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PLENARY SPEAKER

Id-2919

Correlation Between Electrical Performance and Local Structure in LaSrCoO SOFC Films: Probing Sr Segregation and Multiphase Behavior

M. A. SAHINER*

Seton Hall University

* Corresponding Author: mehmet.sahiner@shu.edu

Abstract. The electrical performance of LaSrCoO electrode films is strongly influenced by the local strontium (Sr) environment at the Sr lattice sites and the coexistence of multiphase structures within the films. Owing to their high electrical conductivity, oxygen reduction catalytic activity, and efficiency at low and intermediate operating temperatures, these materials represent leading candidates for solid oxide fuel cell (SOFC) cathodes. Nevertheless, Sr surface segregation remains a critical issue, resulting in structural instability and performance degradation. In the present study, LaSrCoO films were synthesized via a novel approach that involved the periodic introduction of multiple SrO layers into $La_{1-x}Sr_xCoO_3$ {x=0.2, 0.4} films deposited on yttria-stabilized zirconia (YSZ) substrates. This strategy yielded enhanced electrical performance; however, the detailed local crystal structure of the films had not been elucidated. To address this, density functional theory (DFT)-based extended X-ray absorption fine structure (EXAFS) spectroscopy was employed to investigate the crystal symmetries in $La_{1-x}Sr_xCoO_3$ {x=0.2, 0.4} films. Theoretical structural references, calculated using the Vienna Ab Initio Simulation Package (VASP), were used to interpret the EXAFS data. The integration of EXAFS with DFT-based reference structures proved to be a robust methodology for probing local structural variations arising from different deposition conditions and post-deposition annealing treatments in such layered systems. The analysis revealed the presence of additional crystal symmetries, including Ruddlesden–Popper phases. Furthermore, the temporal degradation behavior of the films, as well as the effects of post-deposition annealing, were systematically investigated. The EXAFS findings were correlated with complementary surface chemical analysis by X-ray photoelectron spectroscopy (XPS) and microstructural characterization by transmission electron microscopy (TEM). Collectively, these results establish clear correlations between structural evolution and electrical performance, thereby providing insights into the design of stable and efficient SOFC cathode materials.

Keywords: SOFC Cathodes; EXAFS; LaSrCoO; Perovskite; YSZ.

INVITED SPEAKER

Id-2790

Resonant Interaction of a Signal Electromagnetic Wave with a Modulation Wave of a Dielectric Plate, Placed in a Waveguide

E. A. GEVORKYAN

Moscow Witte University, Professor of the Department of Mathematical and Natural-Scientific Disciplines,

115432, Moscow, 2 nd Kozhukhovskiy proezd, 12

* Corresponding author: gevor_mesi@mail.ru

Abstract. The article provides a review of the author's scientific works devoted to the theoretical study of the features of the interaction of the transverse - electric (TE) and transverse - magnetic (TM) signal waves with a periodically modulated in space dielectric plate of finite length in a waveguide of arbitrary cross - section in the frequency region of the resonant interaction of the signal wave with the modulation wave of the plate [1, 2]. It is assumed that the depth of the modulation wave in the plate is much less than unity. Analytical expressions for the reflection and transmission coefficients are obtained using boundary conditions. The obtained expressions allow us to calculate the power reflection and transmission coefficients in the frequency region of the resonant interaction between the signal wave and the modulation wave of the plate (the first - order Wulf - Bragg condition is satisfied) when the amplitude of minus first harmonic taking into account the normalization condition in absolute value is equal to the unit. The conducted research leads to the following main results:

1. Generalized Fresnel formulas for TE and TM waves are obtained in the frequency region of resonant interaction.
2. Using Fresnel formulas, the power reflection and transvission coefficients for TE and TM waves in the frequency region of resonant interaction are calculated.
3. It is shown that the power reflection and transmission coefficients in the frequency region of resonant interaction are expressed through the hyperbolic functions sine and cosine the arguments of which depend on the small modulation depth to the first degree.
4. It is shown that the sum of the power reflection and transmission coefficients is equal to unity. The fulfillment of such condition is a consequence of the absence of scattering power in the considered periodic medium.
5. With help of limit transition from the results obtained in the work the similar results were obtained in the special case when a harmonically modulated plate is in unlimited space, and the signal wave falls normally on the plate.
6. It is shown that the numerical results for the power reflection and transmission coefficients obtained in this work for the case when the modulated plate is in an unlimited space differ from the numerical results obtained in the article [3] by approximatly 7,5%.

Keywords: Waveguide, Periodically Modulated Plate; Frequency Region of Strong Interaction; Power Reflection and Transmission Coefficients; Small Depth of Modulation.

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INVITED SPEAKER

Id-2814

Developing and Implementing a Digitalization System to Streamline Radiological Characterization of the Facilities Under Decommissioning

C. TUCA*, I. IORGA, E. NEACSU

National Institute for R&D in Physics and Nuclear Engineering, “Horia Hulubei”, IFIN-HH, Radioactive Waste Management Department, P.O.B. MG-6, RO-077125, Magurele, Romania

* Corresponding author: tuca@nipne.ro

Abstract. The paper presents methodology for data digitalization resulted in the radiological characterization process of the obsolete facilities under decommissioning, owened by the National Institute for Research and Development in Nuclear Physics and Engineering, Romania. A data digitalization program was developed, tested and implemented by using a DigiWaste platform in order to optimize the decommissioning process. Data were uploaded, collected and processed into a customizable database framework for developing, tracking and integrating critical information for D&D and waste management. As a result, the legacy system limitations are eliminated, the data security and regulatory compliance is ensured. Also, public confidence in the application of nuclear techniques and technologies as well as the safety of the operators, public and environment are increased. Due to the remote operation capability of the RADHAND 600 PRO instrument of DigiWaste platform, the workers exposure to areas with high radiation risk is minimized. By comparing the gamma spectra generated in situ by the RADHAND 600 PRO instrument with those obtained in the laboratory with traditional measurement systems, the data consistency and the confidence for decision-making was ensured and increased.

Keywords: Data Digitalization; Radiological Characterization, Decommissioning.

INVITED SPEAKER

Id-2815

Memristive Memory Array Based on Chalcogenide Phase Change Materials: Physics, Technology and Applications

A. SMIRNOV*, E. TROYAN, A. STEPANOV

Belarusian State University of Informatics and Radioelectronics, P.Brovki Str. 6, 220013 Minsk, Belarus

* Corresponding author: smirnov@bsuir.by

Abstract. This paper describes the current state and future of memristive memory array based on chalcogenide phase change materials (PCM). In spite of memristive PCM effect was discovered more than sixty years ago [1, 2] and the first 256-bit chip was demonstrated ten years later [3] the mass production of these devices started later when serious technological improvement where made by Intel/Micron, Samsung, STMicroelectonics and other industrial companies by using of modern 14-90 nm technologies [4-6]. During last three decades we were investigating physical effects of memory and switching at the interface of tellurium-based chalcogenide thin films and designed the technological process to manufacture the nonvolatile and reprogrammable memory cells. We have developed the physical model focusing on possible conversion of a normal isolator OFF state into a topological ON state by application of an external electric field that shifts different energies and induced a specific band inversion, which leads to a topological state. The tuning of topological behavior with electric fields would lead to spin-separated, gapless states having spintronic or superconductive features at room temperature. So, the conversion of a normal insulating chalcogenide material into a topological one via electric field provide a multifunctional “field effect transistor” that could manipulate simultaneously both spin and charge carrier. Electron spin can be visualized as the notation of an electron in one of two ways, with the rotation axis pointing up or down. Just like the present or absence of an electric charge represents a bit equaling “1” or “0”, a spin pointing up or down can do so as well. Main parameters of our $Ge_2Sb_2Te_5$ based memory cells – nanosecond times of data recording, long time of data storage (≥ 20 years), practically unlimited erasable cycles (≥ 1018 – 1020), extrimely high peak-to-peak resistance variation during write/read cycles (not less than 106), low voltage operation etc.- demonstrate their advantages before existing devices [7]. It’s important that the developed technological process is compatible with CMOS technology. CMOS compatibility refers to the ease of integration as embedded memory. As of 2024, all technologies are being readily introduced into CMOS technologies, hence the only difference in this case is related to the ease of implementation (number of layers/masks, material compatibility with the rest of the process, etc).

The main differences of our Ge2Sb2Te5 based memory cells over the analogues are the following:

1. Manufacturing process is quite simple and cheap, corresponding to main commercial stimulus.
2. It’s possible to use various substrates (Si, glass or flexible).
3. Memory cells by their functions are the usual resistors with on- or off states.

Keywords: Memristive; $Ge_2Sb_2Te_5$; Chalcogenide Phase-Change Memory (PCM.

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INVITED SPEAKER

Id-2816

Chemical Solution Deposition: Fundamentals and New Approaches

K. A. VOROTILOV

MIREA - Russian Technological University, Russian Federation

* Corresponding author: vorotilov@mirea.ru

Abstract. Chemical Solution Deposition (CSD) is a widely used technique for the deposition of oxide, ceramic and inorganic-organic hybrid films. The main approach for the preparation of inorganic materials is based on sol-gel reactions of metal alkoxides, whose hydrolysis and polycondensation leads to the progressive growth of the metal-oxide network and the formation of oxoalkoxide complexes - the true precursors of oxide phases. As a result, this method offers a unique opportunity to prepare oxides, including multicomponent oxides and inorganic-organic hybrids, with precise stoichiometry control and low formation temperature. For this reason, films prepared by CSD techniques are widely used in electronics, optics, medicine and many other fields. In this report we would like to give an overview of the basics of sol-gel techniques and some recent examples of the creation of new materials with new functionalities. The Evaporation Induced Self-Assembly (EISA) process can be used to produce mesostructured silica thin films with a well-organized porous structure. This process allows the formation of ordered pore structures with good control of pore size. Pore walls can be strengthened by substitution of inorganic silicon-oxygen bonds by organic ones. These proposals can be considered as a starting point for the development of new low dielectric constant porous materials for use in metallization of advanced integrated circuits to reduce signal propagation delay. We discuss the structure, electrical and mechanical properties of periodic mesoporous organosilica films with different ratios of carbon groups between silicon atoms (methylene, ethylene, benzene, etc.) [1]. A similar approach has been realized for the preparation of porous ferroelectric ceramic films with excellent columnar grain structure and strong texture [2]. These porous films exhibit some specific properties due to the stress relaxation phenomenon. On the other hand, these porous films can be filled with different materials to form composite materials with completely new properties. We demonstrate this new approach using the example of PZT/TiO_x composite films, which provide photosensitivity and memristor behaviour [3].

Keywords: Chemical Solution Deposition; Sol-gel; Thin film; Porosity; Composite.

Acknowledgment: This work was supported by the Russian Scientific Foundation, grant № 23-79-30016.

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INVITED SPEAKER

Id-2817

Integrated Ferroelectrics: Historical Outlook and State of The Art

A. S. SIGOV *

MIREA – Russian Technological University (RTU MIREA), Moscow, Russia

* Corresponding Author: sigov@mirea.ru

Abstract. Integrated ferroelectrics is the term that was born in the 80s of the last century and has been growing rapidly until today. It encompasses a wide range of devices and systems based on the unique properties of ferroelectrics and related materials integrated into the semiconductor manufacturing process. In the early years, most attention was paid to ferroelectric memory. The idea was not new, but many previous efforts were unsuccessful due to the lack of suitable techniques for depositing ferroelectric films on silicon. The appearance of new technological approaches, including sol-gel techniques and the transition from 1T to 1C1T cell architecture, leads to advances in the physics and materials science of ferroelectric thin films. As a result, ferroelectric random-access memory has been commercialized. The non-linear properties of ferroelectric materials, such as piezo- and pyroelectric behaviour, non-linear optical properties, etc., stimulate rapid growth in their applications in microelectromechanical systems (MEMS), pyroelectric receivers, sensors and photonics. Further scaling requires a reduction in film thickness and the area occupied by a device. Binary ferroelectrics based on hafnia have attracted much attention in recent years for applications in advanced non-volatile memories and transistors with extremely low power consumption, overcoming the Bolzman limit. In this report we have focused on the main physical properties of ferroelectric films that are important for their applications. Our considerations include polarization switching and charge transport phenomena. We show that interfaces and moving oxygen vacancies play an important role in the electrical properties of ferroelectric thin films. We demonstrate some novel structures based on ferroelectric composites.

Keywords: Ferroelectrics; Thin film; Integrated ferroelectrics; Memory; Interface.

Acknowledgment: This work was supported by the Russian Scientific Foundation, grant № 23-79-30016.

INVITED SPEAKER

Id-2821

Magnetic Properties and Applications of Glass-Coated Ferromagnetic Microwires

V. ZHUKOVA[1,2,3], P. CORTE-LEÓN[1,2,3,4], M. IPATOV[1], J. M. BLANCO[2,3], A. ZHUKOV[1,2,3,5,*]

[1]Dept. Polym. Adv. Mater, Univ. Basque Country, UPV/EHU, 20018 San Sebastian, Spain

[2]Dept. Appl. Phys. I, EIG, Univ. Basque Country, UPV/EHU, 20018, San Sebastian, Spain

[3]EHU Quantum Center, UPV/EHU, 20018, San Sebastian, Spain

[4]Dept. Mater. Science & Metallurgy, Univ. Cambridge, Cambridge CB3 0FS, UK

[5]IKERBASQUE, Basque Foundation for Science, 48011 Bilbao, Spain

[*] Corresponding Author: arkadi.joukov@ehu.es

Abstract. Development of magnetic sensors is focused on the miniaturization of their size, improvement of their features and on finding of new materials. Among new magnetic materials a family of thin amorphous wires with reduced dimensions recently gained considerable attention. Glass-coated magnetic microwires prepared using the Taylor-Ulitovsky technique with thin metallic nucleus (typically with diameters 0.2 to 100 μm) covered by flexible, insulating and biocompatible glass are therefore quite interesting for sensor applications. The purpose of this paper is present last results on tailoring of soft magnetic properties and GMI effect in glass-coated microwires, paying special attention to achievement of high GMI effect and on optimization of domain wall dynamics. Studied Co-rich and Fe-rich as-prepared microwires present rather different magnetic properties and hence GMI effect: Fe-rich microwires with positive magnetostriction coefficient, present perfectly rectangular hysteresis loops exhibiting magnetic bistability and coercivity, Hc, of the order of 50 A/m. In contrast Co-rich microwires with vanishing λs present linear hysteresis loops with an order of magnitude lower Hc. Stress annealing of Fe based microwires allows considerable magnetic softening (Hc decrease) and inducing transverse magnetic anisotropy. Accordingly, remarkable improvement of GMI ratio, ΔZ/Z, is observed in stress-annealed Fe–rich (Fe75B9Si12C4) microwires: improvement of ΔZ/Z –values by an order of magnitude is achieved. Upon annealing the hysteresis loop of Co-rich microwires becomes rectangular presenting considerable magnetic hardening and can present single domain wall (DW) propagation. However, stress-annealed Co-rich microwires present better magnetic softness (lower Hc), faster DW dynamics (higher DW velocity, v, values) and higher GMI ratio compared to as-prepared and annealed without stress Co-rich microwires. Consequently, stress annealing of ferromagnetic microwires allows achievement of interesting combination of magnetic properties, i.e. remarkable improvement of magnetic softness and GMI effect. Stress-annealed Co-rich microwires can simultaneously present single and DW propagation and high GMI effect.

Keywords: Magnetic Wires; Soft Magnetic Properties; GMI Effect; Magnetic Anisotropy; Coercivity.

INVITED SPEAKER

Id-2829

Computational study of the cerium dioxide nanoparticles and surfaces under reaction conditions

G. N. VAYSSILOV*, H. A. ALEKSANDROV, I. Z. KOLEVA

Faculty of Chemistry and Pharmacy, Sofia University "St. Kliment Ohridski", Sofia, Bulgaria

* Corresponding Author: gnv@chem.uni-sofia.bg

Abstract. Cerium dioxide is among the most studied redox metal oxides both experimentally and computationally since it is employed as active phase or support in industrial and environmental catalytic systems. In this report, we focused on understanding the transformations of the ceria nanoparticles or ceria surfaces occurring during their treatment or the catalytic processes. To clarify the atomistic details of these transformations, we employed computational modeling of relevant systems representing regular ceria surfaces or nanoparticles both in absence or presence of noble metal species. The periodic density functional calculations were performed with gradient-corrected exchange correlation functional PW91 and the projector augmented wave method. First, we studied the mechanism of carbon monoxide oxidation on platinum supported by a series of ceria models [1]. The calculated reaction paths suggested that both platinum clusters and isolated cationic species feature relatively low activation barriers, in agreement with experimental results. Our analysis has also shown that the reaction barriers for the individual CO oxidation steps are low when the oxidant is platinum cation or platinum cluster, while when the oxidants are Ce^{4+} cations the reaction barriers are substantially higher. Another computational study allowed us to clarify the structure of the active sites in the Ru/CeO_2 catalyst with minimal content of the noble metal, which is used for NO oxidation and NO storage [2]. Calculations suggested that the ruthenium cations were dispersed as mononuclear species in square planar pockets at the ceria surface. Since the reduction of cerium dioxide with molecular hydrogen is key step in some catalytic processes, we studied hydrogen adsorption on series of cerium dioxide models [3]. In all cases the adsorption of H_2 leading to reduction of ceria and formation of two OH groups is energetically favorable process. We have shown that upon heating of the formed hydroxylated surface molecular water is released up to degree involving removal of O centers with oxygen vacancy formation energy below decomposition enthalpy of water, 2.52 eV. The opposite process, generation of hydrogen from water on reduced ceria, may occur only on O vacancies with formation energy above this value. The stretching O-H vibrational frequencies of the two-fold and three-fold hydroxyls were found in the same range while the experimentally observed bands at lower frequencies were due to formation of hydrogen bonds with neighboring species. In recent work, we applied computational modeling to clarify the structural and chemical changes occurring with ceria nanoparticles, supported on alumina, under flow of CO and NO at high temperature. It has been shown that this transformation of the catalyst results in much higher activity for environmentally important catalytic reactions such as deNOx or CO and NO oxidation. Our computational results, in line with series of advanced experimental techniques, suggested spontaneous dispersion of ceria nanoparticles to very small ceria clusters forming layer of ceria on alumina surface, which features higher reducibility and high density of active catalytic sites [4].

Keywords: PhiKZ; Phage Nucleus; EPI Vesicle; Electron Microscopy; Electron Tomography; Fluorescent Microscopy; Membrane Fluorescent Dye; Giant Bacteriophage; Chimaviridae.

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INVITED SPEAKER

Id-28384

The Structural Pathway from Its Solvated Molecular State to the Solution Crystallization of Para-Amino Benzoic Acid

S. KATSYUBA*, T. GERASIMOVA, A. SAITOVA

Arbuzov Institute of Organic and Physical Chemistry, FRC Kazan Scientific Centre of RAS, Arbuzov st. 8, 420088 Kazan, Russia.

* Corresponding Author: skatsyuba@yahoo.com

Abstract. The nucleation process encompasses the transformation of solute molecules from their solvated state into the formation of stable molecular clusters with other solute molecules within a supersaturated solution. Understanding the structural transition pathway associated with the assembly of molecules from their supersaturated state into the crystalline state remains quite limited. A degree of insight on the crystallization of para-amino benzoic acid (PABA) from ethanolic and acetonitrile solutions was provided with the use of infrared (IR) spectroscopy [1], but aqueous PABA was not studied because of poor IR transparency of water. The purpose of our work is to study the structure of aqueous solutions of PABA at various concentrations with the use of vibrational Raman and electronic absorption UV spectroscopies supported by quantum mechanical (QM) modeling. The Raman and UV spectra of water overlap only slightly with the spectrum of the solute, and only minimally hinder the analysis of the latter. We also investigated the aqueous structure of conjugate of PABA with the drug Xymedon. We demonstrated that molecular and supramolecular structure of aqueous PABA strongly depends on concentration of the solutions. Deprotonated form of PABA, i.e. PABA- anion, dominates only in highly diluted solutions with c ≤ 2·10-5 M. At c ≥ 10-2 M PABA forms self-associated species, represented by major head-to-head and minor stacked dimers. We found also a strong effect of concentration on the composition of aqueous solutions of the PABA-Xymedon conjugate. Highly diluted solutions are shown to consist of separate PABA- anions and neutral Xymedon, whereas concentrated solutions contain about 70% of neutral PABA and Xymedon molecules, and about 30% of PABA- and XymedonH+ counterions. The neutral species are represented by dimers of PABA separated by water from Xymedon, whereas PABA- and XymedonH+ form contact ion pairs. Thus, our study demonstrates a pronounced tendency of PABA to dimerize in aqueous solutions with a concentration of about 10-2 M and higher. Dimers are formed in spite of the ability of water molecules to actively interfere with the system of hydrogen bonds, dipole-dipole interactions and other forces that bind PABA molecules to each other. The dimers are not destroyed even when Xymedon molecules are added to the solution, stimulating the proton transfer from PABA to Xymedon and the formation of contact ion pairs PABA-:XymedonH+. These results are in parallel with polymorphic behavior of PABA and experimental X-ray data on co-crystal of PABA with Xymedon.

