Book of Abstracts

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Vladimir Valentinovich Egorov	NRC Kurchatov Institute, Russian Federation
Kuan-Wei Lee	I-Shou University, Taiwan
Murat Pak	Imec, Belgium
Nilanthy Balakrishnan	Keele University, UK
Vitaly Gruzdev	The University of New Mexico, USA
Kangwoo Cho	Pohang University of Science and Technology, South Korea
Maria C. Iliuta	Laval University, Canada
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Maria C. Iliuta	Université Laval, Canada
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Huseyin Sar	IMEC, Belgium
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Klaudia Zielinkiewicz	West Pomeranian University of Technology in Szczecin, Poland
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PLENARY SPEAKER

Id-1002

Work Function and Spectro-Photo-Electrochemistry of ZnO Single Crystals and Thin Films

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Abstract: ZnO is the generic material, which triggered the success of semiconductor photo/electrochemistry in the mid of the 20th century. Optimizing the electrochemical applications requires information about the electronic structure near the conduction band minimum (CBM), which can be quantified, e.g., by the work function. However, analyzing the CBM structure is challenging and sometimes fundamentally impossible. Several examples of potentially problematic issues are: (i) Determination of flatband potentials and donor concentrations by Mott-Schottky analysis (particularly for nanotextured materials) [1]; (ii) Calculation of work functions and band edges by DFT (ignoring the effects of environment and/or imperfections in real crystals [2, 3]); (iii) Measurement of work functions and band edges by photoelectron spectroscopy (XPS/UPS, including NAP-techniques) and Kelvin probe [4, 5]; (iv) Impurities in single-crystals [6]; (v) Application of the Gärtner-Butler model for carrier dynamics disregarding the gradient of electrochemical potentials as the driving force for e^-/h^+ separation [7]). The work functions of two polar surfaces of ZnO (wurtzite), i.e., O-(000-1) and Zn-(0001) obtained by different techniques and in different environments are much less scattered compared to the fluctuations, reported for TiO_2 (anatase or rutile). The Zn-(0001) surface has a smaller work function for all the solid/vacuum and solid/gas interfaces, and also in the acetonitrile solution. Solely at the aqueous electrochemical interface, the difference is smaller or even opposite. The dissociative water adsorption on the O-(000-1) could be responsible for this irregular downshift [8]. Zinc oxide thin films exhibit high photoelectrochemical activity for water splitting under UV light, but are unstable against photocorrosion [9-11]. It can be suppressed by a protective layer of ALD-SnO_2. The potentials for photocurrent onset are near the flatband potentials in an aqueous electrolyte solution for both ZnO and SnO_2. This work was financially supported by the Czech Academy of Sciences through the AV21 program VP27 "Sustainable energy",

Keywords: Zinc oxide; Work function; Band alignment; Photoelectrochemistry.

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PLENARY SPEAKER

Id-1006

All Solid-State Supercapacitor with Natural Rubber-Based Solid Polymer Electrolyte and 2D Materials-Based Electrodes

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Abstract: Solid polymer electrolytes (SPEs) are pivotal in enhancing the energy density and safety of electrochemical devices. In recent years, natural polymers have garnered significant attention, driven by advances in green technologies aimed at a sustainable future. In this study, SPEs were synthesised using 49% methyl-grafted natural rubber (MG49-NR) and subsequently characterised using powder X-ray diffraction (p-XRD), Fourier transform infrared (FTIR) spectroscopy, and impedance spectroscopy to optimise their electrochemical performance [1]. The SPE exhibited an ionic conductivity of 7.52×10^{-4} S cm^{-1} at room temperature. This SPE was employed in the fabrication of electric double-layer capacitors (EDLCs), where it was sandwiched between two identical reduced graphene oxide (rGO) electrodes or molybdenum disulfide (MoS_2) electrodes. Electrochemical testing revealed a maximum single-electrode specific capacitance (C_{sc}) of 42.5 F g^{-1}, as determined by cyclic voltammetry (CV). The charge storage mechanism was confirmed to be non-faradaic in EDLC with rGO electrodes and faradic in EDLC with MoS_2-based electrodes, as evidenced by the shape of the cyclic voltammograms. Additionally, electrochemical impedance spectroscopy (EIS) indicated dominant capacitive behaviour at low frequencies. Long-term cycling performance over 10,000 charge-discharge cycles at a constant current density of 0.05 A g^{-1} showed an initial drop in specific discharge capacitance (C_{sd}), followed by stabilisation after approximately 5,000 cycles, demonstrating good durability and stability of the device. These findings highlight the potential of natural rubber-based SPEs in advancing the functionality of EDLCs, contributing to the development of sustainable energy storage technologies, particularly relevant for green energy applications.

Keywords: Reduced graphene oxide; Molybdenum disulfide; Natural rubber; Solid polymer electrolyte; Double-layer capacitor.

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PLENARY SPEAKER

Id-1041

Global Semiconductor Industry Trends and Developments: Insights from Taiwan

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Abstract: The semiconductor industry serves as the cornerstone of modern technology, driving advancements in AI, communications, and energy systems. This talk provides a foundational overview of semiconductor materials and their diverse roles in logic, memory, and power electronics. Utilizing Taiwan as a primary case study, it examines the region's pivotal role in the global ecosystem, attributed to its concentrated manufacturing capacity, mature supply-chain clusters, and strong integration between academia, industry, and government. Central to this discussion is the Taiwan Semiconductor Manufacturing Company (TSMC), whose pure-play foundry model and advanced process integration have enabled global design innovation while establishing a competitive advantage that is difficult to replicate. The analysis concludes by addressing future challenges and the ongoing importance of multidisciplinary research and global collaboration in maintaining supply-chain resilience.

Keywords: Semiconductor; Industry; Taiwan; TSMC.

PLENARY SPEAKER

Id-1046

Topologically Protected Quantum Teleportation via Majorana Zero Modes: A Measurement-Only Approach for Scalability and Decoherence Immunity

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Abstract: We present a topologically protected teleportation protocol based on projective parity measurements between spatially separated Majorana zero modes (MZMs), eliminating the need for dynamic braiding. Unlike conventional teleportation schemes, our method preserves logical information through nonlocal encoding and suppresses decoherence exponentially with Majorana separation. We provide a rigorous mathematical framework, including six theorems and a lemma, establishing fidelity bounds, entropy invariance under ideal quantum non-demolition (QND) parity measurement, and compliance with the no-cloning theorem. We show that all measurement-conditioned corrections lie within the Clifford group, enabling efficient fault-tolerant implementation within the protected subspace. Finally, we outline a scalable architecture for multi-qubit teleportation and connect the framework to recent experimental progress in quantum-dot-based Kitaev chains and superconducting nanowire platforms. All operations discussed are Clifford-only; achieving universality requires non-Clifford resources and lies outside our scope.

