACs on various supports such as Zeolites, Metal Oxides and Graphene to be addressed.

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Solvent-Free Shear Mixing vs. Wet Impregnation: Evaluation of Class I Polyamine-Based Sorbents for CO2 Capture ***PB41***

Amine-functionalized solid adsorbents are key materials for CO2 capture, but their practical deployment is often constrained by energy-intensive, solvent-based and time-consuming preparation methods. This study addresses that challenge by evaluating a solvent-free high-speed shear mixing (DRY) method for preparing amine-loaded adsorbents using ZEOFREE® 600, a commercially available calcium silicate. Three polyamines, branched polyethylenimine (PEI), pentaethylenehexamine (PEHA), and tetraethylenepentamine (TEPA), were impregnated at 30-60 wt% loadings and compared with samples prepared via conventional WET impregnation. Results indicated that the DRY method yielded comparable or superior performance across multiple criteria, including morphological stability, textural properties, amine accessibility, thermal resistance, and cyclic durability, while eliminating the need for solvents and prolonged drying and requiring significantly less energy and processing time. Under simulated flue gas conditions (10% CO2), maximum adsorption capacities reached 3.52 $\mathrm{mmol \cdot g^{-1}}$ for TEPA60_DRY, 3.44 $\mathrm{mmol \cdot g^{-1}}$ for PEHA60_DRY, and 3.19 $\mathrm{mmol \cdot g^{-1}}$ for PEI60_DRY. TEPA and PEHA adsorbents exhibited superior uptake capacity, while PEI-based adsorbents provided enhanced thermal and cyclic stability. These findings demonstrate the suitability of ZEOFREE® 600 as a support and confirm the DRY method as a time and energy-efficient alternative for producing CO2 sorbents. ACKNOWLEDGEMENTS: The research was supported by the Ministry of Education, Youth and Sports of the Czech Republic within the framework DKRVO (project number RP/CPS/2024-28/007). Internal grant agency of Tomas Bata University in Zlín (project number IGA/CPS/2025/002) is also acknowledged.

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Sustainable Production of Aromatics, Cyclic Hydrocarbons, and Higher Alcohols via Biomass-Derived Feedstock Conversion *PB42*

In the modern era, the growing global population and fast-paced lifestyles have intensified the dependence on fossil fuels and resources. However, the finite availability of these resources presents significant challenges in producing essential chemicals and fuels. This highlights the urgent need to explore sustainable alternatives for energy and chemical production. A comprehensive investigation was carried out on the hydrogenation and deoxygenation of β-O-4 linkages present in lignin and its derivatives, leading to the formation of saturated cyclic hydrocarbons and cyclic alcohols. Additionally, the upgrading of ethanol to higher alcohols demonstrates as a promising route for generating high-energy-density molecules. These findings demonstrate the potential of the developed catalytic protocol to address energy demands by enabling the production of aromatics via catalytic transfer hydrogenation, cyclic hydrocarbons via hydrogenation, and higher alcohols through ethanol upgrading.

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Single Atom Ruthenium Decorated on MOF-derived Porous Carbon for Overall Water Splitting *PB43*

The scalable production of green hydrogen critically depends on the development of highly active and durable single-atom electrocatalysts capable of operating efficiently for overall water splitting. Yet, poor reaction kinetics and the ongoing challenge of balancing catalytic activity with long-term stability continue to impede progress. This study tackles the pressing challenge of creating efficient and long-lasting electrocatalysts for green hydrogen production by introducing a strategically designed, single-atom catalyst for overall water splitting. The core innovation involves the deliberate incorporation of Ru-N4 single-atom sites into a MOF-derived porous graphitic carbon framework. This design enhances the accessibility of active sites, promotes rapid electron transport, and delivers outstanding stability across a wide pH range. The resulting Ru1/Ni-NPGC catalyst exhibits impressive electrocatalytic activity, achieving low overpotentials of ~191 mV for the oxygen evolution reaction and ~52 mV for the hydrogen evolution reaction under alkaline conditions-surpassing many leading catalysts. Notably, it supports efficient water electrolysis at cell voltages of ~1.48 V to reach a current density of 10 mA/cm2. Operando spectroscopic analyses further reveal the central role of Ru as the active site, shedding light on the underlying structure-activity relationship. By overcoming key limitations such as sluggish kinetics and the trade-off between activity and durability, this work offers a promising pathway toward the development of robust and high-performance electrocatalysts for sustainable hydrogen generation.

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Carbon Dots for Environmental Monitoring and Remediation *PB44*

Environmental pollution remains a pressing global issue, challenging both developed and developing nations. Traditional remediation methods often struggle to effectively address complex contamination scenarios, underscoring the need for innovative and efficient alternatives. In this context, nanomaterials have emerged as promising tools for environmental remediation due to their unique physicochemical properties. Among these nanomaterials, quantum dots (QDs)—semiconductor nanoparticles typically ranging from 1 to 10 nanometers—exhibit distinct optical and electronic characteristics influenced by quantum confinement effects. These properties make QDs valuable for applications in sensing and remediation. However, traditional QDs often contain toxic heavy metals like cadmium, raising environmental and health concerns. To address these issues, carbon dots (CDs), a class of carbon-based QDs, have gained attention. CDs offer several advantages over traditional semiconductor QDs, including lower toxicity, superior biocompatibility, chemical stability, and tunable photoluminescence. These features make CDs particularly suitable for environmental applications, such as pollutant detection and removal. CDs can be synthesized from sustainable and cost-effective precursors, including biomass and waste materials, enhancing their environmental compatibility and supporting waste minimization efforts.

Their synthesis methods are relatively straightforward and can be tailored to produce CDs with specific properties suitable for various applications. In environmental remediation, CDs have demonstrated effectiveness in detecting and removing chemical and microbial pollutants through mechanisms such as fluorescence modulations, adsorption, photocatalytic degradation, and antimicrobial action. These capabilities position CDs as versatile and sustainable nanomaterials for addressing environmental pollution challenges. This study aims to provide an overview of the key role of CDs in environmental monitoring and remediation applications.

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Smart Magnetic Robots for Capturing and Degrading Organic Contaminants from Water ***PB45***

Mikrorobots are miniature devices capable of performing complex tasks such as drug delivery, medical diagnostics, or environmental purification. They can have various mechanisms of motion induction based on the use of energy of external optical or magnetic field, as well as consumption of reactive chemical species. In the microrobots design the ability to control motion is commonly used in combination with additional functionality, such as selective surface sorption of targeted organic molecules. In this work, we developed a concept for microrobots designed to detect and remove organic contaminants from water. The proposed robots are hybrid structures composed of Fe_3O_4 magnetic microparticles whose surface is functionalized with metal organic porous compounds (MOF - metal organic framework). This design of functional microrobots provides a high specific surface area for effective capture of pollutants while it was enhanced by controlled movement of microrobots using an external magnetic field. As part of the work, several types of microrobots with different types of MOFs were prepared and tested for the effective capture of Diclofenac and GenX. The microrobots were characterized at each stage of their preparation using scanning electron microscopy, X-ray structural analysis, vibrational spectroscopy (Raman and Fourier Transform Infrared Spectroscopy), X-ray photoelectron spectroscopy, and BET analysis. The results showed that MOF801 and MIL-101(Cr) are the most effective and stable for efficient removal of pollutants. Microrobots have demonstrated high sorption capacity and the possibility of motion control by an external magnetic field, which makes them promising for the removal and detection of hazardous contaminants from water.

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POSTER SESSION C

Nanomedicine: Diagnostics and Therapy

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Exploring the Therapeutic Efficacy of Bimetallic Single-Atom Materials Against Cancer ***PC1***

Bimetallic single atom materials involve the co-existence of two different types of single metal atoms anchored on single support. These materials offer synergistic effects between the two metals, enhancing catalytic activity, and therapeutic potential beyond what monometallic systems can achieve. Thus, bimetallic single atoms offer a versatile platform for cancer therapy by integrating complementary therapeutic functions of two distinct metals. Their unique dual-site architecture enables precise tumor microenvironment modulation and facilitates multi-step therapeutic reactions with high efficiency. In this study, we have used nitrogen doped graphene (NGA) as a matrix to support bimetallic single atoms viz., Fe/Cu, Ni/Cu and Fe/Ni to form single atom materials (SAMs). Among the three bimetallic combinations evaluated, the Fe/Cu system exhibited superior anticancer activity, showing enhanced cytotoxic effects against HT-1080 human fibrosarcoma cell line. This increased efficacy is likely attributed to the synergistic catalytic behavior of Fe and Cu in promoting reactive oxygen species (ROS) generation and disrupting tumor cell viability. Despite its pronounced anticancer activity, the material exhibited minimal toxicity toward human fibroblast cells (BJ), highlighting its favorable biocompatibility profile. Further mechanistic studies are currently underway to elucidate the precise molecular effects of bimetallic SAMs and to better understand the structure-function relationships underlying their therapeutic action. ACKNOWLEDGMENTS: The financial support of the European Union under the REFRESH - Research Excellence For Region Sustainability and High-tech Industries project number CZ.10.03.01/00/22_003/0000048 via the Operational Programme Just Transition is acknowledged.

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Zinc-Doped Magnetite Nanoparticles for Magnetic Hyperthermia: In Vitro Evaluation in MDA-MB-231 Breast Cancer Cells ***PC2***

Hyperthermia (HT), involving the controlled elevation of tumor temperature to 39-47 °C, enhances the efficacy of radiotherapy and chemotherapy by inducing cell death and modulating DNA repair and stress response pathways. Using magnetic nanoparticles, HT can be strictly localized at the tumor level by means of an external magnetic field. Metal-doped magnetites emerge as promising agents due to their improved magnetic properties and biocompatibility. This strategy is particularly relevant for aggressive malignancies such as triple-negative breast cancer, where the MDA-MB-231 cell line serves as a thermosensitive model for investigating HT-based multimodal therapies. To support this approach, we synthesized zinc-doped magnetite nanoparticles with 10% Zn substitution (Zn10%:Fe_3O_4) via the coprecipitation method. Pluronic F127 was employed as a non-ionic surfactant to enhance colloidal stability in aqueous media. X-ray diffraction confirmed the formation of a single-phase cubic spinel structure. Dynamic light scattering revealed a hydrodynamic diameter of approximately 244 nm while Zeta potential measurements yielded a value of -16 mV, indicating moderate colloidal stability compatible with biomedical applications. In vitro evaluation of Zn10%:Fe_3O_4 in MDA-MB-231 cells was conducted under five treatment conditions, with and without HT. MNPs alone reduced cell viability to ~75%, suggesting mild intrinsic cytotoxicity. Under HT, Zn10%:Fe_3O_4@DOX reduced viability to 64%, showing only slight improvement over non-HT conditions. Physical mixtures and individual agents exhibited limited effects (~73-79%). In conclusion, Zn10%:Fe_3O_4 exhibited modest cytotoxicity, with minimal enhancement under HT. This indicates that the observed effects primarily arise from nanoparticle-drug interactions rather than thermal-MNPs-DOX synergy, highlighting the therapeutic effect of the nanosystems in the absence of additional heating. ACKNOWLEDGMENTS: H2020-ERA-Chair, no 952390 and PN-III-P3-3.6-H2020-2020-0105/35/2021 (UEFISCDI).

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Multimodal SPIO Nanoparticles for HER2 Positive Breast Cancer Detection *PC3*

Early discovery of tumours is one of the utmost importance for their treatment, that's why contrast agents are being widely used to enhance their signals. Nanomaterials, specifically superparamagnetic iron oxide nanoparticles (SPIONs) have been widely studied and modified for various medical applications, including drug delivery and tissue imaging (1, 2). In this study, multimodal contrast agent for detection and imaging of HER2 positive cancer cells was prepared. Firstly, SPIONs were synthetised through a soft biomineralization route, where their in situ surface functionalization with alginic acid led to the formation of colloidal nanoclusters (3). Secondly, further functionalization of SPIONs was achieved with the covalent conjugation of polyethylene glycol (PEG) corona G protein via EDC/NHS bonding. Fluorescently marked ErB2/HER2 antibody was conjugated on the prepared SPIONs by specific bond protein G - IgG region of antibody. SPIONs were thoroughly characterised for their size, surface charge and magnetic properties (10nm by TEM, Dh = 100nm, ζZp = - 29mV). In vivo biocompatibility testing on healthy and cancer cells revealed no high biocompatibility in tested concentrations (up to 150ug/ml). Finally, clustered SPIONs have demonstrated high negative contrast for MRI (relaxivity = 178 s-1/nM), comparable with commercially used compounds like Resovist, and also fluorescent signal for high sensitivity towards HER2 positive tumour cells in vitro and in vivo, respectively (Alexa Fluor 488 for in vitro and Alexa Fluor 750 for in vivo). Obtained results show that our modified SPIONs with monoclonal antibody are promising candidates as dual specific contrast agents for HER2 positive cancer cell detection. ACKNOWLEDGEMENT: This work has been funded from the European Regional Development Fund - Project Excellence in Regenerative Medicine" (No. CZ.02.01.01/00/22_008/0004562) REFERENCES: [1] R. Weissleder, A. Bogdanov, E. A. Neuwelt, M. Papisov, Long-circulating iron oxides for MR imaging, Advanced Drug Delivery Reviews, Volume 16, Issues 2-3, 1995, ISSN 0169 409X; [2] Ulbrich K, Holá K, Šubr V, Bakandritsos A, Tuček J, Zbořil R. Targeted Drug Delivery with Polymers and Magnetic Nanoparticles: Covalent and Noncovalent Approaches, Release Control, and Clinical Studies. Chem Rev. 2016 May 11;116(9):5338-431. doi: 10.1021/acs.chemrev.5b00589. Epub 2016 Apr 25. PMID: 27109701; [3] Zoppellaro, G., Kolokithas-Ntoukas A., Polakova K., Tucek J., Zboril R., Loudos G., Fragogeorgi E., Diwoky C., Tomankova K., Avgoustakis K., Kouzoudis D., Bakandritsos A., Theranostics of epitaxially condensed colloidal nanocrystal clusters, through a soft biomineralization route. Chem. Mater. 26, 2062-2074 (2014)

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Biological Activity of Zinc Oxide Nanoparticles Functionalized with Low-Molar-Mass Polyphenols Against Mouse Neuroblastoma (N2A) Cells *PC4*

The biological properties of zinc oxide nanoparticles (ZnO NPs) are strongly influenced by their morphology and surface features, as demonstrated in numerous studies. ZnO NPs are well known for their inherent antibacterial, anticancer, and antioxidant properties, making them highly attractive for biomedical applications. It has also been shown that the chemical and biological characteristics of low-molar-mass stabilizing agents deposited on the surface of ZnO NPs can enhance their biological activity. A very similar biological activity is also exhibited by low-molecular-weight polyphenols, such as gallic acid (GA) and rosmarinic acid (RA). In addition to their anti-inflammatory and antioxidant properties, they demonstrate anticancer, neuroprotective, and antiallergic effects. It therefore appears highly probable that the functionalization of ZnO NPs with polyphenols may lead to synergistic effects in terms of their biological properties. To verify this research hypothesis, ZnO NPs were synthesized using the precipitation method and subsequently functionalized with both polyphenols. The three resulting types of nanoparticles were subjected to physicochemical characterization, followed by an evaluation of their cytotoxicity against mouse neuroblastoma cells (N2A). X-ray diffraction (XRD) analysis confirmed that the nanoparticles possessed a wurtzite crystalline structure and that surface modification did not affect their crystallographic form. Based on the full width at half maximum of the diffraction peaks, the average crystallite size was determined to be 29±5 nm using the Scherrer equation. The functionalization of ZnO NPs slightly influenced their electrokinetic properties, which was confirmed by the determination of zeta potentials. Generally, each type of ZnO NPs was negatively charged over a broad range of ionic strength and pH. The cytotoxicity of ZnO NPs was evaluated using common biochemical assays, including XTT, LDH, and MDA. Changes in the mitochondrial activity of N2A cells were most pronounced after 48 hours of treatment with a ZnO NP concentration of 15 mg/L. Disruption of membrane integrity was observed after 24 hours of treatment and was associated with lipid peroxidation, as indicated by the results of the MDA assay. Each type of ZnO NP induced a concentration-dependent secretion of SOD activity in a similar manner. Likewise, the secretion of glutathione triggered by each type of ZnO NP was comparable. It was determined that GA-ZnO NPs and RA-ZnO NPs were significantly toxic to the cells, which was particularly evident in the disruption of mitochondrial activity. These findings demonstrate that the functionalization of ZnO NPs with polyphenols influences their toxicity toward N2A cells. ACKNOWLEDGMENTS: This research was funded by the National Science Centre (NCN) under project number 2022/47/O/ST5/01858.