Keywords: Raman and UV Spectra; Quantum Mechanics; Implicit and Explicit Solvation; Dimers; Hydrogen Bonds; Conformers.

Acknowledgments: This work was financially supported by grant 25-23-20097 of Russian Science Foundation and the Academy of Sciences of the Republic of Tatarstan.

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INVITED SPEAKER

Id-2837

Quality and Reliability of SnAgCu Composite Solder Joints

B. ILLÉS[1,2,*], A. PIETRSZKA[3], H. CHOI[1], P. GÓRECKI[3], A. SKWAREK[2,3]

[1]Budapest University of Technology and Economics, Faculty of Electrical Engineering and Informatics, Department of Electronics Technology, Budapest, Hungary

[2]Łukasiewicz Research Network - IMiF, LTCC Technology Research Group, Krakow, Poland

[3]Gdynia Maritime University, Gdynia, Poland

[*] Corresponding Author: illes.balazs@vik.bme.hu

Abstract. The mechanical and electrical structure of the microelectronic circuits is still based on solder joints, so their quality and reliability are essential. The latest solution to improve the solder alloys' properties is adding nano-sized ceramic reinforcement particles (like TiO_2, ZrO_2, Al_2O_3, etc.) into them and making "composite" solder joints [1]. The reinforcement particles improve the solder joints' mechanical properties (shear and yield strength, microhardness, etc.), with some Kelvin of change in the liquidus temperature of the alloy. The mechanical improvement is caused by dispersion-strengthening mechanisms. The ceramic nanoparticles are not soluble in the Sn solders, so they incorporate at the Sn and intermetallic (Cu_6Sn_5, Cu_3Sn, and Ag_3Sn) grain boundaries, where they promote heterogeneous nucleation. This results in the suppression of grain growth and decreases dislocation motions [2]. So, composite solder alloys could be the future of soldering technology, but their quality and reliability parameters are less well-known.

In the present study, the quality and reliability parameters of six composite solder alloys were investigated. $Sn_{99}Ag_{0.3}Cu_{0.7}$ (SAC0307) solder alloy was reinforced by 0.25-0.5wt% Al_2O_3, SiC, ZrO_2, CuO, ZnO, or TiO_2 nanoparticles. Primary particle sizes <100nm were used. The nanoparticles were mixed into the solder paste homogeneously using a YX solder paste mixer for 10 min at 400 rpm. Power FETs and chip resistors were assembled using conventional surface mounting technology (SMT) on FR4- and IMS-based printed circuit boards with different composite solder alloys. The assemblies were kept in 85°C / 85 %RH conditions for 4000 hours. The shear strength and the thermal parameters of the joints were measured before and after the aging test. Furthermore, the corrosion resistance of the different alloys was studied. The microstructure of the solder joints was observed on metallographic cross-sections by a focused ion beam scanning electron microscope (FIB-SIM). The results showed that most of the ceramic nanoparticles enhanced the initial mechanical and thermal parameters of the solder joints. However, some of them increased while others decreased the corrosion resistance of the composite solder joints. So, only an appropriate selection of applied ceramics can ensure the further development of microelectronics. Detailed results of the incorporation mechanism of the different nanoparticles into the solder matrix and their effect on the reliability of the composite solder joints will be discussed in the presentation.

Keywords: Composite Solder Alloy; Reflow Soldering, Nanoparticles, SAC0307; Corrosion; Sn Whisker.

Acknowledgment: This work was executed in the frame of OTKA projects K 145966 financed by the National Research Development and Innovation Office – Hungary (NKFIH).

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INVITED SPEAKER

Id-2841

Alginate-Based Biocomposites for Tissue Engineering Applications

L. BAIA*

Faculty of Physics & Institute for Research-Development-Innovation in Applied Natural Sciences & Interdisciplinary Research Institute on Bio-Nano-Sciences, "Babes-Bolyai" University, Cluj-Napoca, Romania

* Corresponding Author: lucian.baia@ubbcluj.ro

Abstract. Numerous studies have explored biopolymeric hydrogels made from alginate, cellulose, chitosan, gum arabic, and collagen [1]. Alginic acid, a polysaccharide from brown seaweed, forms sodium alginate when combined with sodium. Its gelation, biological, and physicochemical properties depend on the (1,4)-linked β-D-mannuronate (M)/ α-L-guluronate residue ratio (G), molecular weight, and sequence, especially in the presence of divalent cations [2]. Alginate gels with low M/G ratios tend to have higher mechanical stiffness, while those with high M/G ratios are more elastic. Despite this limitation, previous studies have shown that alginate-based structures are successfully used in medical applications, in general, and tissue engineering applications, in particular [5]. Taking into account the alginate properties and the potential applications of alginate-based composites, our group proposed first to develop innovative biocompatible hydrogels by combining Cu-containing bioactive glass-ceramic with alginate and pullulan, aiming for tissue regeneration and antibacterial action. Composites with up to 1.5 mol% CuO showed strong cell viability and antibacterial activity against Staphylococcus aureus. In vivo tests using long bone defects confirmed good regenerative performance. Next, we focused on investigating alginate–pullulan composites incorporating bioactive glass and variously shaped gold nanoparticles, which showed strong potential for regenerating both soft and bone tissue. These materials, along with a β-tricalcium phosphate-hydroxyapatite-based control, were implanted in Wistar rat bone defects, and subcutaneous evaluations at different time intervals (up to 60 days) confirmed that the obtained composites exhibited excellent biocompatibility, significant angiogenesis, and robust tissue growth, as evidenced by the presence of abundant Vimentin-positive cells [3]. Further, the addition of gum arabic to alginate showed promising potential for the development of porous scaffolds, offering improved physicochemical properties and biocompatibility as well as physical flexibility [4]. In this respect, we have recently developed a simple method based on the lyophilization process to produce porous alginate–gum arabic scaffolds incorporating CeO_2 nanoparticles, which provide a moist environment, strong antioxidant properties, and serve as an alternative to the extracellular matrix by supporting cell growth and promoting tissue regeneration [5]. The presented results suggest that these composites hold strong potential for future applications in tissue engineering.

Keywords: Tissue Engineering; Composites; Bioactive Glass-Ceramics; Biopolymer; Metal Nanoparticles.

Acknowledgment: This work was supported by a grant of the Ministry of Research, Innovation and Digitization, CNCS-UEFISCDI, project number PN-IV-P1-PCE-2023-1377, within PNCDI IV.

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INVITED SPEAKER

Id-2842

From Noble Metal Nanoparticles to Multifunctional SERS Substrates

M. BAIA[1,2]

[1]Faculty of Physics, Babes-Bolyai University, M. Kogalniceanu 1, 400084 Cluj-Napoca, Romania

[2]Institute for Research-Development-Innovation in Applied Natural Sciences, Babes-Bolyai University, Fantanele 30, 400294 Cluj-Napoca, Romania

* Corresponding author: monica.baia@ubbcluj.ro

Abstract. Surface-enhanced Raman spectroscopy (SERS) is a sensitive method that allows the detection of molecules at very low concentrations due to the enhancement of the Raman signal of species adsorbed on a metallic nanostructured surface. Over time, SERS has proven to be a powerful technique for applications in various fields such as personalized medicine, environmental monitoring, food safety issues and materials science for the investigation of surface properties and molecular composition [1,2]. The success of a SERS analysis is closely related to the amplification efficiency of the substrate used. Therefore, a wide variety of SERS substrates have been developed, ranging from simple colloidal nanoparticles (NPs) of different shapes and dimensions to tailored substrates obtained by expensive techniques. Moreover, the stability and reproducibility of the substrate are also key issues.

In this context, we obtained and tested different types of SERS substrates. The most common substrates, which have consisted of colloidal Ag and Au NPs, served in our studies as mimics of a biological interface, helping us to clarify the adsorption behavior of different pharmaceuticals and to identify any structural modifications of the adsorbed species with respect to the free molecules [3]. New solid substrates were developed by immobilizing Au NPs on functionalized glass substrates. Their SERS efficiency was tested for different NPs densities by using various laser lines from Vis to NIR spectral region. Our interest was further focused on the development of solid substrates by nanosphere lithography in order to tune their SERS efficiency to different excitation laser lines. More precisely, substrates consisting of noble metal films deposited over regular arrays of polystyrene nanospheres were investigated and their SERS enhancement efficiency was evaluated for different film thicknesses and different excitation laser lines. The large tunability of surface plasmon excitation combined with the advantage of relatively high exhibited enhancement obtained under NIR excitation recommended these substrates as outstanding candidates for investigations of biologically relevant molecules [3]. On the other hand, Au and Ag NPs were incorporated into a TiO2 aerogel network and the obtained porous composites proved to be a very stable and efficient SERS substrate able to detect low concentrations of water pollutants. Additionally, the prepared composites demonstrated their potential to decontaminate water via photocatalysis. Relative recently, some Au/TiO2/WO3 heterostructures were obtained via heat or time-assisted synthesis routes developed by slightly modifying the Turkevich–Frens synthesis methods. The obtained Au/TiO2/WO3 heterojunctions exhibited excellent stability as SERS substrates, yielding strong-intensity Raman signals of the pollutant molecules even after a long period of time. They also proved to possess enhanced photocatalytic activity under both UV and VIS light exposure [4].

Keywords: SERS, Noble Metal Colloidal Nanoparticles, Solid SERS Substrates.

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INVITED SPEAKER

Id-2844

Strategies for Implant-Associated Infection Control: In Vivo Insights on TaCu and NbCu Magnetron-Sputtered Coatings

D. ALONTSEVA[1,2*], Y. SAFAROVA (YANTSEN)[1,3], B. AZAMATOV[1,2], Z. AZAMATOVA[4]

[1]Smart Engineering Competence Centre, D. Serikbayev East Kazakhstan Technical University, 19 Serikbayev Street, 070010 Ust-Kamenogorsk, Kazakhstan

[2]School of Digital Technologies and Artificial Intelligence, D. Serikbayev East Kazakhstan Technical University, 19 Serikbayev Street, 070010 Ust-Kamenogorsk, Kazakhstan

[3]National Laboratory Astana, Nazarbayev University, 53 Kabanbai Batyr ave, Astana,010000, Kazakhstan

[4]School of Geosciences, D. Serikbayev East Kazakhstan Technical University, 19 Serikbayev Street, 070010 Ust-Kamenogorsk, Kazakhstan

[*] Corresponding author: dalontseva@ektu.kz

Abstract. Implant-associated infections remain one of the most prevalent and difficult complications in orthopedic surgery, often resulting in implant failure and the need for revision procedures. These infections are predominantly caused by Gram-positive bacteria such as Staphylococcus aureus and Staphylococcus epidermidis, which form biofilms on implant surfaces. Once established, these biofilms are highly resistant to antibiotic therapy and host immune responses, contributing to persistent infections and delayed osseointegration. Moreover, systemic antibiotic treatments pose risks of cytotoxicity and may impair bone healing. To mitigate these challenges, surface engineering strategies are being explored to impart intrinsic antibacterial properties to implants. Among them, magnetron sputtering (MS) has emerged as a promising technique for depositing antibacterial metal coatings. Binary coatings such as TiCu, TaCu, and NbCu have gained attention due to their ability to simultaneously support osseointegration and inhibit microbial colonization while maintaining adequate mechanical performance. This study aimed to test the hypothesis that TaCu and NbCu coatings, deposited via magnetron sputtering under optimized conditions, can achieve a favorable balance between antibacterial efficacy and biocompatibility. As a result of the work, titanium alloy (Ti6Al4V) substrates pretreated with gas-abrasive methods were coated with TaCu and NbCu films containing 25 at. % Cu at thicknesses of 2 μm and 5 μm. The resulting coatings exhibited good adhesion and hardness, with TaCu coatings demonstrating higher hardness (>5 GPa) and lower elastic modulus (117.9 ± 25.3 GPa) compared to NbCu. In vitro assays, including CCK-8 proliferation testing with rat mesenchymal stem cells, confirmed the absence of significant cytotoxic effects. The TaCu coatings showed the strongest antibacterial performance, with inhibition zones against S. aureus reaching up to 23 mm in vitro. In vivo studies were performed in a rabbit model with S. aureus inoculation to simulate implant-related infection. Confocal microscopy revealed significantly reduced biofilm volume on TaCu-coated implants (247–448 million voxels) compared to uncoated Ti6Al4V controls (251–394 million voxels). TaCu-coated implants also showed complete prevention of osteomyelitis, in contrast to 100% incidence in control implants and 50% in NbCu-coated ones. Mortality rates followed a similar trend: 12.5% for TaCu, versus 37.5% for both NbCu and Ti6Al4V control groups. These findings underscore the promise of magnetron-sputtered TaCu and NbCu coatings for next-generation orthopedic implants, offering dual functionality by enhancing biocompatibility and suppressing infection-related complications. Further studies are warranted to refine coating parameters and assess long-term performance in vivo.

Keywords: Magnetron sputtering; Biofilm inhibition; Biocompatibility; Orthopedic biomaterials; Antibacterial surfaces.

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INVITED SPEAKER

Id-2853

Green ReRAMs through Biomaterials

V. S. VALLABHAPURAPU

Department of Physics, University of South Africa, Johannesburg 1710, South Africa

* Corresponding Author: vallavs@unisa.ac.za

Abstract. Sustainability strategies are pushing towards 'Green Technologies'. Green computing is an emerging field with green ReRAM as an important biomaterial based biodegradable component. Here we present our results on the development of ReRAMs based on various biomaterial composites such as Starch-ZnO, Chitosan-(ZnO, TiO_2, SiO_2) etc. Green-synthesized ZnO nanoparticles as well as ZnO platlets embedded within a starch matrix resulted in a device that exhibits both stable bipolar resistive switching and, for the first time, along with a pronounced Negative differential resistance (NDR) effect. Detailed conduction mechanisms involved will be discussed. Thermal studies are used to extract activation energies involved. Our work contributes to the understanding and development of biomaterial-based ReRAMs and paves the way for developing sustainable, flexible, and potentially multifunctional memory devices.

Keywords: Green Computing; ReRAM.

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INVITED SPEAKER

Id-2862

Possible Spectroscopic Evidence of Electron Nematicity in Na-deficient and Underdoped Na(Fe,Co)As Pnictides

S. A. KUZMICHEV[1,2], T. E. KUZMICHEVA[2*], A.D. ILINA[2], I. A. NIKITCHENKOV[1,2], A. I. SHILOV[2,3], E. O. RAKHMANOV[2,3], AND I. V. MOROZOV[3]

[1] Faculty of Physics, Moscow State University, 1, Leninskiye Gory 119991, Moscow Russia

[2]V.L. Ginzburg Centre for High-Temperature Superconductivity and Quantum Materials P.N. Lebedev Physical Institute of the Russian Academy of Sciences (LPI RAS), 53, Leninsky Ave., 119991 Moscow, Russia

[3]Department of Chemistry, Moscow State University, 1, Leninskiye Gory 119991, Moscow Russia

[*] Corresponding Author: kuzmichevate@lebedev.ru

Abstract. Layered NaFeAs relates to the 111 family of Fe-based superconductors (SC). It has nontrivial phase doping diagram: showing a low Tc ≈ 10 K in the stoichiometric state and a coexistence of spatially separated SC and antiferromagnetic phases, its SC properties could be optimized by (Fe,Co) doping up to Tc ≈ 22 K for (4–5)% Co concentration [1,2]. Due to alkali metal, the SC properties of NaFeAs rapidly degrade even in presence trace amounts of oxygen or water vapor. This feature strongly complicates any studies of the 111 family pnictides, and results to a lack of experimental data on NaFeAs available to date. Using a “self-flux” technique, we have grown large Na-deficient Na1-$_{\delta}$FeAs (δ ≈ 0.05–0.1) and underdoped Na1-□Fe1-xCoxAs single crystals with x = 0.01-0.02 and Tc ≈ 11–19 K, respectively. For all the experiments, the sample mounting was made in a dry argon atmosphere. At 4.2 K, using a planar “break-junction” technique [3] we formed tunneling junctions of SC–constriction–SC (ScS) type. Below Tc, we directly determined the magnitudes and temperature dependences of the large and the small SC gaps ΔL(T), ΔS(T) with extended s-wave symmetry in the k-space [4]. We detected a small decrease of the ΔL anisotropy in overdoped compounds as compared to underdoped one which indicates a spin-fluctuation origin of the observed anisotropy [4]. In the normal state above Tc, we reproducibly observed a feature of the tunneling conductance nonrelated to the SC state, those cannot be attributed to any artifacts, surface or geometric effects. The observed dI(V)/dV nonlinearity represents a hump at zero bias and two closely located dips at eV ≈ 20–30 meV [5]. Similar normal-state effect was observed by us earlier in Ba(Fe,Ni)2As2 and studied along the doping phase diagram [6].

According to classical models [6,7], the dI(V)/dV-spectrum of NcN-junction (N is bulk normal metal) is determined by the electron density of states energy distribution N(ε) near the Fermi level. Remarkably, for the studied NaFeAs-based pnictides the temperature T* >>Tc at which the tunneling conductance flatters agrees with the characteristic temperature of electron nematicity (at which the in-plane resistive anisotropy disappears in accordance with the data in [9]). Thus, the observed dI(V)/dV nonlinearity in NcN junctions based on the NaFeAs-family pnictides could originate from N(ε) features in the vicinity of EF caused by electron nematicity.

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Keywords: NaFeAs superconductors; Electron nematicity; SC gap anisotropy.

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INVITED SPEAKER

Id-2894

Ratiometric Fluorescent Metal-Organic Frameworks: Rational Designs and Analytical Applications

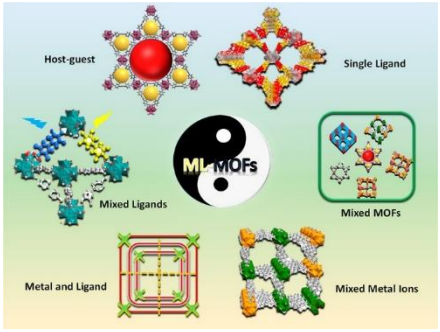
X. CHAI, X. ZHANG, R. ZHAO, C. DONG, S. SHUANG*

Shanxi University, School of Chemistry and Chemical Engineering, and Institute of Environmental Science, Taiyuan, China

*Corresponding Author: smshuang@sxu.edu.cn

Abstract. Metal organic frameworks (MOFs), composed of metal nodes and organic ligands, have demonstrated noteworthy advancements for analytical sensing by virtue of tailored porous, large specific surface area, adjustable metal nodes and diverse functional sites [1]. Nowadays, numerous MOF-based fluorescent sensors have been proposed in analytical applications. The adjustable pore sizes and functionalized sites of MOFs allow for modifying multiple fluorophores and enriching specific analytes, achieving sensitive detection. However, most of reported approaches are limited to one signal [2], which may suffer interferences from background fluorescence, instruments and operations, greatly restricting accurate detections. To ameliorate this defects, MOFs-based ratiometric fluorescent sensors have been rapidly emerged. This dual-emissive characteristics endow self-calibration capacity and effectively avoid interference from external factors, promoting accurate and reliable analytical applications.

For the above advantages, our group has conducted researches on MOF-based ratiometric fluorescence materials. By screening fluorescence metal ions and ligands, inserting abundant guest molecules, MOF-based ratiometric fluorescence sensors greatly acquire improvement (Scheme 1).



Scheme 1. The design strategies of MOF-based ratiometric fluorescence nanomaterials [1].

(1) A novel ratiometric fluorescence MOF (Eu/Al-MOF), endowing dual-emissive characteristic of Eu3+ and ligand, could realize sensing for histidine and trace water due to energy transfer mechanisms. Moreover, Eu/Al-MOF also can visualize and identify fingerprints [3]. (2) ZIF-8 served as a special crystalline container could encapsulate gold nanoclusters (AuNCs) and graphene quantum dots (GQDs), the Eu3+-mediated AuNCs/GQDs@ZIF-8 nanoprobe acquired dual-emissive properties for evaluating anthrax biomarker dipicolinic acid. (3) Considering the AIE property of AuNCs, acid-degradation function of ZIF-8, pH-responsive capacity of GQDs, the constructed multifunctional GQDs/AuNCs@ZIF-8 nanoprobe can realize pH and histamine dual-emissive sensing, achieving simultaneous purposes of biological and food monitoring. (4) By inserting two distinct MOF types, a novel ratiometric fluorescent sensor was designed via growing UiO-66(OH)2 to Y-TCPP, realizing precise Al^{3+} monitoring (Figure 4). Hence, the deep

understanding and making full use of advantages of MOFs, the ratiometric fluorescence sensors will have broad prospects in basic research and practical applications.

