

Abstract Book NANO2024

ORAL: AMN-A

1571057817: Additive manufacturing of Polymer Derived Ceramics (PDCs) Incorporated with 2D Materials for Functional Application

Suhail K. Siddique (Khalifa University, UAE, United Arab Emirates); Kin Liao (Aerospace Engineering, United Arab Emirates); Andreas Schiffer (Khalifa University of Science and Technology, United Arab Emirates)

This work aims to fabricate different architectural polymer-derived ceramics (PDC) with 2D material (graphene) by utilizing 3D printing followed by pyrolysis for dual functional properties. 3D printing can systematically fabricate different structured preceramic polymers with various structures infused with graphene. These polymers are subsequently transformed into ceramics through pyrolysis. The resulting cellular polymer-derived ceramic (PDC) structures exhibit a unique combination of high strength, low weight, and enhanced piezoresistive sensitivity. Mechanical tests reveal substantial improvements in compressive strength and fracture toughness, while piezoresistive characterization demonstrates a clear, consistent response to applied mechanical stress. This innovative approach offers new potential for developing advanced materials with applications in flexible electronics, smart sensor systems, and structural health monitoring.

1571061723: Utilization of Carbon Ashes from Vehicle Exhaust as an Additional or Partial Replacement Material in a Cement Mixture

John Paolo Gaspar R Medina (Mapua University, Philippines & Mapua, Philippines); Joshua Thurston A. Valmonte and Amir Gabriel R. Zamora (Researcher, Philippines)

Concrete production is a major contributor to global carbon dioxide emissions, which is a significant environmental concern. Approximately 8% of total carbon dioxide emissions are generated by cement industries due to insufficient energy conservation in the production process. In light of this, researchers are addressing the challenge of conserving energy and reducing the environmental impact of cement production. The collection of carbon deposits will be used as an additional material in concrete production. The primary objective of this research is to use carbon ashes from vehicles in the production of sustainable concrete while enhancing the energy efficiency of the process. To determine the feasibility of this solution, researchers will conduct an extensive 28-day laboratory experiment to ensure the cement reaches its maximum strength. The experiments will measure the effectiveness of the concrete in reducing cement usage. The results will be critically analyzed to evaluate the potential of this solution in mitigating the negative impacts of cement production. The findings will offer valuable insights into creating a more sustainable future and will be shared with the broader scientific community and relevant stakeholders to promote the adoption of sustainable practices in the cement industry.

1571067212: 3D Printed Flexible Pressure Sensors using MWCNT/PDMS Ink by Direct Ink Writing

Jashanpreet Singh Sidhu, Aviral Misra and Arvind Bhardwaj (Dr B R Ambedkar National Institute of Technology, Jalandhar, India)

The integration of nanoscience and 3D printing has given rise to an emerging field of printable and flexible electronics. Direct Ink Writing (DIW) transforms the field of 3D printing by using carbon-based inks, ensuring benefits in terms of design, intricacy, flexibility, and sustainability. This study presents the fabrication of flexible pressure sensors using multi-walled carbon nanotubes (MWCNTs) based conductive inks by the DIW method. Inks composed of different concentrations of MWCNTs, ranging from 1 to 5 percent by weight, were formulated. Rheological investigations were conducted to ensure the shear thinning behavior, making them suitable for use in DIW. Mechanical tests were also performed on the DIW-printed samples. The MWCNT-polydimethylsiloxane (PDMS) composite was printed on the polyethylene terephthalate substrate. A variety of intricate three-dimensional forms were also printed using the prepared MWCNT-PDMS composite. The sensor response was subsequently examined by evaluating the change in resistance resulting from the applied load. The experimental findings show that the developed flexible pressure sensor has high sensitivity and rapid response capabilities. The exceptional sensing capabilities indicate that the fabricated pressure sensor has significant potential for use in detecting human movement and monitoring personal health.