Keywords: Topological quantum computation; Majorana zero modes; Quantum teleportation.

PLENARY SPEAKER

Id-1048

Few-Cycle Laser-Nanostructure Interactions: From Ultrafast Nanophotonics to Petahertz Nanoelectronics

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Abstract: Rapid progress of artificial intelligence, data centers, big-data processing, and telecommunications has produced a strong demand for fast electronic devices. However, ultimate speeds and frequencies of the traditional semiconductor microcircuits are limited by the fundamental processes of charge transfer in semiconductors [1]. Recently reported results on opto-electronics of nanostructures driven by few-cycle laser pulses [1-9] suggest novel approaches to overcome the limitations and develop petahertz (PHz) nanoelectronic devices that are orders of magnitude faster than the fastest semiconductor microchips. In this talk, we overview state-of-the-art in this rapidly evolving field of science. Starting from formulation of general principles of PHz electronics, we consider two major nanoelectronic systems - flat-strip metal-semiconductor-metal structures (type 1) [1-3] and metal nanotip antennas (type 2) [4-9]. The extremely short duration of driving laser pulses (typically, from 4 to 6 fs) and nanostructure dimensions favor non-collision (ballistic) dynamics of laser-generated free carriers. Scaling of electric signals delivered by the nanostructures with carrier-envelope phase (CEP - phase offset between peak of laser-pulse envelope and nearest positive peak of electric field) is traditionally considered as major direct evidence of the ballistic charge-carrier dynamics in the nanostructures [1-9]. However, generation of CEP-dependent signal is always coupled to generation of much stronger CEP-independent signal in the structures of type 1 [2-9]. Structures of type 2 suffer from reverse currents that substantially reduce total currents per pulse. We discuss the physical processes responsible for those effects and outline other major issues, e.g., lack of reliable testing methods to characterize ultrafast opto-electronic response of nanostructures [10], poor signal-to-noise ratio [1-9], thermal effects, and special features of electronic amplifiers integrated with the nanostructures [11]. Issues of recently proposed models of PHz diodes and memory cells [12] are also discussed. Finally, we outline the major perspectives, challenges, and future developments in the field of PHz nanoelectronics with significant emphasis on applications of half-cycle (monopolar) pulses and transfer of some achievements from the field of terahertz-pulse generation in nano-antennas [13]. We also compare the current research status of the field against earlier reviews and prospects [1, 5-9].

Keywords: Nanoelectronics; Nanophotonics; Petahertz electronics; Nanoantennas; Few-cycle laser pulses.

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PLENARY SPEAKER

Id-1049

Van der Waals Heterostructures

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Abstract: Layer-by-layer assembly of van der Waals (vdW) heterostructures underpins new discoveries in solid state physics, material science and chemistry. In this talk I will review the progress of the field in terms of both their technology and fundamental science. For the technology, I will introduce a novel polymer-free platform for heterostructure assembly using silicon nitride membranes and compare its performance with conventional heterostructure assembly using polymers. This approach enables production of heterostructures with interfaces free from interlayer contamination and correspondingly excellent optoelectronic behaviour. In addition, eliminating polymeric supports allows new possibilities for vdW heterostructure fabrication: assembly at temperatures up to 600°C, and in different environments including ultra-high vacuum and liquid submersion. In the second part, I will discuss control of the twist angle in van der Waals heterostructures, which gives rise to moiré superlattices that dramatically reshape electronic band structures, enabling flat bands, and a wide range of emergent quantum phenomena. I will discuss how precise control of twist angle leads to creation of bespoke stacking configurations and enables new type of ferroelectricity that switched via layer sliding. Unlike conventional ferroelectrics, where polarization arises from ionic displacements within a crystal lattice, sliding ferroelectric systems exploit the weak interlayer coupling and band hybridization in layered materials to create polar states that switch through nanoscale registry changes between adjacent sheets. I will discuss key experimental demonstrations in bilayer and few-layer van der Waals materials, including the observation of robust out-of-plane polarization, electrically controlled switching, and strong coupling between ferroelectricity and other emergent properties such as charge transport and optical properties. Particular attention will be given to how moiré reconstruction, lattice relaxation, and external fields provide additional control over polar textures and domain formation.

Keywords: 2D Materials; Graphene; Nanoelectronics; Optical properties; Quantum materials.

PLENARY SPEAKER

Id-….

Lithography in Today's Microchip Manufacturing From i-line to HNA EUV

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Abstract: Consistent with the estimations of Moore's Law, continued dimensional scaling in semiconductor manufacturing is pursued to enhance device performance and meet the increasing demands of faster compute and higher bandwidth memory systems. This scaling is enabled through advancements in lithographic patterning technologies, each optimized for specific resolution and process requirements. According to Rayleigh criterion, the achievable critical dimension (CD) is mainly governed by the exposure wavelength, numerical aperture, and process-dependent factors, with wavelength being a primary factor for resolving smaller feature sizes and tighter pitch geometries. To illustrate the progression of lithographic scaling, four state-of-the-art patterning regimes are considered: i-line lithography applied to redistribution layer (RDL) fabrication, achieving CDs on the order of 500 nm, KrF lithography utilized for back-end-of-line (BEOL) metal trench and via patterning at pitches of 180 nm and below, ArF immersion lithography enabling magnetic tunnel junction (MTJ) pillar scaling down to ~76 nm pitch, and finally extreme ultraviolet lithography, particularly with high numerical aperture (High-NA) scanner platforms, facilitating random logic via patterning at sub-30 nm pitch dimensions. These examples collectively demonstrate the critical role of wavelength reduction and optical system enhancement in extending lithographic resolution limits and sustaining semiconductor scaling trajectories. I would like to thank you imec advanced patterning department members who have provided guidance and materials for this study.