Keywords: Metal-Organic Frameworks; Ratiometric Fluorescence; Dual-Emissive Probe; Chemical Sensing; Bioimaging.

Acknowledgement

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INVITED SPEAKER

Id-2898

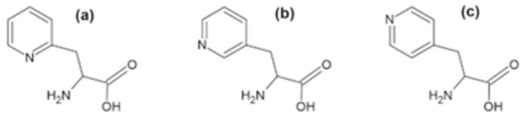
Structure and Piezoresponse of Novel Alanine-Based Hybrid Crystals

M. WOJTAŚ*

Faculty of Chemistry, University of Wrocław, 4 Joliot-Curie, 50-282 Wrocław, Poland

* Corresponding author: maciej.wojtas@uwr.edu.pl

Abstract. Six novel organic-inorganic hybrid crystals were synthesized and thoroughly characterized (1) (2) (3) (4). These compounds are salts formed from small inorganic acids—$HClO_4$ and HBF_4—and relatively large organic alanine derivatives: H-β-(a-pyridyl)-Ala-OH, where α denotes the position of the nitrogen atom in the pyridyl ring (a = 2, 3, or 4).



Most of the synthesized crystals crystallize in the monoclinic space group $P2_1$. However, in the case of compound XXX, the triclinic P1 and orthorhombic $P2_12_12_1$ space groups were observed.

In addition to structural analysis, several complementary experimental techniques were employed:

- Thermogravimetric Analysis (TGA): to assess the thermal stability of the salts.
- Infrared (IR) and Raman Spectroscopy: to investigate hydrogen bonding interactions, interpreted using Hadži's theory.
- Piezoresponse Force Microscopy (PFM): to quantify the piezoelectric response of the studied crystals.

The combined results from these methods allow for a correlation between the parameters of the hydrogen bond network and the observed piezoelectric properties.

Keywords: Piezoelectric Properties; Hydrogen Bonding Analysis; Organic–Inorganic Hybrid Crystals.

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INVITED SPEAKER

Id-2902

Bimetallic and Trimetallic Luminescent Nanocomposites Applied as Multimodal Bio-Imaging and Sensing Platforms

V. SVAČINOVÁ, R. OSTRUSZKA MEHWISH, K. ŠIŠKOVÁ*

Dept. Of Experimental Physics, Faculty of Science, Palacký University, Olomouc, Czech Republic

* Corresponding Author: karolina.siskova@upol.cz

Abstract. Our research group focuses on metallic nanostructures applicable in environmental and/or biomedical fields. With respect to the studied nanomaterial applications, we are trying to exploit solely green chemistry and to obey the principles of responsible research and sustainability. The aim of our work is to develop a new type of nanocomposite (NCs), which can provide multimodal imaging and/or sensing possibilities. Recently, we have revealed several key issues influencing characteristic properties of luminescent gold nanoclusters (LGN), gold-platinum (LGPN), and/or gold-silver nanoclusters (LGSN) embedded in a protein template (1, 2, 3). Protein served as reducing and capping agent in these NCs. We were also investigating the advanced systems where super-paramagnetic iron oxide nanoparticles (SPIONs) are generated simultaneously with LGN in a one-pot sequential synthesis (4). Furthermore, we investigated even more advanced systems where LGSN in conjunction with SPIONs can be combined (5). Optimal conditions such as for instance: reactants ratio, pH value, medium composition, type of heating, time of maturing (6), purification, storage conditions; are found out by careful observation of synthesis and comparison of resulting NCs features. Thorough characterization of the as-prepared NCs is performed by several experimental techniques (including steady-state fluorescence and absorption spectroscopies, dynamic light scattering, zeta potential measurements, circular dichroism, scanning transmission electron microscopy and energy dispersive spectroscopy, X-ray photoelectron spectroscopy, electron paramagnetic resonance (EPR) and light-induced EPR, Moessbauer spectroscopy, inductively-coupled-plasma mass spectrometry). The application potential of purified NCs is further assessed in collaboration with the Institute of Clinical and Experimental Medicine in Prague (IKEM) by means of magnetic resonance relaxivity measurements (at 1.5T, 37°C), imaging (at 4.7T) and cytotoxicity evaluation (performed by the team of dr. Rárová at Palacký University Olomouc). Based on the results, our newly developed NCs possessing unique properties can serve as non-toxic bimodal contrast agents (4, 5) and/or for the detection of selected metal cations (6).

Keywords: Protein-Stabilized Nanoclusters; Multimodal Imaging Nanocomposites; Green Nanomaterial Synthesis.

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INVITED SPEAKER

Id-2907

Synthesis and Application of Nanosized Mordenite

Y. KALVACHEV*, T. TODOROVA

Institute of Catalysis, Bulgarian Academy of Sciences Acad. G. Bonchev St., bl.11, 1113 Sofia, Bulgaria

* Corresponding Author: kalvachev@ic.bas.bg

Abstract. Zeolites with their unique properties are especially useful in various areas of applications, including medicine, agronomy, ecology, production of detergents and drying agents, and in a number of industrial processes. Many zeolites are commercially available as natural minerals and also as synthesized materials. One of the widely used zeolite minerals is mordenite, because of its high thermal and acidic stability. For specific purposes in industry mainly, mordenite is used as acid catalysts in the petrochemical industry for the isomerization of alkanes and aromatics in their synthetic forms. In this work we consider the structure, synthesis and two main types of modifications of mordenite that solve the diffusion difficulties during catalytic processes. The first type of modifications is related to a reduction of the size of the zeolite crystals obtained to submicron or nanometric range, whereas the second ones aim to obtain hierarchical mordenite samples by appropriate post-synthetic treatments. Both types of modifications find many other applications besides solving diffusion constraints in catalytic processes. Attempts to fine-tune and control the particle size in the first type of modifications or the pore size in the second ones by adjusting various parameters during the synthesis are described. The study reports on the hydrothermal synthesis of mordenite crystals without an organic template and on the characterization of resulting crystals, as the ultimate goal has been to decrease the crystal size. Two synthesis approaches have been applied. The first one involved subjecting a standard initial gel $18SiO_2:Al_2O_3:1.24K_2O:1.21Na_2O:xH_2O$ to hydrothermal crystallization for a period of 2 to 7 days (x=600, 280 and 22.5). The second approach included the usage of seeds employing the same initial gel composition. The crystals growth kinetics of mordenite at a different seed content (1, 2 and 5 wt.%) has been studied. The seed-assisted process enabled us to synthesize mordenite crystals of submicrometric range. Particle size distribution of the resulting products strongly depends on the water content in the initial gel and on the amount of added seed. It has been found that seed concentration and water content in the initial gel are the key factors influencing the crystallization time and the physicochemical properties of crystalline products. All products have been characterized by X-ray, scanning electron microscopy (SEM), dynamic light scattering (DLS), and infrared spectroscopy (FTIR).

Keywords: Mordenite Synthesis; Seed-Assisted Crystallization; Hierarchical Zeolites.

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INVITED SPEAKER

Id-2914

Multiferroic Embedded Ferrite Platelets in $BaTiO_3$

A. BARBIER[1*], P.-L. NGUYEN[1], B. SARPI[2,6], PÂMELLA VASCONCELOS[3], F. PETRONIO[1], C. MOCUTA[2], P. OHRESSER[2], D. STANESCU[1], J.-B. MOUSSY[1], A. VLAD[2], A. RESTA[2], E. OTERO[2], R. BELKHOU[2], J. LEROY[4], N. JEDRECY[5], H. MAGNAN[1]

[1]SPEC, CEA, CNRS UMR 3680, Université Paris-Saclay, 91191 Gif-sur-Yvette, France

[2]Synchrotron SOLEIL, 91192 Gif-sur-Yvette Cedex, France

[3]CEA/DES-ISAS, 91191, Gif-sur-Yvette, France

[4]NIMBE, CEA, CNRS, Université Paris-Saclay, 91191 Gif-sur-Yvette, France

[5]INSP, Sorbonne Université, CNRS UMR 7588, 75252 Paris, France

[6]Diamond Light Source, Oxforshire, United Kingdom

[*] Corresponding Author: antoine.barbier@cea.fr

Abstract. Multifunctional materials are highly versatile compounds that have the ability to respond to various external fields and stimuli, making them attractive for applications in sensors and advanced devices. In addition they also allow to optimize materials usage. Among them, multiferroic materials are of particular technological interest due to their high potential in spintronics and sensor devices. Unfortunately, single-phase multiferroic materials are scarce. One approach to overcome this problem is to build artificial compounds composite systems that integrate distinct ferroic properties. We explored a number of possibilities including embedded nanostructures realized by combined oxygen assisted molecular beam epitaxy and laser lithography processes to the expense of structural degrations due to the overall preparation procedures. To recover the desired ferroic functionalities, we systematically explored post-growth thermal treatments. We report on the successful realization of multifunctional systems consisting of ferrimagnetic ferrite spinel platelets - of controlled sizes and nanometric thicknesses - embedded in an epitaxial ferroelectric $BaTiO_3$ perovskite thin film. These structures experience significantly higher isostatic strain than that obtained for single layers. We successfully realized nanometer-thick composite layers having either in-plane or out-of-plane electric polarization orientations. The embedded platelets configuration enhances significantly interface and two-dimensional effects and is thus believed of high interest to realize guenuine functional device structures. Comprehensive characterization was performed using both laboratory-based techniques and advanced synchrotron radiation tools, including X-ray diffraction, magnetic dichroism, and spectromicroscopy, to elucidate the structural, magnetic, and electronic properties of the engineered multiferroic heterostructures.

Keywords: Multiferroic Heterostructures; Embedded Ferrite–$BaTiO_3$ Composites; Multifunctional Thin Films.

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INVITED SPEAKER

Id-2921

Successful Electrochemical Antibiotic Susceptibility Determination

H. P. DEIGNER*, O. RIESTER

Institute of Precision Medicine, Furtwangen University, Germany

* Corresponding author: Hans-Peter.Deigner(at)hs-furtwangen.de

Abstract. The antibiotic crisis is one of the most urgent challenges in global health. Across the world, bacterial pathogens are becoming increasingly resistant to common antibiotics, making the treatment of severe infections significantly more difficult. Difficult-to-treat infections and a considerable burden on the healthcare system, which led to 4.95 million deaths worldwide in 2019 in connection with antibiotic resistance and 1.27 million deaths directly attributable to antibiotic resistance, with an upward trend. Accordingly, rapid and precise identification of effective antibiotics is essential. We have developed a rapid, phenotypic test for the electrochemical determination of antibiotic efficacy—without the need for pre-culturing. Eliminating or drastically reducing this step enables results within hours instead of days. The test system is designed to be compatible with multiple sample matrices, allowing it to be used as a universal test system for several samples and pathogens rather than being specialized for a single sample or pathogen. This allows the rapid identification of the most effective antibiotic from the set tested, ensuring that treatment is targeted, timely, and effective. The test directly measures the response of pathogens to antibiotics in patient samples using a combination of Differential Pulsed Voltammetry and Electrochemical Impedance Spectroscopy. Algorithms afford a clear susceptibility score for each antibiotic tested a reliable, evidence-based recommendation is obtained within the same working day based on initial bacterial concentrations of 1 bacterium per 200 µl measurement chamber corresponding to a bacterial concentration in the serum sample of approximately 20 CFU/ml. A proof-of-concept study has been carried out with serum samples spiked with clinically relevant bacteria at concentrations of 1000 CFU/ml. The test achieved a sensitivity of 95%-CI: 74.2-99.0% (17 out of 18 samples) and a specificity of 95%-CI:79.8-99.3% (23 out of 24 susceptible samples) compared to the gold-standard disk diffusion method.

Keywords: Rapid Antibiotic Susceptibility Testing; Electrochemical Phenotypic Assay; Antimicrobial Resistance (AMR).

ORAL PRESENTATION

Id-2784

Visible-Light-Driven Degradation of Pollutants in Aqueous Solution Using TiO_2-Porphyrin Conjugates

N. MALOMANE, R. MOUTLOALI, M. MANAGA*

Institute for Nanotechnology and Water Sustainability (iNanoWS), Florida Campus, College of Science, Engineering and Technology, University of South Africa, Johannesburg 1710, South Africa

* Corresponding Author: managme@unisa.ac.za

Abstract. The discharge of pollutants into wastewater by various industries poses significant environmental challenges due to their persistence and potential toxicity, necessitating effective degradation strategies [1]. However, traditional wastewater treatment methods (physical, chemical, and biological) often face challenges, primarily due to the complex structure of dyes that limit their efficiency or require extensive energy inputs [2]. The present study explores the application of visible-light-driven degradation of pollutants in aqueous media using TiO_2-porphyrin conjugates. Photocatalysis utilizing TiO_2 nanoparticle semiconductor, due to its robust photocatalytic activity coupled with cost-effectiveness, is a promising strategy for wastewater treatment

TiO2 conjugates with porphyrin were synthesized and optimized with a constant amount of TiO_2 (100 mg) while varying the amount of porphyrin (1, 0.5, 0.25, and 0.1 mg) in the conjugate. Characterization of the conjugates was conducted using FT-IR, XRD, UV-Vis, SEM, EDX, and TEM techniques.

Keywords: TiO_2–Porphyrin Photocatalysts; Visible-Light Degradation; Wastewater Treatment.

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ORAL PRESENTATION

Id-2848

Development Of Sticking Road Line for High Visibility Unver Heavy Weather

J. Y. JOO*, J. S. PYO, S. J. LEE, J. P. KIM

Korea Photonics Technology Institute, Gwangju. Republic of Korea

* Corresponding author: jyjoo@kopti.re.kr

Abstract. This study focuses on the materials engineering development of a new retroreflective tape for road markings designed to enhance visibility during nighttime and rainy conditions. Traditional glass bead-based reflective systems suffer from mechanical and optical limitations due to bead detachment and embedment during application. To overcome these issues, the study introduces an optimized material composition and advanced optical structural design that ensure consistent retroreflective performance. Through the engineering of adhesive and reinforcement layer materials, the tape's durability against mechanical wear, thermal degradation, and moisture ingress is significantly improved. While closed surface designs contribute to abrasion resistance and environmental protection, conventional glass bead systems exhibit limited retroreflectivity and struggle to maintain vivid coloration. In response, microprism-based retroreflection emerges as a promising alternative, offering superior brightness and color fidelity for applications such as road signs, traffic devices, and vehicle markings. However, existing microprism-type tapes present structural limitations and challenges in color implementation when adapted for road surfaces. This study addresses those limitations through precision micro-patterning techniques and durable material integration, resulting in a high-performance, retroreflective road marking solution optimized for real-world environmental stress and long-term use.

Keywords: Road Line; Prism; Retroreflective Film; Optical Design.

Acknowledgment: This research was supported by the Ministry of Trade, Industry and Energy (MOTIE), Republic of Korea (RS-2023-20025039), title by Development of new materials for road marking and convergence sensing system for vehicles to improve driving safety).

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ORAL PRESENTATION

Id-2850

Challenges In the Plastic Deformation of Structurally Heterogeneous Materials

B. PABICH, J. MAJTA, M. KWIECIEŃ, S. BAJDA, P. LISIECKA-GRACA

AGH University of Krakow al. Adama Mickiewicza 30-059 Kraków

* Corresponding author: bpabich@agh.edu.pl

Abstract. The increasing demands placed on structural materials necessitate the development of novel solutions that combine high strength with adequate ductility. One promising class of materials meeting these criteria is metal to metal composites, in particular heterostructured materials, which are characterized by the presence of zones with drastically different mechanical or physical properties [1]. In such heterogeneous systems, for example multilayer composites, differences between constituent materials have significant implications at both the mechanical and microstructural levels. However, the influence of the plastic deformation method on their behavior and properties is often overlooked.

This study focuses on comparing the effects of various deformation techniques on the mechanical properties, material responses, and microstructural evolution in structurally heterogeneous systems. The analysis is based on research on multilayer samples composed of a microalloyed steel matrix and titanium layers [2]. Specimens with similar layer-thickness ratios were subjected to various deformation processes, such as:

- channel-die compression test, where stacks with different matrix-to-layer thickness ratios (2 mm and 4 mm steel, 1 mm titanium sheets) were deformed with strain of 0.25 and 0.5.
- deep wire drawing of two system types (Tube/Rod – St/Ti and Tube/Tube/Rod – St/Ti/St), from a diameter of 6.5 mm to 0.3 mm.
- and accumulative roll bonding, involving multiple rolling passes of St/Ti/St and St/Ti/St/Ti/St stacks.

Computer simulations were also conducted to better understand the differences in the adopted processes. The produced samples were then subjected to microstructural characterization tests, microhardness measurements, mechanical tests, and digital image correlation at various stages of the deformation process. The results demonstrate that material behavior cannot be assessed solely on the basis of the initial rheological properties of the individual components. Crucial importance lies in the microstructural evolution during deformation, which can significantly modify these properties through, for example, severe plastic deformation (SPD) and the architectural design of the multilayer system. These phenomena become especially significant when using materials that differ fundamentally in crystal structure and rheological behavior, such as those examined in the study, BCC-structured ultrafine-grained steel and HCP-structured titanium or magnesium.

Keywords: Hypoxic-Ischaemic Encephalopathy; Microglial; Light Sheet Fluorescence Microscopy.

Acknowledgements: The research was funded in whole by National Science Centre, Poland Grant number: OPUS 2022/45/B/ST8/01383.

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ORAL PRESENTATION

Id-2851

Photoluminescence and ESR Study of Nanosized $TMCe_xDy_xFe_{2-2x}O_4$ (TM = Co, Ni) Ferrites

T.S. MAHULE[1*] , A. MADLALA[2], J. Z. MSOMI[2], V. V. SRINIVASU[1]

[1] University of South Africa, Dept. of Physics, 1710, Johannesburg, South Africa, South Africa.

[2] Walter Sisulu University, Dept. of Chemical and Physical Sciences, P/Bag X01, 5117, Mthatha Eastern Cape, South Africa.

[*] Corresponding Author: mahults@unisa.ac.za

Abstract. The effect of rare earth Ce3+ and Dy3+ ion substitution on the photoluminescence and electron spin dynamics of cobalt and nickel ferrites with fine particles (9 ≤ D ≤11 nm) have been investigated. XRD and FTIR studies of $CoCe_xDy_xFe_{2-2x}O_4$ and $CoCe_xDy_xFe_{2-2x}O_4$ ($0 \le x \le 0.05$) nanoferrites produced by glycol-thermal method showed single phase cubic spinel phases with no impurity peaks. TEM data revealed spherical particles with sizes comparable to crystallite size revealed by XRD results. Rare earth substitutions have significant effects on photoluminescence properties. The compounds subjected to annealing processes from 4000C to 1000 0C showed enhancement of luminescence properties with increasing particle size. An Electron spin resonance analysis shows evidence of novel low field microwave signals, dependent on Ce^{3+} and Dy^{3+} ion concentrations. The evolution of the magnetic parameters such as g-factors, peak to peak widths and ESR signal intensities as a function of composition and particle size are also presented.

Keywords: Ferroics and Multiferroics.

ORAL PRESENTATION

Id-2852

Development of Organic-Inorganic Tandem Resistive ReRAMs for Green Computing

S. VALLABHPURAPU[1*], S. DESARADA[1], T. S. MAHULE[2], I. POLIKARPOV[3], B. B. MAMBA[4], F. NEMANGWELE[5]

[1]School of Computing, University of South Africa, Johannesburg1710, South Africa

[2]Physics Department, University of South Africa, Johannesburg1710, South Africa

[3]IFSC, University of Sao Paulo, San Carlos, Brazil.

[4]CSET, University of South Africa, 28 Pioneer Avenue, Florida Park, Gauteng 1709, South Africa

[5]Department of Physics, University of Venda, University Street, Thohoyandou, 0950, South Africa

[*] Corresponding Author: vallas@unisa.ac.za

Abstract. Resistive Random Access Memory (ReRAM) is a type of non-volatile memory for computers [1,2]. This study investigates the resistive switching mechanisms in chitosan and Starch based ReRAM devices, focusing on single-layer and bilayer structures incorporating Silicon Dioxide (SiO_2), Zinc Oxide (ZnO) (both inorganic and 'Green ' synthesised), and Titanium Oxide (TiO_2). Analysis of the natural logarithmic voltage versus current plots reveals distinct conduction behaviours during forward and reverse voltage sweeps. The single chitosan device exhibits bipolar resistive switching with ohmic conduction at low voltages, transitioning to a low-resistance state (LRS) characterized by steep conductive filament formation. In contrast, the SiO_2/Chitosan bilayer device demonstrates space-charge-limited conduction (SCLC) at low voltages, with enhanced stability due to trap distributions introduced by the SiO_2 layer. The ZnO/Chitosan bilayer displays mixed ohmic-SCLC conduction, resulting in rapid transitions to LRS, while the TiO_2/Chitosan device exhibits more complex charge transport dynamics influenced by trap distribution changes. the use of green-synthesized ZnO nanoparticles embedded within a starch matrix resulted in a device that exhibits both stable bipolar resistive switching and, for the first time in such a system, a pronounced Negative differential resistance (NDR) effect. The optimized device with 1 wt% ZnO displayed a significant memory window with an ON/OFF ratio of approximately 1000, indicating its potential for non-volatile memory applications.The study highlights how material composition significantly affects switching characteristics, with implications for optimizing ReRAM devices for memory applications and can be integrated with the 'Green Computing'.