1571071578: The opportunities and challenges of nanomaterials in metal additive manufacturing

Nesma Aboulkhair (Technology Innovation Institute, United Arab Emirates)

Metal Additive Manufacturing (AM) technologies that utilise metal powder as feedstock for production are receiving interest from both the scientific and industrial communities, alike. New alloy development programmes are booming worldwide to capitalise on the unprecedented opportunities that additive manufacturing has to offer. While a lot of the activities focus on micro-scale metal powders, the use of nanoparticles in this domain is growing. Functionalising micro-scale powder particles with nanoparticles has been explored for improving printability as well as tailoring material/part performance. Examples include (1) employing carbon nanotubes to improve the printability of pure aluminium, (2) enhancing the tribological behaviour of 3D printed aluminium via tungsten disulphide nanoparticles, and (3) functionalising a bespoke AM aluminium alloy with boron nitride for better strength at temperature. This talk will shed the light on these use cases, not only highlighting the benefits and impact of using nanoparticles in metal AM, but also pinpointing the challenges that their use poses in terms of application and industrialisation.

1571071871: Advanced Micro/Nano Manufacturing of Architected Metamaterials

Nicholas Xuanlai Fang (University of Hong Kong, Hong Kong)

Recent advances in data-driven and interconnected manufacturing have the potential to revolutionize the design and processing of multifunctional elements with unprecedented precision and heterogeneity. These elements include architected metamaterials with integrated functions that are highly desirable for a broad range of applications in confined spaces, such as impact absorption, thermal management and chemical processing, optical transparency, structural morphing, and real-time monitoring and repair. To fully realize the potential of these multifunctional elements, an integrated knowledge base is crucial for setting up, steering, and analyzing their functionality. This requires combining different geometries and choices of digital voxels with domain-specific design constraints, as well as a library of accurate designer voxels with predictive analytics that capture essential mechanical and physical properties based on the microstructure.

In this keynote talk, we will explore the three-dimensional microfabrication techniques and expertise required to design and fabricate these architected metamaterials for combined functions, including energy absorption, actuation/morphing, and micro-scale reactors for sustainable energy and environment. I will also discuss our effort on selective ion doping of oxide electrolytes with electronegative metals, which shows promise for reproducible resistive switching critical for reliable hardware neuromorphic circuits.

1571073304: Fabrication of corrosion resistant Ti6Al4V alloy photocatalyst using combined sand blasting-dual acid etching method and their application to methylene blue degradation

Karthigaimuthu Dharmalingam (United Arab Emirates University, United Arab Emirates); A. Madhankumar (King Fahd University of Petroleum and Minerals, Saudi Arabia); Elangovan Thangavel (Periyar University, India); Abdel-Hamid Ismail Mourad (United Arab Emirates University, United Arab Emirates); Ramasundaram S (Yeungnam University, Korea (South))

An alternative simple, economical and efficient acid treatment method was proposed for the ion vacancies formed on the surface and to improve the renewed surface of titanium (Ti6Al4V) alloy. The role of dual acid etching (DAE) in increasing the corrosion resistance of Ti6Al4V subjected to sand blasting (SB) and plasma treatment (PT) was investigated. The Ti6Al4V was tested with the primary etching mixture containing H₂SO₄, HCl and DI water, and then with the oxidizing mixture of H₂SO₄ and H₂O₂. The pure and dual acid treated Ti6Al4V were characterized by XRD, FTIR, UV-vis DRS, SEM and EDAX. The band gap energy (E_g) of the dual acid treated Ti6Al4V was significantly red shifted. Among all, the SB-DAE rendered an increase in E_{corr} of Ti6Al4V by 87.71% and decreased I_{corr} by 93.38%, whereas PT-DAE increased the E_{corr} by 7.94% and decreased I_{corr} by 87.40%. Under irradiation with visible radiation from a commercial halogen lamp source (300 - 700 nm), 1×1 cm of SB-DAE treated Ti6Al4V exhibited 33 % highest photocatalytic efficiency than untreated Ti6Al4V due to the titanium dioxide layer formed after treatment with sulfuric acid and hydrogen peroxide. The aforementioned results suggest that the SB-DAE treated Ti6Al4V has the potential to be used for corrosion resistance and photocatalyst for degrading organic micro-pollutants from water.