Keywords: Lithography, i-line, EUV, KrF, ArFi, immersion, scaling, Moore's law

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INVITED SPEAKER

Id-1010

High-Purity Biohydrogen Production by Intensified Steam Reforming of Biomass Derivatives Over Nanocomposite-Based Hybrid Materials

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Abstract: Energy and environmental issues are now at the forefront of concerns; the rapid increase in the use of fossil fuels to meet growing energy needs has led to major negative environmental impacts. In this context, hydrogen has attracted considerable interest as a carbon-free energy carrier with high energy density [1]. It also has numerous applications, such as chemical feedstock (e.g., ammonia, alcohols, dimethyl ether, and formic acid), as a reducing agent in metallurgy, and in fuel cell applications. Currently, the total demand for hydrogen is around 97-100 million tons (Mt) in 2024/2025, up from 94.3 Mt in 2021, according to the International Energy Agency (IEA). Hydrogen production relies predominantly on the steam reforming of fossil fuels. However, this approach is becoming less favorable, especially for environmental (significant CO_2 emissions) and sustainability (non-renewable nature of fossil fuel feedstock) considerations. In this context, the conversion of abundant, renewable biomass, as well as its processing derivatives, is a promising approach to biohydrogen production via steam reforming [2]. In particular, bio-oil, produced via biomass pyrolysis, is a cost-effective renewable feedstock [3-5]. Bio-oil possesses a significantly higher energy density than raw biomass, making it a more efficient energy carrier. Additionally, its liquid form facilitates easier storage and transportation, addressing key logistical challenges associated with biomass. Due to the complexity of bio-oil (a mixture of different oxygenates), the catalytic activity and long-term stability of catalytic materials used in the steam reforming of bio-oil (SRBO) can be significantly affected by catalyst deactivation, primarily due to coke deposition, which is governed by methane decomposition and the Boudouard reaction. In addition, the SRBO suffers from thermodynamic limitations, resulting in a low H_2 purity (~70%), which is insufficient in practical applications, in particular fuel cells. The intensified sorption-enhanced process, combining the catalyzed reforming reaction with the in-situ removal of CO_2 co-generated in the reaction environment using a dedicated hybrid catalyst-sorbent material, enables the production of a highly pure H_2 stream, thereby considerably heightening the attractiveness of this technology over the conventional steam reforming process [6]. Our presentation focuses on the intensified sorption-enhanced steam reforming of bio-oil (SESRBO) as an advanced route that combines SRBO, water-gas shift (WGS) reaction, and in-situ CO_2 capture in a single reactor, using nanocomposite-stabilized hybrid catalyst-sorbent materials. The bifunctional material developed using the nanocomposite synthesized by a hydrothermal approach was found to offer hydrogen purity of approximately 94% and very good stability, indicating a high

ability to reduce the rate of deactivation typically encountered in this process. The financial support from the Natural Sciences and Engineering Research Council of Canada (NSERC) is gratefully acknowledged.

Keywords: Hydrogen production; Bio-oil; Nanocomposite; Hybrid material; Intensified sorption-enhanced steam reforming.

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INVITED SPEAKER

Id-1012

Tuning Hydrogen Adsorption on Pt/C through CaO-Induced Electron Spin Redistribution: Experimental and DFT Mechanistic Study

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Abstract: Developing cost-effective and efficient electrocatalysts for the hydrogen evolution reaction (HER) is limited by the need for high loadings of scarce platinum to achieve desirable activity. In this work, we show that calcium oxide (CaO)—sourced either as analytical-grade material or from waste paper ash—can serve as a highly active HER support when modified with only 0.2 wt% commercial Pt/C. The resulting Pt/C–CaO composite features a huge performance enhancement, reducing the overpotential from 637.4 mV for pristine CaO to 99.7 mV, while the Tafel slope decreases from 391 to 127 mV dec^{-1}, accompanied by a markedly lower charge-transfer resistance. These improvements arise from a strong synergistic metal–support interaction (MSI) that enables defect-mediated electron transfer from CaO to Pt, stabilizes Pt nanoparticles, and enhances charge delocalization. Density functional theory (DFT) calculations further elucidate the mechanistic basis of this synergy: CaO induces a redistribution of unpaired electron density toward the C–Pt interface, leading to a nearly linear Pt–H–Pt configuration and pronounced spin delocalization. This interaction stabilizes the Pt sites and modifies hydrogen adsorption preferences. The computed Gibbs free energies confirm that CaO tunes the H* binding strength while maintaining exothermic H_2 formation. Moreover, the strong basic O^{2-} sites in CaO facilitate water dissociation during the Volmer step, offering an additional route for accelerating reaction kinetics. Overall, these results present a general strategy for designing low-Pt, high-performance HER electrocatalysts by exploiting oxide-driven spin-state engineering and metal–support interactions.

Keywords: Hydrogen evolution reaction; Electrocatalysis.

INVITED SPEAKER

Id-1013

Molybdenium Disulfide Based for Electrocatalysts – New Insights into Hydrogen Evolution

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Abstract: This work presents the development of MoS_2 two-dimensional nanostructures as advanced catalysts for photo-, electro-, and photoelectrochemical hydrogen production. The synthesis and comprehensive characterization demonstrate a controlled 2H→1T phase transition in MoS_2 and the formation of sulfur vacancies, which together enhance electrical conductivity, activate basal planes, and facilitate charge transfer. Operando and ex-situ analyses confirm the evolution of metallic domains and defect-rich regions responsible for the improved catalytic performance. Additionally, the results reveal the formation of nonstoichiometric Mo–S phases and degradation products, highlighting the need to balance activation with structural stability. Overall, the results identify MoS_2 nanostructures as a promising platform for designing efficient and durable catalysts for sustainable hydrogen generation driven by photo-, electro-, and photoelectrochemistry.

Keywords: Hydrogen evolution reaction; Electrocatalysis.

INVITED SPEAKER

Id-1015

Importance of Exposure Assessment Along Life Cycle of Nanocomposites

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Abstract: Carbon nanotubes (CNTs) possess exceptional mechanical, electrical, and thermal properties, enabling advanced applications such as polymer nanocomposites, conductive coatings, sensors, and energy storage systems. In polymer matrices, CNTs are widely used to enhance mechanical performance and to provide electrical or thermal conductivity. However, certain CNT morphologies, particularly rigid and stiff multi-walled carbon nanotubes, have raised health concerns due to potential asbestos-like behaviour if released and inhaled during processing, use, or end-of-life scenarios. To minimize potential risks, nanomaterial development increasingly follows Safe-and-Sustainable-by-Design (SSbD) principles. From a toxicological perspective, shorter and more flexible CNTs are considered more favourable, as they may be more readily cleared by pulmonary macrophages. Single-wall carbon nanotubes (SWCNTs) are therefore proposed as a promising alternative, although confirmation of their safety requires systematic release and exposure assessment studies across the full life cycle of nanocomposites. In this work, two laboratory-scale case studies were conducted to investigate potential airborne release of SWCNTs from nanocomposites under mechanically relevant conditions. The first case study [1]examined epoxy resin formulations for floor-coating applications, where mechanical abrasion was applied to simulate wear during service life. The second case study [2] focused on lithium-ion battery components containing SWCNTs in the cathode material, which were subjected to mechanical pre-treatment representative of handling and processing steps. In both applications, SWCNT incorporation resulted in functional benefits, including improved mechanical properties of epoxy coatings and enhanced cycle stability and service life of lithium-ion batteries. Exposure assessments were performed to evaluate the presence of airborne SWCNTs during mechanical stress. The results underline the importance of integrating exposure assessment throughout the life cycle of nanocomposites to support SSbD strategies, guide material and process optimization, and enable the responsible scale-up and commercialization of nanotechnology-based products. Some exposure studies involved funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 952934 (SUNSHINE) and N° 953152 (DIAGONAL). Any dissemination of results must

indicate that it reflects only the author's view and that the Commission is not responsible for any use that may be made of the information it contains.