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Calcium Carbonate Casein-Based Microspheres With Bio-CuNPs for Plant Growth Stimulation and Protection Against Phytopathogens *PC5*

Polymer nanocomposites loaded with biosynthesized copper nanoparticles (CuNPs) are efficient and environmentally-friendly agents for agricultural applications. This approach allows for controlled and sustained release of nanoparticles, leading to improved efficiency and reduced toxicity to plants. The aim of this study was to synthesize nanocomposites of biogenic copper nanoparticles, casein micelles and calcium carbonate microspheres, and to evaluate their potential for plant growth promotion and protection. Fungal extract from Fusarium graminearum and copper sulfate, as a precursor salt, were used for the synthesis of CuNPs. Nanoparticles were subsequently loaded into casein micelles and then encapsulated in calcium carbonate microspheres. The obtained materials were characterized using various techniques, such as UV-Vis spectroscopy, SEM-EDX, TEM-EDX, FTIR, XRD, NTA, Zeta potential measurement, and ICP-MS. The agricultural potential of CuNPs, casein-NPs-micelles and casein-NPs-microspheres was assessed based on antimicrobial activity against plant pathogens and the ability to stimulate the growth of 30-day-old maize seedlings. Bio-CuNPs were small, spherical, with crystalline structure and various functional groups on their surface. CuNPs inhibited the growth of selected bacterial and fungal phytopathogens. Maize plantlets treated with microspheres exhibited higher shoot and root length as well as higher fresh and dry weight of leaves, stem, and roots, compared to plants treated with CuNPs or micelles. Calcium carbonate microspheres, which enhance the stability and functionality of nanoparticles, can be a suitable product for various applications, including agriculture and drug delivery.

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Decoration of Gold Nanostars with a Polyamidoamine-Ru(ii) Complex to Increase 1O2 Generation Efficiency in Photodynamic Therapy *PC6*

Photodynamic Therapy (PDT) is a medical treatment consisting of ROS production with the excitation of a photosensitizer (PS) using a suitable light. The excited PS undergoes intersystem crossing from the singlet ground- to the triplet excited state, where its energy transfers to molecular O2, generating the cytotoxic 1O2. A promising PS for PDT is Ru-phenAN, a polyamidoamine copolymer bearing a Ru(II) complex, prepared and characterized by our research groups. Ru-phenAN can produce 1O2 with a good yield and is efficiently internalized by cells, where it accumulates in the nucleus upon irradiation, increasing its effectiveness for PDT. In this project, we functionalized gold nanostars (GNS) with Ru-phenAN to test whether the metal core might increase 1O2 generation through an energy transfer to the photosensitizer via LSPR, hence increasing its PDT efficacy. GNS@Ru-phenAN nanoparticles were prepared by using a layer-by-layer approach: a layer of a negatively charged polyamidoamine first functionalized the GNS surface, followed by a second layer of the positively charged Ru-phenAN. First, their uptake by HeLa cells was measured and compared to Ru-phenAN alone, showing a comparable internalization. The cytotoxicity and the ROS production of the Ru-phenAN copolymer, GNS@Ru-phenAN and the bare GNS were then studied, both in the dark and after irradiation in the visible spectral range, showing a 10-fold increase in the ROS generation and photocytotoxicity of GNS@Ru-phenAN. Lastly, confocal microscopy images of the cells treated with GNS@Ru-phenAN were taken, showing that the GNS and the Ru-phenAN enter together in the cells and co-localize in the cytosol.

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Sustainable Silver Plated Electrically Conductive, Flexible and Hygienic Electrodes for Electrotherapy *PC7*

Muscle atrophy is a well-known consequence of immobilization and critical illness, leading to prolonged rehabilitation and increased mortality. Electrical stimulation can aid in improving muscular structure. Textile electrodes serve a dual purpose: they can be utilized for monitoring bioelectrical signals such as ECG (Electrocardiography), EMG (Electromyography), or EEG (Electroencephalography), and as media for electrostimulation [1]. The core of the study is to evaluate the electrostimulation response of flexible, lower impedance and hygienic dry textile electrodes composed from a source of waste material (cotton). The work was aims to utilize the sustainable waste resources (keep view on ecological and environmental factors) to produce the electrically conductive electrodes. Initially, knitted cotton waste was collected, processed through the yarn manufacturing stage, and subsequently transformed into a knitted fabric structure. Subsequently, the deposition of silver nanoparticles was done sustainably by adopting eco-friendly techniques that minimize chemical usage, waste generation, and environmental impact. To achieve a higher concentration of silver, additional direct electroless silver plating was done. Second, half research project was contained to improve the mechanism of effective electrostimulation by lowering the skin electrodes impedances. Dynamic light scattering and SEM analysis were employed to study the morphology of deposited silver particles. To improve the properties of electrode (when it is subjected to various movement of human body), the conductive fabrics were subjected repeated extension and change in resistivity with stretch was observed. So, it can almost be considered a constant value in the stretch range of 0-80%. The electrical resistance increased after 90% of stretch. However, the fabric resistivity was well maintained after repeated extension even over 100 cycles. Furthermore, there was insignificant change in resistivity with time at constant current was observed. Moreover, the role of deposited particles on antibacterial properties was examined against pathogenic bacteria such as Staphylococcus aureus and Escherichia coli. At the end, the durability of coated fabrics for comfort and electrical properties were examined against several washing cycles. The fabrics showed good retention of the particles, proved by SEM microstructures and small loss in the conductivity of the material after washing.

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Giant Vesicles as Erythrocyte Membrane’s Models: Interaction Between Glycosylated Lipid Aggregates and (bi)functionalized Silica Nanoparticles *PC8*

The interaction between boronic acid (BA) and sugars is of considerable importance across multiple scientific disciplines, including chemistry, biology, and medicine. This reversible interaction, specifically, the formation of a boronate ester through the binding of BA to the cis-diol groups in sugars [1] is fundamental to processes such as molecular recognition, carbohydrate sensing, drug delivery, glycobiology, and synthetic chemistry [2]. In our project, the main goal is to prepare giant unilamellar vesicles (GUVs) as biomimetic models of red blood cells (RBCs). This is accomplished through a technique involving the fusion of selected lipid aggregates at the interface of an oil droplet, facilitated by silica nanoparticles (Si@nPs) [3]. To achieve this, a specific and reversible interaction, such as the BA-sugar binding, is required between the components of the GUV bilayer and the Si@nPs. Building on this concept, we developed bifunctional Si@nPs through an optimized synthetic protocol (proportions, time of reaction and temperature were studied). These nanoparticles feature fluorinated groups for solubility in the oil phase and BA moieties for selective binding to sugars on the lipid bilayer destined to form the membrane. As a proof of concept, glycosylated liposomes were initially used to evaluate how various parameters, including sugar type, pH, surface charge, and lipid composition, affect GUV formation. Based on these results, the methodology was then adapted to use nanoerythrosomes (NERs), isolated from RBCs, which contain glycoproteins with the same sugar motifs in their membranes. Ultimately, GUVs were successfully formed using glycosylated liposomes via rapid mixing and visualized through fluorescence microscopy. Promising preliminary results were also obtained using NERs. REFERENCES: [1] R. Melavanki, et al. Heliyon, 2020, 6, e05081; [2] K. Lacina, et al. Chem Cent J. 2014, 8, 60; [3] J. Waeterschoot, et al. Adv. Sci., 2023, 10, 2302461.

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Zinc-selenium Nanoparticles as Innovative Antibacterial Agents *PC9*

Antibiotic resistance is a rapidly escalating global crisis that threatens the effective treatment of bacterial infections in both human and veterinary medicine. Multidrug-resistant (MDR) bacteria, particularly in clinical and agricultural settings, compromise conventional therapies, endanger patient safety and animal welfare, and contribute to significant healthcare and agricultural losses. Among them, resistant Staphylococcus spp. represent a major concern. This study explores zinc-selenium-based nanoparticles (ZnSe NPs) as innovative antimicrobial agents against resistant staphylococci. Following synthesis and characterization, their antibacterial properties were evaluated using disc diffusion, minimum inhibitory concentration (MIC), live/dead viability, and MTT cytotoxicity assays. Three ZnSe NP formulations (ZnSe A, ZnSe B, ZnSe C) were tested against Staphylococcus aureus, methicillin-resistant S. aureus (MRSA), and Escherichia coli. Antibacterial activity varied with nanoparticle type, concentration, and bacterial species. ZnSe A showed the strongest effect at 0.5 mg/mL, achieving complete (100%) inhibition of S. aureus. At lower concentrations, ZnSe C was more effective, inhibiting up to 57% of S. aureus and 73% of MRSA growth at 0.0625 mg/mL. These findings highlight ZnSe NPs as promising alternatives to conventional antibiotics, particularly against Gram-positive and resistant strains. Future work will focus on optimizing multi-element, metal-core nanoparticles and evaluating their efficacy against clinically relevant Staphylococcus isolates from dairy cows with mastitis and diabetic patients. This research supports the potential of nanomaterials as innovative tools to address antimicrobial resistance and improve both human and animal health outcomes. The authors gratefully acknowledge the financial support of Mendel University in Brno through project IGA25-AF-IP-021.

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Functional Polyphenol-Quantum Dots Nanosystem Mitigate Amyloidogenic Cross-Seeding and Restore Neurophysiological Homeostasis in Alzheimer's Disease *PC10*

Emerging evidence highlights the role of gut microbiota in neurodegenerative disease progression through the release of microbial metabolites, including amyloidogenic proteins. Notably, E. coli biofilms produce curli fibers, structurally analogous to human amyloid-β (Aβ), which can promote cross-kingdom protein aggregation. This study investigates: (i) the potential of bacterial biofilm proteins to accelerate Aβ42 aggregation and induce neurotoxicity, and (ii) whether polyphenol-functionalized nanosytem can inhibit such heterotypic aggregation. Gallic acid-conjugated MoS2 quantum dots (GA@MoS2 QDs; ~9.6 ± 4.2 nm) were synthesized and characterized via spectroscopic and microscopic techniques. GA@MoS2 QDs reduced E. coli biofilm thickness by ~1.84-fold, suggesting direct interaction with biofilm components. Dot blot and MALDI-TOF analysis confirmed the presence of curli protein in bacterial biofilm. Biophysical assays demonstrated that curli protein accelerated Aβ42 aggregation by ~6.76-fold, while GA@ MoS2 QDs inhibited this process by ~17.25-fold. In SH-SY5Y neuroblastoma cells, heterotypic aggregates induced elevated ROS generation, calcium influx, and apoptosis—all significantly mitigated by GA@MoS2 QDs. These findings underscore the critical role of bacterial amyloids in Aβ pathology and present polyphenol-nanomaterial conjugates as promising therapeutic agents targeting early amyloid cross-seeding in Alzheimer's disease.

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Nanomedicine: Diagnostics and Therapy/Drug Delivery Systems/Targeted Therapy

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Synthesis, Characterization, and Cytotoxic Evaluation of Zn-doped Fe3O4 Nanoparticles loaded with DOX for Drug Delivery Applications *PC11*

In the present study, zinc-doped magnetite nanoparticles ($Zn@Fe_3O_4$) were synthesized via a wet chemical route using the coprecipitation method under alkaline conditions, with Pluronic F127 employed as a surfactant. Doxorubicin (DOX) was loaded onto the Fe_3O_4 nanoparticles by adding 15% DOX to the magnetic nanoparticle suspension, followed by incubation at room temperature for 24 h under continuous agitation at 100 rpm. The intrinsic physicochemical and magnetic properties of both $Zn@Fe_3O_4$ and $Zn@Fe_3O_4$-DOX nanoparticles were systematically characterized. Structural and magnetic analyses were conducted using powder X-ray diffraction (XRD) and vibrating sample magnetometry (VSM). XRD confirmed the formation of a cubic spinel structure, with an average crystallite size of approximately 10 nm. VSM measurements demonstrated that the Zn-doped Fe_3O_4 nanoparticles exhibited superparamagnetic behavior, with a saturation magnetization of 70 emu/g. The biocompatibility and cytotoxicity of the synthesized $Zn@Fe_3O_4$, $Zn@Fe_3O_4$-DOX, and free DOX were evaluated at concentrations of 3, 10, 30, and 90 µg/mL over incubation periods of 24, 48, and 72 hours, using human breast cancer cell lines (HCC, and MCF-7) and normal human breast epithelial cells (MCF-10A). Compared to control samples, $Zn@Fe_3O_4$ nanoparticles exhibited low cytotoxicity across all cell lines, indicating their potential suitability for drug delivery applications. Among the cancer cell lines tested, the most pronounced cytotoxic effect was observed in the epithelial breast cancer HCC cell line, which exhibited dose-dependent cytotoxicity, with cell viability reduced to 76.7% after 72 h of treatment with $Zn@Fe_3O_4$ DOX. A comparable reduction in viability (down to 74%) was also observed following treatment with free DOX at a concentration of 30 µg/mL for the same incubation period.