Keywords: ReRAM; Tandem Device; Green Computing.

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ORAL PRESENTATION

Id-2858

Bio-Inspired ReRAM: Turmeric-Based Memory for Green Computing

K. T. P. GURU[1*], B. B. MAMBA[2], T. S. MAHULE[3], S. VALLABHAPURAPU[1]

[1]School of computing, University of South Africa, Johannesburg, 1709, South Africa.

[2]CSET, University of South Africa, Johannesburg, 1709, South Africa.

[3]Department of Physics, University of South Africa, Johannesburg, 1709, South Africa

[*] Corresponding Author: krishnathej@gmail.com

Abstract. Resistive Random Access Memory (RRAM) is receiving considerable interest as a prominent candidate for future non-volatile memory technologies, due to its advantageous characteristics, including high switching speed, low power consumption, and exceptional scalability. These devices often depend on the development and dissolution of conductive filaments within an active material, providing a straightforward yet efficient memory mechanism. This study investigates the possibility of turmeric, a natural and environmentally friendly organic substance, as an active switching layer in RRAM devices. Turmeric, derived from Curcuma longa, exhibits intrinsic semiconducting characteristics and demonstrates potential in many organic electronic applications owing to its abundant availability and affordability. We fabricated our device by applying a 0.5% turmeric solution onto a flexible polyethylene terephthalate (PET) substrate measuring 2 × 2 cm, utilizing a straightforward solution-processing method. Silver paste was utilized as the upper electrode, finalizing the metal-insulator-metal (MIM) device configuration. The electrical characterization of the constructed devices exhibited distinct resistive switching properties, indicating the turmeric layer's capacity to change between high and low resistance states. Preliminary cycling tests demonstrated consistent and steady switching behaviour across roughly 10 consecutive cycles, signifying reliable memory functioning. Nevertheless, beyond this threshold, the distinctive hysteresis loop, essential for memory performance, was noted to deteriorate. The initial findings underscore the viability of employing natural organic substances such as turmeric for the advancement of sustainable and adaptable RRAM systems. This study highlights the need for further analysis and optimisation of the observed endurance constraint, while also laying the groundwork for the exploration of bio-inspired materials in future memory applications.

Keywords: ReRAM; Green Computing.

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ORAL PRESENTATION

Id-2861

Spinel Ferrite Functionalised C3N5 Nanocomposite for Hydrogen Evolution and Photodegradation of Organic Pollutants in Water: Progress Made and Way Forward

N. MASUNGA[1], B. B. MAMBA[2], V. S. VALLABHAPURAPU[1],

[1]University of South Africa, Florida Science Campus, College of Science Engineering and Technology, Physics Department, South Africa

[2]University of South Africa, Florida Science Campus, College of Science Engineering and Technology, Institute for Nanotechnology and Water Sustainability, South Africa

[*] Corresponding Author: masungn@unisa.ac.za

Abstract. Considering the urgent need to adopt sustainable, pollution-free technologies that harness renewable resources such as solar energy, visible light-driven photocatalysis has garnered significant attention. This innovative approach offers an eco-friendly solution for eliminating water contaminants and facilitating hydrogen evolution reactions, all while preventing the generation of secondary waste. The difficulties in electron-hole separation during photocatalysis and the recovery of photocatalysts from treated water present significant obstacles. This review emphasises understanding the work done by spinel ferrite (SF) functionalised C3N5 nanocomposites, ranging from the merits and demerits of their synthesis methods; to confirmation of heterojunctions formed by various characterisation techniques. Moreover, their efficacy in removing organic pollutants from water, hydrogen evolution activities from water splitting, mechanisms followed during photodegradation experiments, and reusability and recoverability studies of the fabricated nanocomposites using a magnet were discussed. Overall, both individual components and SF functionalised C_3N_5 nanocomposites were found to exhibit remarkable potential for both hydrogen evolution and the photodegradation of organic pollutants in water. Finally, the current position of SF functionalised C_3N_5 nanocomposites in photocatalysts was ascertained, the existing research gaps were identified, and the way forward for advancing this technology for industrial applications was proposed. Therefore, addressing the challenges faced when spinel ferrite-functionalised C_3N_5 nanocomposites are used in photocatalysis could pave the way for next-generation sustainable materials in clean energy and environmental technologies.

Keywords: Spinel Ferrite; g-C3N5; Spinel Ferrite Functionalised C3N5, Photocatalysis; Organic Pollutants; Hydrogen Evolution; Heterojunction Confirmation; Magnetic Separation.

Acknowledgements: The University of South Africa is to be commended for making all the resources required for this project work available to the authors

ORAL PRESENTATION

Id-2917

Heterometallic Bifunctional PSS Colloids Based on Lanthanide Chelate Complexes as Contrast Agents and Sensors

A.P. DOVZHENKO[1,2], T.A. KORNEV[1,2], R.R. ZAIROV[1,2]

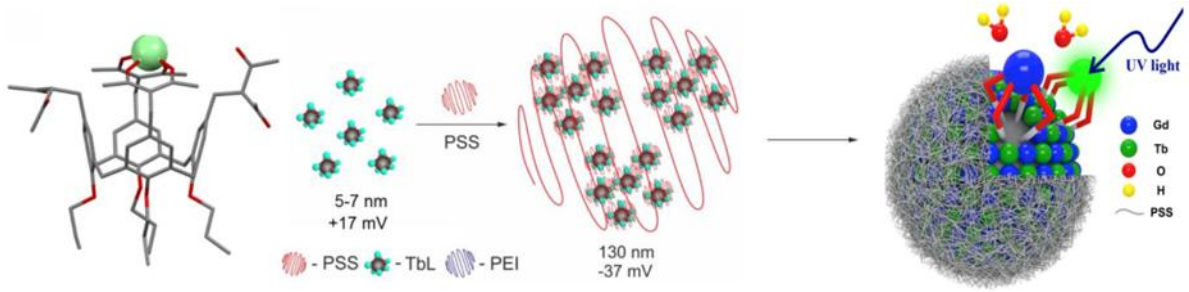
[1]Kazan (Volga region) Federal University, Kazan, Russian Federation

[2]Arbuzov Institute of Organic and Physical Chemistry, FRC Kazan Scientific Center of RAS, Kazan, Russian Federation

[*] Corresponding Author: aleksej_dovghenko@mail.ru

Abstract. Rare-earth-based nanoparticles continue to gain popularity within the scientific community and find applications in various fields, including unique nanomaterials, electronics, and biomedicine. The narrow, high-intensity emission bands and long excited-state lifetimes of lanthanides provide a higher signal-to-noise ratio, enabling more effective detection of changes in the coordination sphere of these metals. The position of the emission bands in this case depends solely on the specific lanthanide ion, while the ligand environment can be used to modulate the intensity and potential sensor properties of the lanthanide-centered luminescence. The temperature dependence of lanthanide-centered luminescence can serve as a basis for developing a non-invasive luminescent thermometric probe. Real-time temperature monitoring in vivo and in vitro is crucial for the detailed study of processes within cells and cellular organelles. It also allows for tracking temperature fluctuations during magnetic hyperthermia (MHT) or photothermal therapy (PTT) — two novel methods for the thermal treatment of cancer. Furthermore, the specific luminescence response of lanthanide complexes to the binding of ions or small molecules makes them exceptionally promising candidates for the development of highly selective luminescent chemo-sensors. Their inherent magnetic properties, particularly of Gd(III) ions, also allow these compounds to function as efficient magnetic relaxation contrast agents for magnetic resonance imaging (MRI). The integration of multiple functionalities, such as luminescent thermometry, chemo-sensing, and magnetic resonance contrast, into a single lanthanide-based nanoplatform represents a highly promising research direction in the field of in-vivo and in-vitro sensors and contrast agents. This work explores the potential of using a polyelectrolytic PSS nanoplatform as a basis for creating heterometallic lanthanide nanoparticles of various compositions. The universal method for hydrophilization and encapsulation of Ln(III) complexes allows for the combination of several functions within the PSS polyelectrolyte nanoparticles. Specifically, isostructural complexes of Eu(III) and Yb(III), Eu(III) and Sm(III), Tb(III) and Gd(III) were pairwise incorporated into the PSS colloids. The specific features of the mutual influence of lanthanide centers on the exhibited luminescent and magnetic relaxation properties are demonstrated. The combination of the unique properties of the lanthanides, the ligand environment, and the

polyelectrolyte shell, which is permeable to low-molecular-weight substrates, is a key advantage of these systems as luminescent probes.



Keywords: Lanthanide-Based Nanoparticles; Luminescent Thermometry & Sensing; Multifunctional PSS Nanoplatforms.

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ORAL PRESENTATION

Id-2918

Fabrication and Characterization of Peptide-Functionalized Laser-Induced Graphene for Explosive Sensing

S. KOL*, A. Y. ORAL

Department of Materials Science and Engineering, Gebze Technical University, Gebze, Kocaeli 41400, Turkey

* Corresponding Author: sedakol@gtu.edu.tr

Abstract. Laser-induced graphene (LIG) is a promising material for biosensors owing to its porous three-dimensional network, high electrical conductivity, and scalable fabrication. In this study, LIG films were fabricated on polyimide substrates via CO_2 laser irradiation and subsequently functionalized with DNT- and TNT-specific peptides through EDC/NHS coupling chemistry. This covalent approach enabled stable peptide binding via amide bond formation between surface carboxyl groups and peptide amino termini.

The structural and chemical characteristics were examined using SEM-EDS, XRD, FTIR, Raman spectroscopy, and XPS. The analyses confirmed the formation of a homogeneous, conductive LIG network and provided clear evidence of peptide immobilization, including amide I bands in FTIR/Raman spectra and characteristic N1s signals in XPS.

Overall, DNT- and TNT-peptide-functionalized LIG demonstrates strong potential as a durable sensing platform, with prospective applications in biosensing, bioelectronics, and security-related detection.

Keywords: Laser-Induced Graphene, DNT/TNT Detection, Peptide Functionalization, Covalent Immobilization.

Acknowledgements: This work was supported by Gebze Technical University (Project No. 2023-A-102-09) and Kocaeli University (Project No. FKA-2024-3756). Raman measurements were performed using the Renishaw Virsa™ system. We thank Renishaw for their support and instrument access.

ORAL PRESENTATION

Id-2920

Exploring Surface Analyzing on Different Substrate with Different Buffer Layer for Magnetic Sensor Applications

M. E. AKOZ[1,*], M. ERKOVAN[2], A. Y. ORAL[3]

[1]Gebze Technical University, Institute of Nanotechnology, Kocaeli/Turkiye

[2]Bolu Abant İzzet Baysal University, Nuclear Radiation Detectors Research and Development Center, Bolu/Turkiye

[3]Gebze Technical University, Department of Material Science and Engineering, Kocaeli/Turkiye

[*] Corresponding Author: akoz@gtu.edu.tr

Abstract. As technology and science advance rapidly, sensors are becoming increasingly indispensable in modern society. Thin magnetic films and magnetic sensors, which demonstrate unique magnetic, electronic, and optical properties, play a pivotal role in driving innovation across various technological sectors. A major focus of research on magnetic materials is the development of perpendicular magnetizations, owing to their clear advantages in data storage, particularly in Out-of-Plane (OOP) configurations. These magnetizations have shown significant promise in Perpendicular Magnetic Tunnel Junctions (p-MTJs), which are central to spintronic applications such as Spin-Transfer Torque Magnetic Random Access Memory (STT-MRAM) and high-performance magnetic sensors. The current study emphasizes synthetic antiferromagnetic (p-SAF) structures, particularly Co/Pt multilayers, due to their ability to generate large Perpendicular Magnetic Anisotropy (PMA) and high interlayer exchange energy. The strong coupling fields in p-SAFs enhance the stability of the reference layer, making them capable of sustaining magnetic performance under several kilo-Oersted conditions. Moreover, the introduction of Ru spacer layers facilitates the modulation of interlayer exchange coupling (IEC) effects, enabling controlled magnetic interactions between ferromagnetic layers. The multilayers were deposited via magnetron sputtering and thermal evaporation, and their structural and magnetic properties were evaluated using Magneto-Optical Kerr Effect (MOKE). The findings highlight the potential of p-SAF systems as robust pin layers for next-generation p-MTJs.

Keywords: Thin Films; Perpendicular Magnetization; SAF Structures; Nanotechnology.

POSTER PRESENTATION

Id-2787

Determination of Substances Formed during Combustion of Wood-Based Materials

K. MIZERA*, M. BORUCKA, J. PRZYBYSZ, A. GAJEK

Central Institute for Labour Protection – National research Institute, Czerniakowska 16, 00-701 Warsaw, Poland

* Corresponding author: kamila.mizera@ciop.pl

Abstract. Wood is a lignocellulosic substance located between the core and the bark of a tree or shrub. It is a renewable and easily processable material that has been widely used around the world for many years. Chemically, wood is primarily composed of three main polymers: cellulose (37-57%), which is a linear and mainly crystalline polysaccharide; hemicelluloses (16-37%), which are generally branched and amorphous polysaccharides; and lignin (17-36%), an aromatic and amorphous polymer [1]. When heated, the structure of wood undergoes changes dependent on its original chemical composition. The three main polymers of wood thermally decompose, forming a mixture of volatile gases, tar, and charcoal. This process occurs in a specific sequence: hemicelluloses decompose first (at temperatures of 180-350 °C), followed by cellulose (275-350 °C), and finally lignin (250-500 °C) [2]. This decomposition generates products such as carbon monoxide (CO), carbon dioxide (CO_2), and water (H_2O), which can pose a threat to human health and life, causing respiratory problems, nausea, vomiting, and even death. As a result of wood pyrolysis, various chemical compounds are formed. Cellulose generates, among others, furfuryl alcohol, furfural, and levoglucosan, while lignin produces eugenol, isoeugenol, vanillin, and guaiacol [3,4]. The content of cellulose and lignin in wood affects the type of products emitted. As the temperature increases, the decomposition of wood components leads to the formation of both flammable and non-flammable gases, which, in combination with other factors such as oxygen concentration, char layer, or the presence of flame retardants, significantly influence the combustion process. However, it is worth noting that some flame retardants containing nitrogen or halogens can also generate toxic compounds [5].

Wood-based materials in the form of board and pellets have been tested to identify substances produced during their combustion. A Purser stove combined with a system of selective analyzers was used for this purpose. The phases of the fire were reflected according to ISO 19700 [6].

It was observed that in addition to products such as carbon and nitrogen oxides, a number of phenolic compounds and substances from the group of polycyclic aromatic hydrocarbons (PAHs) were also present in the mixtures of emitted gases and fumes. Phenolic compounds are harmful substances and have toxic effects on aquatic organisms, causing long-term effects. Furfural is a biomass-derived compound obtained by hydrolysis and dehydration of xylan in lignocellulose, which contains an aldehyde group in its molecule and a conjugated double bond system in the furan ring. Furfural is a toxic substance and irritant. It has a toxic effect on the respiratory tract and is an irritant to the eyes and respiratory tract. Creosol is a phenolic aromatic compound that is a component of wood creosote. Creosote is a component of wood tar, a product of the dry distillation of wood. Among other things, it is emitted from chimney gases during the combustion of insufficiently dried wood. Cresol is an eye and skin irritant.

Keywords: Fire Effluents Analysis; Steady-State Tube Furnace; Fire Toxicity; Chromatography; Wood-Based Materials.

Acknowledgment: This task was completed on the basis of results of research carried out within the scope of the 6th stage of the National Programme “Governmental Programme for Improvement of Safety and Working Conditions”, funded by state services of the Ministry of Family, Labour and Social Policy. Task no.: 3.ZS.08. Entitled: “Analysis of pollutant emissions to the air during combustion of wood-based panels and the resulting pellets”. The Central Institute for Labour Protection – National Research Institute is the Programme’s main co-ordinator.

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POSTER PRESENTATION

Id-2791

Testing Of Clay-Carbonate Type Lithium-Borate Ore. Part I: Chemical Mineralogical Characterization of the Ore

I. JOVANOVIĆ*, D. MILANOVIĆ, V. CONIĆ, M. JANOŠEVIĆ, D. UROŠEVIĆ, M. BUGARIN

"Mining and Metallurgy Institute Bor, Alberta Ajnštajna 1, 19210 Bor, Serbia

* Corresponding author: ivana.jovanovic@irmbor.co.rs

Abstract. The demand for lithium is increasing all over the world. According to estimates so far, significant reserves of lithium, in addition to the countries of the European Union, are located in Serbia. In Serbia, there are certified deposits of lithium, of the clay-carbonate type, in addition to which there is also a significant content of boron. This paper presents the characterization of ore of this type, in which an increased lithium content was determined – 1010 ppm. In addition, the presence of boron in the amount of about 4000 ppm was determined. According to the obtained results, lithium is primarily bound to clay minerals of the smectite and illite type, while boron is predominantly present in the form of the minerals probertite and searlesite. The ore comes from a hitherto unexplored deposit located in the western part of Serbia. Petrological tests have established that the sample of this ore is on the border of carbonate fine-grained clastite and low carbonate marl.

Keywords: Li Clay-Carbonate Type Ore; Chemical Composition; Mineralogical Composition.

POSTER PRESENTATION

Id-2792

Testing of Lithium - Borate Ore of Clay - Carbonate Type Part 2: Methods of Selective Separation of Li From B

V. CONIĆ, M. JANOŠEVIĆ, D. MILANOVIĆ, I. JOVANOVIĆ, D. UROŠEVIĆ, M. BUGARIN

Mining and Metallurgy Institute Bor, Serbia

* Corresponding author: vesna.conic@irmbor.co.rs

Abstract. The demand for lithium is increasing worldwide. According to previous estimates, significant quantities of lithium are found in Serbia, in addition to the countries of the European Union. In Serbia, there are verified deposits of lithium, of the clay type, in addition to which a significant content of boron is also present. The paper presents research of the selective extraction of lithium and boron from clay lithium resources. In order to obtain Li2CO3, steps of selective extraction and precipitation were taken. Two possibilities for separating Li from B showed good results. The first possibility was the application of two-stage leaching of Li ore using H2SO4, where in the first stage 8.31% Li and 95%B were achieved, while in the second stage 85% Li and 4%B were achieved. The second possibility was the leaching of Li ore using 30g/L Na2CO3, where Li leaching was 1.33% and B leaching was 85.20%. The applied procedures achieved satisfactory selectivity of Li from B. This work can provide guidelines for the selective extraction of lithium and boron from clay-type lithium resources in the future.

Keywords: Clay-type Li ore; Selective extraction; Sodium carbonate; Sulfuric acid.

POSTER PRESENTATION

Id-2793

Effect of Glass Surface Orientation on Mechanical Behavior of Acrylate Adhesive Joints

K. V. MACHALICKÁ, M. VOKÁČ*

Czech Technical University in Prague, Klokner Institute, Šolínova 7, 166 08 Prague, CZ

*Corresponding author: miroslav.vokac@cvut.cz

Abstract. Adhesive bonding is considered a mechanically advantageous joining technique for glass components, as it accommodates the material's inherently low tensile strength and brittle behavior, while preserving the optical transparency required in structural glazing applications. The float glass production process results in two chemically and physically distinct surfaces: the bottom tin side, which is modified by direct contact with molten tin, and the top air side, which interacts with the oxidizing furnace atmosphere. These differences in surface composition and properties can affect the interfacial adhesion in glass-to-metal bonded assemblies. This study is part of a research project focused on adhesive joints subjected to long-term mechanical loading and moisture exposure. In this context, the orientation of the glass within the joint is a critical design parameter, and a thorough understanding of the adhesive behavior on both the tin side and the air side of the glass is essential to ensure optimal bonding performance and long-term durability. Previous study on similar adhesive system have reported adhesive failure when glass was bonded on its air side [1]. Therefore, we prepared an experimental program to assess the influence of glass surface orientation in float glass-aluminum specimens on the joint's strength and failure mode. Specimens were prepared as double lap shear joints with a symmetrical arrangement, resulting in two adhesive bonds of 12 x 50 mm. The thickness of the adhesive layer was 1 mm, as recommended by the manufacturer. Specimens bonded on the air side of the glass exhibited an average shear strength of 6.5 MPa and a combined failure mode, including "special cohesion failure" (SCF) as defined by ISO 10365 - characterized by failure close to the substrate – and adhesive mode of failure. In contrast, tin-side specimens showed an average shear strength of 5.6 MPa, with a predominantly cohesive failure mode. The predominant cohesive failure observed on the tin side is likely linked to the formation of –OH groups resulting from oxidation species that develop on the surface during the tin bath process. Lower shear strength for tin side specimens was probably caused by multiple factors combination beyond surface chemistry—such as wettability, bonding mechanisms, and surface roughness.

