Book of Abstracts

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Mariya Hristova	University College London, UK
Eleonora-Mihaela Ungureanu	National University of Science and Technology Politehnica Bucharest, Romania
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12th International Congress on Microscopy & Spectroscopy

PLENARY SPEAKER

Id-781

Micro-Spectroscopic Analysis of Complex Biological Systems

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Abstract. In this presentation, I will discuss the applications of phase imaging techniques, namely Digital Holographic Microscopy (DHM) and Transport of Intensity Equation (TIE), together with fluorescent and Raman spectroscopic imaging to cellular apoptosis, mapping of intracellular iron, ferroptosis and tissue engineered constructs.

Methods of tracking morphological cell changes are based on measurements of phase, which is proportional to the cell thickness and can be extended to measure the optical path length, and, therefore, cell volume changes, which are indicative of apoptosis. Furthermore, Raman micro-spectroscopy is widely used for the mapping of chemical composition within live biological samples, such as cells, organoids, and tissues. It permits non-invasive and non-destructive measurements that do not require special sample preparation processes, such as dye labelling or staining. Currently, only invasive cell biological assays are used to monitor the expression level and subcellular location of proteins that are known to bind iron or be involved in ferroptosis. Our group has previously reported a development of Raman spectroscopic signatures that can be used to monitor the differentiation state and health of salivary organoids derived from progenitor cells that undergo differentiation in culture on their own and in the presence of alginate hydrogel scaffolds. Raman spectroscopy offers an important noninvasive tool capable of assessing cell phenotype. When cell morphology and phenotype change, this process is accompanied by changes in the protein structure within cells. We have previously shown that changes in the secondary/tertiary protein structure can be detected by Raman spectroscopy, even in tissue engineered constructs, before they can be seen histologically. These studies pave the way for future work to test if Raman spectroscopy can be used as an early predictor of the ultimate success of an in vivo implanted construct.

Keywords: Quantitative Phase; Phase Imaging; Digital Holography; Transport of Intensity Equation; Raman Hyperspectral Imaging; Fluorescence.

12th International Congress on Microscopy & Spectroscopy

PLENARY SPEAKER

Id-806

Novel Aspects of the RNA-DNA Primer Synthesis Termination by Human Primosome

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Abstract. The human primosome, a four-subunit complex of primase and DNA polymerase alpha (Polα), synthesizes chimeric RNA-DNA primers for DNA polymerases delta and epsilon to initiate DNA replication on both chromosome strands. Despite recent structural insights into the action of two catalytic centers, the mechanism of DNA synthesis termination is still unclear. Here we report results of functional and structural studies, revealing how the human primosome can count the length of RNA-DNA primer and timely terminate the elongation of both RNA and DNA segments of the primer. Using single-turnover primer extension assay and cryo-electron microscopy single-particle analysis, we found that the RNA-DNA primer length counting mechanism is based on four factors: 1) a tight interaction of the C-terminal domain of the DNA primase large subunit ($p58_C$) with the primer 5'-end; 2) flexible tethering of $p58_C$ and DNA polymerase alpha catalytic core domain ($p180_{core}$) to the primosome platform domain ($p49\text{-}p58_N\text{-}p180_C\text{-}p70$) by extended linkers; 3) a transient interaction between $p180_{core}$ and the platform domain; and 4) by interaction of Polα with a replication protein A (RPA) These factors determine the mature primer length (~35-mer) and prevent DNA synthesis restart by blocking Polα access to the completed primer. In summary, our data revealed that all steps of RNA-DNA primer synthesis are regulated by $p58_C$. The above findings provide new insights into the molecular mechanism of DNA synthesis termination by eukaryotic primosome, a key process for successful primer handover to replication DNA polymerases δ or ε.

Keywords: Cryo Electron Microscopy; X-ray Crystallography; DNA Replication; RNA-DNA Primer.

12th International Congress on Microscopy & Spectroscopy

PLENARY SPEAKER

Id-808

Saving Lives with Quantum mid-IR Microscopy

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Abstract. Breast cancer, in common with many others, is diagnosed and staged primarily using H&E pathology. A tissue biopsy is harvested, fixed, embedded in wax, and sliced, before being stained and graded by eye. The assay is flawed and the treatment (chemotherapy) is dangerous; 27% of cancer deaths are due to overprescribed treatment as opposed to the disease itself. Digistain quantifiess the DNA concentration in a 300μm square biopsy patch, a well known and highly regarded cancer biomarker. It gives an objective "Digistain Index" (DI) which oncologists use to guide treatment decisions. We would like to image the DNA across the biopsy slice, but interference from thermal IR background makes images too irreproducible for clinical decision making. The solution is "Quantum Imaging with Undetected Photons (QUIP)". This uses entangled photon pairs, one in the infrared and one in the visible. When the infrared photon interacts with the biopsy sample, quantum correlations mean its visible twin instantaneously "feels" the event, in a way that allows the transfer the image information from the mid-IR to the visible whilst leaving the thermal background behind. It offers a way of getting reliable clinical images, with cheap uncooled CMOS cameras, with the detection sensitivity increased by ~10^{13}. DI was calculated in 801 patients with hormone receptor-positive, HER2-negative primary breast cancer and ≤3 positive lymph nodes. All patients were treated with systemic endocrine therapy and no chemotherapy. DPS, incorporating the DI, was assessed for prediction of 5- and 10-year outcomes (recurrence, recurrence-free survival [RFS] and overall survival [OS]). Entangled photon pairs, comprising ~792nm "signal" and ~1620nm "idler" photons were generated with pump beam that traverses the non-linear crystal twice then spatially overlapped. When the photons are detected, it is imposible to know which pass generated them, and this ignorance generates interference which can be registered in the signal beam. Blocking part of the idler with an object destroys the interference, so that you can register images with light that has not itself interacted with the sample. We have engineered the original ~1m x 2m lab. setup down to a portable 20 x 30 cm demonstrator that has already been carried around the world in a rucksack and is ~10x cheaper and many decades more sensitive than a thermal IR camera.

DPS was consistently highly accurate and had negative predictive values for all three outcomes, ranging from 0.96 to 0.99 at 5 years and 0.84 to 0.95 at 10 years. Using QUIP we have achieved high quality images of a number of test samples, typically gold microelectrodes and insect wings.

DPS showed high accuracy and predictive performance, was able to stratify patients into low or high-risk, and, considering its cost and rapidity, has the potential to ofer clinical utility . A recent independent analysis, funded by Innovate UK, has concluded that were it to be adopted across the NHS, for Breast Cancer alone, it would result in savings of £287M pa, 450 tonnes of CO_2, and 1266 patient life-years.

Keywords: Imaging; Cancer; mid-IR Microscopy.

12th International Congress on Microscopy & Spectroscopy

INVITED SPEAKER

Id-766

Ensuring the Authenticity of Organic Food Products by Raman Spectroscopy: Challenges and Opportunities for Industries

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Abstract. The market for organic food products is estimated at 12 billion euros in France in 2023 and 135 billion in the world. The economic importance and the rapid growth of this market has led to increased tension between supply and demand, raising the risk of fraud by consumers. Currently, there is no global, standardized method to verify the authenticity of organic products. Instead, a range of unrelated hoc methods are used, weakening the overall control system. The TOFoo (True Organic Food) project proposes the development of a non-targeted approach for the authentication of organic products using several analytical techniques. Among these techniques, Raman spectroscopy offers a promising tool for rapid and non-destructive analysis of food samples due to its ability to measure macromolecules in an aqueous environment and its compatibility with in-line and field control. Our study investigated the feasibility of using Raman spectroscopy to analyze different food products and to correlate their Raman fingerprints with their classification as either organic or conventional food. A variety of food samples (fruits, vegetables, milk, etc.) were collected and analyzed using a portable Raman spectrometer. The first phase in the methodology involved developing a reliable experimental protocol by adapting the Raman parameters according to the food's physical state, chemical composition, texture, etc. The second phase included the elaboration of solid and representative database encompassing samples from different producers, regions and varieties. However, the main challenge lies in developing robust chemometric models capable of extracting the information related to organic characteristics, despite the high variability connected to the nature of the living samples. Therefore, the final phase involves validating the method on new samples to verify the robustness, accuracy and precision of the developed analytical method.

Keywords: Raman Spectroscopy; Chemometrics; Organic Food; Authenticity.

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12th International Congress on Microscopy & Spectroscopy

INVITED SPEAKER

Id-768

Raman Spectroscopy and Civil Engineering Materials. Overcoming Difficulties and Providing Answers

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Abstract. Over the past decade, Raman spectroscopy has started to take a growing place as an analytical technique to characterize civil engineering materials among conventional other ones, mainly suffering of one main limit which is the duration of a measurement.

Civil engineering materials are designed for decades, and their lifetime can reach centuries sometimes. Nevertheless, most of them does overcome chemical alterations which do ultimately change their mechanical properties and their structural integrity. Some ancient ones do have unknown constituents, which make it impossible to properly apprehend their durability.

In this presentation, we will focus on the way Raman spectroscopy will allow us to overcoming the difficulties to establish the kinetics of the alteration processes and to provide answers in the chemical evolution of the cement matrix composition, the spatial distribution, along with the identification of unknown components.

Keywords: Civil Engineering; Raman; Chemometrics.

12th International Congress on Microscopy & Spectroscopy

INVITED SPEAKER

Id-771

Mesoscopically Structured Minerals (Mesocrystals) in Geological Processes. A Review

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Abstract. Mesoscopically structured crystalline material (mesocrystal in brief) formation, categorized as non-classical crystallization, has been a focal point of extensive research over the past three decades. The “mesocrystal” term was originally introduced to designate superstructures of nanocrystals with a common crystallographic orientation. Later, cases where nanoparticles displayed a certain degree of oriententional mismatch were documented. In contrast to the traditional mechanism of crystallization involving the atom/molecule-mediated growth of a single crystal, mesocrystal formation is elucidated through particle-mediated growth and assembly mechanisms. Despite these differences, both pathways are likely rooted in similar physical principles. Mesocrystals have potential applications in many processes such as catalysis, sensing, energy storage and conversion, thus they invoke reasonable interest among scientists. Most research on mesocrystals has been conducted in laboratories where these structures are synthesized, leading to a substantial body of literature. In contrast, the exploration of natural samples is relatively limited, with a focus mainly on biomineralization, diagenetic or supergene processes, or environmental contexts. Studies specifically addressing mesocrystal formation in geological processes such as magmatic and metamorphic processes; hydrothermal mineralizations; sedimentary; diagenetic; and hot-spring processes are even scarcer in comparison. The relative scarcity of such investigations highlights the need for further exploration of mesocrystal formation in diverse geological settings, systems, and processes as well as familiarizing researchers of natural systems and processes. In this report, we provide a review of mesocrystal formation in magmatic, pegmatitic, metamorphic, hydrothermal, sedimentary, diagenetic, and supergene processes. Minerals such as magmatic and metamorphic micas; pegmatitic muscovite; sedimentary clay minerals (kaolinite and smectite); hot-spring calcite, aragonite, and opal-A; hydrothermal to sedimentary sepiolite and palygorskite; W-Fe oxides; hydrothermal quartz, and pyrite are examples of natural mesocrystal formation which are included in the offered review.

Keywords: Mesocrystals; Nano-sized; Minerals; Geological Processes.

Acknowledgment: This research was funded by the Bulgarian National Science Fund under contract KP-06-N54/6.