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Characterisation of the Compressibility of Diffusion Probes Using High-Resolution Ultrasound Spectroscopy *PC12*

The study of diffusion is essential for the development of nanoscale drug delivery systems, particularly in their ability to traverse the extracellular matrix (ECM) and other biological barriers to reach target tissues. One of the most notable examples of the application of targeted nanoscale drug delivery systems is cancer therapy. The efficient transport of nanoparticles (NP) is crucial, and their mobility within the ECM is largely determined by particle size and surface charge. Recent research suggests that compressibility may also significantly impact mobility, as highly compressible systems can pass through pores smaller than their apparent size would suggest. In this work, we present a study of the compressibility of dextran, a polysaccharide intended for future use as a diffusion probe in ECM-mimetic hydrogels. The dependence of compressibility on dextran concentration and molecular weight (Mw) was studied using high-resolution ultrasound spectroscopy (HR-US). Our results indicate a clear decrease in compressibility with increasing concentration, whereas molecular weight had a negligible effect, confirming trends observed in previous studies on biopolymers. Finally, the compressibility of dextran was compared with that of nanoparticles and hyaluronan (HA), which represent models of systems with low and high compressibility, respectively.

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Protein Corona of Nanoparticles Studied by AFM *PC13*

Our work aims to investigate the physicochemical properties of the nanoparticle-protein corona complex and evaluate its stability under conditions that simulate a biological environment. We employ atomic force microscopy (AFM) for sample analysis. When nanoparticles come into contact with a protein-rich environment, proteins can absorb onto their surface, forming what is known as the protein corona. This layer significantly influences nanoparticles' behavior in the biological environment, including their cytotoxicity, stability, and potential for targeted drug delivery. In order to study protein corona formation in close to native biological conditions and closely mimic cellular conditions, AFM measurements of the nanoparticle-protein corona complexes must be conducted in a liquid environment with proper ionic conditions. However, AFM imaging requires that the nanoparticles in the samples be firmly immobilized. Therefore, we developed a functional anchoring layer based on (3-aminopropyl)triethoxysilane (APTES) to ensure stable fixation of the complexes on the substrate. The nanoparticles used in this work were mainly gold nanoparticles (AuNPs) with various diameters. They were immobilized onto APTES anchoring layer, and their anchoring stability was subsequently tested both in air and in aqueous environments. These findings can contribute to a better understanding of protein corona behavior and open up possibilities for these findings can contribute to application in targeted therapy and diagnostics.

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Diffusion of Sulfapyridine in Agarose Hydrogel: Comparison Between Experiment and Simulation *PC14*

This work focuses on the comparison of a numerical model and experimental data describing the diffusion of a drug, sulfapyridine, in an agarose hydrogel, which serves as a model porous medium. The aim is to verify whether numerical simulation can accurately represent the transport behavior of the compound under diffusion-controlled conditions. The model is based on a diffusion pair experimental setup consisting of a donor and an acceptor cuvette. The donor cuvette contained the drug solution, while the acceptor was filled with pure hydrogel. Agarose hydrogels were selected for their optical clarity, mechanical stability, and reproducibility. The numerical model was developed in COMSOL Multiphysics using the Transport of Diluted Species interface. The simulation described a purely diffusive process without convection, with geometry and boundary conditions corresponding to the actual experimental configuration. The model was calibrated to isolate the diffusive component of mass transport. The results showed good agreement between simulation and experimental data, confirming the suitability of numerical modeling for studying transport phenomena in porous systems. This modeling approach provides a solid basis for future extensions incorporating interaction mechanisms such as sorption or complexation.

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A Physico-Chemical Point of View on Membrane Properties of Inhalable Colloidal Systems *PC15*

This contribution aims to propose a characterisation of colloidal systems, especially vesicular systems, with regard to the use of these systems in the inhalation administration of biologically active substances. Fluorescence spectroscopy, dynamic and electrophoretic light scattering techniques were chosen as characterisation techniques. These methods are very suitable for dilute aqueous solutions of vesicles, which represent the basic colloidal system, which is able to solubilise and carry a wide range of biologically active substances, namely water-insoluble, amphiphilic, and, upon subsequent purification, water-soluble substances. Given the expected use of these systems as carriers of water-insoluble and amphiphilic substances, attention is paid in particular to the physicochemical properties of the vesicular membrane, which, with its properties, influences the process of solubilisation of biologically active substances and the overall stability of formulated vesicular systems. Given this fact, data for different types of vesicular systems from measurements of size, zeta potential, hydration and membrane fluidity are correlated to observe the dynamics between the intrinsic local properties of the membrane with the overall characteristics of the formulated vesicular systems. This correlation will subsequently be used to describe the influence of the type of nebulisation, necessary for inhalation delivery of aqueous solutions, on membrane stability and properties. ACKNOWLEDGEMENTS: This project is supported by Interfaculty Junior Project

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Interactions of Detonation Nanodiamonds with Nucleic Acid Components *PC16*

Detonation nanodiamonds (DND) combine ultrasmall dimensions (≈ 5 nm) with tunable surface chemistry, making them attractive candidates for biomedical applications, particularly nucleic acid delivery. A critical prerequisite for such applications is a fundamental understanding of how nanodiamond surfaces interact with DNA and its structural components. In this work, we investigated the interactions of oxidized (DND_O) and hydrogenated (DND_H) nanodiamonds with DNA, nucleosides, and nitrogenous bases. Controlled surface modifications were employed to correlate surface chemistry with biomolecular binding. Oxidation at 450 °C provided oxygen-rich terminations (-COOH, C=O, -OH) and a negative zeta potential, while hydrogenation at 700 °C under hydrogen flow produced C-Hx groups and a positive zeta potential. Colloidal dispersions of these nanodiamonds were incubated with nucleic acid components ranging from individual bases and nucleosides to complete DNA molecules (salmon sperm DNA). Fourier Transform Infrared Spectroscopy (FTIR) served as the primary tool to monitor functional groups and confirm adsorption through phosphate and amine signatures. Complementary techniques, including Dynamic Light Scattering (DLS) and thermogravimetric analysis (TGA), further substantiated the binding behavior. The results reveal distinct binding modes: DND_H exhibited enhanced affinity for DNA, predominantly mediated by electrostatic interactions with the sugar-phosphate backbone, with only minimal involvement of nucleobase regions. In contrast, DND_O bound electrostatically to nucleobase regions. These findings highlight nanodiamonds as highly promising carriers for nucleic acid loading and targeted gene delivery.

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Polymer-embedded MoOx-based Nanoconjugates: Toward Advanced Photothermal Platforms *PC17*

Molybdenum oxide (MoOx) nanomaterials exhibit strong photothermal conversion under near-infrared (NIR) irradiation, enabling therapeutic applications across both NIR-I and NIR-II biological windows. Their pH-dependent activation and versatile conjugations with biomolecules position them as promising candidates for advanced cancer therapies that are functional, selective, and drug-free. In this study, MoOx nanoparticles and conjugates with integrin-binding RGD peptides were embedded within hydrogel matrices, enabling a Trojan-horse approach to the treatment of recurrent glioblastomas. Hydrogels based on 2-oxazoline and bio-based butyrolactone chemistry demonstrated favorable properties, providing optimal stability and biocompatibility for embedding. This polymer-embedded platform combines tumor-specific recognition with controlled photothermal activation, aiming to overcome the challenges posed by the invasive and heterogeneous nature of brain cancer. Acknowledgement: This work was supported by the Slovak Research and Development Agency contract No. APVV-23-0535, DS-FR-24-0051, by the Slovak Grant Agency for Science under contract No. VEGA 2/0056/24, VEGA 2/0170/24, VEGA 2/0153/25 and by the NextGenerationEU through the Recovery and Resilience Plan for Slovakia under the project No. 09I03-03-V04-00297.

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Lipid-Based Nanocarriers as Advanced Systems for the Delivery of Green Propolis Extract in Human Melanoma Cells (A375) *PC18*

Lipid-based nanocarriers have emerged as ad-vanced systems for the delivery of natural com-pounds with limited aqueous solubility and restricted biomedical applicability. Brazilian green propolis extract (PROP) is a complex mixture rich in bioactive molecules with recog-nized antioxidant, antimicrobial, and antitumor properties. However, its therapeutic use remains limited by poor solubility and instability under physiological conditions. In this study, nanostructured lipid carriers (NLCs) were designed to encapsulate PROP in order to improve its physicochemical stability, provide controlled release, and enhance biolo-gical activity. The formulations were produced by emulsification-ultrasonication using solid and liquid lipids combined with surfactants. The nanoparticles exhibited mean sizes between 110 and 130 nm, narrow distribution (PDI < 0.200), and negative zeta potential (-12 mV). Encapsu-lation efficiency was close to 100%, and the systems remained stable for up to six months under storage. In vitro release studies using a dialysis model demonstrated a sustained release profile for the encapsulated extract, in contrast to the rapid diffusion observed for free propolis. Cytotoxi-city assays (MTT) against human melanoma A375 cells revealed that nanoencapsulation potentiated the antitumor activity of PROP, allowing significant effects at lower concentra-tions compared with the non-encapsulated ex-tract. Overall, the findings indicate that lipid-based nanocarriers are effective platforms for encap-sulating green propolis, enabling improved sta-bility, controlled release, and enhanced thera-peutic efficacy. These results reinforce the po-tential of NLCs as innovative nanomaterials for biomedical and pharmaceutical applications of natural products. This work was supported by CAPES, FAPESP, and CNPq (311368/2022-0).

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Nanomedicine: Biosensing

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Bioaffinity-based Surface Immobilization of Antibody on Protein Nanolayer for Biosensing Applications ***PC19***

Biosensors are miniaturized diagnostic devices that employ immobilized detecting molecules to quantify target analytes in complex samples. In immunosensors, the antibody-antigen interaction offers intrinsic specificity and selectivity. However, antibody orientation affects access to antigen binding sites and binding efficacy; therefore, its control is essential for surface biofunctionalization. This study examines IgG antibody immobilization onto protein nanolayers via two site-specific binding strategies: the protein G-Fc region of IgG molecule and the streptavidin-biotin system. [1,2]

Silicon substrates, pretreated with aminopropyltriethoxysilane (APTES) and glutaraldehyde, were modified either with protein G or streptavidin. Antibody adsorption isotherms and antigen-binding affinities were quantified by White Light Reflectance Spectroscopy (WLRS). Time of Flight Secondary Ion Mass Spectrometry (ToF-SIMS) characterized multilayer protein chemical composition and IgG orientation. [3,4] Protein G modification promoted a tail-on orientation at IgG surface density forcing vertical alignment. In contrast, streptavidin surfaces yielded predominantly side-on attachment of biotynylated IgG with a low maximal surface amount. Notably, reducing streptavidin surface coverage enhanced IgG binding capacity and enabled vertical molecules arrangement with mixed tail-on/head-on orientation.

These findings deepen the understanding of how protein nanolayers can be used in immunosensors as specific platforms for detecting binding molecules. ACKNOWLEDGEMENTS: The research was funded by the National Science Centre (NCN Poland) under the grant 2021/43/D/ST5/02231. REFERENCES: [1]Dundas, C. M., Demonte, D. & Park, S. Streptavidin-biotin technology: improvements and innovations in chemical and biological applications. Appl Microbiol Biotechnol 97, 9343-9353 (2013); [2]Akerström, B. & Björck, L. A physicochemical study of protein G, a molecule with unique immunoglobulin G-binding properties. Journal of Biological Chemistry 261, 10240-10247 (1986); [3]Gajos, K., Sanocka, K., Wytrwał, M., Dąbczyński, P. & Budkowski, A. pH-dependent orientation of physisorbed and chemisorbed antibodies on silicon determined with TOF-SIMS and its effect on in-flow capture assay monitored with WLRS sensor. Appl Surf Sci 656, 159644 (2024); [4]Gajos, K., Budkowski, A., Petrou, P. & Kakabakos, S. A perspective on ToF-SIMS analysis of biosensor interfaces: Controlling and optimizing multi-molecular composition, immobilization through bioprinting, molecular orientation. Appl Surf Sci 594, 153439 (2022).

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Synthesis, Characterization of Copper Nanoparticles by the Green Method Using Tropaeolum Majus and their Antimicrobial, Antibiofilm and Antiquarum Sensing Activity *PC20*

Tropaeolum majus is a horticultural plant and extract is found to be rich in phenolics and flavonoids. Nanoparticles synthesized by the green method are considered a clean, safe, less toxic, inexpensive method according to traditional methods. Antibiotic resistance is one of today's most important problems. It is thought that finding new molecules to inhibite the mechanisms involved in pathogenicity would be effective in solving the resistance problem. In this study, Tropaeolum majus leaves extract was used to synthesize the copper nanoparticle and investigated at the characterization and antimicrobial, antibiofilm and antiquarum sensing activity. The fruits of the Tropaeolum majus grown on the Beşevler campus of the Ankara University. Methanolic extract was prepared for nanoparticle synthesis. 50 ml of extract was added to 20 mmol of copper chloride solution and the pH of the solution was adjusted to 10. The solution was incubated at 90 °C for 4 h and centrifuged. The resulting residue was dried. Minimum inhibitory concentration (MIC) method was used for antimicrobial, antibiofilm and antiquarum sensing activity. After the synthesis of Cu NPs, the solution changed color from turquoise to black with time. From the UV-visible spectrum, it was observed that the peak of Cu NP occurred at 266 nm. The characterization of nanoparticles was investigated using Raman, XRD, EDX and SEM and the results were consistent with the literature. The CuNP didn’t show antibacterial activity.In the presence of anti-QS activity, there was a weak inhibition zone around the disks impregnated with Cu NPs.

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Metal Ion- Phosphatate Compexes: Applications in Nanomedicine and Clinical Implications *PC21*

Numerous metal ions are capable of forming nanostructured complexes that may further assemble into micro- and macro-scale architectures. Within biological systems, these structures can lead to significant pathological consequences, including the obstruction of organ excretory pathways or accumulation within body cavities and synovial spaces. Moreover, the formation of such structures has been associated with malignant tumors, highlighting the critical need for systematic investigation in this area. Established methodologies for the synthesis of such nanostructures also offer promising paths for their integration into biomedical applications, such as biosensors and targeted drug delivery systems. For the analytical determination of metal ions within these complexes, a combination of spectrophotometric (UV-Vis, FTIR, AAS) and electrochemical techniques (DPV, CPSA) is employed. The initial identification of these crystalline assemblies typically relies on microscopic visualization. The objective of this study was to synthesize various phosphate-based complexes with selected metal ions and to comprehensively characterize the resulting materials using several analytical techniques, including UV-Vis spectroscopy, Fourier-transform infrared spectroscopy (FTIR), atomic absorption spectroscopy (AAS), electrochemical analysis, and microscopy.