Keywords: Glass-aluminium joints, acrylate adhesive, glass surface, adhesion

Acknowledgement: The authors gratefully acknowledge funding from the Czech Science Foundation, under grant GA22-14105S.

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POSTER PRESENTATION

Id-2796

Comparative Analysis of Two Acrylate Adhesives Exposed to Water Immersion

K. V. MACHALICKÁ*, M. VOKÁČ

Czech Technical University in Prague, Klokner Institute, Šolínova 7, 166 08 Prague, CZ

*Corresponding author: klara.machalicka@cvut.cz

Abstract. The development of adhesives for structural applications has significantly broadened the possibilities for using adhesive joints in civil engineering. This study presents a comparative analysis of two acrylate adhesives from Sika — SikaFast 5215 NT and SikaFast 555 L05 — aiming to assess whether SikaFast 555 L05 offers comparable or improved performance over its predecessor in structural bonding applications. Our investigation included mechanical testing of double-lap shear joints, failure mode evaluation, and dynamic mechanical analysis to determine the glass transition temperature (Tg). The bonded joints were made using various substrates — blank aluminum, anodized aluminum, and continuously galvanized steel — tested in both their natural smooth state and after surface roughening with Scotch Brite. This approach enabled the assessment of adhesion performance across a broad range of materials relevant to civil engineering. The behavior of the bonded joints was assessed under both reference conditions and exposure to water. A subset of specimens was immersed in distilled water at 45 °C for three weeks to simulate the effects of moisture and water ingress, which often impact the long-term performance of adhesive bonds. The results indicate that while SikaFast 555 L05 is marketed as the successor to SikaFast 5215 NT, the two adhesives are not equivalent. Differences were observed in bonding strength, adhesion to specific substrates, Tg after water exposure, and general durability under moist conditions. SikaFast 555 L05 exhibited better adhesion to galvanized steel and slightly higher shear strength than its predecessor. It is therefore concluded that the two adhesives are not directly interchangeable.

Keywords: Metal-To-Metal Joints; Acrylate Adhesive; Adhesion; Durability; Water Immersion.

Acknowledgement: The authors gratefully acknowledge funding from the Czech Science Foundation, under grant GA22-14105S.

POSTER PRESENTATION

Id-2797

Synthesis and SERS Application of Microtubes for Trace Detection of Organic Contaminants

I.V. KOROLKOV [1,2*], A.B. KHAIRUSHEVA [1,2], I.B. MUSLIMOVA[1,2], A.K. SHAKAYEVA[1,2], N.N. ZHUMANAZAR [1,2], M.V. ZDOROVETS [1,2]

[1]The Institute of Nuclear Physics, 050032, Ibragimov str., 1, Almaty, Kazakhstan

[2]L.N. Gumilyov Eurasian National University, Satpaev str., 5, 010008 Astana, Kazakhstan.

[*] Corresponding author: korolkovelf@gmail.com

Abstract. The development of sensitive and reproducible analytical platforms for the detection of hazardous compounds is of increasing importance in food safety and environmental monitoring. This study presents the synthesis of copper and gold microtubes using a template method based on polyethylene terephthalate track-etched membranes (PET TeMs), followed by their application as substrates for surface-enhanced Raman spectroscopy (SERS). The copper and gold microtubes were deposited through a multi-step chemical procedure involving sensitization, activation, and reduction in eco-friendly solutions. The resulting microtubes were then extracted from the polymer matrix or used as flexible substrate during spectroscopic analysis.

The SERS performance of the copper microtubes was evaluated using methylene blue as a model analyte in concentrations ranging from 10^{-1} to 10^{-9} M. Raman spectra were recorded with a 532 nm excitation laser, and the results demonstrated a significant enhancement of the Raman signal. The calibration curve showed a linear relationship (R^2 = 0.974) for the 1440 cm^{-1} peak, indicating excellent sensitivity and potential for quantitative analysis. Notably, copper microtubes themselves did not produce any interfering Raman peaks, making them ideal for SERS-based applications.

Spatial analysis across different zones of microtube assemblies (single, intersected, and clustered) revealed variability in signal intensity, highlighting the importance of morphology in optimizing enhancement effects. These findings confirm the viability of copper microtubes as low-cost, efficient SERS substrates for detecting organic dyes and potentially other hazardous molecules at trace levels.

Keywords: Cu Microtubes; Au Microtubes; SERS; Raman Spectroscopy; Microtube Modification.

Acknowledgment: The research titled “Development of innovative platforms for surface- enhanced Raman spectroscopy” (grant No AP23486127) was funded by the Ministry of Science and Higher Education of the Republic of Kazakhstan.

POSTER PRESENTATION

Id-2799

Facile Synthesis Route for Bulk Production of Complex Fullerene-Like MoS_2 Nanostructures with Enhanced Tribological Properties

A. MRZEL, A. DRNOVŠEK, D. VENGUST, P. ŠUMANDL, D. KORBAR, M. VILFAN

Jožef Stefan Institute, Jamova 39, 1000 Ljubljana, Slovenia

* Corresponding author: ales.mrzel@ijs.si

Abstract. Molybdenum dichalcogenides -based nanoparticles are often used as oil additives to enhance a material's tribological performance. Here, we present first a highly efficient synthetic route for the bulk production of two types of MoS_2 nanostructures: multi-wall nanotubes and fullerene-like nanostructures. The presented two-step synthesis involves the transformation of ammonium heptamolybdate tetrahydrate and aniline into precursor nanowires, which are later transformed into MoS_2 through heating in a H_2S, H_2, and argon atmosphere to approximately 800 °C. Depending on the heating rate, we successfully grew MoS_2 layered compounds in various shapes and sizes. The resulting structures and compositions were characterised by X-ray powder diffraction, Raman spectroscopy, energy-dispersive X-ray spectroscopy, and electron microscopy. To assess the application potential of these MoS_2 compounds, they were dispersed in polyalphaolefin (PAO 6) oil. By comparing their tribological properties, we find that the slowly heated sample with smooth outer layers exhibits a lower friction coefficient than the fullerene-covered nanotubes. More importantly, both show improved friction performance compared to reference commercial MoS_2 and are comparable to previously reported fullerene-like nanoparticles. The presented method can be easily scaled up for mass production in the existing industrial capacities and may in the future find its way into commercial application

Keywords: Molybdenum Dichalcogenides; Nanotubes; Fullerene**;** Tribological Properties.

POSTER PRESENTATION

Id-2801

Adsorption Efficiency of Activated Macadamia Nutshell for the Removal Organochlorine Pesticides: Endrin and 4,4-Ddt from Aqueous Solution

M. J. PHELE[1,*], I. P. EJIDIKE[1,2], F. M. MTUNZI[1,3]

[1]Department of Chemistry, Faculty of Applied and Computer Sciences, Vaal University of Technology, Vanderbijlpark, 1911, South Africa

[2]Department of Chemical Sciences, Faculty of Science and Science Education, Anchor University, Lagos, 100278, Nigeria

[3]Institute of Chemical and Biotechnology, Faculty of Applied and Computer Sciences, Vaal University of Technology Southern Gauteng Science and Technology Park, Sebokeng, 1983, South Africa

[*] Corresponding author: Phelemj85@gmail.com

Abstract. Many Organochlorine pesticides (OCPs) are currently used as pesticides have been of great concern due to their persistence, bioaccumulation as well as their toxicological effects on human health and the environment. The efficiency of activated macadamia nutshell as an adsorbent for removing pesticide mixture from the water was investigated. The treated macadamia nutshell was characterized using Fourier Transform Infrared Spectroscopy (FT-IR), scanning electron microscopy (SEM). Batch mode adsorption experiments were conducted by varying pH, concentration, adsorbent dose and contact time. Pesticide removal was pH-dependent and found to be maximum at pH 2.0. The adsorption data were fitted to Langmuir, Freundlich, and Dubnin-Radushkevich (D-R) adsorption isotherm models. Experimental results showed that the Langmuir isotherm model best describes for the adsorption of endrin and 4,4-DDT. Pseudo-first order, pseudo-second order, and Weber-Morris equations were applied to fit the kinetic results. The kinetics data for the adsorption process obeyed second-order rate equation. It was observed that 10 mg of activated macadamia could remove more than 91 % of endrin and 84 % 4,4-DDT from 10 ml of pesticide solution.

Keywords: Adsorption Isotherms; Pesticides; Macadamia Nutshell, Kinetics; Endrin, 4,4-DDT.

Acknowledgements: The presenter would like to thank Vaal University of Technology, Research Office, for the financial support and the Institute of Chemical and Biotechnology at Science Park, Sebokeng for making their laboratories available to conduct this research.

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POSTER PRESENTATION

Id-2802

Mechanical Properties of Apple Tissue Under Impact Loading Conditions

K. GOŁACKI

28 Głęboka Street 20-612 Lublin, Poland, Department of Mechanical Engineering and Automation, University of Life Sciences in Lublin, Mobile: (48)728493464

* Corresponding author: krzysztof.golacki@up.lublin.pl

Abstract. The aim of this research was to determine the force response-time, velocity-time and displacement-time courses and the parameters to describe course and effects of the impact such as: the maximum stress, the coefficient of restitution, the contact diameter, the peak deformation during apple mechanical loading. The application of two independent measuring systems: the high-speed camera to measure displacement and the force measurement track allowed to avoid errors caused by oscillations. The research was carried out on 'Rubin', 'Florina' and 'Freedom' apple varieties. To eliminate the influence of mass and shape (curvature radius) on bruise size, all fruits were selected to have the weight in the range from 170 g. to 180 g. and the maximum diameter of 75-80 mm. The second criterion of apple varieties selection was their firmness. The 'Florina' variety is considered to be hard, 'Rubin' firm and 'Freedom' soft. The apples were dropped from six different heights to obtain the impact velocities 0.25, 0.5, 0.75, 1, 1.25, 1.5 ms^{-1}. For each drop height, 10 repetitions were made. For tested apple varieties with the weight of 170-180 g, the bruise occurrence beginning at the impact velocity amounting to 0.5 ms^{-1} was found. The experiment confirmed the importance of the critical stress criterion as regards the whole fruit under impact loading conditions. The coefficient of restitution was an appropriate parameter which allowed to determine the initial apple bruising.

Keywords: Apple Impact, Bruise Formation, Coefficient of Restitution, Critical Stress, Impact Velocity.

POSTER PRESENTATION

Id-2804

Surface Modification of Semiconductors Using Radicals Generated by Heated Catalyst

A. IZUMI

Kyushu Institute of Technology

*Corresponding author: izumi@ele.kyutech.ac.jp

Abstract. This presentation reviews research on the surface modification of metals and semiconductors at room temperature using radicals generated by a heated catalyst, a topic the authors have investigated for many years. Hydrogen molecules are decomposed on a catalyst made of tungsten heated to high temperatures, producing hydrogen radicals. These radicals can clean the surface of semiconductors and reduce metal oxides, as well as remove carbon-based contaminants from these surfaces. Furthermore, by adding a small amount of water vapor into the hydrogen gas, it is possible to oxidize the surface of silicon, resulting in the formation of a silicon oxide film of a few nanometers in thickness. Additionally, using ammonia as the source gas enables the nitridation of the surfaces of various materials. This presentation summarizes the findings and discusses the future prospects of this technology.

Keywords: Surface Modification, Hydrogen Radicals, Catalyst-Assisted Reactions, Semiconductor Cleaning.

POSTER PRESENTATION

Id-2806

Corrosion of Al-Mg-Sc Alloy and Its Inhibition by Surface Organosilicon Micro and Nanolayers

M. A. PETRUNIN[1*], L. B. MAKSAEVA[2]

[1]A. N. Frumkin Institute of Physical Chemistry & Electrochemistry of the Russian Academy of Sciences,31 Leninsky pr. 119071 Moscow, Russia.

[2]A. N. Frumkin Institute of Physical Chemistry & Electrochemistry of the Russian Academy of Sciences,31 Leninsky pr. 119071 Moscow, Russia.

* Corresponding author: mmvp@bk.ru

Abstract. The corrosion behavior (including biocorrosion) of an Al-Mg-Sc alloy in corrosive electrolytes and in natural and artificial atmospheres has been studied. The alloy exhibits high resistance (exceeding that of pure aluminum) to the action of corrosive media. It was found that under the uniform corrosion conditions (electrolyte, atmosphere), the corrosion rate of the alloy does not exceed 1 μm/year, while if local (pitting) corrosion occurs, the corrosion rate is not large, either, and not exceeds 2 μm/year.The process of modification of the surface of Al-Mg-Sc alloy with organosilicon monomers (organosilanes) was studied, as a result of which polymeric organosilicon layers are formed on the surface, the thicknesses of the formed surface layers were estimated and it was shown that they vary from 3 nm to 18 pm.The ieffect of formed surface organosilicon layers on the corrosion of an alloy based on the Al-Mg- system has been determined, and their corrosion-inhibiting effect has been demonstrated. 4 It has been established that under conditions of uniform corrosion, a mixture of vinyl (VS) and aminosilanes (AS) inhibits corrosion most effectively. In the case of localized (pitting) corrosion, maximum efficiency was observed when using compositions based on bvinylsilaneThe results of a systematic study and generalization of the patterns ofcorrosi on behavior of Al-Mg-Sc alloy in environments inoculated with sulfate-reducing bacteria and 6 types of micromycetes: Trichothecium roseum, Richothecium roseum, Fusarium sambucinum, Aspergillus flavus, Aspergillus niger and Penicillium funiculosum were obtained.The inhibitory effect of the studied VS, VS+AS and VS+BTA coatings on corrosion in the presence of all studied microorganisms is shown. It is found that the best corrosion-inhibiting effect on mycelial fungi is possessed by coating based on vinylsilane. The best coating for inhibiting SRB-initiated microbiological corrosion is a vinylsilane-based coating.

Keywords: Uniform Corrosion; Localized Corrosion; Accelerated Corrosion Tests; Biocorrosion; Organosilanes; Surface Self-Assembled Organosilicon Nanolayers.

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POSTER PRESENTATION

Id-2822

Single Domain Wall Propagation in Co-Rich Magnetic Microwires with Graded Magnetic Anisotropy

P. CORTE-LEÓN [1,2,3,4], V. ZHUKOVA [1,2,3*], J. M. BLANCO [2,3], A. ZHUKOV [1,2,3,5]

[1]Dept. Polym. Adv. Mater, Univ. Basque Country, UPV/EHU, 20018 San Sebastian, Spain

[2]Dept. Appl. Phys. I, EIG, Univ. Basque Country, UPV/EHU, 20018, San Sebastian, Spain

[3]EHU Quantum Center, UPV/EHU, 20018, San Sebastian, Spain

[4]Dept. Mater. Science & Metallurgy, Univ. Cambridge, Cambridge CB3 0FS, UK

[5]IKERBASQUE, Basque Foundation for Science, 48011 Bilbao, Spain

[*] Corresponding author: valentina.zhukova@ehu.es

Abstract. Studies of amorphous magnetic wires have attracted great interest owing to outstanding magnetic properties, like the giant magnetoimpedance (GMI) or the magnetic bistability and related single domain wall (DW) propagation. The so-called Taylor-Ulitovsky technique allows manufacturing amorphous magnetic wires of the widest diameters range (from 200 nm up to 100 μm) coated with an insulating and flexible glass-coating. The DW velocities observed in amorphous microwires with magnetic bistability are generally an order of magnitude superior to that of planar nanowires produced by lithography or sputtering. For proposed applications the degree of the DW dynamics control is essentially relevant. The controllable domain wall, DW, nucleation and propagation have been predicted in such magnetic materials with graded magnetic anisotropy using the theoretical simulation. Such graded magnetic anisotropy was obtained using rather complex techniques, such as a change in the chemical composition during the thin films deposition. The controllable domain wall, DW, nucleation and propagation have been predicted in such magnetic materials with graded magnetic anisotropy. Recently we proposed simple method to prepare Fe-rich glass-coated microwires with graded magnetic anisotropy by stress-annealing at variable temperature. On the other hand, hysteresis loops of Co-rich microwires can be substantially tunned by annealing temperature, T_{ann}. Accordingly, we studied the effect annealing at variable T_{ann} on hysteresis loops and dependence of DW velocity, v, versus magnetic field, H, in $Fe_{3.6}Co_{69.2}Ni_1B_{12.5}Si_{11}Mo_{1.5}C_{1.2}$ microwire. In such Co-rich microwire we observed a gradual modification of the hysteresis loops along the microwire length. As earlier predicted, in the region with graded anisotropy we observed unusual DW propagation where the DW velocity is non-uniform along the microwire. While in the region annealed at constant Tann, the DW velocity values between the pick-up coils 1-2 and 2-3, v_{1-2} and v_{2-3} respectively are almost the same. Resuming, have proposed rather simple method to design graded magnetic anisotropy in Co-rich magnetic microwire by annealing microwires with a temperature gradient.

Keywords: Magnetic Wires, Domain Wall Propagation, Magnetic Anisotropy, Coercivity, Internal Stresses.

POSTER PRESENTATION

Id-2832

Synthesis of Coumarinphosphonium Salts and Reactions with Aromatic Aldehyde

D. SARALIEVA, N. I. PETKOVA-YANKOVA, A. I. KOLEVA, R. D. NIKOLOVA*

Sofia University "St. Kliment Ohridski", Faculty of Chemistry and Pharmacy, Department of Organic Chemistry and Pharmacognosy, Sofia, 1 James Boucher Blvd., Sofia 1164

* Corresponding author: rnikolova@chem.uni-sofia.bg

Abstract. The present studies investigate several possibilities for obtaining coumarinphosphonium salts from bromo substituted coumarins. Representatives of these salts are potential precursors for phosphorus ylides and, according to the literature review, have not been actively studied under conditions for the Wittig reaction of coumarins. The participation of in situ ylides obtained by us has been previously tested with aromatic aldehydes. As a result of the studies, conjugated systems based on coumarins have been modeled. The influence of the base, solvent and temperature for obtaining the target compounds has been studied. The stereochemical course of the reactions with the formation of π-diastereoisomers has also been examined. The trans (E) - configuration of the obtained compounds has been established, confirmed by NMR spectra. The studies reveal possibilities for further structural diversity of stilbene-type compounds with an included coumarin fragment through appropriate selection of substituents and modifications, as well as for studying their photophysical and biological properties. The mutual arrangement of the substituents determines the potential biological activity of the resulting compounds, which are classified as stilbene compounds and combretastatin A-4 as the main representative.

Keywords: Coumarin; Bioactivity; Optical properties; Synthesis.

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POSTER PRESENTATION

Id-2833

Nanomaterials with Bactericidal Properties for Medical Textile Applications

B. MARATULY *, B. AZAMATOV

Smart Engineering Competence Centre, D. Serikbayev East Kazakhstan Technical University, 19 Serikbayev Street, 070010 Ust-Kamenogorsk, Kazakhstan

*Corresponding Author: makebake9301@gmail.com

Abstract. Healthcare-associated infections (HAIs) remain a critical patient safety concern, with contaminated medical textiles serving as overlooked reservoirs for pathogens. Recent advances in nanomaterial-enhanced antimicrobial textiles offer a compelling solution. This analysis evaluates nanomaterials like silver, zinc oxide, and titanium dioxide nanoparticles, which exhibit broad-spectrum activity against multidrug-resistant bacteria (e.g., MRSA) and enveloped viruses (e.g., SARS-CoV-2). Their effectiveness stems from multiple mechanisms: silver ions disrupt microbial DNA replication, while titanium dioxide generates reactive oxygen species under light, degrading viral envelopes. Integrating these nanomaterials into textiles requires techniques that balance durability with functionality. Magnetron sputtering, for example, creates uniform nanoparticle coatings on fabrics, while electrospinning embeds antimicrobial agents directly into nanofiber matrices. However, real-world adoption faces challenges. After 50 industrial washes, some silver-coated textiles lose 70% of their efficacy, and copper nanoparticles raise concerns about skin irritation in prolonged use. Future efforts prioritize eco-friendly solutions, such as biosynthesized nanoparticles from plant extracts, and smart textiles that respond to infection biomarkers. Innovations like light-activated antimicrobial linens or wound dressings that release antibiotics only in the presence of bacteria highlight the field's potential. For these technologies to translate into clinical practice, interdisciplinary collaboration—materials science, microbiology, and environmental engineering—will be essential to address safety, cost, and scalability.

Keywords: Nanomaterials; Bactericidal Properties; Medical Textiles; Antimicrobial Coatings.