Keywords: Carbon-nanotubes; Productsafety; Risk-assessment; SSbD; Exposure.

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INVITED SPEAKER

Id-1017

Covalent Organic Frameworks for Cancer Theranostics

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Abstract: Despite significant advancements in diagnostics and treatment modalities, cancer remains one of the most pressing global health challenges, responsible for approximately 10 million deaths in 2020 alone [1]. While conventional therapeutic approaches, including chemotherapy, radiotherapy, and surgical resection, have improved survival, they are often undermined by systemic toxicity, a lack of specificity, multidrug resistance (MDR), and high recurrence rates [2]. These limitations underscore the urgent need for novel, effective strategies that can enhance therapeutic efficacy while reducing adverse side effects. Nanotechnology has revolutionized cancer management by enabling the development of nanoscale platforms with tailored physicochemical properties, such as high surface-to-volume ratios, tunable drug release profiles, and selective targeting [3]. Through passive targeting, such as the enhanced permeability and retention (EPR) effect, and active targeting using ligands for receptor-mediated uptake, nanoparticles can achieve site-specific delivery and reduce off-target toxicity. The emergence of theragnostic nanomedicines, which integrate diagnostic imaging and therapeutic functions into a single system, has transformed personalized oncology. These nanomedicines offer real-time monitoring of treatment efficacy and the potential to dynamically adjust therapeutic regimens. However, despite encouraging preclinical results, many conventional nanocarriers (e.g., liposomes, dendrimers, polymeric micelles, and inorganic nanoparticles) face challenges such as instability under physiological conditions, low drug loading efficiency, uncontrolled release, and long-term toxicity due [4]. These issues have limited their clinical translation and highlight the need for safer, more effective alternatives. Covalent organic frameworks (COFs) were first reported by Prof. Yaghi, who won the Nobel Prize in Chemistry in 2016, and his colleagues in 2005 [5]. COFs have recently emerged as a next-generation class of crystalline, porous materials. They are known for their exceptional structural definition, chemical versatility, and functional tunability. COFs are constructed from light elements (C, H, O, B, and N) through dynamic covalent chemistry and form highly ordered two- or three-dimensional networks with intrinsic porosity and π-conjugated architectures. These unique features allow COFs to host a wide range of therapeutic and diagnostic agents, enabling their integration into multifunctional nanoplatforms designed for cancer theranostics. The biodegradability and biocompatibility of COFs can be enhanced by incorporating cleavable linkers (e.g., imine, disulfide, or hydrazone) that respond to tumor microenvironmental stimuli, such as pH, redox gradients, or enzymes, facilitating spatiotemporal control of release. Furthermore, COFs' modularity allows for the precise incorporation of targeting ligands, imaging probes, and stimuli-responsive motifs, offering unparalleled opportunities for designing next-generation theragnostic systems tailored to clinical oncology. This presentation provides a comprehensive overview of recent work by us and others on COFs in cancer nanomedicine. First, we categorize the main nanomaterial platforms in current theragnostic strategies and their limitations. Then, we explore how the unique properties of COFs address these barriers. Finally, we conclude by outlining key challenges and future directions toward clinical translation.

Keywords: Covalent organic frameworks; Nanomedicine; Cancer; Theranostics; Drug delivery; Clinical imaging.

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INVITED SPEAKER

Id-1023

Development of Redox-Active Nanomaterials Based on Cerium Phosphate Nanoparticles for Biomedical Applications

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Abstract: Effective regenerative therapeutics for acute and chronic wounds remain a critical unmet need in biomedicine. The aim of the study was the synthesis, characterization, and investigation of the biomedical effects of nanosized cerium phosphate obtained via different synthesis technique), with evaluation of the influence of various $CePO_4$ concentrations on human cells involved in skin structure regeneration (mesenchymal stem cells, keratinocytes, fibroblasts), as well as antioxidant properties. Cerium (III) orthophosphate was obtained by precipitation with ammonium dihydrogen phosphate from a nitrate solution. By changing the initial concentrations of the solutions and the drying and annealing temperatures, the best conditions for obtaining nanosized phosphate powders were established. The structure of rhabdophane was obtained by X-ray diffraction analysis, and the particle sizes were measured by transmission electron microscopy. The particle sizes ranged from 2-10 nm in the transverse direction to 20-50 nm in the longitudinal direction. In vivo efficacy was tested in Wistar rats with full-thickness skin wounds. On days 3, 7, and 14, healing was assessed clinically, histologically, and morphometrically. Studies on cell lines have shown a high level of safety, as well as the regenerative potential of CePO4 nanoparticles, which have a stimulating effect on the proliferation of MSCs for 48 hours after application, and stimulate the metabolism of human keratinocytes and fibroblasts at a wide range of concentrations. A dose-dependent antioxidant effect of small CePO4 nanoparticles at a concentration of 0.00001-0.01M has been established, which is stronger than ascorbic acid. The animal study results demonstrated significantly accelerated wound healing with nanomaterials based on cerium phosphate nanoparticles versus control groups, evidenced by improved tissue regeneration, reduced inflammation, and increased fibroblast infiltration. The method for obtaining cerium phosphate nanoparticles with beneficial biomedical effects has been developed. Non-cytotoxicity and regenerative potential of $CePO_4$ has been established in a wide range of the concentrations. The research was funded by the Russian Science Foundation, interdisciplinary grant No. 23-65-10040, https://rscf.ru/project/23-65-10040/.

Keywords: Nanoparticles; Cerium phosphate; Rhabdophane; Antioxidant; Regeneration; Wound healing; Proliferation; MSCs; Fibroblasts; Keratinocytes; Wistar rats.