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Nanostructured Surface Functionalization for Selective Immobilization of Target Molecules *PC22*

The fabrication of nanostructured, functionalized surfaces for the detection of specific molecules has attracted significant attention due to its broad applicability in bio-sensing. A typical biosensor comprises a transducer that converts biochemical interactions at the surface into a measurable physical signal. One promising technique for the selective immobilization of small molecules is the use of Molecularly Imprinted Polymers (MIPs). MIPs are synthetic materials designed with molecular recognition sites, formed by imprinting a target molecule (template) into a polymer matrix. The key steps in MIP fabrication involve the imprinting of the target molecule and its subsequent removal, leaving behind cavities complementary in shape and functionality for selective rebinding. This work explore the feasibility of integrating a MIP layer with a Lossy Mode Resonance (LMR) based optical fiber. LMR involves the interaction of light with a thin lossy (absorptive) film deposited on an optical waveguide (like an optical fiber or planar waveguide), resulting in a sharp resonance in the transmitted or reflected light spectrum. The underlying concept is that the interaction of target molecules with the MIP modulates the LMR signal, enabling label-free detection. The core of the optical fiber was coated with a thin, LMR-generating indium tin oxide (ITO) film, and the MIP layer was deposited at top of the ITO to provide molecular selectivity. As a proof of concept, preliminary experiments were conducted using metolachlor as a model target compound. Metolachlor, a widely used herbicide, is commonly found in water sources due to its high solubility and environmental mobility. Exposure through ingestion or dermal contact poses health risks, highlighting the need for its sensitive detection. A measurable shift in the LMR signal was observed after immersion in metolachlor solution, which saturated after a defined exposure period, indicating complete analyte uptake. The template molecule was effectively removed, demonstrating the high reusability of the developed optical fiber sensor. These pilot experiments indicate that the integration of MIPs with LMR-based optical fibers is a viable approach for selective, label-free molecular detection. Although still in the early stages, the concept shows promise in terms of sensitivity and selectivity, motivating for further research.

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Properties of Plasmonic-Semiconductor Systems: Noble Metal and Zinc Oxide Nanoparticles in Colloidal Mixtures *PC23*

Zinc oxide nanoparticles (ZnO) exhibit semiconductor, photocatalytic, antimicrobial, and piezoelectric properties, while noble metal nanoparticles (mNP) possess localized surface plasmonic resonance (LSPR). Integrating both into hybrid systems can enhance their properties and expand their applications in optoelectronics and biomedicine. We investigate the optical properties of aqueous colloidal mixtures composed of 50 nm ZnO (absorption edge at 370 nm) and 20 nm mNP, silver (AgNP; LSPR at 394 nm, near ZnO edge) and gold (AuNP; LSPR at 524 nm, far from ZnO edge), using UV-Vis spectrophotometry and COMSOL simulations. Spectral deconvolution reveals a red-shift of around 4 nm in the plasmonic peak and ZnO absorption edge, attributed to the close spectral overlap of the particle activities. In contrast, AuZnO mixtures show no spectral shifts across various concentration ratios, despite changes in pH, zeta potential, and hydrodynamic size. Scanning electron microscopy confirms no significant mNP aggregation in the mixtures. Numerical modeling indicates that ZnO minimally impacts the plasmonic absorption itself, but it enhances the local electromagnetic field of both mNP via dielectric effects. This enhancement depends on the number and spatial arrangement of surrounding mNP. To preserve plasmonic wavelength, AgNP must maintain >5 nm distance from ZnO, while AuNP exhibit no wavelength change even in direct contact with ZnO. This differs from previously reported plasmon-nanodiamond systems, where plasmon resonance was surface mediated. These findings provide further insight into the physics of plasmonic-semiconductor systems and support their potential use in applications such as sensing or photocatalysis.

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Nanomedicine: Tissue Engineering and Implants/Wound Healing

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Multi-Component Polymer Nanocomposites Modified with Hydroxyapatite (N-Ha/µ-Ha), Iron Oxide Magnetic Nanoparticles (Mnps) and Oleic Acid (Oa) for Bone Tissue Engineering Purposes - Preparation and Spectroscopic Characterization *PC24*

Nowadays, scientific research is increasingly focused on developing innovative materials for use in regenerative medicine, particularly for treating bone tissue damage. In the presented study, composite membranes were prepared using a poly(ε-caprolactone) matrix (PCL) enriched with nano- and micro-hydroxyapatite (n-HA/µ-HA), oleic acid (OA), and iron oxide magnetic nanoparticles (MNPs). The selection of these components aimed to improve the structural and functional properties of the material. MNPs were produced via a controlled co-precipitation method and subsequently functionalized with oleic acid to enable effective transfer of the MNPs into an organic environment and to enhance their dispersion and chemical stability. The modification was confirmed using transmission electron microscopy (TEM), thermogravimetric analysis (TGA), ATR-FTIR, and Raman spectroscopy. Raman spectroscopy analysis, which included measurements at increasing laser power, showed that functionalization with OA stabilizes magnetite, limiting its susceptibility to oxidation. The nanocomposite membranes were produced via the solvent casting method. Scanning electron microscopy (SEM) showed that MNPs and HA acted as nucleating agents, affecting the size and morphology of PCL spherulites, whereas OA promoted more ordered crystallization and enhanced HA dispersion within the matrix. Images of the membrane cross-sections obtained by TEM microscopy revealed that n-HA showed a strong tendency to agglomerate, whereas µ-HA was characterized by relatively good dispersion. Raman spectroscopy confirmed the incorporation of all components into the polymer matrix and indicated that the addition of MNPs led to a decrease in PCL crystallinity. In summary, the presented multi-component membranes seem to be promising materials for use in bone tissue engineering; however, their true potential will only be determined after biological tests. ACKNOWLEDGMENTS: The study was supported by the research part of the subsidy of the Faculty of Chemistry, Jagiellonian University in Kraków, Poland. The research has been supported by a grant from the Faculty of Chemistry under the Strategic Programme Excellence Initiative (Young Labs competition - Edition 4 and 5) at Jagiellonian University. This work was partially funded by the National Science Centre, Poland (Project 2024/08/X/ST4/01426 to A.K.) The study was carried out using research infrastructure funded by the European Union in the framework of the Smart Growth Operational Programme, Measure 4.2; Grant No. POIR.04.02.00-00-D001/20, "ATOMIN 2.0 - Center for materials research on ATOMic scale for the INnovative economy".

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Wet Spinning of Zirconium Phosphate-Loaded Chitosan Fibers for Medical Applications *PC25*

Designing functional materials for biomedical applications is particularly appealing and impactful when approached with the principles of sustainable materials context. For many decades, chitosan-based biomaterials have drawn significant attention in the biomedical field due to their many applications, driven by biological properties such as biocompatibility, limited inflammation from foreign body reactions, and biodegradability, among others. Another advantage of chitosan is its excellent processability where previous studies have demonstrated its use in various forms, such as hydrogels, films, nanoparticles, fibers, and carriers for delivery of active substances. For surgical application use, fabrication by wet spinning to produce chitosan fibers would be beneficial as suture threads. However, a key limitation of chitosan fibers is their relatively low mechanical strength. To address this issue, α-zirconium phosphate (Zr(HPO4)2.H2O, ZrP), a crystalline inorganic reinforcement nanofiller, was synthesized and incorporated into the fibers by mixing it into the chitosan solution. ZrP nanoparticles were obtained with different aspect ratios and sizes depending on reaction conditions; nanoparticles for sol-gel method and nanoplatelets for hydrothermal method. In this work, ZrP-loaded chitosan fibers, fabricated by wet spinning with different drawing ratios and nanofiller concentrations, were evaluated for their structural and mechanical properties. Results showed an enhancement of plasticity upon the addition of ZrP, up to a certain filler threshold, enabling the potential use of the fibers for medical applications.

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Silica Nanofibers with Combined Bioactivity Based on Gentamicin Sulphate with Natural Biomolecules *PC26*

The increasing prevalence of bacterial resistance poses a significant challenge to contemporary healthcare, representing a serious and potentially life-threatening complication in patients with bacterial infections of diverse origins, severities, and anatomical localizations. Strategies aimed at mitigating resistance and identifying novel substances or mechanisms able to suppress it are essential, particularly in the treatment of infected wounds. One promising strategy is the integration of traditional medicine and phytotherapy, which offers a wide spectrum of natural compounds with bioactive properties, including anti-inflammatory, antibacterial, antifungal, and regenerative effects. The synergistic combination of natural substances with conventional pharmaceuticals may enhance therapeutic efficacy, reduce required dosages, and accelerate healing, thereby minimizing systemic burden and shortening treatment duration. Moreover, certain phytochemicals have demonstrated the ability to modulate bacterial resistance mechanisms, such as efflux pump inhibition. However, the limited miscibility and biocompatibility of solvent systems used for natural compound extraction necessitate the development of optimal carriers that are biocompatible, biodegradable, solvent-stable, and capable of targeted delivery. In this context, micro- and nanomaterial-based carriers offer considerable potential. This study investigates the potential of biodegradable silica nanofibers (SiNFs) as carriers for the natural bioactive compounds carvacrol (CAR) and thymol (THY), as well as their combinations with the conventional antibiotic gentamicin sulphate (GEN). The functionalized carrier was evaluated for antibacterial activity and biocompatibility to murine fibroblasts.

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Hybrid Electrospinning Approaches for Tubular Nanofiber Scaffold Fabrication *PC27*

This work focuses on fabricating tubular nanofiber scaffolds using DC and AC electrospinning combined with electrohydrodynamic (EHD) technology. Experiments were performed with a rotating collector to evaluate the influence of applied high voltage, needle-to-collector distance, and polymer solution dosage on process stability and fibre deposition. Suitable processing parameters were identified for each technique, and their mutual compatibility was demonstrated. For AC electrospinning, the needle-to-collector distance was shown to have a critical impact on fibre deposition, resulting in the formation of two distinct structural types. These findings highlight the potential of parameter tuning to precisely control scaffold structure, supporting their application in tissue engineering and related biomedical fields.

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Organic Films with Amino Groups on Nanofibrous Structure Control Innate Immune Response *PC28*

Polycaprolactone (PCL) nanofibers are widely used as scaffolds in tissue engineering, but their hydrophobic surfaces limit protein adsorption and cell adhesion. Plasma-enhanced chemical vapor deposition (PECVD) of amino-functionalized thin films offers a simple, tunable method to enhance surface hydrophilicity and biocompatibility. These coatings promote electrostatic interactions with proteins and cells, improving viability and proliferation of human dermal fibroblasts [1], mouse myoblasts [2], and rat vascular smooth muscle cells [3]. In addition to supporting proliferation, amine surfaces enhance cell adhesion, particularly in non-endothelial cells, due to electrostatic interactions between the positively charged surface and the negatively charged glycocalyx [4], [5]. While effective for non-immune cells, the impact of amino-rich films on immune cells remains underexplored. To address this, we evaluated three PECVD coatings with varying nitrogen content and surface properties. Neutrophil-like (dHL-60) and macrophage-like (dTHP-1) models were used to assess early and late immune responses, respectively. In neutrophils, films with high nitrogen content, positive surface charge, and low water stability triggered strong pro-inflammatory activation, evidenced by elevated cytokine expression. Macrophages showed moderate responses across all coatings. These results emphasize the importance of including immune models in biomaterials testing and guide the design of immunomodulatory scaffolds. REFERENCES: [1] L. Štrbková et al., Surf. Coat. Technol. 295, 70, (2016); [2] A. Manakhov et al., Plasma Process. Polym. 14, 7, (2017); [3] I. Nemcakova et al., Int. J. Mol. Sci. 21, 24, (2020); [4] P. Černochová et al., Sci. Rep. 10, 1, 9357, (2020); [5] M. Buchtelová et al., Plasma Process. Polym. 20, 6, (2023).

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Equipment for Producing Multilayer Nanofibrous Structures *PC29*

The article presents the development of a laboratory device for producing combined nanofibrous structures using DC electrospinning (DCES), AC electrospinning (ACES), and electrohydrodynamic printing (EHD printing). The objective was to assess the applicability of these techniques for preparing multilayer and hybrid structures and to design a device concept that enables their implementation. Experimental work focused on identifying key parameters influencing process stability and fibre quality. The effects of applied voltage, capillary-to-collector distance were investigated. In addition, simulations of the electric field were carried out to provide a basis for optimising electrode geometry and the arrangement of functional components. Based on experimental data and simulation results, a device concept integrating the three techniques into a single system was proposed. The article describes the configuration of individual modules and their adjustment options. Initial tests are presented, showing the preparation of nanofibrous structures with different morphologies and properties depending on the selected process parameters. The findings indicate that combining DCES, ACES, and EHD printing is suitable for the fabrication of composite nanostructures. The proposed device concept provides a foundation for further development aimed at applications in tissue engineering, functional coatings, and biomedical materials.

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Solution Blow Spinning of Polymeric Solutions Containing Benign Solvents *PC30*

In recent years, the solution blow spinning (SBS) process has gained interest due to its numerous advantages like high production rate or absence of high voltage for nanofiber fabrication. This technology utilizes coaxial nozzle systems, polymeric solution and high-velocity gas or airflow. One of the SBS research directions is represented by a potential in situ application of nanofibrous wound dressings of SBS in medicine. The spun polymeric solutions for SBS are usually prepared using toxic solvents due to the suitable properties required for spinning like high vapor pressure. Regarding the prospective medical application, ensuring that the spinning method poses no harmful effects is crucial. This statement contradicts the use of toxic solvents. Replacing toxic solvents with so-called nontoxic benign solvents seems to be a suitable solution. However, benign solvents pose a problem for the SBS process in terms of evaporation. It must be compensated for by one of the technology parameters e.g. nozzle diameter. This paper presents the results of SBS process of polymeric solutions based on aliphatic polyesters containing benign solvents such as ethyl acetate and acetone. The influence of a change in nozzle diameter on the SBS process is shown. The morphology of the produced fibers was studied using scanning electron microscopy. According to the results, the process of replacing toxic solvents with environmentally friendly ones is not trivial and it is still necessary to address this issue to obtain optimal fiber morphology using the SBS method and solutions containing benign solvents.