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INVITED SPEAKER

Id-772

Raman Microscopy and Spectroscopy of Carbon Nanocomposite Materials for EMI Shielding Performance

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Abstract. The growing demand for efficient electromagnetic interference (EMI) shielding materials has led to the exploration of novel carbon-based nanocomposites due to their exceptional electrical conductivity, mechanical strength, and versatility. This work investigates the application of Raman microscopy and spectroscopy to characterize carbon nanocomposite materials, with a focus on their potential for EMI shielding. The study employs Raman spectroscopy to analyze the structural and electronic properties of various carbon-based nanomaterials, such as graphene, carbon nanotubes (CNTs), and graphene oxide, graphene nano-onions (CNOs) incorporated into composite matrices. Raman modes such as the G and D bands are used to probe the degree of graphitization, defects, and interactions between the carbon nanomaterials and the composite matrix, which are key factors influencing the EMI shielding effectiveness (SE). The correlation between Raman spectra and the materials' electrical conductivity, microstructure, and EMI shielding performance is explored. Results indicate that tailored nanocomposites with controlled dispersion and alignment of carbon nanomaterials offer enhanced shielding performance, and Raman spectroscopy provides a valuable tool for real-time monitoring of material properties at the nanoscale. This work highlights the role of Raman spectroscopy in the design and optimization of carbon nanocomposites for advanced EMI shielding applications.

Keywords: Carbon Nanomaterials (CNs); Raman Microscopy; EMI Shielding Performance.

12th International Congress on Microscopy & Spectroscopy

INVITED SPEAKER

Id-775

X-ray Fluorescence (XRF) as a Tool for Sulfur Uniformity Assessment in High-Strength Packaging Paper

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Abstract. Global environmental campaigns emphasize the need to understand better how renewable raw materials can be utilized effectively. There is a notable trend towards replacing fossil-based materials with fiber-based alternatives across various packaging applications. Solid and lightweight composite packaging structures can be produced in an environmentally friendly and energy-efficient way. In recent years, wood fibers have gained popularity as a packaging material. High-yield pulps, such as CTMP (Chemithermomechanical pulp), which achieves a 95% yield, are increasingly used in packaging. Worldwide, 5-10 Mt/y of CTMP are produced from softwood and hardwood chips for paperboard manufacturing. During tailor-making CTMP, wood chips are impregnated with aqueous sodium sulfite (Na_2SO_3) to sulfonate the wood's lignin. This sulfonation ($-SO_3^-$) softens the wood chips, enabling more selective defibration into the pulp. As a result, the pulp properties, including the bulk and strength characteristics of the final packaging, are enhanced. Several factors influence the quality of wood chips, including the chipping method used for pulpwood, sawmill chipping practices, and the chip screening system. Developing an impregnation technology that ensures an even distribution of sodium sulfite (Na_2SO_3) can be challenging. It is essential to measure the distribution of sulfonate groups in individual fibers and wood chips at a micro-scale; however, existing processing methods often need to be more robust and complex, making this difficult. If better measurement techniques were available, we could understand how sulfonation operates before defibration, improving the impregnation process. Sulfur impregnation can be studied using spatial and spectral resolutions to investigate the degree of sulfonation at the microscale. Therefore, we propose creating a laboratory-scale miniaturized X-ray fluorescence (XRF) scanner to measure sulfur distribution in wood chips on-site. We aim to minimize differences in sulfonate content between fibers, allowing us to reduce the dosage of sulfite (SO_3^{2-}) needed for fiber separation and, consequently, lower the overall electrical energy used in chip refining. Research facilities, including APS beamline in the United States, Elettra beamlines in Italy, and Diamond light source in Oxford, United Kingdom, have validated X-ray fluorescence (XRF) techniques developed in-house. These techniques enable the measurement of sulfonated lignin distribution, providing a more detailed understanding of distribution within and between individual fibers. To ensure the homogeneity of sulfur distribution required for CTMP, we typically need a spatial resolution of 10-15 µm. We have developed our methodology based on this spatial resolution, which informs us about homogeneity. Our research has shown that sulfonation at the fiber surface is the most effective process parameter. Therefore, it is crucial to understand how sulfonate ions ($-SO_3^-$) are integrated into the structure of lignin in wood fibers, as this knowledge could be vital for developing future products and processes of high-strength packaging.

Keywords: X-ray Fluorescence; Sulfur Uniformity; CTMP; Packaging; Synchrotron.

12th International Congress on Microscopy & Spectroscopy

INVITED SPEAKER

Id-776

Phase Transition in Supercritical-fluid Phase for Hydrogen at Room Temperature

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Abstract. To utilize hydrogen effectively and safely as the energy, it is necessary to understand the physical properties of fluid hydrogen (H_2). According to the current phase diagram of H_2, the phase transition pressure from the supercritical-fluid (SCF) phase to the solid phase I is known to be 5.4 GPa at room temperature. However, we know little information concerning the SCF phase. In addition, it was thought that the phase boundary between gas and liquid of H_2 would be difficult to observe at room temperature. As results of measurements of the molar volume and ultrasonic velocity of liquid H_2, a single equation of state was presented up to 2 GPa at room temperature. According to the recent research by Raman spectroscopy and x-ray diffraction, the ratio of change in the Raman shift and compressibility decreased at room temperature and around 1 GPa. It was analyzed that the increase in intermolecular interactions may be based on the phase transition to the liquid or solid phase. It is important information that cannot be overlooked in the development of hydrogen-storage materials, but until now such detailed phenomena occurred in the megapascal-pressure range have not been found. In this study we used a diamond anvil cell to generate pressure and investigated the rotational $S_0(J)$ and vibrational $Q_1(J)$ (J = 0, 1, 2, 3) spectra on the SCF phase of H_2 at room temperature under pressure up to 2 GPa through Raman spectroscopy. Every $S_0(J)$ and $Q_1(J)$ line showed jumping in the Raman shift at around 0.5 GPa. It is considered that the anomalous phenomena of pressure changes in Raman shifts and broadening of the linewidths at around 0.5 GPa are due to the pressure-induced phase-transition of H_2. The value of transition pressure was determined using two tangent lines drawn on the Raman shift-pressure plots for each mode. The average value of P_c in the SCF phase was obtained to be 0.56 GPa. The peak-intensity analyses of $S_0(J)$ and $Q_1(J)$ lines revealed that an ortho-para conversion on hydrogen nuclear spins occurred under pressures exceeding 0.56 GPa at room temperature. The anomaly is probably due to a phase transition in the SCF phase, causing a significant change in the equilibrium-composition ratio between ortho- and para-H_2. For more details on the results, please refer to our report. This finding that the ortho-para conversion can occur at room temperature and at pressures of 1 GPa or less without the use of a catalyst, is great important information for the storage and transport of H_2.

Keywords: Hydrogen; Supercritical Fluid; Phase Transition; Pressure; Ortho-Para Conversion.

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INVITED SPEAKER

Id-780

Morphological and Structural Characterization of Metal Oxide-Based Materials for Advanced Optoelectronic Applications

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Abstract. Metal oxide-based materials, particularly zinc oxide (ZnO), are prominent candidates for advanced optoelectronic applications due to their unique structural, optical, and electronic properties. This research investigates the morphological and structural characteristics of ZnO doped with rare-earth elements such as lanthanum (La), europium (Eu), and samarium (Sm), etc., focusing on the modifications induced by doping. Rare-earth doping alters the electronic structure, enhances conductivity, introduces defect states, and enables novel functionalities beneficial for optoelectronic devices. Comprehensive characterization techniques, including scanning electron microscopy (SEM), transmission electron microscopy (TEM), and X-ray diffraction (XRD), were employed to analyze the crystalline structure and surface morphology of the doped materials. XRD revealed enhanced crystallinity and phase stability, with lattice parameter variations indicating successful doping. Morphological analyses showed a strong effect of the dopant concentration on the materials structuring, leading to various morphologies. Theoretical simulations indicated a strong correlation between optical bandgap shifts and La concentration, highlighting the influence of cluster size and morphology on optical properties. Additionally, computational predictions of the dielectric constant revealed the impact of microstructural topology on material performance, providing insights for tuning ZnO properties. Distinct microstructural features, such as "fluffy" clusters composed of crystalline grains and rods, emphasize the potential of rare-earth doping in tailoring ZnO's properties. The integration of experimental and theoretical methodologies offers a comprehensive framework for understanding the synergistic effects of doping and nanostructuring. This study advances the development of ZnO-based materials, opening avenues for next-generation optoelectronic devices optimized for specific electromagnetic radiation absorption and other targeted functionalities.

Keywords: Metal Oxide-based Materials; ZnO-based Materials; Rare-earth Doping.

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INVITED SPEAKER

Id-784

Spectral Parametrization of Two-Dimensional Systems of Randomly Distributed Particles

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Abstract. 2D nanoparticle systems have a growing number of applications as sensors, lithography masks, catalysts, photonic crystal waveguides, enhancers of solar cell performance, substrates for spectroscopy, antireflective surfaces, and many others. They can be produced using a variety of experimental methods. Once the monolayer is formed, it is usually necessary to assess its quality. Commonly, these systems are characterized by using image analysis methods that rely on the direct identification of individual particles. However, this can be a major challenge in the case of close-packed monolayers or monolayers with clusters of tightly packed particles. In addition, the cost of numerical calculations increases rapidly with the number of particles per frame. To overcome this problem, we have recently developed a novel method for particle-monolayer parametrization, based on least-squares fitting to the power spectral density of the monolayer image. Recent findings indicate that this strategy not only effectively avoids the need for identifying individual particles but is also insensitive to distortions in apparent particle size. Moreover, unlike most currently used methods, the standard errors in this approach decrease with increasing particle surface coverage. This method is particularly attractive today, as many image-analysis software programs provide all the necessary tools and procedures.

Using two images of random particle assemblies from the literature, we demonstrate the implementation of the method. Specifically, we determine the dimensionless particle radius and surface coverage, along with their standard errors. For homogeneous monolayers of monodisperse particles, the errors are on the order of 1%. The errors increase with particle polydispersity and monolayer heterogeneity. We also show that the method is not sensitive to distortions in apparent particle size, which frequently occur in optical microscopy, SEM, and AFM measurements.

Keywords: Particle Image Analysis; 2D Random Packing; Finite Size Effect; Static Structure Factor; Random Sequential Adsorption.

Acknowledgment: This work has been supported by the statutory funds of ICSC PAS. We gratefully acknowledge Polish high-performance computing infrastructure PLGrid (HPC Center: ACK Cyfronet AGH, WCSS) for providing computer facilities and support within computational grant no. PLG/2024/017899.

12th International Congress on Microscopy & Spectroscopy

INVITED SPEAKER

Id-785

Surface Morphology and Elemental Analysis of Corrosion Changes in Stainless Steels

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Abstract. Stainless steels are Fe alloys containing at least 12% Cr, which is necessary for the formation of a thin, adherent passive film on the surface, which provides corrosion resistance by separating the steel from the corrosive environment. Increasing the Cr content and optimal content of elements such as Ni, Mo, N, etc. can provide high corrosion resistance in various environments. The purpose of this research is to examine the corrosion resistance of stainless steel samples in aggressive environmental conditions. Analysis of the elemental composition of the tested stainless steel samples was performed using the Inductively coupled plasma optical emission spectroscopy (ICP-OES) method to determine the initial composition of the samples before exposure to aggressive environmental conditions, i.e. induction of corrosion changes. Semi-quantitative analysis of the metal content was determined using the energy-dispersive X-ray spectroscopy (EDX) method coupled with SEM. The surface morphology of the samples before exposure to water, sodium chloride solution and radiation showed no corrosive changes. After a defined time of exposure of the samples to distilled water, a changed surface structure was observed, while the samples treated with NaCl solution showed the appearance of pitting changes with deposits present near the pits. Deeper pits with an inhomogeneous surface and a layer of chloride deposits around the pits were formed on the samples after radiation. Elemental analysis of the samples using EDX spectroscopy shows changes in the elemental composition of the samples exposed to aggressive conditions. The pit formation in stainless steel samples is a complex multi-phase process, with nucleation being the first phase as an unstable and violent process. EDS spectroscopy confirmed the presence of oxide layers on the surface of the samples and changes in the homogeneity of the composition of stainless steels, especially in the depth of the pits and their surroundings. Analysis of corrosion changes on metal surfaces indicates the occurrence of general and pitting corrosion, altered morphology and the appearance of several metal oxides.