1571075603: Piezoresistive strain-sensing performance of laser-sintered CNT/PA12 honeycomb nanocomposite structures under cyclic compression loading

Muhammad U Azam and Andreas Schiffer (Khalifa University of Science and Technology, United Arab Emirates); Khalid Askar (Khalifa University, United Arab Emirates)

Additive manufacturing (AM) technology has gained significant popularity in the past few decades due to its major advantage of fabricating highly intricate structures that are impossible via conventional fabrication techniques [1]. In the last decade, significant research has been conducted on developing electrically conductive polymer composites by incorporating conducting nanofillers, such as carbon nanotubes (CNTs) and graphene etc [1]. These developed composites have potential applications in self-sensing devices that can monitor early signs of damage in an installed component/structure to avoid a catastrophic failure. Among various structures, hexagonal honeycombs are lightweight materials with outstanding thermal insulation and energy absorption characteristics [2]. Among various AM techniques, selective laser sintering (SLS) is a unique technique that has several advantages, such as higher strength of the part, recycling of unfused powder, larger batches, and supportless structures [1]. This experimental study investigates the mechanical and piezoresistive performance of laser-sintered hexagonal honeycomb composite structures (LS-HHS) under cyclic compressive loading. Since HHS has anisotropic behavior in different loading directions, we evaluated their performance in two directions (i.e., in-plane and out-of-plane). 3D printed HHS were manufactured with different relative densities (20, 30, and 40%) using a feedstock of 0.3 wt.% CNT/polyamide 12 (PA12) nanocomposite powder, as optimized in our earlier work [3]. The LS-HHS, with a relative density of 40%, exhibited a maximum specific energy absorption of 18 J.g⁻¹ subjected to an out-of-plane direction. The LS-HHS exhibited excellent strain-sensing performance in the elastic range, as indicated by gauge factors of up to 25. Furthermore, the LS-HHS exhibited a stable and reliable piezoresistive response subjected to 100 consecutive compression cycles within the elastic range (strain amplitude ≤ 1%). The findings suggest that the LS-HHS has great potential for use in lightweight smart structures that can detect strain and damage-sensing attributes.

1571078855: Dynamic Photochromic Fresnel Lenses via 4D Printing for UV and Light Modulation Applications

Murad Ali (Khalifa University, United Arab Emirates); Bilal Bukhari (Khalifa University of Science and Technology, Abu Dhabi, United Arab Emirates); Rashid Abu Al-Rub (Khalifa University-ADAM Center, United Arab Emirates); Haider Butt (Khalifa University, United Arab Emirates)

This study focuses on the use of 4D printing and vat photopolymerization (VPP) to fabricate smart Fresnel lenses with photochromic properties using digital light processing (DLP). These lenses are capable of dynamically changing color when exposed to UV light, offering excellent UV and blue light blocking capabilities in their inactive state. Upon UV activation, the lenses darken and absorb parts of the visible light spectrum, with the response depending on the concentration of photochromic materials. The lenses maintain precise optical performance and durability across multiple UV exposure cycles, demonstrating their potential for applications requiring dynamic light modulation and UV filtering.

ORAL: ANC-B

1570981156: Harnessing Nanocoating Technology for Enhanced Compressed Earth Blocks
Jana Aya Dkhil (ESPRIT School of Engineering, Tunisia)

This research investigates the application of nanocoating technology to enhance the durability of two traditional earth-based construction materials: compressed earth blocks (CEBs) and adobe blocks. These materials have long been recognized for their sustainability and low environmental impact. The study formulates and applies a specialized nanocoating, composed of carefully selected nano materials, to assess its impact on the structural integrity and longevity of both CEBs and adobe blocks. Through comprehensive testing and comparative analysis between coated and uncoated blocks, significant improvements are observed in multiple key parameters. The coated blocks exhibit heightened resistance to environmental factors such as weathering, erosion, and moisture ingress. Structural strength and load-bearing capacity are notably enhanced, showcasing the potential of nanocoatings to reinforce and extend the lifespan of these traditional earth-based materials in contemporary construction practices

1571057218: Atomic Resolution 4D-STEM Analysis of Organic Semiconductor Nanocrystals

Mohammed Noorul Hussain and Yansong Hao (University of Antwerp, Belgium); Tizian Lorenzen (Ludwig-Maximilians University Munich, Germany); Ferdinando Malagrecia and Yves Geerts (Université Libre de Bruxelles, Belgium); Knut Müller Caspary (Ludwig-Maximilians University Munich, Germany); Sandra Van Aert (University of Antwerp, Belgium)