INVITED SPEAKER

Id-1040

Electronic and Magnetic Properties of Salophene-Based Molecular Systems on Noble Metal Surfaces

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Abstract: Magnetic molecules adsorbed on surfaces constitute promising building blocks for nanoscale spintronic devices. However, their functionality is often limited by Kondo screening, which masks the intrinsic magnetic moment and restricts external control. Understanding and controlling molecule–substrate interactions is therefore essential for designing magnetic nanostructures with tailored properties. In this talk, I will present a theoretical investigation of the electronic and magnetic properties of dibromosalophene complexes with transition-metal and rare-earth centers (Co, Dy, and Cr) adsorbed on Au(111) and Ag(111), based on density functional theory (DFT) calculations and their comparison with scanning tunneling microscopy and spectroscopy (STM/STS) measurements. For Co-salophene, the experimentally observed Kondo resonance on Au(111) is absent on Ag(111), despite the presence of a localized magnetic moment. The DFT results show that this originates from a substrate-dependent shift of spin-polarized orbitals relative to the surface state, which suppresses the screening mechanism [1]. Replacing the central atom with Dy and Cr enables the formation of stable planar complexes with distinct electronic fingerprints. The calculated local density of states is in excellent agreement with the experimental STS spectra, allowing identification of orbital contributions and providing insight into the bonding and magnetic properties of these systems. These results demonstrate how substrate choice and molecular design govern magnetism at the atomic scale, providing pathways for future molecular spintronic systems.

Keywords: Density functional theory; Molecular magnetism; Kondo effect; Rare-earth complexes; Molecular spintronics.

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INVITED SPEAKER

Id-1050

Advanced Transmission Electron Microscopy for Understanding Functional Oxides and Nanomaterials

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Abstract: Transmission electron microscopy (TEM) and scanning TEM (STEM) is one of the few techniques able to directly image local elemental composition and atomic structure down to the atomic scale. This supports development of improved performance in structural oxides, for example we have applied state of the art TEM and STEM to investigate presence of interlocked monoclinic and tetragonal polar nanoregions which boost the piezoelectric response of (K,Na)NbO_3-based ferroelectric films [1]. We have also used it to uncover local nanostructure and link this to the performance of electrocatalysts for water oxidation catalysts [2]. Yet (S)TEM imaging is typically performed in high vacuum environments which can cause artefacts relative to the sample in operando conditions. In situ (S)TEM using specialist holders or instruments enables imaging of catalysts in more realistic environmental conditions. In this talk I will present some of our recent work illustrating in situ STEM imaging of nanocatalyst materials. Specifically, we have applied in-situ gas cell STEM to investigate how the catalyst morphology evolves during activation heat treatment of cobalt oxides depending on the amount of doping with Mn promotor to optimise performance of Fischer Tropsch catalysts.[3] I will also report experiments using our graphene heterostructure liquid cells, which allow atomic resolution spatial resolution of solid catalysts surrounded by liquids including atomic scale dynamics at a solid-liquid interfaces [4]. We have developed a new polymer-free transfer technique to produce such graphene cells with minimal contamination and for a wide range of solvents [5]. Here we will report how this approach can be combined with an automated machine learning image analysis pipeline [6] to allow new investigations of the dynamic behaviour of single atoms at solid-liquid interface as a function of solvent environment [7], technology which we believe will have wide impact on the field of functional oxides and nanomaterials.

Keywords: Transmission electron microscopy; Nanomaterials; Atomic behaviour.

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INVITED SPEAKER

Id-1051

Silicon Photonics Testing: Challenges, Bottlenecks, and Emerging Innovations

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Abstract: As silicon photonics platforms evolve toward higher integration density and heterogeneous electro-optic functionality, test development has become a critical limiter in device validation and technology scaling. Ensuring measurement accuracy and reproducibility across wafer-, die-, and package-level test requires addressing key technical bottlenecks: low-loss and repeatable optical coupling at scale, stable high-frequency EO/RF characterization, automated probing with sub-micron alignment tolerances, and efficient extraction of broadband device parameters under shrinking design margins. This work will examine the underlying constraints of modern photonic test architectures, including hybrid RF–optical measurement chains, instrumentation bandwidth requirements, and limitations imposed by thermal drift, modal dispersion, and coupling variability. We highlight emerging innovations such as automated multi-instrument test platforms, Python-based high-throughput measurement frameworks, optimized EO S-parameter methodologies, and advanced wafer-level probing strategies supporting dense I/O photonic circuits. We further discuss how test data pipelines, statistical analysis, and cross-domain feedback loops accelerate device learning cycles.

Keywords: Silicon Photonics; Testing; Waveguides; Photodetectors; Parallel Testing.

ORAL PRESENTATION

Id-1009

Pinecone-Based Adsorptive Bionanocomposites as Modifiers for Monodoped and Co-doped Amorphous TiO_2 for Use in Wastewater Remmediation

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Abstract: The scourge of water shortage is continuously revealing the need for newer and more efficient water treatment technologies to be unearthed. This is because the conventional wastewater treatment methods have been shown to fail to remove a wide range of pollutant molecules, particularly those from the dye industries. Photocatalysis and adsorption are among the most technically feasible techniques for the removal of undesirable dyes from water. In this work, pinecone derived photocatalytic and adsorptive bio-nanocomposites for use in dye removal were developed. The propensity of doping and compositing of TiO_2 to reduce crystallinity was harnessed to engineer TiO_2 nanocomposites for photocatalytic degradation of textile dyes via a facile solgel process in a slurry of repurposed plant-based adsorbents to in order to enable the repurposed adsorbents to influence the precipitation of the TiO_2. The repurposed adsorbents are unmodified composites pinecone and magnetite (PMC) while the modified composites are surface modified via in-situ grafting of polyacrylic acid, hereby rereferred to as polyacrylic acid grafted pinecone composites (GAA). The freshly synthesized doped TiO_2–GAA, TiO_2–PMC and the control photocatalysts (TiO_2 and $NTiO_2$) were extracted from the precursor slurry via drying heating at ambient pressure. All the photocatalytic composites were confirmed to be amorphous with N-doping demonstrating an additional influence on the morphological and surface features of the bio-nanocomposite as evidenced by the small particle size and high surface area of the N-doped photocatalysts. While compositing with the repurposed adsorbents saw a reduction in the indirect energy band gap, all the photocatalytic nanocomposites absorbed in the UV region, albeit higher photosensitivity in the visible region for the adsorbent-modified photocatalysts. As such, the photocatalytic performance was evaluated under UV light for the degradation of a dye cocktail constituted of reactive red 120 (RR 120) and rhodamine B (RhB) of the same concentration (25 ppm) which had been spiked up to pH 8 to simulate the pH conditions typical in real textile wastewater. The degradation by the N doped photocatalysts ($NTiO_2$, PMC– NTO_2 and GAA–NTO_2) all followed the pseudo zero order kinetics while the others followed pseudo 1st order kinetics-with the GAA-based nanocomposites and TiO_2 having the highest overall dye removal. This work has demonstrated that acrylic acid grafted adsorptive repurposed adsorbents make suitable modifiers for greener amorphous photocatalysts with a performance that is comparable to those of highly crystalline forms of doped TiO_2.