Keywords: Corrosion; Stainless Steel; ICP-OES; SEM; EDX.

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INVITED SPEAKER

Id-786

Spectroscopic and Microscopic Study of Silicon-Lignin Interaction: Effects on Plant Cell Walls and Industrial Potential

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Abstract. Silicon (Si) is one of the most abundant elements on Earth and plays a crucial role in plant biology. It is a beneficial element for plants, contributing to their mechanical support, enhancing grain yield, facilitating mineral nutrition, and bolstering stress response mechanisms. Si is present in plant cell walls (CWs), where it is covalently bound to polysaccharides and lignin. This incorporation strengthens CWs, increases mechanical resilience, and mitigates the effects of biotic and abiotic stresses. Despite its importance, the precise interaction between Si and the lignin formation process in CWs remains poorly understood. This study explores the interaction between Si and lignin model compounds during in vitro synthesis, with a particular focus on how Si concentrations modulate lignin polymerization dynamics over time. Fluorescence techniques (microscopy and spectroscopy), combined with FTIR spectroscopy and atomic force microscopy (AFM), proved effective in monitoring the effects of Si on molecular conformation and aggregation behavior. We investigated the interaction of SiO_2 (complexed with NH_4OH) with the peroxidase-catalyzed polymerization of a lignin monomer into a dehydrogenation polymer (DHP) as a model system. Three Si concentrations (0.1 mM, 0.6 mM, and 6 mM) were analyzed and compared with a pure DHP sample. Samples were monitored at three synthesis intervals: 1 minute, 4 hours, and 24 hours. Results demonstrate that lower Si concentrations promote the aggregation of lignin oligomers into larger particles, while higher concentrations increase oligomer repulsion, preventing particle growth. Fluorescence spectroscopy revealed that polymer fragments containing conjugated -C=C- and -C–C- bonds exhibit red shifts in the green region (500–520 nm), with the extent of the shift correlating to Si concentration. Fluorescence microscopy and AFM showed that samples with higher Si concentrations formed more compact structures, with increased rigidity attributed to Si binding. FTIR spectroscopy identified Si-specific bands (967 cm^{-1} and 1093 cm^{-1}) in the final polymers, indicating Si's integration into the lignin structure. Notably, Si did not form new intermolecular bonds but interacted with dimers formed during DHP synthesis, inhibiting the formation of larger lignin fragments. Bands above 1200 cm^{-1} in the FTIR spectra of Si-containing samples became less prominent, suggesting a significant impact of Si on lignin chemistry. These findings provide valuable insights into the complex interaction between silicon (Si) and lignin, demonstrating Si's role in restructuring lignin, shaping cell wall architecture, and improving stress tolerance—key aspects for advancing research in plant biology. Additionally, the exploration of lignin-silica composites offers significant potential, enabling the development of sustainable materials with diverse applications in industries such as construction, medicine, energy, environmental protection, and advanced technologies.

Keywords: Lignin; Silica; Fluorescence Techniques; FTIR; AFM.

INVITED SPEAKER

Id-789

Elucidating Puzzling Asymmetry in Ionic Liquids Electro-wetting of Solid Electrodes: Step Towards Single-Cell Detection

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Abstract. Room-temperature ionic liquids (RTIL) is a new family of materials composed entirely from cations and anions, exist in liquid state at room temperature, non-volatile, not flammable, thermally and chemically stable, electrically conductive, and capable to withstand up to 6 eV without decomposition and in the same time biocompatible – can provide environment for DNAs and proteins to maintain their structure and functionalities for long period of time. There exist about 10^{18} possible cation/anion combinations for potential ILs making them tuneable for practically endless number of applications including batteries, supercapacitors, catalysis, synthesis, pharmaceutical, etc. It has been recently discovered a phenomenon of the asymmetric electro-wetting of the ionic liquids with imidazolium-based cations on the surfaces of highly ordered pyrolytic graphite (HOPG) and gold: the ionic liquid wets at a positive bias and de-wets at a negative bias of the substrate. The puzzling effect of the asymmetric electro-wetting, nevertheless, makes it possible to direct the RTIL movement just by applying low voltage bias to the electrode. The electrically driven motion/migration of liquids on the microscopic scale has never been reported before. We observed the directed flow of the [EMI][FSI] ionic liquid and motion of microscopic particles embedded in the ionic liquid in real time by scanning electron microscopy. The idea of the project, we currently running, is to prove a concept of the synergetic combination of RTILs´ properties: biocompatibility and the electro-mobility for bio-sensing application, more specifically to extract single cell/ single organic molecule from the analyte, isolate and encapsulate cell/molecule in RTIL microdroplet and drive the whole assembly to the detection site to recognize the cell by deploying surface enhanced Raman spectroscopy (SERS) technique. The single cell analysis has a great potential to revolutionize cancer early diagnosis, evaluation of disease progression and treatment, and drug evaluation by getting information at the single-cell level instead of acquiring ensemble averaged data from a bulk population of cells. Microfluidic platforms or microfluidic chips, termed as “lab-on-a-chip”, technologies have been developed to handle single tumour cells. However, they are still away from the practical implementation because it is not trivial to isolate rare tumour cells with high sensitivity and selectivity even in the laboratory, not to mention clinical practice. This project aims to prove a potentially disruptive concept of deploying room temperature ionic liquids (RTIL) for single cell/single molecule isolation and detection. In the course of the project we address the following goals: 1) systematically study the structure and dynamics of the polarized electrode-RTIL interface; 2) introduce the concept of electro-migration in RTIL to assess the mechanisms behind the asymmetric electro-wetting and electro-mobility of the ionic liquids; 3) to assess the effect of ionic liquid-solid electrode interaction on the electro-wetting and electro mobility, particularly focusing on the role of surface defects; 4) to assess the impact of aqueous additives to RTIL, specifically mixture with water will be addressed; 5) generalize the obtained knowledge to assess the ability of the RTILs to extract, stabilize and transport single cells/organic molecule under applied electrical force in the pump-free setup. To achieve these ambitious goals we apply an one-of-a-kind experimental approach which includes growth of 1-10 nm thick RTIL thin films of RTIL on various substrates (gold, HOPG, ITO, etc) and an “inverse system” – nanoparticles (gold, silver, metal oxides, etc) deposited by PVD on the RTIL films. To reveal the structure of

the polarized liquid- solid interface we will deploy a combination of the state-of-the-art techniques: scanning electron microscopy (SEM), transmission electron microscopy (TEM), atomic force microscopy (AFM) coupled with Raman spectroscopy operated in the SERS mode, X-ray photoelectron spectroscopy (XPS). Thin films of RTILs will deposited in an ultra- high vacuum (UHV) chamber via thermal evaporation on various substrates. The nanoclusters will be deposited into the RTILs using PVD techniques (magnetron sputtering, effusion cell, e-beam assisted evaporation). RTILs mixed with water, hydrated ionic liquids, will be assessed by means of the SEM operating in high pressure mode. Dynamics of the RTILs micro-droplets on the polarized electrode will be monitored via in-situ electrochemical SEM (EC-SEM). As a probe cells to test our concept we plan to use gastric cancer cells, due to their high expression of a membrane receptor called programmed cell death-1/programmed cell death-ligand 1 (PD1/PD-L1). This receptor is a biomarker for several types of cancer, making it an ideal model to test the applicability of our proposed solution. The breakthrough in the problem is expected to come from the 1) synergy of a multidisciplinary research team with the wide range of expertise in electron microscopy, surface science and microbiology; 2) the comprehensive experimental framework providing a novel physical insights into the dynamics of the solid-liquid interface under electrical field in the case of neat RTILs and cell-biomarker-RTILs complexes; 3) proven concept of a the pump-free microfluidic setup for single cell/single molecule detection.

Keywords: XPS; SEM; TEM; Ionic Liquids; Nanoclusters.

INVITED SPEAKER

Id-802

Synthesis, Structural, Characterization and Antitumoral Activity of $(NH_4)_4Li_2V_{10}O_{28}\cdot 10H_2O$ Compound

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Abstract. The decavanadate compound with inorganic cations, $(NH_4)_4Li_2V_{10}O_{28}\cdot 10H_2O$, was synthesized by slow evaporation from aqueous solution. It was characterized by Infrared (IR) spectroscopy, Scanning Electron Microscopy (SEM) with Energy Dispersive X-Ray Analysis (EDX) as well as thermal analysis such as Differential Scanning Calorimetry (DSC), differential thermal analysis (DTA) and thermogravimetry (TG). The formula unit consists of one decavanadate cluster $[V_{10}O_{28}]^{6-}$, two lithium cations, four ammonium ions and ten water molecules. In the crystal, molecules are linked into a three-dimensional network by O-H…O and N-H…O hydrogen bonds. The prevalence of these intermolecular interactions was confirmed by an analysis of the Hirshfeld surface (HS) and fingerprint plots (FP). The relative contribution of different interactions to the HS indicates that the O…H/H…O and H…H contacts account 86.8% of the total HS area. In this study, the cytotoxic and the antiproliferative activities of $(NH_4)_4Li_2V_{10}O_{28}\cdot 10H_2O$ on human cancer cells (U87, IGR39 and MDA-MB-231) were investigated. This compound demonstrated dose-dependent antiproliferative activity on U87, MDA-MB-231 and IGR39 with IC_{50} values of 2 µg/mL, 18 µg/mL and 12 µg /mL, respectively. These data provide evidence on the potential anticancer activity of $(NH_4)_4Li_2V_{10}O_{28}\cdot 10H_2O$.

Keywords: Decavanadate; Synthesis; Infrared Spectroscopy; SEM-EDX; Thermal Analysed; Hirshfeld Surface; Anticancer Activity.

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INVITED SPEAKER

Id-804

Structural Studies of the Earlier Stages of PhiKZ Infection

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Abstract. During infection, the giant phiKZ phage forms a specialized structure at the center of the host cell called the phage nucleus. This structure is crucial for safeguarding viral DNA against bacterial nucleases and for segregating the transcriptional activities of late genes. Here, we describe a morphological entity, the early phage infection (EPI) vesicle, which appears to be responsible for earlier gene segregation at the beginning of the infection process. Using cryo-electron microscopy, electron tomography (ET), and fluorescence microscopy with membrane-specific dyes, we demonstrated that the EPI vesicle is enclosed in a lipid bilayer originating, apparently, from the inner membrane of the bacterial cell. The phiKZ EPI vesicle contains both viral DNA and viral RNA polymerase. EPI vesicle further migrates from the cell pole to the center of the bacterial cell together with ChmA, the primary protein of the phage nucleus. Thus EPI vesicle acts as a membrane transport agent, efficiently delivering phage DNA to the phage nucleus while protecting it from the nucleases of the bacterium.

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

INVITED SPEAKER

Id-812

Anticancer and Antioxidant Activity of Ln(III) Complexes of Bioactive Coumarins

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Abstract. The study of the complexes structure and of their biological importance represents the major research interest toward the use of organic drugs as ligands in coordination chemistry for their application in the biomedical field. The molecules of bioactive coumarins have one or more unshared electron pairs that can function as preferred ligands in complexation reactions. The reported lanthanide(III) complexes of coumarins have been studied by using a wide range of techniques. The spectral methods such as Fourier transform infrared spectroscopy, Raman spectroscopy, etc. provided information about the complexes and ligand structure. Other techniques such as elemental analysis and thermal methods were also employed for the physicochemical characterization of complex composition. Many theoretical studies (molecular modeling, vibrational assignments, reactive sites and structural properties) were conducted to help the binding mode elucidation in the obtained Ln(III) complexes. The synthesis of Ln(III) complexes was carried out in order to evaluate their antineoplastic and antioxidant properties. It was demonstrated that the cytotoxic activity of the studied compounds against different cancer cell lines and their antioxidant activity was increased upon complexation making the ligand a more powerful agent. The complexes of coumarin derivatives with Ln(III) ions exhibited antineoplastic and antioxidant activity with low toxicity.