Zinc Phthalocyanine (ZnPc) is an organic semiconductor which is a complex of a metal atom i.e., Zinc incorporating into an organic structure i.e., phthalocyanine. ZnPc exhibits excellent optoelectronic properties, making it useful in many applications such as phototransistors, biosensors and for 6G technology devices. It can also serve as a base molecule to form other optically active chiral molecules. The properties of ZnPc stem from its molecular structure, making it essential to study the material at the atomic scale. Scanning Transmission Electron Microscopy (STEM) offers advanced capabilities to do so, with the advantage of elucidating non-planar structures and providing direct elemental information better than techniques like Atomic Force Microscopy and Scanning Tunneling Microscopy. However, issues such as high electron beam damage and weak scattering limit the analysis of metal-organic materials with conventional STEM. Nevertheless, four-dimensional STEM (4D-STEM) is a promising technique since it uses electron doses much more efficiently, benefiting the imaging of beam sensitive materials. In conventional HAADF-STEM (High Angle Annular Dark Field), electron detectors are annular-shaped and do not collect the electrons at low scattering angles. In contrast, 4D-STEM uses state-of-the-art pixelated detectors that record a full CBED pattern for every scan position, and at a high rate. As a result, each scan position in a 2D scan of the sample produces a 2D CBED, hence the name 4D-STEM. This data can be processed in multiple ways to reconstruct an image of the sample under study. 4D-STEM techniques have been proven to be effective in studying various beam sensitive samples such as zeolites. In this work, nanocrystals of ZnPc are analyzed by 4D-STEM using three different reconstruction methods to obtain atomic resolution images of the crystals. The samples are analyzed with a probe-corrected Titan Themis Z microscope (Thermo Fisher Scientific) at an acceleration voltage of 300 kV. The microscope is equipped with an AdvaPIX TP3 camera which has a Timepix3 readout chip as a pixelated detector. For sample preparation, ZnPc nano crystals are drop casted on a graphene based TEM (gold) grid. The experimental variables in the study are: a) deposition parameters, b) electron dose and c) convergence angle of the electron beam. The three reconstruction methods used are riCOM, AIRPI and ptychography. riCOM is an in-house developed method that reconstructs the projected potential from the center of mass of the CBED at each scan position, whereas AIRPI is also an in-house developed method that uses convolutional neural networks to reconstruct the complex electron wave function. Ptychography is a method that uses interferences in the diffraction discs in the CBED patterns for phase reconstruction. The goal of this study is to identify the optimal method for achieving direct and reliable atomic resolution imaging of ZnPc. This is the first time ZnPc will be studied using various 4D-STEM methods. This approach has the potential to be extended to other similar materials. Preliminary results indicate that 4D-STEM method such as riCOM significantly outperforms conventional STEM in providing atomic scale information. Results will be further corroborated with simulations.

1571058192: Size and morphological fine tuning of spinel ferrites for improving infrared reflective characteristics in buildings

Saithathul Fathima Sameera and Sheik Muhammadhu Aboobakar Shibli (University of Kerala, India)

Innovative solutions must be developed to address the rising urban heat island effect and the energy demands of urban buildings.[1] This work explores the potential of NIR reflective pigments to address these challenges. Subsequent research for an environmentally benign alternative colorant with equivalent colour strength is still being pursued, with some recent developments. [2] Spinel ferrites exhibit promising potential as a sustainable alternative to rare-earth materials for large-scale energy applications, demonstrating superior safety, accessibility, and reduced environmental impact. Frontline spinels are being researched to develop NIR reflecting materials in $ZnFe_{1-x}M_xO_4$ ($M = Al^{3+}, Si^{4+}, Ti^{4+}, La^{3+}$ and Y^{3+}) and $ZnFe_{1-x}Al_xO_4$ ($0 \leq x \leq 0.8$), magnesium doped $ZnFe_2O_4$, $Mg_{1-x}Mn_xFe_2O_4$ systems. Unfortunately, compared to its parent ferrite, the color parameters for all the compositions were gone unfavorable.[3-5] The present work focuses on different spinels in $Zn_{0.5}M_{0.5}Fe_2O_4$, including various synthesis methods via solid state route employing mineralizers and sol-gel methods. Morphology and particle size tuning were obtained in different compositions through effective control. Accordingly, spinels were tuned to yield the best performance utilizing particle size to yield max reflectance as high as 60 %. This material may serve as an effective passive method for reducing CO₂ emissions.