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The Effect of Silver Nanoparticle Impregnated Wound Dressings in Dialysis Catheter Care *PC31*

Introduction: The intersection of chronic kidney disease, hemodialysis, and the persistent threat of catheter-related infections presents a significant challenge in modern healthcare (Rybka et al., 2022). Hemodialysis, while life-sustaining, necessitates the insertion of catheters, which unfortunately become a nidus for microbial colonization and subsequent biofilm formation (Polinarski et al., 2021). The establishment of biofilms within these catheters poses a formidable barrier to conventional antimicrobial therapies, often necessitating catheter removal and replacement, leading to increased morbidity and healthcare costs. In this context, innovative strategies aimed at preventing and managing catheter-related infections are of paramount importance. Aim: This study aims to delve into the potential of silver nanoparticle impregnated wound dressings as a proactive measure in dialysis catheter care, addressing concerns of infection prevention and promoting optimal patient outcomes. Methodology: The methodology involves a comprehensive literature review of studies evaluating the efficacy of silver nanoparticle dressings in reducing catheter-related infections. Databases such as PubMed, Scopus, and Web of Science will be searched using relevant keywords. Inclusion criteria prioritize randomized controlled trials, cohort studies, and case-control studies assessing the impact of dressings on infection rates, catheter dwell time, and patient-reported outcomes. Results and Conclusion: The findings suggest that silver nanoparticle-impregnated wound dressings show promise in reducing microbial colonization and biofilm formation on dialysis catheters, leading to decreased infection rates and extended catheter dwell times. Furthermore, patients report improved satisfaction and quality of life with these dressings.

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Microbiology and Others

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Colloidally Stable Silver Nanoparticles Functionalized with Spirulina-Derived Sulfated Polysaccharides for Biotechnological Applications *PC32*

Sulfated polysaccharides from the cyanobacterium Arthrospira platensis (Spirulina) exhibit notable biological activities, including antiviral, antioxidant, and immunomodulatory effects. Due to their complex structure and the presence of sulfate groups, these biopolymers are used to functionalize nanoparticles, enhancing colloidal stability and imparting specific biological properties. Sulfated polysaccharides were extracted from native Arthrospira biomass using distilled water (1:45m/v) at 90°C for 2 hours, precipitated using cetyltrimethylammonium bromide, washed with 95% sodium acetate and 96% ethanol, then dissolved in distilled water (10 mg/ml). For biofunctionalization, 20 nm silver nanoparticles (AgNPs) were added (100 µg to 10 mL of a polysaccharide solution) and stirred at room temperature for 12 hours. FTIR analysis revealed a decrease in the intensity of bands specific to sulfate and polysaccharide groups, suggesting direct interactions between the nanoparticles and the sulfated polysaccharides. These changes indicate the formation of covalent or coordinative bonds between functional groups of the polysaccharides and the nanoparticle surface. A 30% reduction in reducing power compared to native polysaccharides confirmed altered antioxidant capacity following biofunctionalization. This interaction led to the formation of a colloidally stable complex, in which nanoparticles were efficiently dispersed and protected against aggregation by sulfate groups on the polysaccharide surface. This enhanced colloidal stability imparts improved physicochemical characteristics, supporting potential applications in controlled drug delivery, targeted release systems, and the design of novel bioactive nanomaterials. This work was supported by a grant of the Ministry of Research, Innovation and Digitization, CNCS-UEFISCDI, contract number 12ROMD/20.05.2024, project PN-IV-P8-8.3-ROMD-2023-0060, within PNCDI IV.

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Active Bacterial Orientation for New Generation Biodevices *PC33*

Piezoelectric elements are new generation of bio-devices such as biosensors and biometers. Biodegradable materials are the most suitable form for bio-devices and regenerative medicine. One of the promising materials is polyhydroxybutyrate produced by bacteria e.g. Cupriavidus necator H16 (used in this work) which when oriented and crystalized in defined orientation becomes piezoelectric. We have demonstrated active orientation of Cupriavidus necator H16 via surface acoustic waves (SAWs) and spin-coating in microstructures. SAW or SSAW was propagated directly on the piezoelectric substrate by pair of interdigital transducers which were powered by radiofrequency generator. SAWs were employed to migrate bacteria to pressure nodes in microchannels. An open channel was fabricated directly on the piezoelectric substrate and as well on SI wafer which was bonded to base substrate to achieve higher-quality results, enabling additional analytical methods to be applied. The nodes on the prepared device were spaced 150 µm apart by the design of the IDTs directly on the piezoelectric substrate. This phenomenon allows bacteria to be oriented on a macroscopic scale. Another method employed was orientation in microstructures on Si wafers and PDMS molds using spin-coating. Microfabricated structures featured different shapes to determine which was the most suitable for orientation on microscopic scale even on the levels of single bacteria. Different spin-coater speeds were used to obtain the most promising results. Bacteria were analyzed by bright-field microscopy and atomic force microscopy after orientation to observe the outcomes.

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Selective Reductive Functionalization of C-N and C-O Bonds using MeOH as H2 and C1 source *PC34*

Transforming simple MeOH into powerful tool for complex synthesis is redefining sustainable chemistry- Selective activation of C-C, C-N, and C-O bonds remain a central challenge in molecular design. We presented a green strategy using methanol as both a hydrogen (H_2) and C_1 source via the Borrowing Hydrogen (BH) approach. Our tandem catalytic protocols merged transfer hydrogenation and methylation into a single step, reducing waste and improving efficiency. The system enabled diverse reductive transformations, including a three-component coupling for N-methylated amines, and in-situ aminomethylation using ammonium formate. We further demonstrated selective hydrogenation and methylation of N-heteroarenes and regiodivergent reductive ring-opening of epoxides, selectively accessing Markovnikov and anti-Markovnikov alcohols by simply tuning the reaction conditions. These results highlighted methanol's dual role as a green hydrogen donor and methylating agent, offering an efficient platform for C-C and C-N bond functionalization.

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Synthesis of Gellan Gum-Lignin Composites for a Potential Use in Biomedicine *PC35*

Lignin, a complex heteropolymer with a key structural role in plant cell walls, is traditionally regarded as a low-value byproduct of the pulp and paper industry. However, its inherent antioxidant and antimicrobial properties make it a promising candidate for biomedical applications. In this work, two types of lignin—sodium lignosulfonate and calcium lignosulfonate—were incorporated into gellan gum, a thermoresponsive polysaccharide capable of forming hydrogel networks and solid composites. This approach aims to valorize lignin through the development of biofunctional materials for in vitro biomedical evaluation. Rheological characterization via oscillatory analysis revealed that gellan gum-calcium lignosulfonate hydrogels exhibited the highest storage modulus, attributed to favorable ionic interactions between calcium cations and the polymer network. FTIR spectroscopy confirmed the presence of electrostatic interactions without the formation of new covalent bonds. Textural analysis demonstrated that the resulting solid composites possessed a highly organized porous architecture, with porosity exceeding 95% and a broad distribution of pore sizes ranging from the nano- to the microscale. Furthermore, increasing lignin content led to a marked decrease in swelling capacity (from 1500% to 550%), consistent with the hydrophobic nature of lignin. In vitro assays confirmed the biocompatibility of the gellan-lignin composites, supporting their potential as scaffolding materials in biomedical applications, where their mechanical, structural, and swelling properties can be advantageously tailored.

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POSTER SESSION D

Health, Toxicity, Environmental Challenges, Safety

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Mechanistic Trends in Nanoparticle-Induced Cellular Stress: A Multi-Marker, Multi-Compound In Vitro Analysis *PD1*

Understanding the mechanistic nanoparticle-induced toxicity is important for predictive risk assessment. The aim of the paper was to perform a trend-based analysis of four key cellular stress markers — mitochondrial membrane potential (MMP), cell membrane damage (CMD), nuclear size (NS), and nuclear intensity (NI) — in response to increasing doses of six widely used engineered nanomaterials: silver (Ag), zinc oxide (ZnO), copper (Cu), cerium dioxide (CeO_2), silicon dioxide (SiO_2), and titanium dioxide (TiO_2). The responses were evaluated on three mammalian cell lines HEPG2, HepaRG and RAW264.7. With increasing doses: - MMP was significantly affected by Cu and ZnO, indicating mitochondrial dysfunction - CMD showed an increasing trend of membrane stress almost for all compounds, displaying reliability as an early toxicity predictor - NI generally increased with exposure, except Cu where the trend was negative, potentially reflecting chromatin condensation. - NS displayed visible divergent trends: Cu induced nuclear shrinkage, while ZnO exposure was associated with nuclear enlargement, hinting at compound-specific nuclear effects. Notably, for cell lines, although the sensitivity of each cell line was different, the trends were consistent, indicating universal cellular pathways. By isolating trend directions and magnitudes across diverse cellular contexts and nanoparticle types, this study brings the value of a multivariate, marker-driven approach to nanoparticle hazard profiling. These mechanistic patterns highlight the potential of CMD, MMP, NI, and NS as early-response biomarkers, enabling more informative and rapid screening strategies in nanotoxicology. ACKNOWLEDGEMENTS: Tomas Bata University in Zlín is acknowledged for all support provided in kind. FUNDINGS: The Ministry of Education, Youth and Sports of the Czech Republic supported this study financially within the framework of DKRVO (project number RP/CPS/2024-28/007).

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Tiny Particles, Big Questions: Investigating (geno)toxic Potential of Ferrite-based Nanoparticles *PD2*

Recent developments have highlighted the exceptional physical, optical, magnetic, and electrical properties of spinel ferrite magnetic nanoparticles (MNPs), which have attracted significant interest for applications in magnetic fields, microwave absorption, and biomedicine. However, data on their potential health risks remain scarce. Our study assessed the (geno)toxic potential of three zinc- and/or manganese-doped MNPs: γFe2O3, Zn0.7Fe2.3O4, and Mn0.4Fe2.6O4 using a 3D cell model (spheroids) derived from the human hepatocellular carcinoma cell line (HepG2). Cytotoxicity was evaluated by measuring intracellular ATP levels, while genotoxicity was assessed by the comet assay and flow cytometry targeting γH2AX (for double-strand breaks) and pH3 (for mitotic cells), markers of clastogenic and aneugenic activity, respectively. In addition, generation of reactive oxygen species (ROS) was measured by DCFH-DA assay, whereas the influence on DNA damage and oxidative stress response genes was analysed by qPCR. Transmission electron microscopy (TEM) was used to investigate nanoparticle internalisation. Spheroids were exposed to up to 250 µg/mL MNPs for 2 to 96 hours. Zn0.7Fe2.3O4 and Mn0.4Fe2.6O4 exhibited higher cytotoxicity than γFe2O3 at 24 and 96 hours. While the comet assay indicated significant DNA damage after 96 hours, no increase in γH2AX or pH3 levels was detected. A dose- and time-dependent increase in ROS generation was observed only for γFe2O3. Gene expression remained largely unchanged, except for consistent MYC downregulation across all MNPs at 24 hours. TEM analysis confirmed MNPs penetration into the peripheral regions of the spheroids. Our findings contribute towards safer use of MNPs in biomedical and other applications. Funding: H2020-MSCA NESTOR (101007629), HE CutCancer (101079113), ARRS P1-0245 and J1-4395, and ARIS MR grant to IR.

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The Effect of ZnO Nanoparticle Morphology on Biomass and Phycocyanin Content in the Cyanobacterium Arthrospira Platensis *PD3*

Metallic nanoparticles, particularly zinc oxide nanoparticles (ZnONPs), are innovative tools for modulating the metabolic activity of photosynthetic microorganisms and are increasingly used in bionanotechnology. The morphology of nanoparticles significantly influences their interaction with biological systems and the resulting effects, making the study of their properties essential for the development of biotechnological applications. In this study, the effects of lab-synthesized ZnONPs with multipod morphology, were compared with those of commercially available spherical ZnONPs (Sigma-Aldrich) on the cyanobacterium Arthrospira platensis (spirulina). Nanoparticles were added to the spirulina culture at the beginning of the exponential growth phase (day 3), in two concentration ranges: 0.01-1.0 mg/L and 10-30 mg/L. To evaluate the cyanobacterial response to nanoparticle interaction, two parameters were assessed at the end of the cultivation cycle (day 7): accumulated biomass and C-phycocyanin content, a photosynthetic pigment with high biotechnological value. The results demonstrated that both ZnO multipods and spherical ZnONPs stimulated biomass production by 12-14% at higher concentrations. However, a marked difference in pigment response was observed. Spherical nanoparticles caused a substantial reduction in C-phycocyanin content by 57.5-87.9%, whereas multipod ZnONPs stimulated pigment synthesis at low concentrations and exerted a weaker inhibitory effect at high concentrations (50.3-59.7%). ZnONP morphology significantly modulates pigment biosynthesis and cytotoxicity in Arthrospira platensis, with multipod structures showing a more favorable interaction profile. These data support the morphological optimization of metal oxide nanoparticles for use in controlled cyanobacterial cultivation systems. ACKNOWLEDGEMENTS: This research was funded by National Agency for Research and Development, Republic of Moldova, Project 25.80012.7007.26 SE" ZnONP Morphology in Interaction with Photosynthetic Microorganisms - Effects and response Mechanisms".

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Evaluation of Biological Effects of Graphene Oxide and Polyethylene Glycol-modified Graphene oxide nanoparticles in Long Evans male rats *PD4*

Recently, nanosized graphene oxide (GO) has gained significant scientific interest for biomedical strategies. However, prior to their application GO nanomaterials should be proved as safe and biocompatible. Therefore, in this study we have examined the in vivo effects of pristine and polyethylene glycol-modified GO (GO-PEG) nanoparticles in male hooded rats, following intraperitoneal administration (4 mg/kg body weight, eight doses over four weeks). We found that GO-PEG reduced only hematocrit levels while the other blood parameters remained unaffected. Liver and kidney functions were evaluated by the serum levels of aspartate aminotransferase (AST) and alanine aminotransferase (ALT), and serum and urine creatinine and urea nitrogen. Both GO and GO-PEG significantly retarded gain and reduced 18-hour diuresis. The calculated organ coefficients of the treated animals revealed significant augmentation of the mean liver, kidney, and spleen weights, while reduced testes weights. Increased serum AST, ALT, and creatinine, and creatinine and urea nitrogen in the urine were measured in both treated groups indicating potential hepatorenal toxicity. The treated rats exhibited higher serum glucose levels. These results suggest that repeated exposure to GO and GO-PEG nanoparticles may adversely affect the homeostasis and therefore further studies on the mechanisms underlying these toxicological effects are needed. Acknowledgement: The support of the Centre of Competence "Sustainable Utilization of Bio-resources and Waste of

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Impaired Skeletal Muscle Functions in Rats Caused by Nanoscaled Unmodified and Polyethylene Glycol-functionalized Graphene Oxide Particles *PD5*

Despite the recent interest in the nanocarbon-based biomaterials, their safety for in vivo application remains insufficiently understood. Our study evaluated the effects of subchronic exposure to graphene oxide (GO) and GO nanoparticles, modified with polyethylene glycol (GO-PEG), on the motor activity of male Long Evans rats. After eight intraperitoneal injections at a dosage of 4 mg/kg body weight, a set of behavioral tests was performed, including an open field to assess the rats' general locomotor activity and a rotarod test to evaluate the motor coordination. Serum levels of creatine kinase (CK) were determined as the most sensitive indicator of muscle damage. Blood and urine levels of creatinine and urea were also measured to assess renal function. Lower locomotor activity was found in the GO and GO-PEG groups as shown by the decreased number of line crossings in the open field, while impaired coordination was not observed in the rotarod results. The treated rats showed a significant increase of serum CK and creatinine levels along with higher levels of creatinine and urea in their urine. These findings suggest possible muscle-related complications after GO and GO-PEG exposure with a potential to trigger failure in other organs, particularly kidneys, warranting further investigation into nanoparticles' long-term biosafety. Acknowledgement: The support of the Centre of Competence "Sustainable Utilization of Bio-resources and Waste of Medicinal and Aromatic Plants for Innovative Bioactive Products" (BIORESOURCES BG), project BG16RFPR002-1.014-0001, funded by the Program "Research, Innovation and Digitization for Smart Transformation" 2021-2027, co-funded by the EU, is greatly acknowledged.