Keywords: Pine cone; Photocatalyst; Nanocomposite; Wastewater; Armophous TiO_2.

ORAL PRESENTATION

Id-1043

Fabrication of Ca-Doped $LaCoO_3$ Nanofibers via Electrospinning Method

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Abstract: Perovskite nanofibers offer a distinctive combination of structural and functional advantages by integrating diverse material characteristics. They integrate the extensive surface area, adaptability, and directed morphology characteristic of nanofibers with the exceptional optoelectronic and catalytic properties of perovskite materials. In this study, electrospinning was used to successfully create Ca-doped LaCoO3 (LCC) perovskite nanofibers. The carrier polymer was chosen as polyacrylonitrile (PAN), and an optimization process revealed that the optimal composition for an electrospinning solution was 7 wt% PAN and LCC precursors at a PAN:LCC ratio of 1:1. Perovskite fiber structure was attained by calcining the obtained nanofibers at various temperatures. Stable LCC phase formation was confirmed by FTIR, TGA, and XRD analyses. Phase identification further indicated that the perovskite nanofibers crystallized into a rhombohedral perovskite structure with an average diameter of 578 nm. Findings highlighted the great potential of LCC perovskite nanofibers for use in energy conversion, gas sensing, catalysis, and intermediate-temperature solid oxide fuel cells by showing that they can be produced with high surface area, nanoscale diameter, one-dimensional architecture, and tunable oxygen vacancy concentrations. This study was supported by Scientific and Technological Research Council of Turkey (TUBITAK) under the Grant Number 124M101. The authors thank to TUBITAK for their supports.

Keywords: Nanofibers; Perovskites; Electrospinning.

ORAL PRESENTATION

Id-1044

Design and Optimization of Synthetic Antiferromagnetic Structures for p-MTJ Devices

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Abstract: This study reports a comprehensive magnetic investigation of Co/Pt multilayer thin films with an emphasis on buffer layer engineering and perpendicular magnetic anisotropy (PMA) tailoring for magneto-resistive device applications. Multilayer stacks were deposited on Si substrates incorporating two distinct buffer layer configurations (Ta/CuN and Ta/Ru) to systematically evaluate their impact on magnetic switching behavior, coercivity, loop squareness, and thermal robustness. The magnetic response was characterized using magneto-optical Kerr effect (MOKE) measurements in both In-Plane and Out-of-Plane geometries, complemented by vibrating sample magnetometry (VSM) analysis. A strong dependence of magnetic performance on buffer layer selection was observed. Structures incorporating Ru-based buffers exhibited enhanced perpendicular anisotropy, sharper and more coherent magnetic reversal, and higher coercive fields compared to their CuN-based counterparts. Post-deposition annealing at 330 °C further improved the perpendicular magnetic characteristics and magnetic stability of Ru-buffered stacks, while CuN-buffered samples showed comparatively reduced anisotropy strength and broader switching distributions. The findings underline the critical role of interfacial engineering and buffer-induced texture control in determining anisotropy evolution and magnetic performance in Co/Pt multilayers, offering practical guidelines for the design of perpendicular synthetic antiferromagnetic and spintronic structures.

Keywords: Buffer Layer Engineering; Spacer Layer Engineering; Perpendicular Magnetic Anisotropy; Synthetic Antiferromagnetic Structures.

ORAL PRESENTATION

Id-1045

Urea-Derived Nitrogen Incorporation in Laser-Induced Graphene for Tunable Thermoelectric Response

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Abstract: Laser-induced graphene (LIG) is a porous nanostructured carbon material that offers tunable surface chemistry and scalable fabrication; however, controlled heteroatom incorporation in such laser-derived architectures remains an active area of research. In this study, urea is employed as a nitrogen precursor to modify LIG via a simple solution-assisted process followed by thermal activation, enabling systematic investigation of structure–property relationships at the nanoscale. X-ray diffraction and Raman spectroscopy reveal structural reorganization and partial restoration of graphitic domains after annealing, while XPS analysis confirms the stabilization of graphitic nitrogen species within the carbon framework. Thermal treatment eliminates crystalline urea residues and promotes the transformation from surface adsorption to lattice-level nitrogen incorporation. This nanoscale chemical modification alters the electronic structure of LIG, resulting in a transition from positive to negative Seebeck coefficient together with enhanced electrical conductivity. The results demonstrate that urea-derived nitrogen incorporation provides an effective route for tuning carrier type and thermoelectric response in porous graphene nanostructures. The proposed approach offers a scalable strategy for engineering functional carbon-based nanomaterials for flexible electronic and energy-harvesting applications.

Keywords: Laser-induced graphene; Urea, Nitrogen doping; Seebeck coefficient.

POSTER PRESENTATION

Id-1005

Grafting Bulrush with Acrylic Acid Using Fenton's Redox Initiator for the Removal of Methylene Blue Dye from an Aqueous Solution

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Abstract: Methylene blue dye in wastewater poses significant environmental and health risks due to its toxicity and resistance to conventional treatments. It disrupts aquatic ecosystems by reducing light penetration and harming photosynthetic organisms. A study was conducted on grafting Bulrush with acrylic acid using an innovative approach based on the Fenton redox initiator to enhance its adsorption capacity for methylene dye. Poly (acrylic acid) grafted Bulrush demonstrated a much higher adsorption capacity of 75 mg/g. The grafting procedure was improved, and the optimal conditions were determined to be an acid concentration of 0.9 mol/L and a monomer ratio of 8:10. The grafted Bulrush was characterised using FTIR and SEM/EDX. These analyses revealed that grafting with polyacrylic acid (PAA) introduced carboxyl (-COOH) and ester (-COOR) functional groups onto the surface of the material. The adsorption capacity was assessed through batch experiments, identifying the optimal conditions as an adsorbent dose of 2g, a pH of 8, an initial methylene blue dye concentration of 100 mg/L, and a temperature of 60°C. The Langmuir model best described the adsorption mechanism, with a high R^2 value of 0.9970. The pseudo-second-order model, which demonstrated an excellent ft to the adsorption data, provided compelling evidence that chemisorption was the dominant mechanism in the adsorption of methylene blue dye onto PAA grafted Bulrush. The reusability of the adsorbent was tested, with NaOH being the most effective desorbing agent, followed by water. This approach offers a sustainable and efficient method for removing methylene blue dye from wastewater, contributing to environmental protection and public health.

Keywords: Grafting; Bulrush; Acrylic acid; Fenton's reagent; Methylene blue dye; Adsorption.