1571069862: Development And Optimization of Nanostructured Lipid Carriers of Nilotinib for Treatment of Cancer Through Oral Route

Ananda Kumar Chettupalli (Galgotias University, India)

Background: Leukemia is a malignant tumor that arises from a clone of hematopoietic stem cells, resulting in a disruption of the normal functioning of the hematopoietic system. Traditional medications exhibit limited therapeutic efficacy as a result of their inadequate specificity and stability. The advancement of nanotechnology has introduced nonviral nanoparticles as a promising solution for the effective treatment of leukemia. Nilotinib, a tyrosine kinase inhibitor, exhibits a notably limited solubility in water and a somewhat poor and inconsistent ability to be absorbed orally. An enhanced solubility in a pharmaceutical formulation can improve the bioavailability and decrease the variability of both its own solubility and the pharmacokinetics. Objective: The study's goal was to create and improve nanostructured lipid carriers so that Nilotinib could be delivered more efficiently against acute leukemia. This was done so that its anti-cancer effects on the KG-1 leukemia cell line could be studied in vitro. The medicine belongs to BCS class II and is characterized by low solubility in water, a short half-life, and significant first-pass metabolism. Method: An evaluation was conducted on various types of excipients, including solid lipid, liquid lipid, and surfactant, to determine their impact on medication solubility. Out of the excipients that were examined, stearic acid, oleic acid, and Tween 80 were chosen as independent variables, each representing a different factor. The preparation of Nilotinib loaded nanostructured lipid carriers (NLCs) involved the use of high pressure homogenization followed by ultra sonication technique. The formulations were produced using Design-Expert (DoE) and optimized for different formulation parameters such as the ratio of lipids and surfactant concentration, homogenization speed, and time. The Nilotinib loaded NLCs formulation was improved and subjected to several physicochemical characterization techniques including FTIR, DSC, PXRD, SEM. Additionally, the in-vitro drug release and anti-leukemic impact on the KG-1 cell line were examined. Results: A total of 17 formulations were developed, with sizes ranging from 140.695 ± 2.67 to 389.64 ± 8.59 nm. The entrapment efficiency varied from 46.52 ± 0.49 to $81.047 \pm 7.1\%$. The results of FTIR and DSC indicated that the drug was entrapped inside the NLCs and there was no chemical bonding between the drug and NLCs. The SEM examination verified that the NLCs were consistent in shape, with a uniform distribution throughout. The in vitro drug release experiments demonstrated a sustained release pattern for up to 48 hours. Pharmacokinetic studies showed a 2.31-fold rise in AUC (area under the curve) and an increase in half-life from 0.43 hours to 2.887 hours. A significant decrease in clearance and elimination rate was present along with this, indicating a longer period of systemic circulation. This prolonged circulation is beneficial in the treatment of leukemia. The sustained release behavior efficiently increased the toxicity of Nilotinib loaded NLCs to KG-1 (leukemic) cell lines in a time-dependent manner with lower IC₅₀ values than that of drug solution. Conclusion: The experimental findings indicate that Nilotinib loaded NLCs serve as an effective carrier for mitigating dose-related toxicity, while also offering a prolonged release pattern to maximize the anti-cancer effect. The system's limitations encompass its stability during extensive manufacturing and its applicability from laboratory testing to practical implementation in healthcare settings.

1571073704: Unveiling the Future of Perovskite Solar Cell Materials: Advanced Microscopy Modalities at the Helm

Dalaver Anjum and Inas Taha (Khalifa University, United Arab Emirates)

Due to their fabrication methods and flexible designs, inorganic perovskite solar cells (PSCs) are efficient and low-cost. Conventional solution-based methods of their synthesis result in defects and carrier transport barriers at grain boundaries and interfaces in perovskite films, thus limiting the device's efficiency. Till today, several physics and chemistry-based research attempts have been proposed to sort out the origin of defects and their passivation [1]. For instance, a proper organic or self-assembly monolayer can simultaneously passivate the surface/interface perovskite layer, annihilate defects in the grain boundary and surface/interface, properly align the atomic arrangement with the adjacent layer, and help the surface reconstruction.

The versatility of molecules for the passivation of perovskite thin films and the shortage of NanoCharacterization of their defects pose the most significant challenge for enhancing the efficiency of PSC devices beyond the benchmark of 26%. Primarily, the efficiency of PSC has been hindered by defects in the perovskite crystals and at the interface of perovskite films. In this regard, a myriad of bulk techniques can be employed to characterize the defects in the perovskite films, including X-ray photoelectron spectroscopy (XPS), steady-state and time-resolved photoelectron spectroscopy, impedance spectroscopy, electro-spin resonance spectroscopy, Deep-Level Transient Spectroscopy (DLTS) and secondary ion mass spectroscopy. However, the characterization techniques mentioned above could characterize the defects in an indirect mean. In recent years, a few researchers have used 4DSTEM and STEM-EELS to analyze perovskite film [2, 3]. These nanometer-scale-based techniques, in combination with macroscale-based techniques, could be used to obtain more information about defects and investigate passivation defects using different passivation strategies.