Keywords: Lanthanide(III) Complexes; DFT; Vibrational Characterization; Cytotoxicity; Antioxidant Activity.

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INVITED SPEAKER

Id-813

Quantitative Analyses of Gas Mixtures Using an Infrared Spectrometer – Methodologies and Example Results

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Abstract. The possibility of using an FTIR spectrometer to identify gaseous products, even in cases where the gases are mixtures of several or even dozens of chemical species will be discussed. Our research utilized an authorial integration of a thermogravimetric analyzer (TGA) with an FTIR spectrometer, developed to enable simultaneous thermal analysis and identification of exhaust gases.

In commercial integrated systems, such as those offered by Netzsch or PerkinElmer, software for quantitative calculations is not available. Quantitative gas analysis in these systems is hindered by factors such as cuvette size, optical path length, and the sampling method, all of which contribute to the non-linearity of the absorbance signal relative to the concentration of released gases. We employed a highly specialized FTIR spectrophotometer with high spectral resolution. Such analyzers are offered by companies like Protea by MLU or Waters by TA Instruments. These spectrophotometers are typically dedicated to measuring exhaust gases, where not only the quality but also the quantity of specific emitted gases is of critical importance.

The application of TG-FTIR will be demonstrated using the example of the thermal decomposition of polyolefins in gas mixtures with varying oxygen content in the carrier gas, as well as providing insights into partial processes occurring during combustion in a power boiler. Additionally, the potential of using an FTIR spectrophotometer for monitoring processes in a fluidized bed reactor will also be demonstrated.

Keywords: TG-FTIR; FB-FTIR; Combined Techniques.

12th International Congress on Microscopy & Spectroscopy

INVITED SPEAKER

Id-814

Optimizing Porous Silicon Bragg Mirrors for Photonic Crystals: A Study on Fabrication and Characterization

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Abstract. Materials known as photonic crystals possess a specifically designed periodic structure that alters their optical properties, holding significant potential for optoelectronic devices. An example of this is the Bragg mirror, which takes the form of a one-dimensional periodic structure. When composed of porous silicon (PSi), a Bragg mirror consists of layers with varying optical properties and thicknesses. Placing two of these mirrors with a spacer layer in between creates a Fabry-Pérot interferential filter or resonant microcavity. In our study, PSi is produced through an electrochemical method involving a silicon wafer, diluted hydrofluoric acid, and electric polarization. By varying current densities, we can control the formation of single or multiple layers of PSi. Various techniques, such as gravimetry, optical reflectivity, scanning electron microscopy, and spectroscopic ellipsometry, are employed to optimize the material's properties for use in photonic crystals. The quality of the microcavity structure is assessed by analysing the optical reflectivity spectrum, confirming its successful creation. With a achieved full width at half maximum (FWHM) of approximately 50 nm, we can confirm the high quality of the filter.

Keywords: Photonic Crystal; Porous Silicon; Electrochemical Etching; Spectroscopic Ellipsometry; Optical Reflectivity; Microcavity.

12th International Congress on Microscopy & Spectroscopy

INVITED SPEAKER

Id-815

Scanning Probe Microscopy for Mechanical and Thermal Investigation of Biological and 2D Materials

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Abstract. Scanning Probe Microscopy (SPM) techniques have long been employed in several research fields. Here, we will mainly focus on the mechanical and thermal investigation methods with SPM. AFM force vs distance curves can be used on a wide variety of samples to determine their mechanical properties such as the Young's modulus, adhesion force, dissipated energy, and hardness. We employed a cube-corner diamond tip to acquire force curves on two species of marine seashells. The results have been used in resonant ultrasound spectroscopy analysis that allowed to obtain the mechanical properties of the whole mollusks shell and to perform a dynamic, frequency-domain, analysis. The study showed that the specific features of the considered shells, in particular their helicoconic and hierarchical structure, can also be linked to their vibration attenuation behavior. Force vs distance curves have also been fundamental in the investigation of DNA-based and 3D-printed nanomechanical resonators, and the main results will also be presented. Scanning Thermal Microscopy (SThM) is a powerful tool for the thermal investigation at the nanoscale. Despite this technique hardly providing a quantitative determination of the thermal conductivity of the sample, SThM has an unmatched spatial resolution (a few tens of nanometers or less), which cannot be achieved by other popular methods such as Raman optothermal technique or by electrical methods. Graphene and related materials have attracted intense research efforts, because of their exceptional electrical, thermal, and mechanical properties. Several individual reduced graphite oxide (RGO) flakes were analyzed by SThM, both as obtained after conventional thermal reduction and after a subsequent annealing at 1700 °C. Significant differences in the thermal maps were observed between pristine and annealed flakes, reflecting higher heat dissipation on annealed RGO flakes compared with pristine ones. We also performed measurements on single layers of chemical-vapor-deposited (CVD) graphene supported by different substrates, namely, SiO_2, Al_2O_3, and PET using a double-scan technique to remove the contribution to the heat flux through the air and the cantilever. Quantitative determination of the thermal conductivity will be presented as well as a comparison with finite-elements analysis.

Keywords: AFM Force Curves; SThM; Biomaterials; Mechanical Properties; Thermal Properties.

Acknowledgment: European Commission under the FET Open 'Boheme' Grant No. 863179.

INVITED SPEAKER

Id-816

Structural Insights into Photosystem II Supercomplexes Using Cryo-Electron Microscopy

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Abstract. Photosystem II (PSII) is a pivotal protein-pigment complex in oxygenic photosynthesis, responsible for initiating the light-driven splitting of water, producing molecular oxygen, and supplying electrons for the photosynthetic electron transport chain. The PSII dimeric core comprises over 36 subunits and associates with peripheral light-harvesting complexes composed of various Lhcb proteins. These associations form distinct types of supercomplexes, enabling PSII to optimize light capture and energy transfer efficiency under diverse environmental conditions.

Cryo-electron microscopy (cryo-EM) has become a key technique for elucidating the structures of protein complexes with near-atomic resolution. Over the past decade, cryo-EM has provided unprecedented insight into the structural arrangements and functional adaptations of PSII supercomplexes from a wide range of plant and green algae species. These studies have revealed species-specific differences in the arrangement of PSII, the arrangement of light-harvesting proteins and the mechanisms underlying the regulation of photosynthesis.

In this lecture, I will present our recent findings on PSII cryo-EM supercomplexes from plants. By comparing structural data in different organisms, I will highlight key evolutionary and functional adaptations that optimize photosynthetic performance. General conclusions will also be drawn about the broader implications of these structural insights for understanding photosynthesis, their application and further development.

Keywords: Single Particle Electron Microscopy; Photosynthesis; Photosystem II Structure.

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INVITED SPEAKER

Id-819

Application of Microscopy in Identification of Water Pollutants

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Abstract. Lake Ada Ciganlija is located on the southern bank of the Sava River, near the confluence of the Sava and Danube, 4 km from the center of Belgrade (Serbia). In summer, the lake and the surrounding peninsula become a cultural and entertainment center, attracting many visitors every day. Covered with dense deciduous forests and dotted with glades and meadows, Ada is the largest and most visited recreation and swimming spot for Belgrade residents. Another name for this popular site is „The Belgrade Sea“. A few years ago, something resembling bird feathers was spotted floating on the surface of the water. Pigeons and gulls live in the area, so the presence of feathers in the water was not surprising. Most visitors did not notice it, and some assumed it was of natural origin. As it appeared every day, the author decided to take some samples and collect them in 1.5 ml molecular tubes. The aim of the study was to examine this material under a microscope. Microphotographs were made using an Olympus BH-2 microscope with Nomarsky contrast and bright-field microscopy, a digital camera and Motic Images Plus 2.0 ML software.

The results were surprising, revealing transparent, plastic-like hollow microtubes or microfibers that were clearly not of natural origin. The microfibers varied in length (100-3,000 μm) and width (5-20 μm). They were connected to each other in pairs or multiple pairs, sometimes fused together in clumps, and adhered very well to human tissue. Many questions arose: Where did it come from? What is the purpose of these microtubes? Who made it? A literature survey of microfibers in fresh waters in foreign countries showed that their microfibers originate mainly from wastewater. But it was not the case here. The Belgrade sea i.e. lake is fed directly by rivers, and the microfibers are so tiny that they float for a few seconds and sink to the bottom when the water moves. They must first fly through the air and then settle on the surface until they reach the bottom or some organism. In both cases, the microfibers are water pollutants, since they are not natural and were not present in the lake before.

Government authorities should pay more attention to such pollutants, since they can cause disruptions in the aquatic ecosystem and become a serious environmental hazard. In addition, microfibers can have adverse effects on the lungs, gastrointestinal tract and many other physiological systems of organisms. In this sense, citizen science will be important in future, to alert for unusual artifacts and processes in our environment. But first, the public needs to be informed.

Keywords: Microscopy; Water; Pollutants; Microfibers.

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12th International Congress on Microscopy & Spectroscopy

INVITED SPEAKER

Id-822

Advances in Surface Modification for Bone Tissue Engineering: Image-Based Structural and Functional Enhancements

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Abstract. Surface modification of biomaterials (ex. Titanium) has gained attention for bone tissue engineering by mimicking the native bone extracellular matrix (ECM). Recent progress in material synthesis and scaffold functionalization, combined with advanced imaging technologies, has significantly enhanced mechanical properties, bioactivity, and therapeutic efficacy. High-resolution imaging has provided critical insights into scaffold architecture, cell interactions, and mineralization processes, facilitating optimized scaffold design. Surface functionalization with apatite minerals, bioactive proteins, and controlled drug release systems further improves bone healing. Additionally, 3D electrospun scaffolds enable spatially organized cell growth and vascularization. These bioengineered surface modifications, aided by imaging studies, hold promise for advancing bone tissue engineering and regenerative medicine.

Keywords: Bone Tissue Engineering; Surface Functionalization; Titanium; Osteogenic Differentiation; Imaging Analysis.

INVITED SPEAKER

Id-824

Application of Raman Spectroscopy for Characterizing Soil Material. Results of Field Experiments

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Abstract. Chemical composition of soils is variable and influenced by many factors. Compared with bulk soil, the rhizosphere soil is more variable. Plants are able to control the quantity and quality of the root exudation and change the properties of the soil to adapt and ensure their survival. Our knowledge of the processes controlling root exudation and the relationships between rhizosphere soil and plants is still insufficient. This is particularly relevant for the temporal variability of root exudation and its impact on the surrounding soil. It is expected that daily fluctuations in the physicochemical parameters of the soil can be associated with temperature and rhizosphere activity. In addition, short-term (diurnal) variations may be due to circadian changes in plants and in the rhizosphere soil. There is an increasing demand for the efficient identification of soil organic matter. This requires the development of rapid high-quality multicomponent analytical techniques. Raman spectroscopy (RS) is a promising non-destructive technique that allows fingerprinting at the molecular level. This method has a great potential for soil analysis. However, to date, the main reason for the rare use of RS in soil analysis is fluorescence interference, which occurs mainly due to complex organic/mineral composition of soils and spectral interference. In this study, we explored the potential of RS in identification of mineral and organic compounds in bulk soils and in the rhizosphere soil of several widespread plant species. The main objectives of the research were the following: to develop procedures to improve the signal-to-noise ratio of Raman spectra; to reveal possible differences in the composition of the rhizosphere soil of different plant species arising as a result of plant growth in the sites with different soil properties; to assess how the root activity of each plant species can change soil characteristics; to study short-term variability in the composition of the rhizosphere soil of the selected plants. To decrease the intense fluorescence background, it was subtracted by fitting the smoothed curve with a second-order polynomial. We also used the algorithm of piecewise approximation of the spectral contour. Our experimental study demonstrated that RS can be successfully applied to study the chemical structure and composition of soil material. The physicochemical analysis and RS showed that experimental sites differed in the concentrations of minerals and various organic compounds as well as in the pH of the soils. In general, rhizosphere and bulk soils contain similar mineral and organic compounds. However, metabolic processes performed by roots created a specific physicochemical environment within the rhizosphere that differed significantly from that of the bulk soil. It was shown that the release of the same organic compounds by plant roots into different soils changed the chemical properties of the soils differently. The concentrations of main biomolecules presented in the rhizosphere soil varied during the day. The fluctuations were often different for the rhizosphere of different plant species. This can be the result of very distinct ways of adaptation of the plants to the Earth's rotation.