Acknowledgement: This research was funded by Ministry of Science and Higher Education of the Republic of Kazakhstan, grant number AP25794661.

POSTER PRESENTATION

Id-2843

One-Pot Synthesis of Fused-Rings Heterocyclic Systems Based on Symmetrically Benzofuran Annulated 1,8-Naphthalimides

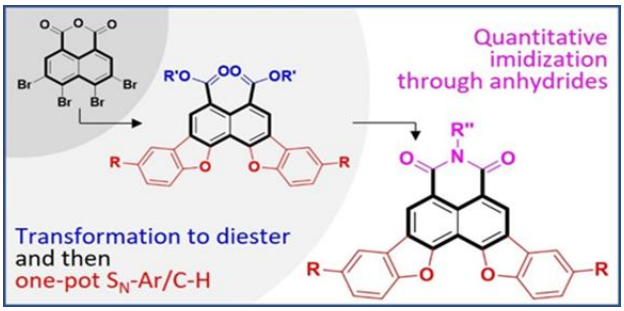
Y. ZAGRANYARSKI[1,*], M. MUTOVSKA[1], Z. VLAHOVA[2], I. UGRINOVA[2]

[1]Sofia University "St. Kliment Ohridski", Faculty of Chemistry and Pharmacy, 1 J. Bourchier Ave., 1164 Sofia, Bulgaria

[2]Institute of Molecular Biology "Acad. Roumen Tsanev", Bulgarian Academy of Sciences, Acad. G. Bonchev str., bl. 21, 1113 Sofia, Bulgaria

[*] Corresponding author: ohjz@chem.uni-sofia.bg

Abstract. Linearly fused acenes and heteroacenes were unambiguously recognized as one of the most important class of organic semiconductor materials. Hence, myriads of synthetic strategies for preparation of such systems from perylene and naphthalene diimides (PDIs and NDIs respectively) were successfully implemented. In stark contrast, the use of naphthalene monoimides (NMIs) as starting material to build π-extended aromatic systems is not fully developed. Despite providing more positions for annulation of additional rings, compared to NDIs, and successful valorization in various fields (bioimaging, anti-cancer drugs, DNA intercalators, and semiconductors), some substitution patterns remain overlooked or simply unexplored. This is, for instance, the case for the annulation of five-membered heterocyclic rings at positions 3 and 4. To the best of our knowledge, only two examples of unsymmetrical benzofuran fused NMIs are reported, and just a few for their N- and S-containing analogues. There are indeed, to date, no examples of symmetrical NMI derivatives constituted of two five-membered heterocyclic rings fused at both 3,4 and 5,6 positions respectively. In this context, we report herein a straightforward, accessible, and versatile strategy to afford such new and original heteroacene-like systems with two non-linearly condensed dibenzofuran units [1].



Keywords: 1,8-Naphthalimides; Heteroacenes; Anti-Cancer Drugs; DNA Intercalators; Semiconductors.

Acknowledgment: This research was funded by the Bulgarian National Science Fund, grant number KP-06-H61/1.

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POSTER PRESENTATION

Id-2846

Magnetron Sputtering of Radio-Absorbing Multilayer Co-C-Cr Coatings on Undoped Monocrystalline Silicon

N. PROKHORENKOVA[1,2*], A. ZHILKASHINOVA[1], D. ALONTSEVA[1,2]

[1]Sarsen Amanzholov East Kazakhstan University, 34 Tridtsatoy Gvardeiskoy Division Str., 070002, Ust-Kamenogorsk, Kazakhstan.

[2]D. Serikbayev East Kazakhstan Technical University, 19 Serikbayev Street, 070010 Ust-Kamenogorsk, Kazakhstan.

[*] Corresponding author: nadin_kaz@mail.ru

Abstract. The development of radio-absorbing materials with improved characteristics in a wide range is an urgent task due to the growing requirements for electromagnetic compatibility. In the last decade, special attention has been paid to nanostructured and composite films obtained by magnetron sputtering (MS), which provides control over the thickness, composition and phase structure of the material. In such films, the formation of amorphous-crystalline and nanocrystalline phases is often observed, which contributes to the emergence of additional scattering and absorption mechanisms. Composite materials based on transition metals and carbon, in particular the Co-C-Cr system, are of interest due to the combination of electromagnetic, mechanical and thermal properties. The objective of this work was production of multilayer Co -C -Cr coatings by magnetron sputtering (MS) onto substrate from porous undoped monocrystalline silicon and study of coating structural-phase characteristics and microwave-range radio-absorbing properties. The microstructure of the coatings was studied by transmission and scanning electron microscopy, and the phase state was studied by X-ray diffraction (XRD) analysis. Modeling of absorption of four- and eight-layer material was carried out according to the dependences of complex permittivity epsilon = er * (1 - i * loss tangent). Studies of the coating absorption characteristics were carried out using the VectornetworkanalyzerP9373A equipment. The reflection coefficient was measured by the vector network analyzer method in the range of 1–12 GHz. As a result of the work, four- and eight-layer MS coatings with a thickness of 4 ± 0.2 μm and 8 ± 0.2 μm correspondently were obtained. The four-layer Co-C-Cr-Co coating is characterized by a multilayer structure with a clear separation by composition and a combined structural-phase state. Metallic layers (Cr and Co) are in a nanocrystalline state, with possible texture in the surface areas. The carbon layer is predominantly amorphous, which is confirmed by the absence of characteristic XRD peaks. The interphase boundaries are clear and stable, without signs of diffusion and formation of intermetallic phases. A structure with alternating amorphous and crystalline phases is created, and sharp boundaries between the layers enhance the scattering and absorption of electromagnetic waves. The eight-layer Co–Cr–C coating is a multilayer composition with alternating layers that differ in elemental and phase composition. The structure includes metallic phases of Co and Cr, as well as amorphous or nanocrystalline carbon components. Significance of the results. The results indicate the successful formation of a controlled nanostructured system with potentially high functional properties. Such multilayer radar-absorbing coatings are much more effective than single-layer analogs due to a combination of loss mechanisms, improved impedance matching, multi-stage reflection, interference attenuation and the possibility of adaptation to broadband application, which makes them promising for use in radar camouflage systems and protection from microwave radiation.

Keywords: Structural-Phase State; Amorphous Phase; Nanocrystalline Component.

Acknowledgement: This research was funded by the Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan, grant number AP19680101.

POSTER PRESENTATION

Id-2857

A Facile Electrochemical Method for Functionalization of Anthraquinone Derivatives

E.M. KIRILOVA*, A. GRIGORJEVS, I. MIHAILOVA, R. FRIDMANS, I. BOREIKO, M. KIRJUSINA

Institute of Life Sciences and Technology, Daugavpils University, Daugavpils, Latvia.

* Corresponding author: jelena.kirilova@du.lv

Abstract. Anthraquinone derivatives are of great practical importance due to their unique spectral and oxidation-reduction properties. Numerous studies on the synthesis of anthraquinones have been devoted to the development of industrial dyes, pigments and luminophores [1]. Anthraquinone derivatives are promising for the creation of new materials for optoelectronics, photo printing, and as chemosensors and photopolymerization initiators. The development of methods for functionalization of anthraquinones is of fundamental importance for the targeted synthesis of new desired compounds. The structural features of anthraquinones crucially affect their chemical properties and the possibilities of their modification [2]. Electrochemical functionalization is a rapidly growing area of interest in organic synthesis. Electrochemical processes allow for shorter reaction times, safer working environments, and better selectivity [3]. The aim of present work is to expand the scope of application of electrochemical methodologies for anthraquinone derivatives, providing new functionalized intermediates for potential applications in organic synthesis and materials science. Electrochemical approach was used to introduce halogen atoms into the 1-aminoanthraquinone molecule, focusing on reaction efficiency, product selectivity and environmental benefits. The process was optimized for chlorine and bromine using different tetraalkylammonium halides in various solvents (ethanol, acetone etc.) and analyzed for potential applications in materials science. The results indicate that the developed method provides a robust and efficient route for the halogenation of 1-aminoanthraquinone.

Keywords: Anthraquinone; Electrochemistry, Synthesis; Functionalization; Halogenation.

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POSTER PRESENTATION

Id-2860

Insights Into the Defect Structure of $NaBa_{12}(BO_3)_7F_4$ (NBBF) Crystals Using Raman Spectroscopy and Dielectric Measurements

T.B. BEKKER,[1,2] A. V. DAVYDOV,[1,2] N. E. SAGATOV[1], A. YU. MOLOKOV[3], E. YU. KOROLEVA[3], S. B. VAKHRUSHEV[3], A. F. VAKULENKO[4]

[1]Sobolev Institute of Geology and Mineralogy, Siberian Branch of Russian Academy of Sciences, 630090 Novosibirsk, Russia

[2]Novosibirsk State University, 630090 Novosibirsk, Russia

[3]Ioffe Institute, Polytechnicheskaya, 26, 194021 St. Petersburg, Russia

[4]Peter the Great SPbPU, Polytechnicheskaya, 29, 195251 St. Petersburg, Russia

[*] Corresponding author: t.b.bekker@gmail.com

Abstract. Borate crystals are characterized by many functional properties, most pronounced in the field of nonlinear and polarization optics. The $NaBa_{12}(BO_3)_7F_4$ (NBBF) ($P4_2bc$) crystals belong the extremely interesting class of "antizeolite" borates, the optical properties of which have been actively studied in recent years [1-3]. We believe that the most striking characteristics of NBBF crystals are their dichroic properties and the strong dependence of the color of grown crystals on the composition of the initial high −temperature solution in the absence of any chromophore ions. There is no doubt that it is the intrinsic structural defects that determine the difference in properties. The study of optical transparency, electronic properties, and Raman spectra with 532 nm and 325 nm excitation of differently colored NBBF crystals has been conducted. All Raman−active modes determined for the pristine NBBF structure by *ab initio* density functional calculations coincide perfectly well with the observed modes in the experimental spectra. These additional modes are attributed to the presence of an extra borate group within the structural channels [4].The dielectric properties of two deep-purple *"antizeolite"* borate crystals were investigated. Dielectric response measurements were performed both parallel (|| z) and perpendicular (⊥ z) to the crystallographic z-axis. In NBBF-1 || z, a dielectric permittivity maximum appears near 290 K, reaching ε' ≈ 370 at 0.1 Hz. A similar permittivity peak is observed in NBBF-2 || z, though at significantly lower temperatures. In contrast, the NBBF ⊥ z samples exhibit no dielectric anomalies, with ε' remaining below 20 – a typical value for borates. The relaxation dynamics in NBBF || z are attributed to polar defect dynamics, with a distinct relaxation process linked to the observed dielectric anomaly. Notably, ferroelectric hysteresis loops are detected in NBBF-1 at 270 K, suggesting that the polar defect system induces weak ferroelectricity in the crystal [5].

Keywords: Antizeolite Borates, NBBF Crystals, Structural Defects, Optical and Dielectric Properties.

Acknowledgments: The study was supported by the Russian Science Foundation under grant № 24-19-00252, https://rscf.ru/project/24-19-00252/.

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POSTER PRESENTATION

Id-2864

Low-Cost Synthesis of Iodine-Doped Carbon Dots as A Promising Contrast Agent for Ct

T. S. ATABAEV*

Nazarbayev University, Department of Chemistry, Astana, Kazakhstan

* Corresponding author: timur.atabaev@nu.edu.kz

Abstract. Carbon dot-based radiocontrast agents have recently sparked the interest of researchers owing to their better contrasting capabilities, simple synthesis protocols, high colloidal stability, and good biocompatibility. In this study, we propose for the first time the synthesis of iodine-doped carbon dots (I-CDs) using low-cost reagents such as citric acid, urea, and potassium iodide. The as-prepared I-CDs demonstrated excellent colloidal stability (with a zeta potential value of −64.7 mV), excitation-dependent fluorescent properties (with a maximum quantum yield of ~8.9%), and a mean iodine concentration of ~4.67 wt%. Notably, the as-prepared I-CDs displayed greater X-ray attenuation efficiency (42.87 HU mL mg^{-1}) as compared to the commercially employed iopromide radiocontrast agent (30.98 HU mL mg^{-1}). Furthermore, ATPase activity, cytotoxicity analysis with HeLa, NHDF, HEK293, and A549 cell lines, and live-cell imaging experiments of the Drosophila neuroblasts in intact brain lobes suggested high biocompatibility and nontoxicity of the prepared I-CDs [1]. Overall, biocompatible and low-cost I-CDs show great promise as bifunctional radiocontrast and fluorescent agents for biomedical applications.

Keywords: Carbon dots; Contrast Agent; CT; X-Ray Attenuation; Cytotoxicity.

Acknowledgment: This research was funded by the Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan (Grant No. AP19578878).

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POSTER PRESENTATION

Id-2865

Correlation of the Electronic Properties of 2d Conjugated MOFs with Their Linker Aromaticity Using Nuclear Independent Chemical Shift

K. B. SIMEONOVA[A], P. ST. PETKOV[A], T. I. IVANOV[B]

[1]Faculty of Chemistry and Pharmacy, Sofia University "St. Kliment Ohridski", Sofia, Bulgaria

[2]American College of Sofia, Sofia, Bulgaria

* Corresponding author: ohks@chem.uni-sofia.bg

Abstract. By using first-principles calculations, we have investigated a series of prototypical 2D Metal-organic frameworks with different aromatic linkers. The role of π-orbitals in determining their electronic structure and the tendency to form delocalized π-systems is analyzed in relation to the chemical nature of the linker unit. To investigate the strength of the π-conjugation of the studied 2D MOFs systems, we have calculated Nuclear Independent Chemical Shift (NICS). NICS is a well-established measure of aromaticity.[1, 2] The major advantage over other measures of aromaticity is that NICS is applicable to macrocyclic systems and even to non-planar structures. Moreover NICS has been already tested for predicting the electronic properties of 2D COFs. [3] We investigated the NICS for isolated linkers with various functional groups (OH, NH_2, SH), and also for 2D MOFs fragments to check: i) The influence of the functional groups on the aromaticity strength in the linker; ii) The influence of the dimerization with transition metal ions (Cu^{2+}, Zn^{2+}) on the aromaticity in the outhermost aromatic ring in the fused polyciclic aromatic systems. Moreover, we have analyzed the correlation between the calculated NICS and the band structures of isolated 2D layers of prototypical MOFs. Based on our preliminary results, we found that in the single ring aromatic systems (like benzene) the functional groups tend to decrease the aromaticity in the middle of the benzene ring in the following order SH > NH_2 > OH functionalized benzene. For the larger aromatic systems, the functional groups have a minor influence on the NICS values.

Keywords: DFT calculations, MOFs, NICS, Electronic properties, Aromaticity

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POSTER PRESENTATION

Id-2867

CuO/Graphene Composites for Enhanced Visible-Light Photocatalytic Degradation of Methylene Blue

Y.N. KANAFIN, T. S. ATABAEV*

Department of Chemistry, Nazarbayev University, Astana, Kazakhstan

*Corresponding author: timur.atabaev@nu.edu.kz

Abstract. This study presents the synthesis and characterization of CuO/graphene nanocomposites for enhanced visible-light-driven photocatalytic degradation of methylene blue (MB). CuO nanosheets were prepared via a facile co-precipitation method and subsequently combined with graphene through ultrasonic treatment and thermal annealing. The morphological and structural properties of the materials were thoroughly investigated using scanning electron microscopy (SEM), transmission electron microscopy (TEM), energy-dispersive X-ray spectroscopy (EDX), and X-ray diffraction (XRD). SEM and TEM images showed that CuO nanosheets were distributed across the graphene surface, forming regions of interfacial contact that contribute to a more compact morphology compared to pure CuO. XRD analysis confirmed the monoclinic phase of CuO and indicated improved crystallinity, increased crystallite size, and reduced dislocation density and lattice strain in the composite. CuO/graphene composite exhibited significantly enhanced photocatalytic activity, achieving nearly complete degradation of MB within 20 minutes under visible light. The apparent rate constant (0.19881 min^{-1}) was over 31 times higher than the photolysis control. Moreover, systematic studies on catalyst dosage, pH, and ionic species provided a deeper understanding of key operational parameters affecting photocatalytic efficiency. The results demonstrate that CuO/graphene composite is a promising photocatalyst for efficient dye degradation in wastewater treatment applications.

Keywords: Water Treatment; CuO, Graphene; Composites; Photocatalysis; Methylene Blue.

Acknowledgment: This research has been funded by the Committee of Science of the Ministry of Science and Higher Education of the Republic of Kazakhstan (Grant No. BR28712489).

POSTER PRESENTATION

Id-2870

Photoelectrochemical Activity Testing of Graphene Oxide Embedded TiO_2 Thin Films Decorated with Au or Ir Nanoparticles

I. SERKUL, K. RUSTEMBEKKYZY, T. S. ATABAEV*

Department of Chemistry, Nazarbayev University, Astana, Kazakhstan

*Corresponding author: timur.atabaev@nu.edu.kz

Abstract. The development of cost-effective photoanodes with enhanced structural and photoelectrochemical (PEC) properties is essential for “green” water splitting applications. In this study, we investigated the PEC performance of TiO_2 thin films incorporated with varying concentrations of graphene oxide (GO), prepared via the spin coating method. SEM, XRD, photoluminescence (PL), UV-Vis spectroscopy, and Raman spectroscopy were employed to characterize the morphological, structural, optical, and vibrational properties of the prepared samples. The influence of different GO loadings on the PEC activity was systematically evaluated and compared to a reference TiO_2 sample without GO. The optimized sample, denoted as TiO_2-1, exhibited an average photocurrent density of 83.77 μA/cm^2, which is approximately ~ 74.4% higher than that of the reference TiO_2 sample (~ 48.02 μA/cm²). Next, the surface of the optimized TiO_2-1 was decorated with Au and Ir nanoparticles (NPs) to test their influence on PEC characteristics. It was found that the photocurrent density significantly decreased upon metal NPs loading. Specifically, TiO_2-1 (Au) exhibited a photocurrent density of 23.43 μA/cm², while TiO_2-1 (Ir) showed an average of 38.31 μA/cm², representing reductions of ~72% and ~54%, respectively, compared to the bare TiO_2-1 sample. A plausible mechanism has been proposed for observed behavior. In summary, results demonstrated that the fabricated TiO_2-1 sample was the most effective and stable photoanode, exhibiting higher photocurrent density. These properties suggest its strong potential for application in solar-powered PEC cells.

Keywords: TiO_2-GO, Thin Films, Photoelectrochemical Activity, Gold NPs, Iridium NPs.

Acknowledgment: This research has been funded by the Committee of Science of the Ministry of Science and Higher Education of the Republic of Kazakhstan (Grant No. BR28712489).

POSTER PRESENTATION

Id-2871

Hydrothermal Synthesis of CuO for the Photocatalytic Degradation of Methylene Blue

T. KARATAY[1], K. RUSTEMBEKKYZY[2], T. KERİM[2], T. ATABAEV[2*]

[1]Nazarbayev University, Department of Biology, Astana, Kazakhstan

[2]Nazarbayev University, Department of Chemistry, Astana, Kazakhstan

[*] Corresponding author: timur.atabaev@nu.edu.kz

Abstract. Dyes found in industrial wastewater, particularly from textile effluents, pose serious environmental issues due to their persistence and toxicity, with up to 80% of dye- containing wastewater often discharged untreated. In this work, copper (II) oxide (CuO) nanoparticles were synthesized via a hydrothermal method and evaluated for the degradation of methylene blue (MB) dye (3×10^{-5} M) under visible light in the presence of H_2O_2. The CuO/H_2O_2 system achieved up to 96.65% degradation within 30 minutes, significantly outperforming H_2O_2 or CuO alone. Kinetic analysis revealed a pseudo-first-order rate constant of 0.1124 min^{-1} for the CuO/H_2O_2 system, showing a 22.5-fold increase as compared to MB alone, which highlights the strong synergistic effect between CuO and H_2O_2. Ion interference studies showed that carbonate and bicarbonate ions suppressed degradation due to radical scavenging, while nitrate had a minimal inhibitory effect. The catalyst also demonstrated excellent stability and reusability, maintaining an efficiency of over 93% across five cycles. These results underscore the potential of CuO as a low-cost, efficient photocatalyst for dye-contaminated wastewater treatment.

Keywords: Copper (II) Oxide; Photocatalysis; Hydrothermal Synthesis; Methylene Blue; Wastewater Treatment.