POSTER PRESENTATION

Id-1016

Green Nonotechnology: The Promise of Biopolymers Emulsions in Crafting the Next Generation of Eco-Friendly Pesticides

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Abstract: The growing demands of global agriculture underscore the urgent need for improved, eco-friendly pesticides. However, conventional pesticides are largely inefficient, with over 90% failing to adhere properly to plant leaves, particularly in wet conditions. This project aims to revolutionize pesticide science by developing adhesive, bio-polymeric pesticides. By converting plant-oil raw materials into bio-polymeric emulsions, we aim to develop all-weather, environmentally friendly pesticides. Non-edible plant oils have emerged as a promising alternative materials for agriculture. These oils are plentiful, affordable, and renewable, making them excellent candidates for developing new types of pesticide carriers. Furthermore, plant oils contain functional groups that can form hydrogen bonds, enhancing the adhesion of pesticides to leaf surfaces. They can also be chemically modified to produce bio-polymers that act as adhesives and emulsifiers, potentially improving the retention and effectiveness of pesticides. We use chemistry to convert plant oils into bio-polymers, which are then chemically engineered into adhesive bio-polymeric emulsions. The effect of the bio-polymeric emulsions is tested in dose-response experiments with weed and crop plants to compare the effect commonly used pesticide formulations. The first project results will be presented at the conference. This work was partly supported by the project “From Lab to Field: The Promise of Biopolymer Emulsions in Crafting the Next-Generation of Eco-friendly Efficient Pesticides - 0095324” funded by the Novo Nordisk Foundation, Denmark.

Keywords: Nano-encapsulation; Herbicide efficacy; Herbicide testing; Herbicide performance.

POSTER PRESENTATION

Id-1025

Liquid-Phase Aerobic Oxidation of Pentadecane in the Presence Ultrasonic Pretreatment of Fullerene Soot

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Abstract: The development of efficient catalytic systems for the activation of inert C–H bonds remains a crucial challenge in modern oxidation chemistry. Liquid-phase aerobic oxidation of alkanes, including long-chain substrates such as pentadecane, is of particular interest due to its relevance for producing value-added oxygenates under mild and sustainable conditions. Fullerene-containing materials have recently emerged as promising catalytic additives, yet their practical application is often limited by aggregation, low dispersibility, and restricted accessibility of active sites. Ultrasonic pretreatment offers an effective strategy to modify the morphology and surface properties of fullerene soot, improving its dispersion in liquid media and potentially enhancing its catalytic performance. In this work, the influence of ultrasonic pretreatment of fullerene soot on its behavior in the aerobic oxidation of pentadecane is investigated, providing insight into structure–activity relationships and offering a pathway toward more efficient oxidative transformations of alkanes. Liquid-phase oxidation of pentadecane with molecular oxygen was carried out in a bubble-type oxidation unit in a glass reactor [1]. Ultrasonic treatment of the catalyst in a hydrocarbon was carried out on a cavitation installation of the Hielscher brand (Ultrasound Technology, made in Germany) UP200St. In the cavitation process, a titanium sonatrode of the s26d7 brand (Hielscher) was used, with a diameter of 7 mm and an amplitude of 190 µm. The fullerene soot used as a catalyst in the experiments was purchased from Xzillion GmbH (Germany). According to the provided certification, the soot contains 8% C_{60} [2]. The research results on liquid-phase aerobic oxidation of pentadecane (150 ml) with molecular oxygen in the presence of fullerene soot treated with ultrasound are shown below in Table (T = 135-140^{0}C, amount of air – 100-120 l/h) (SFA - synthetic fatty acids; SOFA - synthetic oxyfatty acids):

Catalyst	US, min	Amount of cat-st, %	Time of reaction., hour	A.n. of reac.mix., mgKOH/g	Yield of SFA,%	Yield of SOFA %
-	-	-	12	28.3	-	-
Full.soot	-	0.01	8	48.2	9.1	0.6
Full.soot	1	0.01	4.5	90.4	14.0	0.4

Research has shown that the catalytic efficiency of microscale catalyst systems is enhanced by the use of ultrasound as an irritant. It is believed that a synergistic effect is created between heterogeneous catalyst particles and ultrasound, increasing the acidity (A.n.) of the oxidate. Furthermore, ultrasonic treatment of the catalyst particles effectively disperses them, resulting in a larger active surface area.

Keywords: Fullerene soot; Ultrasonic waves in catalysis; Oxidation; Catalysis; fullerene C_{60}.

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POSTER PRESENTATION

Id-1037

Impact of Pore Structure and Surface Modification on Loading Capacity and Drug Release Profiles of Two Types of Cubic Mesoporous Silicas Loaded with the Fluoroquinolone Antibiotic Lomefloxacin

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Abstract: Fluoroquinolones are among the most widely used classes of antimicrobial drugs, yet they have several limitations, including poor solubility, rapid absorption after topical application, and potential side effects due to high local concentration. Burst release and high peak concentrations can lead to both phototoxic reactions and bacterial resistance. The goal of this work was to determine whether modifications to the pore structure of two types of cubic mesoporous silicas (KIT-6 and FDU-12) could be utilized to create controlled-release formulations for topical use of the fluoroquinolone antibiotic lomefloxacin. We tested the influence of surface carboxylation on the release of lomefloxacin from these porous silicas using a combination of methods to characterize their physical properties and drug release profiles. The porous silicas were carboxylated using APTES grafting and succinic anhydride coupling and then loaded with lomefloxacin using the method of solvent impregnation. These modifications resulted in increased encapsulation efficiencies for both types of silicas: 42.3% vs 61.2% for KIT-6, and 38.8% vs 65.4% for FDU-12. For pristine (non-functionalized) KIT-6 particles, approximately half of the lomefloxacin was released into solution within 1 hour (48.6%). Approximately 42% of the lomefloxacin was released into solution during the same time period for pristine FDU-12 particles. In contrast, the carboxylated versions of each type of particle released significantly less lomefloxacin into solution during the first hour: 26.4% for the carboxylated KIT-6 particles and 21.8% for the carboxylated FDU-12 particles. However, the amount of lomefloxacin released into solution after 24 hours did not differ as greatly between the carboxylated and pristine versions of either type of particle: cumulative release of lomefloxacin was approximately 72% for carboxylated KIT-6 particles, compared to 89% for pristine KIT-6 particles, and was approximately 69% for carboxylated FDU-12 particles, compared to 85% for pristine FDU-12 particles. Therefore, although the carboxylated particles released less lomefloxacin into solution than the pristine particles over the first 24 hours, they still released most of it. Both types of carboxylated particles exhibited Fickian diffusion-controlled release kinetics consistent with the Higuchi model ($R^2 \geq 0.97$), with diffusion exponents (n) ≤ 0.45. This indicates that lomefloxacin release from both types of particles was primarily controlled by diffusion through the pore networks. Furthermore, we determined that surface charge was a stronger determinant of release behavior than pore architecture, allowing for sustained release of antibiotics for controlled dermal therapy. The reason for the reduced burst release from the carboxylated particles is likely due to the electrostatic attraction between the negatively charged carboxyl groups on the surface of the particles and the positively charged piperazinyl group of lomefloxacin, which stabilized the drug adsorption within the pore networks. Although FDU-12 has larger cage-type pores, surface chemistry was the dominant factor controlling the release behavior of the particles. This demonstrates that the strength of adsorption to the surface of the particles controls the diffusion kinetics through the pore networks of cubic mesoporous materials. Therefore, controlled release from such systems could potentially prevent sub-inhibitory concentrations of antibiotics and reduce peak local exposure leading to phototoxicity. This research was funded by the European Union-NextGenerationEU, through the National Recovery and Resilience Plan of the Republic of Bulgaria, project № BG-RRP-2.004-0004-C01.