Keywords: Rhizosphere Soil; Grasses; Organic Compounds; Daily Variations; Raman Spectroscopy.

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INVITED SPEAKER

Id-825

Spectral and FTIR Studies on Complexes with the N,N-bis(3,3-dimethyl-allyl)-Dithiocarbamate in view of Their Use as Precursors for Nanofibers

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Abstract. New complexes of N,N'-bis (3,3-dimethyl-allyl)-dithiocarbamate with different metal ions (such as Zn (II), Ni(II), Pt (II), Cd(II)) were synthesized and investigated. The structural characterization of the ligands and their metal complexes was achieved using FTIR, ^{1}H-NMR, ^{12}C-NMR, and MS techniques. Ligand' structure was investigated by DFT computations in order to establish the best conformer, lower in energy and able to perform complexation with various heavy metal ions. Prediction of properties, molecular and topological descriptors were obtained at ground state using two DFT levels of theory (B3LYP—the Becke's three-parameter hybrid exchange functional with the Lee–Yang–Parr correlation functional with basis set 6-311 (d, p) and ωB97XD with basis set 6-311G (d, p). The new metal dithiocarbamate complexes served as single-source precursors of the metal sulphide nanoparticles. The shape changes of the derived nanoparticles were studied by transmission electron microscopy. The metal calcogen nanoparticles were used as inorganic filler for the formation of polyacrylonitrile-metal sulphide nanofibers with improved surface area and diameters analyzed by scanning electronic microscope.

Keywords: N,N-bis(3,3-dimethyl-allyl)-dithiocarbamate; Synthesis; FTIR; NMR; MS; DFT Calculations; Nanofibers.

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INVITED SPEAKER

Id-827

$BaTiO_3$-based Functional Materials Used in Electronics: from Nanopowders to Micro- and Nanostructured Ceramics

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Abstract. Understanding the intricate relationships between grain size and functional properties in $BaTiO_3$-based systems can pave the way for designing and optimizing materials for targeted applications in micro- and nano-electronics. For this purpose, undoped, as well as *A* and *B*-site doped $BaTiO_3$ nanopowders and related ceramics were prepared by appropriate wet chemical methods followed by different consolidation procedures. Electron microscopy investigations emphasized the significant influence of the synthesis conditions and sintering strategy in controlling particle / grain size and morphology. Two homovalently *B*-site substituted $BaTiO_3$ systems, *i.e.* $BaTi_{1-x}Zr_xO_3$ (BTZ) $BaTi_{1-x}Hf_xO_3$ (BTH) were investigated in detail. Ceramics derived from nanopowders synthesized by different wet-chemical methods (modified Pechini method, sol-gel) were consolidated by conventional sintering (CS), as well as by spark plasma sintering (SPS), in order to tailor grain size and, consequently, functional properties for specific applications as multilayer ceramic capacitors, ferroelectric random access memories, energy storage devices and tunable products for microwave devices. The functional properties in micro- and nano-structured BTZ and BTH ceramics are comparatively discussed. It was found that nanostructuring strongly influences the dielectric response, inducing a significant decrease of the dielectric constant, as well as the flattening of the permittivity maximum versus temperature. As *A*-site homovalent dopant in $BaTiO_3$, strontium (Sr^{2+}) was chosen. An exhaustive study was devoted to $(Ba,Sr)TiO_3$ (BST) ceramics derived from nanopowders synthesized by the acetate-variant of the sol-gel method and then consolidated by alternative sintering techniques. It was found that downscaling grain size toward the nanometre range represents a key-factor for tuning the crystalline structure, phase transitions, dielectric and ferroelectric behaviour in $Ba_{0.8}Sr_{0.2}TiO_3$ and $Ba_{0.6}Sr_{0.4}TiO_3$ ceramics. Not only chemically-homogeneous $Ba_{1-x}Sr_xTiO_3$ ceramics, but also compositionally-graded products were prepared by an innovative procedure in order to improve the pyroelectric properties. Regarding *A*-site substituted materials, Ce^{3+} on barium sites was used as aliovalent solute. $Ba_{0.95-}Ce_{0.05}Ti_{0.9875}O_3$ (BCT) one-dimensional nanostructures were elaborated by template-mediated colloidal chemistry. The as-prepared BCT nanowires and nanoshell tubes revealed piezoelectric and ferroelectric properties. The imprint found in the "butterfly"-loop of the piezoresponse amplitude signal of 5 mol.% Ce^{3+}-doped $BaTiO_3$ nanoshell tubes is almost missing in the case of the nanowires with similar composition, indicating that the restrictive tubular geometry might play a key-role in generating flexoelectric effect. On the other hand, single-phase Ce^{3+}-doped $BaTiO_3$ powders, described

by the nominal formula $Ba_{1-x}Ce_xTi_{1-x/4}O_3$, were also synthesized by sol-gel method. The structural parameters, particle size, and morphology are strongly dependent on the Ce^{3+} content. From these powders, dense ceramics with variable grain sizes were prepared by the two consolidation techniques already mentioned. The fine-grained $Ba_{0.95}Ce_{0.05}Ti_{0.9875}O_3$ ceramic showed an almost temperature-independent colossal dielectric constant, which originated from very high interfacial polarization. The same strategy for preparing ceramics with a wide range of grain size was used also for the complex $Ba_{0.85}Ca_{0.15}Ti_{0.9}Zr_{0.1}O_3$ (BCTZ) perovskite. It was found that as the grain size decreases, there is a noticeable decrease in the maximum permittivity, a significant reduction in dielectric losses, and a shifting of the Curie temperature towards lower values.

Keywords: $BaTiO_3$; Grain Size Effect; Nanostructure; Spark Plasma Sintering; Ferroelectric Properties.

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INVITED SPEAKER

Id-830

Terahertz Time-Domain Spectroscopy for Security Applications

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Abstract. The rise of counterfeit merchandise at different levels, including documents, electronics, commercial products or even pharmaceuticals, poses both economic and safety risks. To address this issue, scientists and technologists have been focusing on the development of security devices featuring physical unclonable functions (PUFs). Among them, optical PUFs emerge thanks to their enhanced security that goes beyond complex morphological designs, achieved through advanced manufacturing techniques. Traditional optical tagging methods exploit materials with distinctive optical properties—such as dyes, quantum dots, nanoparticles, or liquid crystals—to create unique fingerprints. However, these tags are usually easily detectable under visible light and require them to be placed on the device surface; conditions that make these tags vulnerable to falsification and damage, respectively. More secure alternatives consist in adding PUFs transparent to visible light (i.e., nanometric-thick conductive film as ITO or graphene) or embedding the authentication tags within the device. In the past, these approaches have been explored with UV-light (i.e., fluorescent dyes or particles) or X-ray (in the case of tags hidden in multilayered device), however, these high-energy light sources may pose a risk both for the device and the operator. A nondestructive, safe decoding procedure presents thus a significant challenge. Terahertz time-domain spectroscopy (THz-TDS) has emerged as a promising solution. THz-TDS has been widely used in medical imaging, cultural heritage preservation, and quality control. In anticounterfeiting applications, it allows the detection of hidden security features within complex devices. In particular, while nanometric conductive films may not be detected by visible light, they present a characteristic fingerprint at the THz radiation, that can be tuned as a function of the film thickness. A manufacturing approach allowing introducing unpredictable thickness variation consents to pattern a PUF hardly to be recognized by standard techniques but easily detected through THz spectroscopy. Embedding the tag between opaque dielectric layers allows to add a further security level, as the PUF is not only invisible in standard operating condition but cannot be detected through morphological investigation. THz-TDS allows for non-invasive analysis of multilayered structures due to its ability to penetrate nonconductive materials while remaining non-ionizing—unlike X-ray technologies. However, standard time- and frequency-domain analyses may still struggle to accurately decode multilayered structures, especially when crucial information is embedded within intermediate layers or presents subwavelength features. Multiple reflections and subwavelength structures can obscure relevant data, requiring advanced imaging techniques. An innovative physics-based approach, focusing on the interaction between each material composing the device and the THz radiation, allows for determining effective figures of merit that greatly improve the image contrast and enhance hidden tag identification.

Keywords: Terahertz Imaging; Terahertz Time-domain Spectroscopy; Anticounterfeiting Devices; Fabry–Perot.

Acknowledgment: The work of T.R., D.C.Z., S.T., and R.B. was supported by the European Union, Next GenerationEU, through the project ECS00000024 “Ecosistemi dell’Innovazione”—Rome Technopole— CUP B83C22002890005 of the Italian Ministry of University and Research, public call n. 3277, PNRR-Mission 4, Component 2, Investment 1.5. The work of Walter Fuscaldo was supported by the European Union, Next GenerationEU, through the Project PRIN 2022 “Spiral and Focused Electromagnetic fields” (SAFE) of the Italian Ministry of University and Research (MUR), under Grant 2022ESAC3K.

INVITED SPEAKER

Id-831

Neonatal Hypoxic Ischaemic Brain Damage – New Experimental Treatments and Biomarkers

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Abstract. Neonatal hypoxic-ischaemic encephalopathy (HIE) is a leading cause of neonatal mortality and morbidity, affecting 1-3 per 1000 live-births in developed countries with rates about 26 per 1000 in low-income setting. About 40% of the affected children die in the neonatal period with further 30% developing life-long neurological disabilities. During HI, inflammatory response and oxidative stress occur, causing subsequent cell death. The presence of an infection sensitizes the neonatal brain, making it more vulnerable to HI damage. The only clinically approved care for moderate to severe neonatal hypoxic-ischaemic (HI) brain injury is therapeutic hypothermia (TH), however its application and effectiveness are very limited. TH reduces death and disability only by 11% with about 40% of the treated infants still developing neurological incapacities. The number of HI infants needed to treat with TH for one to be saved from death or disability at age of 18-22 months, is approximately 6-7, which highlights the need for development of alternative effective, simple and safe treatments to replace TH. This study aims development of new experimental treatments and novel biomarkers for neonatal HI brain damage. We use a neonatal mouse model of HIE to mimic the clinical scenario of human birth asphyxia, and test different experimental treatments. We then histologically assess the levels of brain damage through microscopic evaluation of microglial and astroglial activation, cell death, tissue loss, oxidative stress and levels of myelination. We also assess eye microglia and whether it can be used as a proxy for the changes in the neonatal brain following HI. There is a paucity of data on the participation of the alternative complement pathway, and particularly the role of properdin in HI brain damage. We demonstrated a critical role for properdin, and possibly also a contribution in neonatal HI alone and in infection-sensitized HI brain damage. Stem cell therapy decreases brain injury either by replacing lost cells, promoting host progenitors' differentiation, and/or modulating the host immune response. We demonstrated that a single contralateral injection of human amniotic fluid stem cells into the neonatal HI mouse brain decreased tissue loss, cell death and microglial activation, prevented demyelination and reduced TGFβ1 levels. We also demonstrated that immediate post-HI inranasal application of MSC derived extracellular vesicles reduced HI brain damage. Curcumin is a natural compound which is an antioxidant, reactive oxygen species scavenger, with reported anti-tumour and anti-inflammatory activity. Curcumin has been shown to attenuate mitochondrial dysfunction, stabilize the cell membrane, stimulate proliferation, and reduce injury severity in adult models of spinal cord injury, cancer, and cardiovascular disease.