POSTER PRESENTATION

Id-2872

Microwave-Synthesized g-C_3N_4-TiO_2 for Visible-Light-Driven Photocatalytic Degradation of Organic Pollutants

T. KERIM, K. RUSTEMBEKKYZY, T.S. ATABAEV*

Department of Chemistry, Nazarbayev University, Astana, Kazakhstan

* Corresponding author: timur.atabaev@nu.edu.kz

Abstract: Water pollution caused by persistent organic contaminants such as synthetic dyes and pharmaceutical residues presents a critical global challenge. In this study, a g-C_3N_4-TiO_2 nanocomposite was synthesized via a microwave-assisted method and evaluated for the photocatalytic degradation of methylene blue (MB) and chlortetracycline hydrochloride (CTH) under simulated solar irradiation. The microwave synthesis enabled rapid and uniform nanocomposite formation while maintaining eco-friendly and cost-effective process parameters. Several characterization techniques confirmed that the formation of a heterojunction between g-C_3N_4-TiO_2 helped to overcome the main drawbacks of pristine g-C_3N_4 by increasing its porosity, enhancing charge carrier separation and improving light harvesting. The optimal sample achieved ~90% of MB removal in 60 minutes and ~70% of CTH degradation in 120 minutes, outperforming pristine g-C_3N_4 and self-degradation of contaminants. Anion interference experiments have shown that carbonate and bicarbonate ions improve degradation, due to the formation of carbonate radicals, while nitrates and chlorides moderately inhibited activity. The catalyst maintained its photocatalytic activity over five consecutives cycles without significant structural degradation and can be reused without any additional complex post-treatment. These findings underscore the potential of microwave-synthesized g-C_3N_4-TiO_2 as a promising candidate for future implementation in sustainable and economically feasible wastewater treatment applications.

Keywords: Carbon Nitride, Titanium Dioxide, Photocatalysis, Wastewater Treatment, Organic Pollutants.

POSTER PRESENTATION

Id-2875

Polymer-Engineered Aβ-Degrading Enzymes for Alzheimer's Disease Therapy via ATRP Conjugation

A. MAKHAMBETOVA[1,2], A. TSOY[2], S. ASKAROVA[2], B. KAUPBAYEVA[2]

[1]Faculty of Natural Sciences, L.N. Gumilyov Eurasian National University, 13 Kazymukan Street, Astana, 010000, Kazakhstan

[2]The Laboratory of Bioengineering and Regenerative Medicine, Center for Life Sciences, National Laboratory Astana, Nazarbayev University, 53 Kabanbay Batyr Avenue, Astana, 010000, Kazakhstan

*Corresponding author: bibifatima.kaupbayeva@nu.edu.kz

Abstract. Alzheimer's disease (AD) is a progressive neurodegenerative disorder characterized by the accumulation of toxic β-amyloid (Aβ) peptides in the brain. A promising therapeutic strategy involves the use of Aβ-degrading proteases (AβDPs), such as neprilysin and insulin-degrading enzyme, which catalytically eliminate Aβ. Compared to monoclonal antibody therapies—currently the dominant clinical approach—enzymatic degradation is far more efficient and potentially cost-effective. Antibody treatments are not only extremely expensive due to the high cost of production, but also mechanistically limited: one antibody molecule neutralizes only one Aβ molecule. In contrast, a single enzyme can degrade an essentially unlimited amount of substrate, provided it remains stable and active. Moreover, antibody therapy requires repeated biweekly injections, which are physically and emotionally burdensome for patients. These factors highlight the catalytic and practical advantages of using enzymes as a more sustainable therapeutic strategy.To address the significant limitations of native AβDPs—namely instability, immunogenicity, and rapid inactivation in biological environments—we are developing a new class of bioengineered AβDP conjugates using oxygen-tolerant, visible-light-mediated photo-ATRP (atom transfer radical polymerization). This mild, aqueous-compatible method enables direct polymer growth from protein surfaces. As a critical first step, we performed all optimization and characterization using bovine serum albumin (BSA) as a model protein. BSA was successfully modified with NHS-activated ATRP initiators to generate BSA-Br macroinitiators, followed by the synthesis of BSA-polymer conjugates with monomers such as oligoethylene glycol methacrylate (OEGMA) and carboxybetaine methacrylate (CBMA). These conjugates were thoroughly characterized via GPC, fluorescence assays, and microscopy.Importantly, we demonstrated that polymer conjugation significantly enhanced BSA's resistance to proteolytic degradation and masked antibody recognition, validating the shielding effect of the polymers. These findings confirmed that photo-ATRP is a robust and protein-compatible platform for grafting functional polymers under physiologically relevant conditions.Building on these results, we have now synthesized and fully characterized AβDP-Br macroinitiators and are initiating the polymer grafting phase to create the first generation of AβDP-polymer conjugates. These novel constructs are expected to retain catalytic activity against Aβ while displaying enhanced proteolytic stability and reduced immunogenicity. Functional evaluation will include enzymatic degradation assays of Aβ42 oligomers, protease resistance, immune evasion studies, and analytical methods such as fluorescence microscopy and MALDI-ToF.This work represents the first application of photo-ATRP "grafting-from" methodology to engineer Aβ-degrading enzymes, advancing the field of enzyme-based therapeutics for neurodegenerative diseases. By integrating bioengineering, polymer chemistry, and neurobiology, we aim to create a transformative platform for next-generation protein-polymer hybrids capable of overcoming key limitations in current AD treatment strategies.

Keywords: Alzheimer's disease, amyloid-β (Aβ), neprilysin, enzyme therapy, photo-ATRP, protein–polymer conjugates, protein engineering

POSTER PRESENTATION

Id-2878

Cytoprotective Potential of Novel 3-Aminopyridin-2(1H)-one Derivatives in NIH/3T3 Fibroblast Culture

A. URAZBAYEVA[1]*, Z. SHULGAU[2], I. KULAKOV[3]

[1]National Laboratory Astana, Nazarbayev University, Astana, Kazakhstan

[2]CF «Institute of Innovative and Preventive Medicine», Astana, Republic of Kazakhstan

[3]School of Natural Science, Tyumen State University, Tyumen, Russia

*Corresponding author: assel.urazbayeva@nu.edu.kz

Abstract. This study investigates the cytoprotective potential of novel 3-aminopyridin-2(1H)-one derivatives (compounds 7a, 7b, 8a, 8b, 8d, 9b, and 9c) using an in vitro NIH/3T3 mouse fibroblast cell culture model, aiming to identify candidates for pharmacological and toxicological applications. These synthetic compounds, designed through materials science-driven approaches, represent a promising class of molecules for enhancing cellular resilience against stress-related damage, with potential therapeutic relevance in conditions involving oxidative or metabolic stress, such as neurodegenerative diseases, ischemia, or drug-induced toxicity. The primary objective was to assess the compounds 'effects on cell viability and explore their dose-dependent cytoprotective properties, providing a foundation for further pharmacological development. The compounds were synthesized and tested at concentrations of 25, 50, and 100 mM, dissolved in 10% dimethyl sulfoxide (DMSO) to ensure solubility and compatibility with cell culture conditions. NIH/3T3 fibroblast cultures, a well-established model for evaluating cytotoxicity and cytoprotection, were exposed to the compounds for 24 hours, with control wells receiving only 10% DMSO to account for solvent effects. Cell viability was quantified using the MTT assay (BioVision), a colorimetric method that measures mitochondrial activity as an indicator of cell health. The assay's sensitivity allowed for precise detection of viability changes, ensuring reliable assessment of the compounds 'effects. Results demonstrated that none of the tested compounds exhibited cytotoxicity, as cell viability matched or exceeded that of the control group (100% survival). Notably, compounds 7b, 8a, 8b, 8d, 9b, and 9c showed a dose-dependent increase in cell survival, with the most pronounced effects observed at 100 mM. This enhancement suggests a cytoprotective mechanism, likely involving the mitigation of spontaneous viability decline due to oxidative or metabolic stress in the culture environment. The dose-dependent response indicates that these compounds may modulate cellular pathways, such as antioxidant defenses or metabolic homeostasis, warranting further mechanistic studies. These findings highlight the therapeutic potential of 3-aminopyridin-2(1H)-one derivatives as cytoprotective agents. Their lack of cytotoxicity and ability to enhance cell survival position them as promising candidates for further investigation, particularly in models of chemically induced cytotoxicity (e.g., doxorubicin exposure) and primary cell cultures, which more closely mimic physiological conditions. Future studies will focus on elucidating the molecular mechanisms underlying their cytoprotective effects, exploring their efficacy in vivo, and evaluating their safety profiles. This work advances materials science-driven pharmacological development, offering new avenues for designing protective therapies against cellular stress.

Keywords: 3-Aminopyridin-2(1H)-one, Cytoprotection, NIH/3T3 Fibroblasts, MTT Assay, Cell Viability.

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POSTER PRESENTATION

Id-2880

Histopathological Assessment of Cytoprotective Effects of 3-Aminopyridone Derivatives in a Rat Model of Metabolic Syndrome

S. SERGAZY[1]*, Z. SHULGAU[2], Y. KAMYSHANSKIY[3]

[1]National Laboratory Astana, Nazarbayev University, Astana, Kazakhstan

[2]Institute of Innovative and Preventive Medicine, Astana, Kazakhstan

[3]Karaganda Medical University, Karaganda, Kazakhstan

*Corresponding author: shynggys.sergazy@gmail.com

Abstract. The objective of this study was to evaluate the histopathological effects of two novel 3-aminopyridone derivatives (3a and 3b) on multiple organs in female Wistar rats with experimentally induced metabolic syndrome, assessing their cytoprotective potential under chronic oxidative and metabolic stress. Metabolic syndrome was induced via bilateral ovariectomy, high-fat diet, and low-dose streptozotocin, followed by 4-week oral treatment with 3a or 3b (50 mg/kg/day). Liver, pancreas, colon, kidney, heart, adipose tissue, and femur were analyzed using H&E staining, with histopatho- logical changes scored semi-quantitatively or dichotomously. Control rats exhibited severe hepatic steatosis, periportal fibrosis, pancreatic islet atrophy, colon inflamma-tion, renal glomerulopathy, cardiac myocyte hypertrophy, and reduced trabecular bone mass. Both compounds significantly attenuated these pathologies. Notably, 3a and 3b reduced hepatic steatosis and inflammation, with 3b showing superior antifibrotic effects. Pancreatic islet morphology improved, with reduced stromal edema. Colon tis-sues displayed preserved mucosal integrity and less crypt atrophy. Renal and cardiac tissues showed decreased degenerative changes, and femoral bone analysis indicated improved density and osteoblast/osteoclast ratios. These results demonstrate the sys-temic cytoprotective effects of 3a and 3b, mitigating oxidative damage, inflammation and degeneration across multiple organs. The significance of this work lies in the therapeutic potential of these compounds for metabolic and age-related degenerative disorders, offering a promising avenue for developing novel treatments in materials science-driven pharmacology.

Keywords: 3-aminopyridone; Cytoprotection; Histopathology; Metabolic Syndrome; Oxidative Stress; Wistar Rats.

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POSTER PRESENTATION

Id-2881

Rare-Earth Codoping Strategy in TiO_2 Downconverting Layer for Enhanced Performance of Sensitized Solar Devices

D. GOPONENKO, K. ZHUMANOVA, T. SH. ATABAEV*

Department of Chemistry, Nazarbayev University, Astana, 010000, Kazakhstan

* Corresponding author: timur.atabaev@nu.edu.kz

Abstract. Ultraviolet (UV) radiation is known to degrade the active layers of photovoltaic devices and limit their operational stability. In dye-sensitized cells (DSSCs), where light absorption is mostly restricted to the visible region, UV photons remain largely unutilized. As a result, transparent thin-film coatings that can both block and convert UV photons into the visible spectrum have gained attention as an effective strategy to enhance solar cell performance and stability. In this study, porous europium-doped TiO_2 thin films were fabricated via a simple spin-coating method and demonstrated notable UV-blocking capability. To further enhance their optical properties, yttrium (Y^{3+}) ions were introduced as optically inert co-dopants. Photoluminescence analysis revealed that Y codoping increased the absolute quantum yield (QY) of TiO_2:Eu films up to 31.85% while maintaining the characteristic red emission centered at 617 nm corresponding to $^5D_0 \rightarrow {}^7F_2$ transition of Eu^{3+}. The TiO_2:Eu,Y luminescent films were deposited as external coating on the illuminated side of DSSCs. Photovoltaic performance exhibited significant improvement in short-circuit current density (Jsc) and power conversion efficiency (PCE) by up to 29.36% and 32.42%, respectively, attributed to the downconversion of UV light and partial reabsorption of emitted red photons by active layer. These findings demonstrate the potential of codoped TiO_2-based optical coatings as a practical route for enhancing DSSCs performance through spectral conversion and UV protection.

Keywords: Downconversion; TiO_2; Solar Energy; Thin Films; DSSCs.

Acknowledgment: This research has been funded by the Committee of Science of the Ministry of Science and Higher Education of the Republic of Kazakhstan (Grant No. BR28712489).

POSTER PRESENTATION

Id-2882

Microwave-Assisted Synthesis of Graphene-Zno Nanorods for Efficient Solar Photocatalytic Degradation of Methylene Blue (Mb) Dye

L. KHAMKHASH, T. SH. ATABAEV *

Department of Chemistry, Nazarbayev University, Astana 010000, Kazakhstan

* Corresponding author: timur.atabaev@nu.edu.kz

Abstract. The widespread use of Methylene Blue (MB) dye in the textile industry contributes to environmental pollution, as it is hard to degrade and can pollute water and soil, negatively affecting aquatic life and ecosystems. This study presents the development of a Graphene-ZnO nanorods-based (Gr-ZnO) photocatalyst suitable for efficient MB degradation through a combination of soaking and microwave-assisted synthesis. It was found that prepared Gr-ZnO photocatalyst consists of radially-grown ZnO nanorods with a mean length of ~237 nm and a width of ~40 nm, growing from a common Gr sheet center. The synthesized Gr-ZnO photocatalyst exhibited remarkable photocatalytic performance, successfully degrading ~ 97.5% of an MB solution (V = 30 mL, Co = 3 × 10-5 M) in just 40 minutes under solar irradiation by using only 3 mg of the photocatalyst. The effects of catalyst dosage, pH, and the presence of $HCO3^-$, $CO3^{2-}$, $NO3^-$, and Cl^- anions was also evaluated to confirm the potential of the photocatalyst for real wastewater treatment. The potential mechanism of MB degradation was examined and proposed with the help of radical scavengers. In conclusion, the synthesized Gr-ZnO photocatalyst was shown to be effective and reusable, underscoring its potential for wastewater treatment applications.

Keywords: Gr-ZnO Nanorods; Photocatalyst; Wastewater Treatment; Solar Irradiation; Microwave-Assisted Synthesis.

POSTER PRESENTATION

Id-2884

Surface Deposition of Ti_3N_4 MXene and MoS_2 on TiO_2 Nanorods for Enhanced Photoelectrochemical Performance

K. RUSTEMBEKKYZY, AND T. S. ATABAEV*

Department of Chemistry, Nazarbayev University, 53, Kabanbay batyr Ave., Astana, 010000, Kazakhstan

* Corresponding author: timur.atabaev@nu.edu.kz

Abstract. Photoelectrochemical (PEC) devices are promising tools for solar-driven hydrogen generation due to their environmental compatibility. Among various materials, TiO_2-based photoelectrodes remain widely studied owing to their chemical stability and suitable band alignment. In this study, vertically aligned TiO_2 nanorods were synthesized through hydrothermal growth by optimizing the concentration of titanium butoxide. The morphology and structure of the electrodes were characterized by scanning electron microscopy, while their optical and charge carrier properties were evaluated using UV-Vis absorption spectroscopy and photoluminescence spectroscopy. The optimized TiO_2-100 electrode exhibited the highest photocurrent density of 781.84 μA/cm^2 under AM 1.5G illumination. To further improve charge separation and electron transport, Ti_3N_4 MXene or MoS_2 flakes were deposited onto the TiO_2 surface. Systematic optimization of spin-coating parameters revealed that uniform flake distribution is key to maximizing PEC efficiency. The modified electrodes, TX1-1000 and TS1-1000, achieved significantly enhanced photocurrent densities of 1020.6 μA/cm^2 and 991.8 μA/cm^2, respectively. All modified samples showed excellent stability and reproducibility under repeated light on/off cycling. The photoluminescence quenching observed after 2D material modification confirms suppressed charge recombination and enhanced interfacial charge transfer, validating the effectiveness of MXene and MoS_2 integration in improving PEC performance.

Keywords: Photoelectrochemistry; Photoelectrode; TiO_2; 2D Materials; Spin-Coating; Solar Energy.

POSTER PRESENTATION

Id-2885

Mesoporous SiO_2–TiO_2 Composite for Efficient Photocatalytic Degradation of Organic Pollutants in Wastewater

Y. SISSEMBAYEVA, K. RUSTEMBEKKYZY, T. KERIM, T. ATABAEV*

[a] Department of Chemistry, Nazarbayev University, Astana 010000, Kazakhstan

* Corresponding author: timur.atabaev@nu.edu.kz

Abstract. Up to 80% of dye-containing wastewater from the textile industry is discharged untreated into natural water sources [1]. Even at 1 ppm, dyes can visibly discolor water and harm aquatic ecosystems, underscoring the urgent need for sustainable purification solutions [2]. This study explores the photocatalytic potential of reusable, low-cost, and environmentally friendly mesoporous SiO_2–TiO_2 ($mSiO_2$–TiO_2) composite for degrading both dyes and pharmaceutical pollutants in wastewater. The synthesized material exhibits a high surface area (698.8 m^2/g), uniform particle size (340–450 nm), pore size of 19.2 Å, and a zeta potential of –39.9 mV, indicating strong colloidal stability and surface reactivity. Photocatalytic activity was assessed using Rhodamine B (RhB; 3×10^{-5} M), Methylene Blue (MB; 3×10^{-5} M) and Chlortetracycline Hydrochloride (CTH; 50 ppm) under solar light in the presence of 10 µL H_2O_2. Degradation efficiencies reached 97.5% for RhB, 95.5% for MB, and 78% for CTH. Kinetic studies showed up to ~794-fold enhancement in degradation for RhB, ~48-fold for MB, and ~8.6-fold for CTH over their respective self-degradation rates. pH-dependent behavior revealed enhanced activity for RhB and CTH under acidic conditions attributed to increased electrostatic interactions between the negatively charged catalyst and cationic dye molecules, while MB showed optimal activity near-neutral pH. Ion interference studies confirmed that CO_3^{2-} and HCO_3^- inhibited the degradation of RhB and CTH due to their hydroxyl radical scavenging effects, while Cl^- ions showed a weak inhibitory effect on all pollutants. The composites retained over 80% efficiency after four reuse cycles, demonstrating excellent reusability and potential for practical wastewater treatment.

Keywords: Mesoporous Silica-Titania ($mSiO_2$–TiO_2), Photocatalysis, Dye Degradation, Methylene Blue, Rhodamine B, Chlortetracycline Hydrochloride, Wastewater Treatment.

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POSTER PRESENTATION

Id-2886

Effects Of Polystyrene Sphere Size and Concentration on the Photoelectrochemical Activity of Porous Tio$_2$ Films

A. YESTOREYEVA, K. RUSTEMBEKKYZY, AND T. SH. ATABAEV*

[a]Nazarbayev University, Department of Chemistry, Astana, Kazakhstan

* Corresponding author: timur.atabaev@nu.edu.kz

Abstract. Photoelectrochemical (PEC) water splitting is a process that generates hydrogen from water using sunlight and a photoanode. TiO_2 is considered a promising material for PEC water splitting due to its composition of non-toxic, earth-abundant elements, along with its excellent photostability, low cost, and ease of fabrication into thin films. Recent studies have introduced a TiO_2 thin film fabrication method utilizing polystyrene (PS) particles as pore-templating agents to enhance PEC activity. This study investigates the influence of PS particle size and concentration on the PEC performance of porous TiO_2 thin films. Films were prepared using PS particles with diameters of 350, 750, and 1000 nm at two different concentrations, and were characterized using scanning electron microscopy, X-ray diffraction, X-ray photoelectron spectroscopy, photoluminescence, and absorbance spectroscopy. PEC testing showed that films fabricated with 350 nm PS beads demonstrated optimal performance, achieving a photocurrent density of approximately 118 μA cm^{-2} — around 1.2 times higher than that of non-porous double-layered TiO_2 thin films—at both concentrations. Absorbance and photoluminescence results suggest that the improved PEC activity stems from enhanced light absorption and reduced charge carrier recombination.

Keywords: Photoelectrochemical Water Splitting, Porous TiO_2 Films, Polystyrene Spheres, Pore-Templating Agents, Photoelectrochemical Activity.