Keywords: Controlled release; Mesoporous silica; KIT-6; FDU-12; Lomefloxacin.

POSTER PRESENTATION

Id-1038

Design of MCM-41 Mesoporous Silica Nanoparticles for Delivery of Pyrrole Hydrazones and Improvement of Their Biopharmaceutical Properties

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Abstract: Pyrrole hydrazones exhibit promising antioxidant and potential neuroprotective activity but their extremely low aqueous solubility limits pharmaceutical development and bioavailability. The aim of this work was to synthesize new pyrrole hydrazones, evaluate their radical-scavenging activity, and overcome solubility limitations by incorporation into mesoporous silica carrier MCM-41. Hydrazones were synthesized via condensation reactions and structurally confirmed by IR, NMR and MS spectroscopy. Antioxidant activity was evaluated using DPPH and ABTS assays. The most active compound was loaded into MCM-41 via solvent impregnation and characterized by TEM and DLS. Hydrazone 9j demonstrated the highest antioxidant activity with ABTS radical-scavenging comparable to Trolox but showed extremely poor aqueous solubility. Successful incorporation into MCM-41 was achieved with 18% drug loading and 83% encapsulation efficiency. Particle size increased from 220±15 nm to 260±17 nm and zeta potential changed from –32±5 mV to –25±7 mV, while ordered mesoporous morphology was preserved. The results indicate stable host–guest interaction and expected amorphization leading to improved dissolution potential. The study demonstrates that mesoporous silica MCM-41 can transform poorly soluble hydrazones into pharmaceutically viable candidates and represents a general strategy for development of antioxidant neuroprotective agents. This research was funded by the European Union-NextGenerationEU, through the National Recovery and Resilience Plan of the Republic of Bulgaria, project № BG-RRP-2.004-0004-C01.

Keywords: Mesoporous silica; MCM-41; Pyrrole hydrazones; Solubility enhancement; Antioxidant activity.

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ALL SUBMISSIONS & TOPICS

Nanostructured Catalysts and Sustainable Reaction Engineering	Id 1010 - High-Purity Biohydrogen Production by Intensified Steam Reforming of Biomass Derivatives over Nanocomposite-Based Hybrid Materials
	Id 1012 - Tuning Hydrogen Adsorption on Pt/C through CaO-Induced Electron Spin redistribution: Experimental and DFT Mechanistic Study
	Id 1013 - Molybdenium Disulfide Based for Electrocatalysts - New Insights into Hydrogen Evolution
	Id 1016 - Green Nonotechnology: The Promise of Biopolymers Emulsions in Crafting the Next Generation of Eco-Friendly Pesticides
	Id 1025 - Liquid-Phase Aerobic Oxidation of Pentadecane in the Presence Ultrasonic Pretreatment of Fullerene Soot
Computational Nanotechnology	Id 1040 - Electronic and Magnetic Properties of Salophene-Based Molecular Systems on Noble Metal Surfaces
Magnetics and Superconductor Technology	Id 1044 - Design and Optimization of Synthetic Antiferromagnetic Structures for p-MTJ Devices
Nanobiotechnology	Id 1037 - Impact of Pore Structure and Surface Modification on Loading Capacity and Drug Release Profiles of Two Types of Cubic Mesoporous Silicas Loaded with the Fluoroquinolone Antibiotic Lomefloxacin
Composites and Nanocomposites	Id 1005 - Grafting Bulrush with Acrylic Acid Using Fenton's Redox Initiator for the Removal of Methylene Blue Dye from an Aqueous Solution
	Id 1009 - Pinecone-Based Adsorptive Bionanocomposites as Modifiers for Monodoped and Co-doped Amorphous TiO_2 for Use in Wastewater Remmediation
	Id 1015 - Importance of Exposure Assessment Along Life Cycle of Nanocomposites
Nanoelectronics	Id 1048 - Few-Cycle Laser-Nanostructure Interactions: From Ultrafast Nanophotonics to Petahertz Nanoelectronics

	Id 1049 - Van der Waals Heterostructures
Nanoenergy	Id 1006 - All Solid-State Supercapacitor with Natural Rubber-based Solid Polymer Electrolyte and 2D Materials-based Electrodes
Nanofibers	Id 1043 - Fabrication of Ca-doped $LaCoO_3$ Nanofibers via Electrospinning Method
Nanomedicine	Id 1017 - Covalent Organic Frameworks for Cancer Theranostics
	Id 1023 - Development of Redox-Active Nanomaterials Based on Cerium Phosphate Nanoparticles for Biomedical Applications
Nanoparticles	1008 - Structure–Function Relationships of Engineered Oxide Nanoparticles for Wettability Alteration in Porous Media
	Id 1038 - Design of MCM-41 Mesoporous Silica Nanoparticles for Delivery of Pyrrole Hydrazones and Improvement of Their Biopharmaceutical Properties
	Id 1041 - Global Semiconductor Industry Trends and Developments: Insights from Taiwan
Optical Lithography	Id 1051 - Silicon Photonics Testing: Challenges, Bottlenecks, and Emerging Innovations
Quantum Informatıon Scıence And Enablıng Technologıes	Id 1046 - Topologically Protected Quantum Teleportation via Majorana Zero Modes: A Measurement-Only Approach for Scalability and Decoherence Immunity
ZnO & Metal Oxides: Advances in Synthesis, Defects, and Applications	Id 1002 - Work Function and Spectro-Photo-Electrochemistry of ZnO Single Crystals and Thin Films
	Id 1050 - Advanced Transmission Electron Microscopy for Understanding Functional Oxides and Nanomaterials