Our data demonstrates a dose-dependent neuroprotective effect of curcumin in neonatal HI brain damage thus proposing it as a potent neuroprotective agent with potential for the treatment of HIE. The delayed application of curcumin following neonatal HI further increases its clinical relevance. Properdin can be considered a novel target for treatment of neonatal HI and infection-sensitised HI brain damage. Stem cell and extracellular vesicle therapy, as well as natural anti-inflammatory and antioxidant compounds have potential as alternative therapies for neonatal HIE.

Keywords: Neonatal Hypoxia Ischaemia; Microglia; Neonatal Brain Damage; Cell Death.

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ORAL PRESENTATION

Id-796

Generation Characteristics of MOS Structures Based on Monocrystalline Silicon

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Abstract. Background is the study of the influence of rear-earth elements on generation characteristics of silicon MOS-structures. The investigated samples were single crystals of n- and p-type Si doped with rare earth elements (Gd and Sm) both in the diffusion process and during growth from the melt. The specific resistance of the samples ranged from 5 to 300 Ω·cm, the dimensions of the samples were 12x6x1 mm^3 with different orientations.

Objective is the study of physical processes in silicon multilayer structures doped with rare- earth elements, both by diffusion and during growth from the melt.

Deep levels transient spectroscopy, C-V measurement techniques. To carry out capacitive measurements, Schottky diodes were created by high vacuum deposition of Au on n-Si or antimony on p-Si, Ni was chemically deposited or Sb was deposited on n-type Si, and Au or Al was deposited on p-Si as an ohmic contact.

Based on the conducted comprehensive studies of generation-relaxation effects in silicon and silicon multilayer structures of the metal-insulator-semiconductor type doped with rare-earth elements, the following conclusions was made: the technology for engineering silicon multilayer structures of the metal-insulator-semiconductor type by adding trichloroethylene vapors C_2HCl_3 in an atmosphere of humid O has been improved.

It has been found that by embedding impurities of rare earth elements (Gd and Sm) into silicon, it would be possible to reduce the efficiency of thermal defect formation and slow down the processes of growth-defects formation. Various electronic processes occurring in the bulk of a dielectric, semiconductor, at their interface, as well as in the Si-SiO_2 transition layer were studied and their contribution to the picture of relaxation processes in MOS structures was assessed.

Keywords: MOS Structures; Monocrystalline Silicon; Rear-earth Elements.

12th International Congress on Microscopy & Spectroscopy

ORAL PRESENTATION

Id-797

Optical and Electrophysical Properties of Transparent Conductive Layers of Metal Oxides and Sensors Based on Them

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Abstract. In the present research paper, a number of materials consisting of metal oxides have been investigated, which have sensitivity at room temperature in conditions of irradiation with visible light, covering a wide range of radiation. Materials are nanocomposite compounds based on wideband metals oxides, on the surface of silicon, which are used as the sensors of irradiation.

The objective is development of a technique and reveal pre-conditions for obtaining nanocomposite materials based on wide-band metal oxides ZnO, $Sn0_2$ and In_20_3 and their complexes, determining the composition and structure of synthesized materials and the distribution of components in them.

Gas transportation equipment and molecular beam epitaxy equipment are used for film growth, as well as the magnetron-ion ion sputtering equipment. The structure and morphology of oxide films and sensor structures based on them are studied using XRD structural analysis and a SEM. The current-voltage characteristics and C-V characteristics of sensors based on wide-bandgap metal oxide compounds are studied.

Stable sensory structures were created and investigated on thin wide -bandgap oxide semiconductors. Sensors could be used for the measurement of moisture, the temperature and gas compounds. The developed sensors also have sensitivity to hydrogen and other components of air, CO_2 and methane, propane and other compounds.

Stable sensor structures for environmental protection based on thin wide-bandgap oxide semiconductors have been designed and studied. The results obtained will significantly increase the efficiency of sensors due to the developed technology for structures based on various combinations that can successfully withstand the influence of external factors.

Keywords: Wide-bandgap Semiconductors; Molecular Beam Epitaxy; Metal Oxides; Sensors.

12th International Congress on Microscopy & Spectroscopy

ORAL PRESENTATION

Id-803

Novel hexa-[methylimidazolium] decavanadate(V) dihydrate: Synthesis, Characterization, and Antiproliferative Effects on IGR39 Melanoma and U87 Glioblastoma Human Cancer Cells

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Abstract. Melanoma, a malignancy derived from melanocytes, and glioblastoma (GBM), the most aggressive and fast-growing brain tumor, both exhibit inherent resistance to conventional therapeutic approaches, necessitating the development of novel treatment options. Decavanadate-based compounds have shown promise in this context due to their potential antiproliferative effects. In this context, new potential drugs based on decavanadates are being developed as possible treatments for brain and skin tumors [1-2]. This study explores the synthesis, structure-function relationship, and antiproliferative effects of a novel decavanadate compound: hexa-[methylimidazolium] decavanadate(V) dihydrate $(C_4H_7N_2)_6V_{10}O_{28}\cdot 2H_2O$, characterized using single-crystal X-ray diffraction, FT-IR, UV-Vis, and ^{51}V-NMR spectroscopies. The compound crystallizes in the monoclinic system space group $P2_1/n$. Important intermolecular interactions in the structure are N-H···O and O-H···O hydrogen bonds and π-π stacking interactions between the organic cations. The Hirshfeld surface (HS) and their relative two-dimensional fingerprint plots (2D-FP) reveal that the structure is dominated by O…H/H…O and H…H contacts. Interestingly, this decavanadate salt $(C_4H_7N_2)_6V_{10}O_{28}\cdot 2H_2O$ inhibit the viability of U87 and IGR39 cells with IC_{50} values of 0.96 µM and 1.01 µM, respectively, after 72 h of treatment.

Keywords: Decavanadate; Glioblastom; U87; Melanoma; IGR39; Anticancer Activity.

Acknowledgment: Ministry of Higher Education and Scientific Research of Tunisia (PRF code of this project**:** PRF2019-D3P2).

12th International Congress on Microscopy & Spectroscopy

ORAL PRESENTATION

Id-832

Microglial Development in the Eye and the Potential of Eye Microglia as a Marker for Changes in the Brain in Health and Disease

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Abstract. Hypoxic-ischaemic encephalopathy (HIE) is a major cause of mortality and morbidity in neonates with an estimated incidence of 1-3 per 1,000 live births in the developed countries, and the occurrence rate can be as high as 26 per 1000 in developing set-up. HI accounts for 23% of infant mortality, with 5-10% of survivors suffering motor disabilities and up to 50% of survivors demonstrating sensory and cognitive disorders. A lot of clinical and experimental evidence suggests that neonatal HI does not result in a uniform or global brain injury but causes selective damage to different brain structures, which depends on the severity and duration of the insult as well as on the developmental stage of the brain when it occurs. However, the mechanisms underlying this sex difference remain elusive with. Microglial cells are the immune competent cells in the CNS and PNS and their activation is considered a marker for inflammation and damage. However, they also are involved in clearing of the debris and production of anti-inflammatory cytokines, thus having a "double" role - pro- and anti-inflammatory. Differentiation between the two types is really difficult and achievable mainly through gene sequencing, therefore understanding of the microglial networks can provide more insight into their participation in initiation and resolving of inflammation following neonatal HI.

The aims of this study are:

1. To determine the gender differences of microglial development, a field that remains largely unexplored.
2. To determine sex differences in microglial morphology during eye and brain development in newborn mice by using Light Sheet Fluorescence Microscopy (LSFM), with a particular focus on brain regions most susceptible to HI.
3. Assess morphological changes in microglia during eye and brain development in C57BL/6J neonatal mice of different sexes from postnatal day 1 (P)0 to postnatal day 28 (P28, adult).
4. Assess the correspondence between eye microglia and brain microglia development.
5. Scanning the whole brain and eye using LSFM. Find central nervous system network connections more clearly by 3D imaging.

Using mice with ages from postnatal day 0 (corresponding to premature human brain) to postnatal day 28 (corresponding to adult human brain) we assessed microscopically assessed brain and retina microglia through immunohistochemistry. We quantified the ration between the different morphological types of microglia through ramification index manually and also employed support vector machine analysis. 3D imaging of eye and brain tissue obtained from P0-P28 naive mice, following clearing for LSFM and demonstrating microglial networking in eye and brain. The current study suggests that the morphology and number of microglia in the brain are influenced by sex, age, and region. This study establishes, for the first time, a baseline for correlation between eye and brain microglial development in healthy mice suggesting that eye microglial development falls behind brain microglial development by around 3 days. Our study demonstrates the correlation between eye and brain microglial development and highlights the sex differences in brain and eye microglial development. Our future research will focus on using eye microglia as

biomarkers to reflect changes in the brain, which will provide a more rapid and non-invasive method of assessment of HIE severity levels in newborns.

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

12th International Congress on Microscopy & Spectroscopy

POSTER PRESENTATION

Id-777

A Scanning Electron Microscopic (SEM) Investigation on the Structure and Micromorphology of Aerial Organs from *Echium Vulgare* L.

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Abstract. *Echium vulgare (*blueweed or viper's bugloss) is a species of the Boraginaceae family, widely distributed as a native species in Europe and Asia, and introduced in America, some African countries, and Australia. It is a melliferous species, sometimes used as an ornamental plant or in ethnomedicine, and it also has significant value in phytoremediation.

The purpose of this paper is to provide a detailed characterization of the micromorphology of the aerial organs (both vegetative and reproductive) of this species, with a particular focus on non-glandular trichomes which are numerous and morphologically diverse. These trichomes are a key characteristic that helps define species within the Boraginaceae family. The leaves have a bifacial heterofacial structure, with a single or bilayered palisade parenchyma located beneath the upper epidermis; the midvein protrudes prominently on the abaxial surface, with a central crescent-shaped vascular bundle. Non-glandular trichomes are present on both epidermises of the leaves. They are either short, with a slightly swollen base, inserted among the epidermal cells, or long and massive (bristles), with a base surrounded by a pedestal of epidermal cells arranged in a rosette. The external surface of the bristle wall is echinate, as is the basal part of some of the simple, unicellular trichomes. Stomata are present on both epidermises of the leaf (amphistomatic lamina), as well as on those of the sepal, with a higher density in the lower epidermis. The same types of trichomes are also found on the sepals and petals, with the larger ones primarily located in the lateral-lower areas, having a base surrounded by 16-20 epidermal cells. Towards the tip of the sepal, the trichomes have smooth walls. Rare, short glandular trichomes are visible on the leaves, sepals and petals, formed by a basal cell, a stalk cell and a pyriform glandular cell. The non-glandular trichomes of *Echium vulgare* play an important role in protecting the plant against herbivores (especially the large ones, bristles, which also have walls strongly impregnated with calcium carbonate), as well as in reducing water loss (particularly the short ones, which are dense, appressed covering a significant area of the epidermis surface). These structural features significantly contribute to the species' adaptive capacity, enhancing its competitiveness and enabling it to spread over a vast area. Additionally, their micromorphological characteristics can aid in the taxonomic identification of the species.

Keywords: Echium vulgare; Epidermis; Non-glandular Trichomes; Bristles; SEM.