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Comparative Effects of Cu, CuO, ZnO, And TiO2 Nanoparticles on the Antioxidant Activity of Arthrospira Platensis Extracts *PD6*

The antioxidant activity assessed using the ABTS assay can serve as an indirect marker of moderate oxidative stress, specific to adaptive physiological responses. This study aimed to evaluate the influence of copper nanoparticles (CuNPs), copper oxide nanoparticles (CuONPs), zinc oxide nanoparticles (ZnONPs), and titanium dioxide nanoparticles (TiO2NPs) on the antioxidant activity of the cyanobacterium Arthrospira platensis (spirulina), using the ABTS method. The cyanobacterium was cultivated in mineral medium supplemented with two concentration ranges of nanoparticle: low (0.01-0.5 mg/L) and high (1.0-20 mg/L). Antioxidant activity was measured in both aqueous and ethanolic extracts of the resulting biomass. The results revealed that aqueous extracts exhibited a significant increase in antioxidant activity (77.6-95.3% ABTS inhibition) at higher concentrations of CuNPs, CuONPs, and ZnONPs, following a clear concentration-dependent trend. In ethanolic extracts, the response was more variable: CuNPs induced a moderate increase in antioxidant activity, while

CuONPs caused a decrease. TiO2NPs showed relatively stable antioxidant values across all tested concentrations, with minimal variation between solvents. The study demonstrates that metal-based nanoparticles modulate the antioxidant mechanisms of Arthrospira platensis, triggering adaptive responses to oxidative stress, with effects depending on the nanoparticle type, dose, and type of extract. Extracts obtained from exposed biomass may be considered valuable functional products with biotechnological potential. This research was funded by the MINISTRY OF EDUCATION AND RESEARCH OF REPUBLIC OF MOLDOVA, Research Subprogram 020101 ”InBioS”.

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Calcined Mg-Al Layered Double Hydroxides Have Potential to Reduce Cadmium Toxicity in Zebrafish *PD7*

Layered double hydroxides (LDHs) are anionic nanoclays consisting of positively charged mixed-metal hydroxide layers intercalated with anions and water molecules. Because of their anionic exchange capacity and adsorption properties, LDHs have attracted attention for their potential in removing pollutants, including heavy metals, from the aquatic environment. Cadmium is one of the metals that can induce adverse biological effects even at low concentrations, particularly in the nervous system. Our study aimed to evaluate the potential of calcined zinc-aluminium LDH-nitrate (c-Zn Al LDH NO3) and calcined magnesium-aluminium LDH-nitrate (c-Mg Al LDH NO3) to prevent cadmium-induced toxicity in zebrafish (Danio rerio) early life stages. We measured mortality, malformations, and hatching rate after exposure of Danio rerio embryos and larvae to cadmium alone and in combination with 100 mg·l-1 c-Zn-Al LDH-NO3 or c-Mg Al LDH-NO3 following the OECD 236 guideline. The molecular changes at DNA level were assessed using a comet assay. Cadmium exposure at tested concentrations after 24-96 h resulted in significant developmental malformations, including pericardial edema, incomplete yolk sac absorption, and tail deformities. Furthermore, DNA damage was observed after 96 h of exposure to the LC50 concentration of cadmium. Notably, co-exposure with c-Mg-Al LDH-NO3 substantially reduced cadmium toxicity, whereas c-Zn-Al LDH-NO3 did not demonstrate a comparable protective effect. These findings suggest that c-Mg-Al LDH-NO3 holds promise as a nanomaterial for reducing cadmium toxicity in aquatic environment. Further testing is needed to unveil why the other nanomaterial was not so effective.

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Submicron TiO_2 Rutile Fibers Exhibit No Toxic Effects in Zebrafish *PD8*

The development, production, and environmental presence of inorganic fibers of various diameters is steadily increasing worldwide implying raising concerns about their potential ecological safety. Despite their growing use, there is still a lack of comprehensive data on their effects on freshwater organisms. Titanium dioxide is widely utilized across industry due to its excellent properties. In this study, newly synthesized TiO2 rutile fibers with an average diameter in the sub-micrometer range produced via centrifugal spinning were evaluated for their potential ecotoxicological effects in zebrafish (Danio rerio) early life stages, i.e. eggs and larvae, as a biological model. The fibers were tested across 0-100 mg·L-1 concentration range. We assessed developmental toxicity (i.e. malformations), biochemical responses (i.e. markers of oxidative stress and neurotoxicity), and molecular alterations at DNA level in zebrafish larvae following exposure. The results showed no observable developmental malformations or statistically significant biochemical or molecular changes in exposed zebrafish larvae. Based on our findings, the tested TiO2 rutile fibers can be considered as non-toxic to Danio rerio under the given experimental conditions. ACKNOWLEDGEMENT: This study follows prior work by Bacova et al. (Environ. Sci.: Nano 9, 2022) and was supported independently under the FCHT/SGS/2025/004 project.

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Biocompatibility Assessment of Photocatalytic Nanoparticle-Functionalized Polyacrylonitrile Nanofibers for Protective Textiles ***PD9***

Polyacrylonitrile (PAN) electrospun nanofibers are promising for use in protective clothing due to their non-toxic character, large surface area, high porosity, and chemical resistance. Incorporation of nanoparticles into polymeric nanofibers can provide them with additional functionalities, such as antimicrobial, chemical or radiation protection. In this study, PAN nanofibers were functionalized with various photocatalytic nanoparticles, namely with 15% TiO_2, Ce_2O_3, Er_2O_3, or WO_3, to produce multifunctional hybrid materials. FTIR, SEM, and TGA were used to verify morphology and presence of the nanoparticles within the fibers. Given their potential use in skin-contact textiles (e.g., masks, protective garments), we performed in vitro biocompatibility evaluation. Murine 3T3 embryonic fibroblasts were exposed to 24-hour leachates obtained from nanofibers incubated in cell culture medium, and to controls (PAN and cell culture medium). After 24- and 72-hour incubation, cell viability, morphology, and metabolic activity were assessed by live/dead fluorescence staining, light microscopy, and MTS assay, respectively. All samples maintained >90% cell viability compared to control cells, indicating absence of cytotoxicity. Dynamic light scattering analysis did not show release of nanoparticles from the fibers into distilled water nor phosphate buffer saline. Altogether, these results demonstrate that hybrid PAN nanofibers with incorporated TiO_2, Ce_2O_3, Er_2O_3, or WO_3 nanoparticles are biocompatible and stable, supporting their potential for use in protective materials designed for direct skin contact. ACKNOWLEDGEMENTS: The project was funded by the European Union European Defence Fund, EDF-2021-OPEN-R-2 call, under grant agreement 101110262, project Nano-SHIELD, and by MEYS of the Czech Republic (ExRegMed CZ.02.01.01/00/22_008/0004562, and RI NanoEnviCz LM2023066).

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The Impact of Polycaprolactone Fiber Diameter on Bacterial Colonization and Retention ***PD36***

Electrospun nanofibrous materials have found broad applications across diverse fields, including medicine, food industry, and biotechnology. This study addresses their microbiological safety, a critical factor given the propensity of microorganisms to colonize commonly used nanomaterials. Ensuring microbiological safety can be achieved by either functionalizing nanofibers with antimicrobial agents or by modifying their morphology. Previous studies have indicated that fiber diameter and surface density markedly influence interactions between nanomaterials and microbial cells. In this work, we investigated the effect of fiber diameter on biofilm formation and bacterial cell retention using two polycaprolactone (PCL) nanofibrous materials, PCL45 and PCL80. Four model bacterial strains—Escherichia coli (ATCC 25922 and 8739) and Staphylococcus aureus (ATCC 25923 and 6538) —were selected as representative opportunistic pathogens of relevance to biomedical, food, and biotechnological contexts. Compared to polystyrene (used as a control), the thinner-fibered PCL exhibited reduced biofilm formation. Fiber diameter did not significantly affect biofilm formation for three strains ($p > 0.05$), but did influence one E. coli strain ($p < 0.05$). Additionally, fiber morphology affected the structure and spatial distribution of biofilms. Bacterial retention assays further demonstrated that fiber diameter significantly influenced cell retention ($p < 0.01$), with PCL45 showing generally higher retention. Notably, PCL45 fully retained Staphylococcus cells, whereas E. coli was retained to a lesser extent. These findings support the hypothesis that fiber morphology modulates microbial interactions and underscore the necessity for further in-depth investigation. The research was supported by Czech Science Foundation Grant No. 23-05154S.

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Diffusion of Diclofenac in Reactive Humic Hydrogel ***PD46***

Transport and reactivity mapping of pharmaceuticals in soil and aquatic environments is vitally important for environmental safety. Pharmaceuticals can interact with organic matter which can result in their partial immobilization and suppression of their migration, bioavailability, and toxicity. Humic substances as important constituents of natural organic matter were used for the preparation of hydrogel medium for the monitoring of drug transport accompanied by the interactions between humic substances and pharmaceuticals. Humic hydrogel can be considered as a model system of soil with characteristic content of organic matter. Diclofenac was chosen for the investigation of their transport in hydrogels as a representative of widely used non-steroidal anti-inflammatory drugs. The method of instantaneous planar source was used for the transport and reactivity mapping of diclofenac in humic hydrogel. The method is based on a small defined amount of diffusing substance placed on the circular surface of cylinder-shaped hydrogel (placed in glass tube to achieve one-dimensional diffusion). The method can provide diffusion parameters as effective diffusion coefficients characterizing drug transport affected by interactions with active sites of humic substances and apparent equilibrium constant between immobilized and free movable drug particles. Diffusion study was complemented by adsorption and desorption experiments to compare traditional and our novel approaches. The mobility of diclofenac in humic hydrogel as well as its immobilization ability and bioavailability of pharmaceutical are discussed.

POSTER SESSION E

Advanced Methods of Preparation and Characterization of Nanomaterials

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Material Interaction with Dielectric Barrier Discharge in Dual-Frequency Mode at Atmospheric Pressure *PE1*

Dielectric barrier discharges (DBD) are an important source of plasma in industry and research. Commonly used high voltage (HV) power supply frequencies range from tens of Hz to hundreds of kHz in ambient air. Continuous DBD at MHz frequencies in ambient air leads to rapid overheating. The solution to overheating is the use of a dual-frequency (DF) HV generator with the possibility of combining low frequencies (tens of kHz) and high MHz frequencies. In the literature, DF mode was reported to power atmospheric pressure DBDs in, e.g. argon at 13.56 MHz. However, commercially available power supplies do not have sufficient voltage amplitude. Thus, we developed novel resonant MHz transformers suitable for DF applications. When the MHz component is pulsed with a sufficiently low duty cycle, the overheating is rapidly reduced. Thus, the discharge becomes suitable for plasma treatment of various materials. The project's aim is to investigate the DF-DBD behaviour for potential further application in novel material processing. In this work, we studied the interaction of DF-DBD with chosen model materials from the class of metal, glass, ceramic and polymer. The main goal was to investigate the working domain of DF-DBD, in terms of discharge gap, ignition voltage, voltage range for stable generation of DF-DBD and other limitations during interaction with different classes of materials. ACKNOWLEDGEMENTS: This research was supported by project No. GF25-20010L, funded by the Czech Science Foundation (GAČR) and by project LM2023039, funded by the Ministry of Education, Youth and Sports of the Czech Republic.

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Absolute Quantification of Nanoparticles by Evaporated Volume Analysis (EVA) *PE2*

Accurate quantification of nanoparticles is essential for material standardization, environmental monitoring, and toxicological assessment. Here, we present Evaporated Volume Analysis (EVA). EVA is a simple, absolute quantification method that counts all nanoparticles in a macroscopic droplet after solvent evaporation [1]. An optical microscope scans the dried droplet. Images are stitched and nanoparticles counted via a convolutional neural network. Theoretical detection limits were derived from Poisson statistics and the distribution of nearest-neighbor distances. EVA proved compatible with various nanoparticle types and sample matrices, including biological fluids and organic solvents. Compared to other single-particle counting methods, EVA offers unique advantages: simplicity, robustness, and a straightforward uncertainty model. Its accuracy stems from nanoparticle counting, not from calibration curves or material-specific parameters. With microscope automation and a convolutional neural network, EVA holds promise as a scalable and generalizable approach for nanoparticle quantification. REFERENCE: [1] Hlaváček et al., Anal. Chem. 2025, 97, 2588-2592. ACKNOWLEDGMENT: This work was supported by the Czech Science Foundation (grant no. 24-11183S) and by the institutional support for long-term conceptual development of research organizations (RVO: 68081715), provided by the Institute of Analytical Chemistry of the Czech Academy of Sciences.

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Ordered GaN and InGaN Nanostructures Fabricated Using Nanosphere Lithography Technique *PE3*

Lithography is an important step in the fabrication of ordered nanostructures. In order to process a large area, the selected fabrication method must have a high throughput and be low-cost. This can be achieved by employing nanosphere lithography (NSL). The basic principle of NSL is to deposit a single layer of spheres that serve as a mask through which the final nanostructure is etched. This work aims to demonstrate that NSL is a viable technique for fabricating GaN and InGaN triangular nanostructures, as well as nanowires. The whole fabrication process consists of depositing polystyrene spheres, depositing metal to cover the entire sample, and lifting off the spheres to expose the material beneath. In the final step, a $SiCl_4$/Ar plasma was used to finalise the triangular nanostructure, which can then be etched in an etchant to produce nanowires. For each step, it is necessary to find the optimal parameters to achieve reliable reproducibility. The entire fabrication process will be characterised using an electron microscope, cathodoluminescence spectroscopy and EDX. The resulting nanostructures should have a large surface area, which would be advantageous for applications in photocatalytic water splitting and various other applications, depending on the selected material.