POSTER PRESENTATION

Id-2895

Targeting Accelerated Cellular Senescence for the Prevention of Post-COVID-19 Pulmonary Fibrosis: Screening of Synthetic and Natural Senolytics

Z. SHULGAU[1,2*], S. SERGAZY[1,3], A. GULYAYEV[1,3]

[1]JSC «Victus Pharm», Astana, Kazakhstan

[2]Astana Medical University, Astana, Kazakhstan

[3]National Laboratory Astana, Nazarbayev University, Astana, Kazakhstan

*Corresponding author: zarina.shulgau@icloud.com

Abstract. The COVID-19 pandemic has revealed a substantial burden of post-infectious pulmonary fibrosis, a condition associated with chronic inflammation, oxidative stress, and tissue remodeling in the lung. Addressing this challenge requires new preventive and therapeutic strategies that target fundamental cellular mechanisms. In this context, the present study explores accelerated cellular senescence phenotypes as potential targets for identifying compounds capable of mitigating fibrosis risk after SARS-CoV-2 infection. The work integrates advanced cellular models, molecular biomarker analysis, and the systematic testing of both synthetic and natural bioactive compounds. A comprehensive library of synthetic derivatives (notably 3-aminopyridones and related heterocycles) and plant polyphenols (including grape, blueberry, cranberry, bilberry, currant, and cloudberry extracts, as well as isolated flavonoids quercetin and dihydroquercetin) was generated and characterized for antioxidant and senolytic activity. The compounds were evaluated using DPPH and ABTS radical scavenging assays, with several molecules demonstrating strong antioxidant potential (e.g., KN-76, KMM-85, KL-5, KL-19). In parallel, senescence-associated secretory phenotype (SASP) induction was modeled in bronchoalveolar lavage cells and alveolar epithelial cells (AE2) exposed to two SARS-CoV-2 vaccines: CoronaVac (inactivated whole-virus) and Convasel (recombinant nucleocapsid protein). Both vaccines enhanced the expression of senescence biomarkers (SA-β-gal, IL-6, TNF-α, TGF-β1), highlighting their capacity to accelerate cellular aging processes in vitro. Preliminary screening of candidate compounds revealed promising senolytic and antifibrotic effects in AE2 cultures under SASP conditions. Several synthetic derivatives (e.g., KIP-36, KIP-55, KIP-96, KIP-97, KIP-118, KAO-20) and polyphenolic extracts demonstrated protective effects, reducing markers of senescence and inflammation. The methodological framework developed in this study incorporates validated cell culture models, a broad panel of senescence biomarkers, and established senolytic controls (quercetin + dasatinib), ensuring scientific rigor and reproducibility. The findings underscore the global importance of both synthetic libraries and natural polyphenols as modulators of accelerated senescence and fibrotic remodeling. This research provides a scientific rationale for advancing selected compounds into preclinical pipelines, with the long-term aim of reducing the global burden of post-COVID-19 pulmonary fibrosis. By addressing an urgent worldwide health challenge, the study contributes to the development of novel therapeutic approaches that may alleviate the long-term consequences of pandemics and chronic respiratory diseases.

Keywords: Cellular Senescence; SASP; Pulmonary Fibrosis; Post-COVID-19; Senolytics; Polyphenols; Antioxidants; Biomarker Analysis.

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POSTER PRESENTATION

Id-2896

Microwave-assisted Synthesis of CuO-Fe_2O_3 Composites for Photocatalytic Dye Degradation

A. ZHARKINA, A. YESTOREYEVA, T. SH. ATABAEV*

Department of Chemistry, Nazarbayev University, Astana, 010000, Kazakhstan

* Corresponding author: timur.atabaev@nu.edu.kz

Abstract. Dyes in wastewater pose a high risk to both human health and the environment due to their potential toxicity and ecological impact. Hematite (α-Fe_2O_3) is a low-cost, stable, and environmentally friendly form of iron oxide that has become a promising photocatalyst for dye removal in water treatment. However, its practical use is limited by low light absorption and electrical conductivity, which could be resolved by doping with transition metal ions. This study proposes a rapid one-step method of synthesis of CuO-doped hematite nanoparticles by microwave irradiation. The main objective is to explore the photocatalytic activity of CuO-Fe_2O_3 composites in degrading methylene blue (MB) dye under visible light. The characterizations of the samples were performed by using scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDX), X-ray diffraction (XRD) analysis and Nitrogen adsorption-desorption experiments. The experimental results showed that the best-performing catalyst was obtained by incorporating 25 mmol concentration of CuO into hematite, the catalytic activity of which reached 99.5% degradation of a 10 mL MB solution (3×10^{-5} M) within 40 minutes. The effect of pH, catalyst dosage and presence of anions like NO_3^-, HCO_3^-, CO_3^{2-} and Cl^- on the photocatalytic activity of the 0.025 mM CuO-Fe_2O_3 sample was investigated. The catalytic efficiency of this sample is attributed to improved crystallinity, increased surface area, and enhanced generation of electron-hole pairs and hydroxyl radicals. The high photocatalytic activity and cost-effective synthesis underscore the practical usability of the produced CuO-Fe_2O_3 photocatalysts for dye degradation.

Keywords: Photocatalysis; Dye degradation; Methylene Blue; Hematite.

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POSTER PRESENTATION

Id-2897

Enhanced Photoelectrochemical Performance of Inverse Opal-Like Tio_2 Films Via Combination of Spin- and Dip-Coating Techniques

ZH. KALI, K. RUSTEMBEKKYZY, T. SH. ATABAEV*

Department of Chemistry, Nazarbayev University, Astana, 010000, Kazakhstan

* Corresponding author: timur.atabaev@nu.edu.kz

Abstract. The advantageous properties such as light absorption, large surface area and improved catalytic activity of inverse-opal like TiO_2 films make them currently very attractive for various applications. In this work, we showed that such films can be reliably fabricated using a spin-coating method with a TiO_2 nanoparticle suspension mixed with polystyrene (PS) beads. Moreover, significant improvements in the photoelectrochemical (PEC) performance of these films were achieved by using a simple dip-coating process with titanium isopropoxide precursor. Notably, the dip-coated films exhibited a photocurrent density of ~66.5 μA cm^{-2} at 1.23 V versus RHE, compared to ~40.9 μA cm^{-2} for untreated films. The approximately 38.5% increase in PEC activity is believed to be due to the formation of a thin TiO_2 bridge layer, which improves charge transport and reduces recombination, rather than changes in bandgap or reflectance. These results demonstrate that the proposed method is simple, reproducible, and applicable for large-area deposition, showing potential for use in solar cells and photocatalytic devices.

Keywords: Inverse-Opal Like Films; TiO_2;Dip-Coating; Spin-Coating; Photoelectrochemical Performance.

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POSTER PRESENTATION

Id-2899

Modification of Photoactive PVA Containing WO_3 Thin Films by Intense Pulsed Ion Beam

A. ABDUVALOV*, M. KAIKANOV

Nazarbayev University, Department of Physics, Astana, Kazakhstan

* Corresponding author: alshyn.abduvalov@nu.edu.kz

Abstract. Intense pulsed ion beam (IPIB) irradiation has become a powerful method for tailoring material properties through its ability to produce ultrafast heating and rapid cooling cycles [1]. Our previous reports investigated the impact of IPIB irradiation on different materials, particularly plasmonic particles and catalytic thin films [2,3,4]. WO_3 thin films are attractive photocatalysts for PEC water splitting, but their visible light absorption is typically limited in solar spectrum range between 400 and 700 nm. In this work, PVA-assisted WO_3 thin films were fabricated via spin coating method and subsequently modified using intense pulsed ion beam (IPIB) irradiation to overcome this drawback and enhance photocatalytic efficiency. Following irradiation and annealing, the initially uniform PVA-containing WO_3 films transformed into porous layers with greater thickness, leading to improved light absorption and increase in photocurrent density up to 70 % compared to films treated only by annealing. Results demonstrate that IPIB irradiation is a promising approach for precisely modifying material structures at the nanoscale for applications in photoelectrochemical water splitting and purification.

Keywords: Photocatalysis; Thin films; Functional nanomaterials; Pulsed ion beam accelerators; Ion beam modification.

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POSTER PRESENTATION

Id-2905

Synthesis of High Entropy Composite Coatings of (Tialtazrnbn)Agx: Influence of Silver Content on Microstructural, Mechanical and Tribological Properties

G. BEJARANO G.[1]*, D. MARÍA CHIMÁ A.[1], S. WEIß[2], A. OBROSOV[2]

[1]Centro de Investigación, Innovación y Desarrollo de Materiales - CIDEMAT, Universidad de Antioquia, Calle 67 No. 53- 108, Medellín, Colombia

[2]Department of Physical Metallurgy and Materials Technology, Brandenburg University of Technology Cottbus, Senftenberg, 03046, Cottbus, Germany

*Corresponding author: gilberto.bejarano@udea.edu.co

Abstract: High entropy nitride coatings of (TiAlTaZrNbN)Agx doped with 3 different silver contents of 3.7, 11.9 and 21.3 at% were fabricated, and their influence on the microstructural, mechanical and tribological properties was studied. The coatings were deposited on 420 stainless steel samples by co-deposition of two targets, one of the equiatomic alloy of Ti-Al-TaZr-Nb, and the other of silver, using the direct current magnetron sputtering technique DC. Energy dispersive spectroscopy (EDS) analysis shows that the silver content increases with the power supplied to this target of 50, 70 and 90 W, while scanning electron microscopy (SEM) cross-section images exhibit a homogeneous columnar-like structure. The grain size increases with silver content from 400 nm to 508.1 nm as does the surface roughness from 8 nm to 12.4 nm. X-ray diffraction (XRD) patterns show a single peak of the (TiAlTaZrNbN) coating with preferential growth in the (200) plane, suggesting a high-entropy nitride solid solution crystalline phase with face-centered cubic structure FCC. In addition, two peaks of the crystalline phase of fcc cubic silver are observed with preferential growth in the (111) and (200) planes. The coefficient of friction increases with silver content from 0.9 to 1.0. The highest hardness of 25.3 GPa and lowest wear rate of $1{,}7x10^{-4}$ $mm^3/N.m$, were obtained for the coating deposited with the lowest silver content. Compared with the hardness, coefficient of friction and wear rate of steel of 3 GPa, 0.7 and $4x10^{-2}$ $mm^3/N.m$, respectively, the coating with the lowest silver content has a significant protective effect on steel against wear.

Keywords: Heigh Entropy Coatings; Composite Coatings; Solid Lubrication; Silver Nanoparticles; Magnetron Sputtering.

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POSTER PRESENTATION

Id-2906

Analysis of Oil-Paper Insulation Material in Power Transformers Using Frequency Dielectric Spectroscopy

M. GUTTEN*, D. KORENCIAK

Faculty of Electrical Engineering and Information Technology

University of Zilina, Zilina, Slovakia

* Corresponding author: miroslav.gutten@uniza.sk

Abstract. This paper presents an in-depth study of transformer insulation material oil-paper assessment using the method of frequency dielectric spectroscopy (FDS). The research focuses on two main aspects: (i) the comparison of transformers with different power ratings and insulation qualities under identical indoor temperature conditions, and (ii) the evaluation of insulation properties at varying operating temperatures. The FDS method was applied to determine capacitance and loss factor characteristics, allowing a comprehensive analysis of the dielectric response. The study confirms that evaluating insulation state through capacitance in FDS exhibits lower sensitivity to temperature variations compared to the conventional loss factor approach. This was verified through systematic measurements across a range of temperatures. However, the analysis also revealed a significant limitation: the influence of the geometric configuration of the insulation system, which introduces dependence on the transformer type and rated power. The experimental results demonstrate that FDS provides a more reliable diagnostic tool for assessing insulation material aging and degradation under fluctuating temperature conditions. These findings highlight the potential of FDS to improve predictive maintenance strategies, extend transformer service life, and reduce operational risks in power systems. At the same time, the observed impact of insulation geometry suggests the need for further model-based compensation methods to standardize results across different transformer designs.

Keywords: Transformer; Insulation; Material Oil-Paper; FDS Method, Diagnostics

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POSTER PRESENTATION

Id-2912

Plant-Derived Exosome-Like Nanoparticles from Berries as Novel Carriers of Polyphenols: Safety and Anti-Inflammatory Properties In Vitro

N. KALAMOV*, R. SEYDAKHMETOVA

JSC «Victus Pharm», Astana, Kazakhstan

*Corresponding author: nursultankalamov@gmail.com

Abstract. Exosomes of animal origin, particularly milk-derived exosomes, have been widely investigated as carriers for drug delivery. In contrast, plant-derived exosome-like nanoparticles (PDENs) represent a relatively new area of research, with emerging evidence of intrinsic biological activity and potential advantages for the transport of polyphenolic compounds. Polyphenols are characterized by low bioavailability, and incorporation into PDENs may enhance their stability, antioxidant potential, and cytoprotective activity. This study aimed to isolate PDENs from grapes, blueberries, and strawberries, evaluate their mutagenicity, and investigate their anti-inflammatory properties in vitro. Mutagenicity was assessed using the Ames MPF™ Penta I test kit (Xenometrix, Switzerland) with five bacterial strains (S. typhimurium TA98, TA100, TA1535, TA1537, and E. coli WP2 uvrA/WP2 pKM101) in accordance with GLP standards. PDENs were tested at dilutions of 1:10, 1:100, and 1:1000, with and without rat liver S9 fraction. The results showed no increase in revertant colonies relative to negative controls, confirming the absence of mutagenic activity in PDENs from all three berry sources. Anti-inflammatory activity was evaluated in LPS-stimulated RAW264.7 macrophages through measurement of iNOS and COX-2 mRNA expression by qRT-PCR. PDENs significantly reduced inflammatory biomarker expression, with the strongest effects observed for blueberry-derived PDENs (iNOS ratio to LPS control: 0.62 ± 0.04 at 1:100 and 0.30 ± 0.15 at 1:10; COX-2 ratio: 0.47 ± 0.11 at 1:100 and 0.28 ± 0.06 at 1:10). Comparable but less pronounced effects were recorded for grape- and strawberry-derived PDENs. The inhibitory effects approached those of dexamethasone (10 μM). These findings demonstrate that berry-derived PDENs are non-mutagenic and exhibit anti-inflammatory activity in vitro, highlighting their potential as safe and effective nanocarriers for enhancing the bioavailability and therapeutic effects of polyphenols. This research provides a foundation for the development of novel functional foods and targeted delivery systems based on plant exosome-like nanoparticles.

Keywords: exosome-like nanoparticles; polyphenols; plant-derived exosomes; mutagenicity; anti-inflammatory activity; nanocarriers; drug delivery.

Acknowledgment: This research is funded by the Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan (Grant No. AP23490945).

POSTER PRESENTATION

Id-2923

CuO and Co_3O_4 Nanostructures as Efficient Non-Enzymatic Sensors for Glucose and Hydrogen Peroxide

I. MIHAILOVA, V. GERBREDERS, M. KRASOVSKA, E. SLEDEVSKIS, V. MIZERS, J. KEVISS

Department of Technology, Institute of Life Sciences and Technology, Daugavpils University, LV-5401 Daugavpils, Latvia.

* Corresponding author: irena.mihailova@du.lv

Abstract. In this study, copper oxide (CuO) and cobalt oxide (Co_3O_4) nanostructures were synthesized and investigated for their electrochemical sensing performance toward glucose and hydrogen peroxide detection. The nanostructures were prepared using a simple and cost-effective chemical precipitation method, followed by thermal annealing to enhance crystallinity and surface activity. The morphology and composition of the obtained materials were characterized by scanning electron microscopy (SEM), X-ray diffraction (XRD), and energy-dispersive X-ray spectroscopy (EDS), confirming the formation of highly crystalline nanostructures with large specific surface areas. Electrochemical measurements demonstrated that both CuO and Co_3O_4 nanostructures exhibit excellent electrocatalytic activity toward the oxidation of glucose and the reduction of hydrogen peroxide in alkaline media. The CuO-based sensor showed high sensitivity and fast response time for non-enzymatic glucose detection, while the Co_3O_4 nanostructures provided superior performance for hydrogen peroxide sensing due to their high redox activity and stability. These results suggest that CuO and Co_3O_4 nanostructures are promising candidates for the development of efficient, low-cost, and enzyme-free electrochemical sensors for biomedical and environmental applications.

Keywords: Copper Oxide; Cobalt Oxide; Nanostructures; Electrochemical Sensor; Glucose Detection; Hydrogen Peroxide.

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POSTER PRESENTATION

Id-2845

In Vitro Biocompatibility of Robotic Microplasma Sprayed Zirconium Coatings on Titanium Alloy for Orthopedic Applications

A. KADYROLDINA[1], A. KRASAVIN[1], Y. SAFAROVA (YANTSEN)[2], S. VOINAROVYCH[3], D. ALONTSEVA[1]

[1]School of Digital Technologies and Artificial Intelligence, D. Serikbayev East Kazakhstan Technical University, 19 Serikbayev Street, 070010 Ust-Kamenogorsk, Kazakhstan

[2]National Laboratory Astana, Nazarbayev University, 53 Kabanbai Batyr ave, Astana,010000, Kazakhstan.

[3]E.O. Paton Electric Welding Institute, National Academy of Sciences of Ukraine. 11 Kazymyr Malevych Str., Kyiv, 03150, Ukraine.

* Corresponding author: kadyroldina@edu.ektu.kz

Abstract. The demand for advanced materials and innovative manufacturing for patient-specific orthopedic implants continues to rise due to increasing joint replacement surgeries, particularly among younger, active patients. These needs challenge conventional titanium (Ti) based materials and traditional surface treatments. This study explores microplasma spraying (MPS) of zirconium (Zr) coatings to enhance endoprosthetic bioactivity. Zr and its alloys offer exceptional biocompatibility, superior corrosion resistance, and lower rejection rates compared to Ti-based alloys. Additionally, Zr inhibits bacterial adhesion better than Ti, reducing post-operative infection risk. However, Zr's high melting point poses challenges, such as overheating and substrate deformation during thermal plasma spraying. Achieving strong adhesion, controlled porosity, and uniform thickness on complex geometries is also difficult. To address this, robotic MPS was optimized for Zr wire on Ti6Al4V substrates, ensuring uniform coatings with precise porosity and adhesion. However, the relationship between coating material, porosity, roughness, and bioactivity remains under investigation. *Key research objectives* were to establish key characteristics of robotically microplasma sprayed Zr coatings and evaluate their biocompatibility to provide scientifically validated MPS parameters for improving endoprosthetic implants. Additionally, it explores how MPS parameters influence the microstructure and properties of Zr coatings, laying the groundwork for future orthopedic advancements. The *primary goal* was to develop a new control algorithm for a robotic arm equipped with a microplasmatron. This system is designed to maintain optimal spray distance and trajectory, allowing uniform coating application on complex-shaped titanium implants to enhance their biocompatibility.The *main achievements of this work* are as follows: the optimized MPS process produced Zr coatings with a thickness of 300 ± 10 µm, porosity of 20.3 ± 2.0%, surface roughness of 17 ± 0.1 µm, and adhesion strength of 26 ± 2.1 MPa, exceeding ISO 13179-1:2021 standards. Electrochemical testing in saline revealed enhanced corrosion resistance compared to uncoated Ti6Al4V. In vitro cytocompatibility was validated using lactate dehydrogenase (LDH) assays, which showed no cytotoxic effects, and BM-MSC proliferation assays confirmed favorable biocompatibility. Osteogenic differentiation of BM-MSCs was enhanced by 5%, indicating improved osseointegration potential. Antibacterial testing showed a 35% reduction in E. coli viability after 15 hours, supporting the coating's role in preventing implant-associated infections. Additionally, angiogenesis analysis using human umbilical vein endothelial cells (HUVECs) and ImageJ Angio Plugin revealed a 42% increase in master segment length and an 18% increase in branch length, indicating pro-angiogenic properties. Morphological assessment of BM-MSCs on Zr-coated surfaces showed well-spread cells with elongated filopodia and lamellipodia, suggesting strong adhesion and surface compatibility.These findings demonstrate that robotic MPS of Zr coatings is a viable and effective strategy for improving orthopedic implant

performance. The approach offers a multifaceted enhancement—combining biocompatibility, antibacterial effects, angiogenesis promotion, and mechanical robustness—positioning robotic MPS as a next-generation technology in biomedical surface engineering. Its integration into implant manufacturing marks a significant step forward in personalized, high-performance orthopedic care.95

Keywords: Medical Implants, Robotic Arm; Control Algorithm; Implant Biocompatibility.

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Topics & All Submissions

Condensed Matter Physics	Id-2831 - The structural pathway from its solvated molecular state to the solution crystallization of para-amino benzoic acid
	Id-2846 - Magnetron sputtering of radio-absorbing multilayer Co-C-Cr coatings on undoped monocrystalline silicon
	Id-2860 - Insights into the defect structure of NaBa12(BO3)7F4 (NBBF) crystals using Raman spectroscopy and dielectric measurements
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	Id-2923 - CuO and Co_3O_4 Nanostructures as Efficient Non-Enzymatic Sensors for Glucose and Hydrogen Peroxide
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	Id-2844 - Strategies for Implant-Associated Infection Control: In Vivo Insights on TaCu and NbCu Magnetron-Sputtered Coatings
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	Id-2895 - Targeting Accelerated Cellular Senescence for the Prevention of Post-COVID-19 Pulmonary Fibrosis: Screening of Synthetic and Natural Senolytics
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