12th International Congress on Microscopy & Spectroscopy

POSTER PRESENTATION

Id-778

Using Scanning Electron Microscopy in Exploring the Morphology of *Antrocephalus Hypsopygiae* (Hymenoptera: Chalcidoidea: Chalcididae)

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Abstract. *Antrocephalus hypsopygiae* Masi, 1928 (Hymenoptera: Chalcidoidea: Chalcididae) has the only one certainly primary known host, the moth *Hypsopygia costalis* (Fabricius, 1775) (Lepidoptera: Pyralidae) (The Gold Triangle, The Clover Hay Moth, The Clover Hayworm). It was also associated with *Chilo suppressalis* (Walker, 1863) (Lepidoptera: Crambidae) and with *Naranga aenescens* Moore, 1881 (Lepidoptera: Noctuidae). The caterpillars of *H. costalis* feed on dry vegetable matter, been found in haystacks and thatching. It's a serious pest to clover hay and to stored grains, dried fruits and seeds, even crackers and dry pet food. The caterpillars create webbing that can spoil and clump the stored products, making them unsuitable for consumption, leading to economic losses. *A. hypsopygiae*, by parasitizing the pupae of *H. costalis*, can be a useful species in the natural biological control of this pest. Current geographical distribution of *A. hypsopygiae* include Morocco, Spain, France, Croatia, Cyprus, Russia, Kazakhstan, Turkmenistan, Iran, Iraq. Recently we found it in Romania, and we see exemplars from Greece. We see also pictures with exemplars from Bulgaria and Hungary on internet platforms like iNaturalist and some Facebook groups. With the help of the Scanning Electron Microscopy (SEM) we investigate the micromorphology of *Antrocephalus hypsopygiae*, including the morphology of the head, mouthparts, antenna, mesosoma, metasoma, legs, wings, ovipositor, genital armature, ovarian eggs. Using a stereomicroscope, we examinate the external morphology of the ovarian eggs and with a DSLR camera we present macro photographs with living specimens of *A. hypsopygiae*. SEM proved to be very useful in the study of the micro sculptures of the surface of the body and in investigating the types of the sensilla present on the body. *Antrocephalus* Kirby, 1883 (Chalcididae: Haltichellinae) genus, with more than one hundred thirty species, majority of them in the tropical and subtropical regions, it's quite difficult taxonomically. Using the SEM technique, we can see some hidden and cryptic characters, difficult or impossible to see using the classic light microscopy, this helping in characterize and identify these microhymenoptera species.

Keywords: Antrocephalus hypsopygiae; Chalcididae; Scanning Electron Microscopy; Morphology.

12th International Congress on Microscopy & Spectroscopy

POSTER PRESENTATION

Id-783

Microstructural Analysis of the Brain Extracellular Matrix and Glia Based on Confocal Microscopy and Artificial Intelligence Tools

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Abstract. The brain extracellular matrix and glia undergo complex morphological, biochemical and translational changes upon a range of pathologic conditions including injury and inflammation. Understanding of causal mechanisms and physiologic consequences of those changes requires multimodal studies involving cell and tissue imaging techniques. Confocal microscopy is advantageous in that regard as it retrieves high 3-dimentional resolution and is compatible with a broad range of fluorescent markers, transgenic expression models and staining techniques. We previously reported a number of quantitative algorithms for the extracellular matrix microstructural analysis. In the present study we used high resolution confocal microscopy data of *Wisteria floribunda* agglutinin staining for the N-acetylgalactozamine epitopes within the chondroitinsulfate proteoglycans in rodent cerebral cortex to address quantitative patterns of the chondroitinsulfate distribution. Furthermore, we also used confocal images of cortical sections stained for glial fibrillary acydic protein to study quantitative parameters of the astrocyte morphology. The aim was to reveal astrogliosis correlates and to develop a high throughput method for extracting and quantification of those morphological features. We developed artificial intelligence (machine learning) -based protocols for automatic annotation of the confocal data both for the chondroitinsulfate proteoglycan spatial distribution and astrocyte morphology. Both convolutional neural network (U-Net architecture used as a generator) and generative adversarial networks were used within 1) image-to-contour translation with Pix2Pix GAN model (Model 1) and 2) image-to-image translation with the same Pix2Pix model (Model 2). Among the 2 methods Model 2 demonstrated successful learning through over 100 epochs. The resulting quantitative measurements based on the AI-assisted data annotation matched pretty accurately with the results of alternative semi-automatic analysis providing validation of the AI-based method. We then demonstrate that AI-assisted segmentation of the astrocyte glial fibrillary acidic protein staining in high resolution confocal data can be used to quantify the protein hyperexpression and the astrocyte cell body geometry as the gliosis-associated markers.

Keywords: Extracellular Matrix; Glia; Confocal Microscopy; Artificial Intelligence; Machine Learning; Gliosis.

Acknowledgment: The study was supported by the Russian Science Foundation, project number 24-75-00123.

12th International Congress on Microscopy & Spectroscopy

POSTER PRESENTATION

Id-787

Synthesis and Characterization of Cross-linked Poly(*N*-(2-hydroxyethyl)acrylamide)

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Abstract. The monomer *N*-(2-hydroxyethyl)acrylamide is used in many investigations for the synthesis of various copolymers, e.g. block- or graft- copolymers. Polymers based on this monomer have been widely investigated, e.g. as capillary adsorbed coatings, for stimuli-sensitive polymer synthesis, in bioengineering research, for adhesive hydrogels. They have good biocompatibility, stability and durability. This study describes the process of the synthesis of homopolymer hydrogels based on monomer *N*-(2-hydroxyethyl) acrylamide by the free radical polymerisation method with thermal initiation using 1,2-ethanediol dimethacrylate as a crosslinker. The polymerization process was initiated by 2,2'-azobis(2-methylpropionamidine) dihydrochloride. The cross-linked homopolymer poly(*N*-(2-hydroxyethyl)acrylamide) hydrogels were structurally characterized after the purification of unreacted reactants. Structure characterization of the obtained homopolymer was performed using the Fourier transform infrared spectroscopy (FTIR). Analysis of the obtained FTIR spectra confirmed that the polymerization process was successfully completed, by breaking the double bonds from the *N*-(2-hydroxyethyl) acrylamide and the 1,2-ethanediol dimethacrylate, which resulted in the formation of a new crosslinked homopolymer products. Hydration capacity of synthesised homopolymer hydrogels was examined in the function of pH values and temperatures. Based on the obtained results, these homopolymer hydrogels show great potential for further research opportunities and new applications.

Keywords: Hydrogels; Hydration Capacity; FTIR.

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12th International Congress on Microscopy & Spectroscopy

POSTER PRESENTATION

Id-795

Achievements of the Research Institute of Semiconductor Physics and Microelectronics of the National University of Uzbekistan

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Abstract. The activities of the Scientific Research Institute of Semiconductor Physics and Microelectronics are based on the Resolution of the Cabinet of Ministers of the Republic of Uzbekistan № 639 dated October 12, 2021 aimed at developing renewable power, electrical engineering and microelectronics, boost the efficiency of research in the field of semiconductor physics in Uzbekistan. The objective is to become the leading research institute in the field of semiconductor physics and microelectronics in Central Asian region. Development of technologies for unveiling new semiconductor materials and study of the parameters of multilayer structures based on them, which are the basic elements of microelectronics and photonics. Ensure the integration of fundamental and applied science with the educational process at all stages.

The activity of laboratories and affiliated research facilities, in particular, corresponds to the comprehensive program to further increase energy efficiency of economic sectors and social sphere, introduction of energy-saving technologies and development of renewable energy sources in the Republic of Uzbekistan. Solid basis was created for boosting research in semiconductors.

The Scientific Research Institute of Semiconductor Physics and Microelectronics over the past 5 years has been actively developing its infrastructure and research activities. Solving the complex task of establishing international relations of the Institute, ensuring their strength and carrying out activities aimed at strengthening the research, educational, cultural potential of the Institute based on the strategic directions of the Institute's unified scientific policy has brought its results and currently the Institute is well positioned to become the leading semiconductors research institute in Uzbekistan and the region.

Keywords: Renewable Power; Semiconductors; Microelectronics.

12th International Congress on Microscopy & Spectroscopy

POSTER PRESENTATION

Id-805

Wet Spun Biodegradable and Biocompatible 3D Composite Materials for Medical Applications

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Abstract. In this study a simple and efficient wet spinning method of the production of a novel type of porous continuous fiber based on poly-3-(R)-hydroxybutyrate (PHB) and other composite materials was described. The principle of this method lies in the process of slow precipitation of biopolymer (PHB) dissolved in chloroform solution into a high glass cylinder filled with cooled ethanol. Because the materials are intended to find applications in biomedical engineering (i.e bone or cartilage implants), authors created PHB-ceramics composites. As PHB fillers authors have selected calcium phosphate (CaP) powders, such as hydroxyapatite (HAp) , and tricalcium phosphates (α-TCP and β-TCP) due to their wide use as bone substitutes, thanks to their good biocompatibility and osteoconductivity. Fibrous materials produced out of different concentration of pure biopolymer and combination with various ceramic fillers were broadly characterized to establish optimal production parameters. The influence of various PHB concentrations and precipitation rates on fibers and pore diameter was studied using scanning electron microscopy (SEM). Thermal properties and stability of full range of materials were studied by differential scanning calorimetry (DSC). The newly produced materials could be applicable in regenerative medicine as a replacement of currently used materials. Their scope of application can be also widened due to the known biodegradable properties of PHB, which will allow the use of materials in the form of elements absorbable inside the patient's body. New generation biodegradable materials are an essential element in the further development of biomedical techniques, because they cannot only effectively replace traditional polymers, but also present features and properties previously unattainable for commonly used polymers. The transition to biodegradable materials is an inseparable element of the currently promoted circular economy and fits perfectly into the concept of sustainable economy, which is one of the main objectives of the European Union's environmental policy.

Keywords: PH; 3D printing; Electrospinning; Wet Spinning; Biopolymers.

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12th International Congress on Microscopy & Spectroscopy

POSTER PRESENTATION

Id-809

Production of Biopolymers as an Example of the Applicability of a Circular Strategy

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Abstract. Most of the polymers used in the plastics industry are of fossil origin, i.e. they are produced from fuels such as oil and others, i.e. natural gas and coal. In general, they fall into the categories defined by the Society of the Plastics Industry, which include polyethylene terephthalate (PET), high-density polyethylene (HDPE), polyvinyl chloride (PVC), low-density polyethylene (LDPE) and poly(propylene) (PP), poly(styrene) (PS), among others. Of these, polyolefins (PP and PE) are the leading polymers, as they cover about 50% of all possible applications (PlasticsEurope, 2019), including food packaging. The latter requires, indeed, huge quantities of these polyolefins, but also other polymers such as PET and PS, for the production of beverage packaging and trays for fresh food packaging. The huge consumption of polymers in this sector has to be attributed to some of their main advantages, including lightness, flexibility, strength, transparency, impermeability, chemical inertness and ease of sterilisation. Despite these benefits, plastic products are associated with the exploitation of primary energy resources and the emission of greenhouse gases (GHG) and other pollutants, resulting in a range of highly damaging effects in almost all life cycle phases. The huge consumption of plastic goods results in the generation of constant amounts of waste, with detrimental environmental and socio-economic consequences for the welfare of humans, animals, plants and the quality of the global ecosystem. In addition, petroleum-based polymers do not readily biodegrade and, due to their resistance to microbial degradation, accumulate in the environment. These materials remain non-degradable for decades in the environment where they are stored. On the other hand, another concern is the increasing scarcity of petrochemical resources, which will reduce the availability of petroleum-based plastics. Such and other related concerns point to the need for sustainable recycling systems that enable the production of high-quality materials and alternatives to fossil-based plastics. This can be a good opportunity for business owners to find opportunities to reduce the environmental and economic costs of their products. In this regard, attention has been focused over the years on the development of environmentally friendly, innovative materials: the most important of these are polymers made from biological feedstock, known as biopolymers, which have been documented as effective counterparts to unsustainable fossil fuel plastics. They can be derived from a wide range of biomass types, including agricultural products such as corn or soya, as well as algae or food waste. The production of biopolymers can also be a solution to the environmental problems caused by petroleum-based plastics. There is strong evidence that polymer production, and common management practices, have caused irreversible environmental damage. Production from unsustainable fossil raw materials and their slow degradation are major issues of concern, which is why attention has turned to the production of biodegradable polymers using renewable resources. At the same time, it is an example of the application of a closed-loop economy solution at company level. By the same token, such a solution has a positive impact on the environment at both the process and end-product stages. In this way, the management process can be improved, operations can be managed and greener innovations can be implemented.