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Analysis of Porous Au and Ag Black Metals Using Rutherford Backscattering for Different Angles of Ion Incidence *PE4*

Thin films of black metals prepared by magnetron sputtering in the presence of an inert gas atmosphere are formed with extreme porosity [1], which is a dominant parameter used in various applications, including solar energy harvesting, catalysis, gas sensing, and microelectronics [2, 3]. A challenging task for diagnostics of black metals is the determination and analysis of their porosity [4]. In this work, thin layers of porous nanostructures of Au and Ag were synthesized and subsequently annealed in vacuum at temperatures of 250 °C and 500 °C. Their porosity was analyzed by the Rutherford backscattering (RBS) method, which was used for different angles of incidence of ions (alpha particles with energy of 2 MeV). For each measured spectrum, a simulation was performed to determine the porosity level in a given direction. The analysis provided information on profiling of porosity of thin black Au and Ag films in different directions and depths, which is otherwise difficult to determine by other methods. REFERENCES: [1] P. Hruška, J. More-Chevalier, M. Novotný, J. Čížek, O. Melikhova, L. Fekete, M. Poupon, J. Bulíř, L. Volfová, M. Butterling, M.O. Liedke, A. Wagner, P. Fitl, Journal of Alloys and Compounds 872 (2021) 159744; [2] R. Zhang, H. Olin, Porous Gold Films—A Short Review on Recent Progress, Materials (Basel) 7 (2014) 3834; [3] E. Kurowska-Tabor, K. Gawlak, K. Gawlak, K.E. Hnida-Gut, tarzyna E. Hnida-Gut, G.D. Sulka, Synthesis of porous thin silver films and their application for hydrogen peroxide sensing, Electrochimica Acta 213 (2016) 811; [4] M.R. Baklanov, K.P. Mogilnikov, A.S. Vishnevskiy, Challenges in porosity characterization of thin films: Cross-evaluation of different techniques, J. Vac. Sci. Technol. A41 (2023) 050802.

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Monolithic Interferometric Modules for Multi-Axis Coordinate Positioning with Sub-Nanometre Precision *PE5*

We present the development and experimental validation of a compact, monolithic laser interferometric assembly for ultra-precise two- and three-axis displacement measurement, tailored for integration into modern nanopositioning and nanometrology systems. Designed as an OEM-ready solution, the system targets applications in semiconductor manufacturing, precision coordinate metrology, and ultra-high vacuum (UHV) environments. The assembly features a robust L-shaped monolithic base integrating multiple interferometric channels operated by a single laser source, delivering sub-nanometer periodic error performance in X-Y motion platforms. Its pre-aligned and thermally stable architecture minimizes geometric drift and simplifies system integration, supporting long-term stability and high metrological reliability.

Verification based on quadrature phase analysis and comprehensive error metrics confirms sub-nanometer resolution and repeatability, positioning the system as a scalable solution for next-generation nanotechnological instrumentation and motion control. ACKNOWLEDGEMENTS: Authors acknowledge support from the Technology Agency of the Czech Republic (project TN02000020) and Czech Academy of Sciences (RVO:68081731).

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MXene Nanoflakes Decorated with Single-Atom and nanoparticle sites via Microwave Solvothermal Synthesis for Hydrogen Evolution ***PE6***

Two-dimensional transition metal carbides (MXenes) are among the most widely studied materials today, with applications spanning critical fields such as electrocatalysis, energy storage, photochemical processes, and biomedical sensing. Their high electrical conductivity, water dispersibility, and versatile surface functionalization capabilities make them a universal platform for applied 2D nanomaterials. Moreover, their ability to host additional catalytic sites enables the tuning of catalytic activity for specific chemical processes. However, achieving optimal performance requires a simple, rapid, and reliable method for decorating MXene nanoflakes with catalytic sites. In this work, a microwave-assisted solvothermal method was employed to decorate Ti_3C_2, Nb_2C, and V_2C MXene nanoflakes with single-atom catalytic sites of noble metals (Pt, Rh, Pd) to enhance their electrocatalytic performance in the hydrogen evolution reaction (HER). The modified MXene samples were characterized using XRD, HR-TEM, EDS, XPS, and Raman spectroscopy. Results showed that the treatment preserves the structural integrity of the nanoflakes while enabling the formation of either atomically dispersed metal sites or anchored nanoparticles, depending on the specific MXene and metal used. The modified MXene nanoflakes demonstrated significantly enhanced HER catalytic activity compared to pristine MXenes. Turnover frequencies of the catalytic sites were benchmarked against the values of platinum surface atoms. The proposed structures and catalytic efficiency of the single-atom sites were investigated using density functional theory calculations.

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

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Hydroxylation of Nanodiamonds via Fenton Reaction: Comparative Study of Hydrogenated vs. Oxidized Surfaces ***PE7***

Homogeneous coverage of nanodiamond (ND) surfaces with hydroxyl groups is important for ensuring consistent physicochemical properties and enabling further chemical functionalization. Among various surface modification strategies, the Fenton reaction stands out as an efficient method for introducing -OH groups through in situ generation of hydroxyl radicals from hydrogen peroxide and iron salts. However, insufficient attention has been paid to the influence of the initial surface chemistry of ND on hydroxylation. In this study, we performed a comparative investigation of four types of nanodiamonds: high-pressure high-temperature (HPHT) and detonation nanodiamonds (DND), each with either oxidized or hydrogenated surface termination. The aim was to determine whether the initial ND surface chemistry is significant and which initial chemical composition of the surface leads to the most effective and homogeneous hydroxylation under standard Fenton reaction conditions. Complete chemical analysis of the surface and the degree and uniformity of surface hydroxylation were evaluated using zeta potential and dynamic light scattering, infrared and X-ray photoelectron spectroscopy, supplemented by thermal analysis with temperature-programmed desorption. The obtained complex data revealed that initially hydrogenated nanodiamonds—both HPHT-H and DND-H—achieved the highest density and homogeneity of hydroxyl groups after Fenton treatment, whereas oxidized counterparts exhibited lower hydroxylation efficiency and more heterogeneous surface chemistry. Based on these results, hydrogenated ND surface can be recommended as the optimal starting point for achieving uniform and efficient hydroxylation of nanodiamonds via the Fenton reaction.

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Direct Amino-Termination of Nanodiamonds and Investigation of Their Optical Properties upon Annealing *PE8*

Point defects in crystals may constitute the elemenary unit of quantum information, the quantum bits. Among these, the negatively charged nitrogen-vacancy (NV^-) center in diamond has attracted considerable attention due to its stability at room temperature for quantum biosensing. Nanodiamonds are commonly synthesized by high-pressure, high-temperature (HPHT) methods. During post-synthesis cleaning, strong oxidizing acids (e.g., HNO_3, H_2SO_4, $HClO_4$) are employed, introducing various surface functional groups such as carboxyls. These surface groups can influence the charge state stability and operation of NV^- and offer possibilities for further chemical modification. One such modification is Hofmann degradation, a well-known organic reaction that enables the direct formation of amino groups from carboxyl functionalities via decarbonylation. This process yields primarily primary amine terminations, which can facilitate the formation of C−N−C bonds, thereby favorably affecting NV^- center stabilization. Carboxyl- and amino-functionalized nanodiamonds were annealed at 600 °C, 750 °C, and 850 °C for 10 minutes. The NV^-/NV^0 ratio in the fluorescence spectrum was monitored. Significant annealing-dependent variations in this ratio were observed. These differences are attributed to surface chemical transformations as confirmed by infrared (IR) spectroscopy and X-ray photoelectron spectroscopy (XPS). ACKNOWLEDGEMENTS: The work was supported by the Quantum Information National Laboratory sponsored by National Research, Development and Innovation Fund (NKFIH) Grant No. 2022-2.1.1-NL-2022-00004. The research reported in this paper and carried out at Wigner Research Centre for Physics is supported by the infrastructure of the Hungarian Academy of Sciences.

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Strategies for Ionic Liquids Immobilization on Cellulose Toward Sustainable Functional Materials *PE9*

Functionalizing cellulose materials and nanomaterials with ionic liquids (ILs) has emerged as a promising strategy for developing advanced functional materials with unique and tunable properties. ILs can be chemically bonded to the cellulose chain and the covalent attachment results in a material known as supported ionic liquids. They combine the advantageous characteristics of both components: the structural versatility, renewability, and biodegradability of cellulose with the customizable physicochemical properties of ILs. In this work, we performed two approaches for cellulose functionalization with ILs The direct functionalization involved the reaction of cellulose with glycidyltrimethylammonium chloride under alkaline conditions, which led to the surface modification with quaternary ammonium groups. Key parameters influencing the efficiency of this process included the concentration of reactants and the reaction temperature [1]. The indirect functionalization followed a three-step protocol designed to introduce ammonium groups with varying alkyl chain lengths, which enabled greater control over the structural diversity of the functional groups introduce [2]. The obtained materials were subjected to physicochemical characterisation using the following methods: SEM; FTIR; TGA; DSC; low-temperature nitrogen adsorption/desorption and NMR. The materials obtained through two different functionalisation processes differ in terms of structure and other parameters, due to the varying content of ammonium compounds and the varying degree of development of these compounds. ACKNOWLEDGEMENTS: This work was financed by the National Science Centre project SONATA 18, grant agreement number UMO-2022/47/D/ST8/02389. REFERENCES: [1] MORAL, A., et.al. Fibers and Polymers. 2016, 17, 857-861; [2] WANG, X., et.al. ACS Applied Polymers Materials, 2024, 6, 12992-13001.

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AC Spinning Electrode for Continuous Collectorless Production of Linear Nanofiber Sliver *PE10*

Polymer nanofibers are unique materials with a high specific surface area, porous structure, and the possibility of precise morphology control. These properties make them promising materials for medical applications, particularly in tissue engineering, as well as in technical fields including filtration, sensor technology, and composite reinforcement. Currently, nanofibers are mainly used in the form of flat membranes produced by DC electrospinning. This work focuses on the production of nanofibers using AC electrospinning technology with high productivity and specific morphology. This is achieved, primarily, by replacing a physical and electrically active counter-electrode with a virtual collector. The possibility of using a virtual collector to form nanofiber structures without frictional forces opens the way to the production of advanced nanofiber structures, including low-volume cohesive linear formations. Previous technologies for producing nanofiber yarns used a supporting core around which the nanofibers were wrapped. In the case of nanofibrous yarn without the supporting core, the method required contact of nanofibers with a mechanical collector during yarn formation, resulting in a higher volume of nanofibers needed to maintain the minimum strength necessary for removal from the collector. As a result, the minimum achievable fineness is limited and the material is excessively compacted in order to be able to transmit the necessary forces. The presented work describes a method that enables the continuous production of linear nanofiber sliver directly in the virtual collector area of AC electrospinning technology, and without mechanical contact with any physical elements. The resulting unique structure is cohesive, with minimal twisting and no excessive compaction. The described continuous technology has sufficient production speed for practical use, and the materials produced have application potential, particularly in medicine, where they can support cell cultivation and proliferation.

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Mechanical Properties of Copper Containing Nanocomposite Carbon-based Thin Films *PE11*

Due to their unique combination of properties and the ability to be modified not only through deposition parameters but also by intentional doping, carbon-based thin films prepared by PECVD represent a highly versatile class of materials with broad industrial applicability. Given the significant influence of both doping and deposition conditions on the resulting microstructure and performance, a systematic investigation of the mechanical properties of thin carbon films using complementary characterization techniques is essential. Mechanical properties such as hardness, elastic modulus, adhesion, and wear resistance are strongly affected by chemical composition and microstructural modifications induced by dopants. The present work is focused on the study of copper-doped nanocomposite carbon-based thin films prepared by plasma-enhanced chemical vapor deposition (PECVD). A combination of advanced nanoindentation techniques (quasi-static, quasi-static with partial unloading, rapid mechanical mapping - XPM, nanoDMA, etc.) and scratch resistance testing is employed to evaluate the mechanical response of the films. The experimental results are analyzed in order to establish correlations between the chemical composition of the coatings, determined by X-ray photoelectron spectroscopy (XPS) and energy-dispersive X-ray spectroscopy (EDX), and their mechanical properties. This approach provides deeper insight into the structure-property relationships of copper-doped carbon thin films and contributes to the development of optimized coatings for targeted industrial and biomedical applications. Acknowledgement: This research has been supported by the project GA23-06263S, funded by the Czech Science Foundation, LM2023039, funded by MEYS and TN01000038, funded by , funded by the Technology Agency of the Czech Republic.

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Unveiling the Consequences of Complete Substitution of Sn for Ni in $LaNi_5$: A DFT Perspective ***PE12***

The intermetallic compound $LaNi_5$ is a promising material for hydrogen storage. The ternary phase diagram La-Ni-Sn contains phases in which Ni atoms are substituted by Sn atoms resulting in several Sn/Ni different ratios. In order to describe the La(Ni,Sn)5 system by phenomenological CALPHAD modelling, the energy of the completely substituted LaSn5 is needed. As this compound does not exist under ambient conditions, it is difficult to examine experimentally. Therefore, its properties were computed by quantum-mechanical calculations. Density functional theory (DFT) was employed to determine the structural characteristics of LaSn5, along with its electronic structure, energetics and thermodynamic stability as well as its mechanical stability. Our DFT calculations revealed a dramatic volume expansion upon this extreme case of substitution of all Ni atoms by Sn atoms, but the hexagonal structure remains stable without any significant distortions. The electronic calculations also revealed that the electronic density of states has a minimum at the Fermi level, which is in line with the lattice stability.

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 Komensky Operational Program financed by the European Union and from the state budget of the Czech Republic. DH acknowledges the financial support by the Austrian Federal Ministry for Labour and Economy and the Christian Doppler Research Association. 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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Characterization of Ti_3AlC_2 Synthesized by Using a Cost-Effective Approach ***PE13***

Ternary carbide materials have been proposed for novel technological applications due to the combination of their specific properties as metals and ceramic materials. Among this vast family of compounds, Ti3AlC2 got particular attention because it can be converted through an etching process into the famous MXene Ti3C2, a laminar material with attractive properties for different fields of research and application. In our previous work, we showed the optimization of the synthesis of Ti3AlC2 (temperature gradient, soaking time and temperature, and gas flow) in a highly controlled furnace in an Ar atmosphere. In this work, we present the morphological characterization of the Ti3AlC2 MAX phase produced by an innovative industry-oriented approach. For this purpose, the previously activated Ti/Al/C precursor mixture was subjected to a thermal regime at several soaking temperatures (1150, 1200, 1250, 1300, 1350, 1400 °C), in a Molten salt environment. The methodology allowed us to achieve products with more than 90% by weight of purity, according to the phase composition analysis based on the X-ray diffraction patterns. The scanning electron microscopy confirms the presence of Ti, Al, and C as the majority elements and its analysis allowed us to identify possible secondary products. In addition, the skeletal density of the samples was evaluated by He pycnometry, resulting in all cases in close values to the theoretical one, indicating a successful synthesis process. The slight deviation was attributed to the presence of non-desired phases.