Keywords: Biopolymers; Applicability; Circular Strategy; Productions.

12th International Congress on Microscopy & Spectroscopy

POSTER PRESENTATION

Id-818

Photoinduced Rearrangement of Chromones to Form Fluorescent Products. Influence of UV-irradiation and Magnetic Action

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Abstract. The purpose of our investigation was synthesis of non-luminescent compounds which could be transformed into fluorescent products by UV-irradiation. Such properties allow considering these compounds as units of archival optical memory with non-destructive reading of information. We have studied in detail UV irradiation of initially non-luminescent 3-acyl-2-furyl- or -thienylchromones that led to their photorearrengement to form intensely fluorescent products. In the presentation show photoinduced changes in the absorption and fluorescence spectra of chromones in toluene. They were typical for all studied derivatives. Majority of compound are characterized by the absorption band lying in the UV spectral range with the maximum at 300-320 nm and no fluorescence. Two absorption bands of the photoproduct and the structured fluorescence band (500-550 nm) appear during UV irradiation. Based on these chromones, a working model of the optical memory device with a multilayer optical disk has been created.

In continuation of this work, we present today hybrid chromons which we expect will be able to react both to UV-irradiation and to magnetic influence. It seems promising to investigate photophysical and magnetic properties of spin-labeled chromones, as well as the specific influence of the paramagnetic group on the processes of their photoisomerization resulting in the formation of a multispin system in the excited state. We can expect that these radicals may also show some anti-cancer activity. We have obtained 2-Furyl-3-acylchromones containing paramagnetic groups of different nature and have shown that in the course of their UV-irradiation they rearrange and form spin-labeled fluorescent products. X-ray data, EPR spectra and UV-irradiation results for all compounds will be presented at the Congress.

Keywords: Chromones; UV-irradiation; Photoinduced Rearrangement; Paramagnetic Groups; Synthesis.

12th International Congress on Microscopy & Spectroscopy

POSTER PRESENTATION

Id-826

Insights in the Use of Hydroxyapatite-doped Coatings with Maple Deposition Technique

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Abstract. In recent years, there has been a growing interest among researchers worldwide in the development of innovative materials that exhibit superior biological properties. One particular area of focus is bone tissue engineering, where the goal is to create materials that not only possess superior biological properties but also strong mechanical properties. Hydroxyapatite, a widely studied biomaterial, is favored for its biological properties, similarity to natural bone tissue, osteoinductivity, and ability to integrate with bone. Regardless of its advantages, hydroxyapatite does have some limitations such as corrosion, release of toxic ions, and wear. Researchers have been exploring ways to enhance its properties and overcome these drawbacks, especially in the field of biomedical applications. One promising approach is to source hydroxyapatite from natural materials, as they contain trace elements like Na+, F−, Zn2+, K+, Mg2+, Si2+, and CO32− that closely resemble those found in human bone. Using hydroxyapatite from natural sources is not only environmentally friendly but also cost-effective. This ceramic material possesses the capacity to substitute doping ions at key sites within its lattice, which can significantly improve its biological performance after implantation. This study focuses on synthesizing Cu-doped hydroxyapatite from natural sources at different concentrations (1% and 5%) sing Matrix-Assisted Pulsed Laser Evaporation (MAPLE) for deposition onto a titanium substrate (> 99% Ti). To confirm the successful deposition, Scanning Electron Microscopy was conducted on the developed materials. This innovative approach shows great promise in enhancing the biological properties of hydroxyapatite and overcoming potential challenges in its application in bone tissue engineering.

Keywords: Mapple; Coatings; Biocompatibility; Hydroxyapatite; Tissue Engineering.

12th International Congress on Microscopy & Spectroscopy

POSTER PRESENTATION

Id-828

Porous Scaffolds Based on Partially Crystallized Bioglasses - Synthesis and Characterization

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Abstract. The main scope of the present study was to investigate the effects of doping the 47S5 bioglass with less explored ions, namely lithium. The bioglasses, i.e., bioglass and Li-doped bioglasses at 2.5, 5, and 10 %wt, were synthesized through the sol-gel method, which ensures a high degree of homogeneity and purity in the final product, as well as the ability to control the porosity and surface area of the material. After complete water evaporation from the gel, powders were calcined at 600 °C for 1 h to ensure the complete formation of the bioglass. The X-ray diffractograms proved the formation of a vitroceramic, as there were numerous crystalized phases, such as wollastonite, calcium orthosilicate, calcium sulphate, sodium calcium phosphate, and combeite. The Fourier-transform infrared and Raman spectroscopy revealed the presence of the characteristic groups, namely Si-O, Si-O-Si, P-O, Ca-O, and Li-O. Subsequently, by using the polymer sponge replication method, a series of ceramic bodies were obtained and subjected to heat treatments at 800 °C, which led to an increase in the crystallinity of the samples. The scanning electron microscopy images revealed the formation of a porous material consisting of irregular granules, with a mineral-like appearance. The addition of doping ions increased the mechanical resistance and the bioactivity of the ceramic bodies, as the micrographs show the formation of acicular structures on the surface which can be attributed to the mineralization of hydroxyapatite after simulated body fluid immersion. The MTT assay performed on the MG-63 osteoblast cell line confirmed the biocompatibility of both powder and ceramic body forms. Furthermore, samples also demonstrated antimicrobial properties against *E. coli* and *C. albicans* strains. In this manner, the materials obtained in this study, both in powder and ceramic body forms, have great potential for improvement, not only due to their exceptional inherent properties but also because of the positive effects of dopants, which introduce multiple outstanding characteristics.

Keywords: Bioglass-ceramics; Lithium Substitution; Sol-gel Method; Bioactive Materials.

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All Submissions & Topics

Topic	Submission
1 - Applications of Microscopy &Spectroscopy in the Biological Sciences	802 - Synthesis, Structural, Characterization and Antitumoral Activity of $(NH_4)_4Li_2V_{10}O_{28}.10H_2O$ Compound
	803 - Novel hexa-[methylimidazolium] decavanadate(V) dihydrate: Synthesis, Characterization, and Antiproliferative Effects on IGR39 Melanoma and U87 Glioblastoma Human Cancer Cells
	816 - Structural Insights into Photosystem II Supercomplexes Using Cryo-Electron Microscopy
	819 - Application of Microscopy in Identification of Water Pollutants
	831 - Neonatal Hypoxic Ischaemic Brain Damage – New Experimental Treatments and Biomarkers
	832 - Microglial Development in the Eye and the Potential of Eye Microglia as a Marker for Changes in the Brain in Health and Disease
3 - Biomedical Applications	812 - Anticancer and antioxidant activity of Ln(III) complexes of bioactive coumarins
	822 - Advances in Surface Modification for Bone Tissue Engineering: Image-Based Structural and Functional Enhancements
4 - Biopolymers	805 - Wet spun biodegradable and biocompatible 3D composite materials for medical applications
	806 - Novel Aspects of the RNA-DNA Primer Synthesis Termination by Human Primosome
	808 - Saving Lives with Quantum mid-IR Microscopy

	809 - Production of biopolymers as an example of the applicability of a circular strategy
6 - Botany	777 - A scanning electron microscopic (SEM) investigation on the structure and micromorphology of aerial organs from Echium vulgare L
9 - Entomology	778 - Using Scanning Electron Microscopy in Exploring the Morphology of Antrocephalus Hypsopygiae (Hymenoptera: Chalcidoidea: Chalcididae)
15 - Neurobiology	783 - Microstructural Analysis of the Brain Extracellular Matrix and Glia Based on Confocal Microscopy and Artificial Intelligence Tools
21 - Applications of Microscopy & Spectroscopy in the Physical/Chemical Sciences	771 - Mesoscopically Structured Minerals (Mesocrystals) in Geological Processes. A Review
	785 - Surface Morphology and Elemental Analysis of Corrosion Changes in Stainless Steels
23 - Biomaterials	828 - Porous Scaffolds Based on Partially Crystallized Bioglasses - Synthesis and Characterization
24 - Ceramics	827 - $BaTiO_3$-based Functional Materials Used in Electronics: From Nanopowders to Micro- and Nanostructured Ceramics
29 - Materials for energy conversion	776 - Phase Transition in Supercritical-Fluid Phase for Hydrogen at Room Temperature
35 - Phenomena at Surfaces/Interfaces	789 - Elucidating puzzling asymmetry in ionic liquids electro-wetting of solid electrodes: step towards single-cell detection
36 - Polymers	787 - Synthesis and characterization of cross-linked poly(N-(2-hydroxyethyl)acrylamide)
38 - Semiconductor Materials and Devices	795 - Achievements of the Research Institute of Semiconductor Physics and Microelectronics of The National University of Uzbekistan
	796 - Generation Characteristics of MOS Structures based on Monocrystalline Silicon
	797 - Optical and Electrophysical Properties of Transparent Conductive Layers of Metal Oxides and Sensors Based on Them

	814 - Optimizing Porous Silicon Bragg Mirrors for Photonic Crystals: A Study on Fabrication and Characterization
39 – Surfaces / Films / Coatings	826 - Insights in the use of Hydroxyapatite-Doped Coatings with Maple Deposition Technique
62 - Image Analysis	784 - Spectral Parametrization of Two-Dimensional Systems of Randomly Distributed Particles
89 -Scanning Electron Microscopy	780 - Morphological and Structural Characterization of Metal Oxide-Based Materials for Advanced Optoelectronic Applications
94 - Scanning Probe Microscopy	815 - Scanning Probe Microscopy for Mechanical and Thermal Investigation of Biological and 2D Materials
99 - Transmission Electron Microscopy	804 - Structural Studies of the Earlier Stages of Bacteriophage PhiKZ Infection
125 - Fluorescence Spectroscopy	786 - Spectroscopic and Microscopic Study of Silicon-Lignin Interaction: Effects on Plant Cell Walls and Industrial Potential
128 - Fourier transform infrared spectroscopy (FTIR)	813 - Quantitative Analyses of Gas Mixtures Using an Infrared Spectrometer – Methodologies and Example Results
	825 - Spectral and FTIR Studies on Complexes with the N,N-bis(3,3-dimethyl-allyl)-dithiocarbamate in view of Their use as Precursors for Nanofibers
160 - Raman Spectroscopy	766 - Ensuring the Authenticity of Organic Food Products by Raman Spectroscopy: Challenges and Opportunities for Industries
	768 - Raman spectroscopy and civil engineering materials. Overcoming difficulties and providing answers
	772 - Raman Microscopy and Spectroscopy of Carbon Nanocomposite Materials for EMI Shielding Performance
	781 - Micro-spectroscopic Analysis of Complex Biological Systems
	824 - Application of Raman Spectroscopy for Characterizing Soil Material. Results of Field Experiments
172 - THz Time Domain Spectroscopy	830 - Terahertz Time-Domain Spectroscopy for Security Applications
175 - UV/vis Spectroscopy	818 - Photoinduced Rearrangement of Chromones to Form Fluorescent Products. Influence of UV-irradiation and Magnetic Action

180 - X-ray Fluorescence (XRF) Spectroscopy	775 - X-ray fluorescence (XRF) as a Tool for Sulfur Uniformity Assessment in High-strength Packaging Paper