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Metrology/Progress in STM/AFM Applications

KLAPETEK Petr ***Czech Metrology Institute, Brno, Czech Republic, EU***

Machine Learning Tools for SPM Data Processing in Gwyddion ***PE14***

Machine learning tools are becoming increasingly popular when analyzing scientific data, as they can help understanding relations hidden in it. In Scanning Probe Microscopy, they can be particularly useful when treating large datasets coming from novel scanning regimes (e.g. force volume) and from complex samples (e.g. biological). Gwyddion is an open source software for Scanning Probe Microscopy data processing that features many direct and statistical data evaluation tools. In this contribution we review the tools that were added to Gwyddion for machine learning based data classification, clustering and image artifacts estimation, discuss their potential validation routes and compare them to conventional data processing algorithms.

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Development and Characterisation of Two-Axis Interferometric Measurement Systems with Sub-Nanometer Precision *PE15*

This work presents the development and characterisation of compact interferometric systems designed for monitoring the motion of X-Y positioning stages. The systems use a pair of mutually perpendicular interferometers integrated into a monolithic L-shaped base to track movement in both axes. An optional third interferometer can be added along one of the axes to detect the stage's non-coaxial motion. The compact, monolithic design is optimised for precision coordinate systems and vacuum environment applications. To evaluate system performance, we introduced a calibration method based on analysing quadrature signals recorded during controlled motion of a reference positioning stage. The developed interferometric systems achieve sub-nanometer measurement accuracy and repeatability in vacuum conditions. Their design minimises thermal drift and allows straightforward integration into various high-precision applications.

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Dual Probe SThM Measurements of Thermal Diffusivity *PE16*

Thermophysical properties at microscale and nanoscale are important when developing heat management materials and structures, needed in the microelectronics industry and related fields. One of the potential parameters to be measured is thermal diffusivity. In this contribution we present a novel dual probe Scanning Thermal Microscopy setup and methodology for addressing measurements of thermal diffusivity using two Scanning Thermal Microscope probes placed at mutual distance between 1 to 60 µm, measuring and analyzing propagation of heat pulses from one probe to another one through the studied sample. Even if the experimental setup and methodology has to be relatively complex to get rid of all the potential error sources, it will be shown that the resulting signals show the expected dependencies and thermal diffusivity can be evaluated from them with a help of a numerical modeling.

Co-authors: ***VALTR Miroslav, HORTVÍK Václav, KLAPETEK Petr***

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Young Modulus Measurement of Cells by AFM *PE17*

One of the essential markers of living cells' condition is the rigidity of their outer membrane. Therefore, cell microrheology is a promising source of information about cells and their well-being. One of the powerful techniques in cell microrheology is atomic force microscopy (AFM). Thanks to force-distance curves measured by AFM, we can obtain information about the rigidity of the cell, respectively, about its Young's modulus. Unfortunately, we can not measure Young's modulus directly, but we can determine it by fitting the force-distance curve with an appropriate model whose choice depends on the sample's shape and the AFM tip's shape. For curved surfaces and rounded AFM cantilever tips, it is relevant to use the Hertz model, and for flat surfaces and a cone cantilever tip, it is suitable to use the Sneddon model. Therefore, we used these two models to analyse the behaviour of the cell membrane after the phagocytosis of nanoparticles. The problem of choosing between the two models is solved by comparing the residuals and errors of fitting both models to the data.

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SThM Thermal Conductivity Uncertainties on Rough Surfaces *PE18*

Scanning Thermal Microscopy (SThM) is a method for determination of thermal conductivity of bulk materials, thin films or nanoparticles. In order to switch from qualitative mapping to quantitative measurement, a calibration procedure based on measurement of a series of samples with known conductivities and fitting the data with some model of the microscope response can be used to evaluate data on an unknown sample. The calibration procedure assumes, however, that all samples are flat showing minimal roughness. In this contribution we show that even battery electrode materials exhibiting large roughness can be analyzed. We used Scanning Electron Microscopy to image nickel manganese cobalt oxide cathode material and to assess its local chemical composition. Based on this information, SThM was used to measure local thermal conductivity on top flat areas of measured particles. We found that thermal conductivities were in the range from 0.237 to 0.436 W/(m*K).

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High-stability Silicon Calibration Patterns Enabling Accurate SPM Measurements *PE19*

Scanning Probe Microscopy (SPM) is a key technique for nanoscale surface characterization, offering both imaging and quantitative analysis. Its applications in materials science, semiconductor technology, and nanobiology demand reliable measurements, which depend on rigorous calibration. The objective of the project was to fabricate nanoscale patterns that can serve as calibration standards in SPM techniques. To develop calibration standards, silicon micromachining was employed. Structures produced with this method exhibit high dimensional stability over time and can be easily cleaned if contaminated. This approach focuses on defining a highly repeatable and precise pattern across a large area, which enhances the utility of these standards in practical applications. Two groups of calibration standards were designed, distinguished by their critical dimensions and spacing. The first group, with a critical dimension of 0.25 µm (HP), was fabricated using electron-beam lithography. The second group, with a 1 µm (HP) dimension, was produced through projection lithography. In both cases, the periodic patterns extend across areas of 3 mm × 3 mm. This large-scale periodicity also allows use in scanning tunnelling microscopy (STM), where navigation and localization are particularly challenging. Each structure includes an identifying label in addition to the central periodic pattern. The calibration standards were fabricated on 6-inch silicon wafers with (100) crystallographic orientation and n-type conductivity. Subsequent substrate preparation steps varied depending on the design and lithographic technique applied. The project is co-financed from the state budget by the Minister of Education and Science under the Polish Metrology II program (registration number PM-II/SP/0044/2024/02).

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SZARY Karol — *Jan Kochanowski University, Kielce, Poland, EU*

Nanostructured Silicon Patterns as Candidates for SPM Calibration Standards: Analysis and Development of Measurement Procedures *PE20*

We present a metrological analysis of newly fabricated silicon nanostructured standards, which, together with the developed procedures, are intended to be routine calibration standards for scanning probe microscopy (SPM). The patterns were produced using electron-beam lithography and projection photolithography techniques at Łukasiewicz-Institute of Microelectronics and Photonics (IMIF) in Piaseczno. Measurements of the patterns were performed at Jan Kochanowski University (UJK) in Kielce, using a SPECS Aarhus 150 scanning tunneling microscope, and Marie Curie-Skłodowska University (UMCS) in Lublin, using Bruker/Veeco NanoScope V atomic force microscope. The instruments were calibrated with Au(111) crystal (MaTecK) and certified commercial standards (NT-MDT TGZ1/TGQ1 amd Ted Pella TGZ-

20/TG3D-3000/20), respectively. The measurement process of the produced patterns included the following key steps: sample preparation, instrument stabilization, selection of measurement parameters and image analysis. The primary goal of the measurements was to verify key metrological parameters of the patterns: the size of the nanostructures and their periodicity. Analysis of the acquired images took into account factors such as scanner errors, tip shape, and the use of various software filters. Preliminary results indicate that the patterns meet the requirements of calibration standards used in SPM techniques. Final results, along with statistical analysis, will be published after the measurements are completed. Currently, interlaboratory comparisons are underway between UJK, UMCS, and the Central Office of Measures, where measurements of the produced patterns will be performed using the SIOS nanopositioning and nanomeasuring machine (NMM-1). These will allow for quantification of the accuracy of the produced patterns, demonstration of their consistency with measurements of other standards, and assessment of the long-term stability of the height and horizontal scale calibration in SPM techniques. The project is co-financed from the state budget by the Minister of Education and Science under the Polish Metrology II program (registration number PM-II/SP/0044/2024/02).

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CHARVÁTOVÁ CAMPBELL Anna *Czech Metrology Institute, Brno, Czech Republic, EU*

Novel Approaches to the Determination of the Tip Area Function in Nanoindentation and AFM Indentation *PE21*

Nanoindentation is widely used to determine the mechanical properties of materials at the nanoscale, with the accuracy of the method strongly depending on the correct determination of the indenter area function. Typically in nanoindentation, reference samples or atomic force microscopy (AFM) are employed to establish this function. Particular challenges arise from the fitting of the area function and from the question of how to reliably perform AFM characterization of AFM tips themselves. We discuss these issues and outline potential strategies to improve the robustness and transferability of indentation data.

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KYLIÁN Ondřej *Charles University, Prague, Czech Republic, EU*

SERS-active Non-plasmonic Substrates Based on Conducting Polymers *PE22*

Surface-enhanced Raman scattering (SERS) spectroscopy is a highly sensitive, important non-contact analytical technique valued for its ability to provide unique molecular fingerprints. While traditional SERS platforms rely on plasmonic metal nanostructures, there is a growing interest in developing alternative, non-plasmonic SERS-active materials. Among them, conducting polymers, such as quaterthiophenes or thiophenes, are highly promising candidates due to their cost-effectiveness, flexibility, and easy of processability. This study explores the SERS performance of spin-coated and thermally cured poly(3,4-ethylenedioxythiophene) polystyrene sulfonate (PEDOT:PSS) films. We demonstrate that the SERS activity of these films is directly linked to their electrical conductivity. When optimized, the PEDOT:PSS platform can detect methylene blue, a model molecule, with high spectral reproducibility and a detection limit as low as 2×10-8 M. In addition, we demonstrate that placing a highly reflective silver film beneath the PEDOT:PSS layer further amplifies the SERS signal by a factor of five, providing a simple yet effective strategy for signal enhancement. This research thus highlights the potential of PEDOT:PSS as a viable and robust non-plasmonic SERS substrate, suggesting its suitability for broader application in analytical chemistry. ACKNOWLEDGEMENTS: The authors thank the Czech Science Foundation (grant No. 24-12197S) for financial support.

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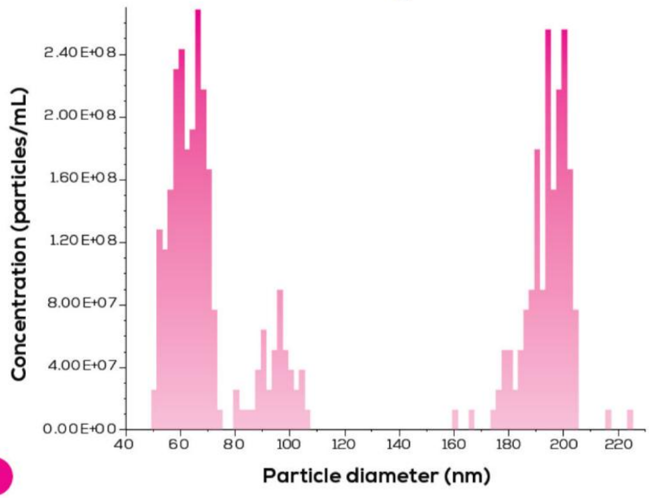

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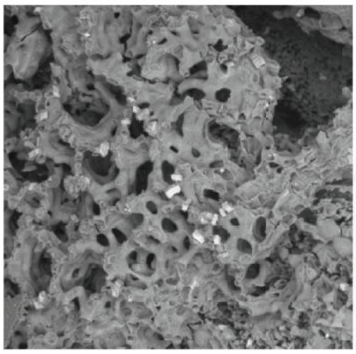

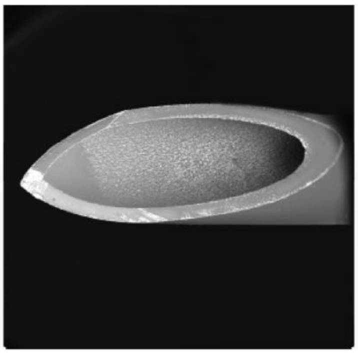

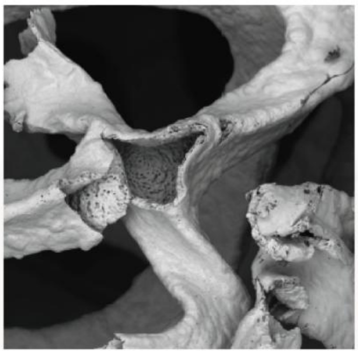

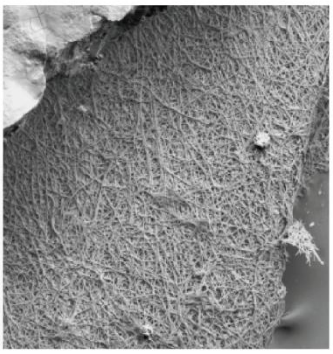

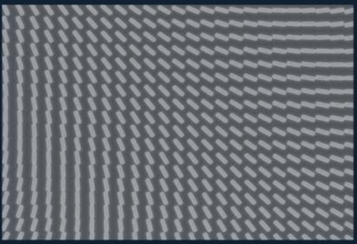

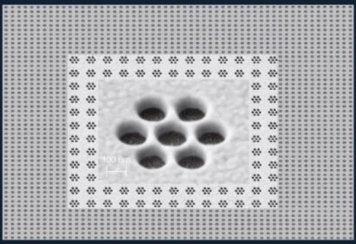

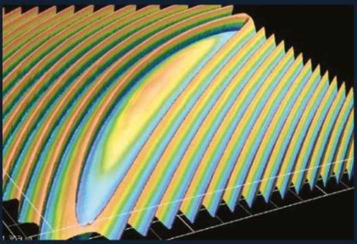

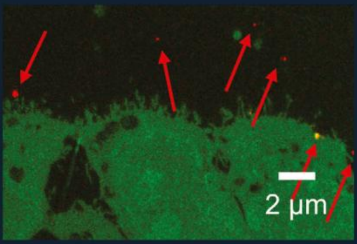
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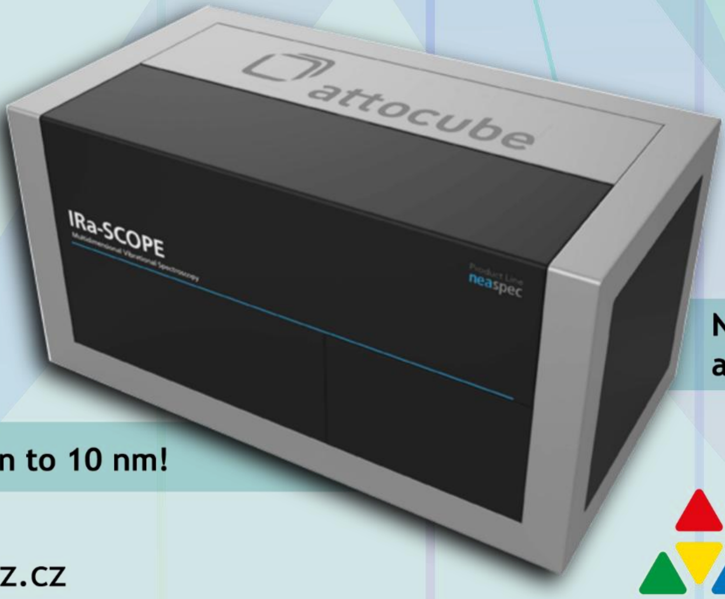

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