In this presentation, various scanning probe microscopy (SPM) and electron microscopy (EM) modalities will be used to determine the nature of performance-limiting defects and their effect on the properties of charge carriers. This way, novel strategies will be developed to target making the PSC devices with higher than 26% efficiency. Advanced microscopy-based nanocharacterization has been applied to hybrid inorganic-organic perovskite structure comprises of ABX_3 : A = An organic cation - methylammonium ($CH_3NH_3^+$) or formamidinium ($NH_2CHNH_2^+$), B = An inorganic cation - usually lead (II) (Pb^{2+}), Tin (Sn^+), Germanium (Ge^+), and Europium (Eu^{+2}), X₃= A slightly smaller halogen anion - usually chloride (Cl^-), Bromine (Br) or iodide (I^-). An efficient solar cell demands ultra-smooth perovskite surface morphology with an optimum thickness and defect-free perovskite films [4]. High-resolution electron microscopy is a powerful technique for understanding the type and localization of point defects in perovskite thin films. Figure 1 (a) contains a high-resolution TEM image of $PbCsBr_3$ perovskite material along with the Fourier-filtered image of its smaller region is given in Figure 1 (b) to show the capability of this technique to enable visualizing the presence of point defects or crystal imperfections due to the lack of passivation. The TEM analysis presented in Figure 1 also poses new challenges, such as the formation energy of these defects and their interactions with charge carriers. These challenges can be addressed using state-of-the-art techniques, such as 4DSTEM and STEM-EELS, and hence are included as a main objective of this proposed study.

1571075273: Influence of sintering conditions on low temperature degradation of zirconia dental ceramics

Mohamed Abbas (Qatar University & Center for Advanced Materials, Qatar); Maryam Al-Ejji and Rawia Abdullahi Suliman (Qatar University, Qatar); Teeba Ali Mare (Center for Advanced Materials, Qatar)

This study explores the impact of cerium oxide (CeO_2) doping on the low-temperature degradation (LTD) behavior of alumina-toughened zirconia (ATZ). Different concentrations of CeO_2 (0.05, 0.1, 0.2, 0.5, and 1 wt%) were added to ATZ, and the ceramic composites were sintered at 1250°C with a heating rate of $10^\circ\text{C}/\text{min}$. The primary objective was to investigate the influence of CeO_2 on the hydrothermal aging resistance of ATZ. The experiment was conducted under autoclave conditions with distilled water heated to 180°C at 10 bar pressure, for durations extending up to 100 hours. X-ray diffraction (XRD) analysis was performed to evaluate phase stability, with a focus on the tetragonal-to-monoclinic phase transformation, which is indicative of LTD. Initial results showed that CeO_2 doping helped mitigate monoclinic phase formation during hydrothermal exposure, with lower monoclinic content observed at higher CeO_2 concentrations. Surface morphology changes and crack formation were examined using field emission scanning electron microscopy (FESEM) post-aging. CeO_2 -doped samples displayed improved resistance to LTD, with fewer microstructural defects compared to undoped ATZ. This study suggests that CeO_2 is effective in enhancing the aging resistance of ATZ.

1571077326: Investigating Nanoscale Crystal Discontinuities in Continuum Mechanics: New Insights into Material Transformations and Properties

Alessandro Genovese (KAUST, Saudi Arabia)

The study of the deformation of crystalline materials is crucial for understanding not only the rheological behavior of natural and synthetic compounds but also for predicting their physicochemical properties and transformations under varying chemical, thermal, and pressure conditions. But what might seem like completely unrelated phenomena—a seismic event, a malfunctioning monophasic superconducting device, or thermally-driven chemical reactions in nanocrystals—have in common? The answer lies in their discontinuities, or more precisely, in the crystal defects that significantly alter how these materials respond to both internal and external stimuli. Crystal defects can be categorized into four primary types: i) point defects, ii) line defects, iii) interfacial defects, and iv) bulk defects. These imperfections disrupt the crystal's ideal structure and profoundly influence its crystal potential. The defect content within a crystal is often a reflection of its history, encompassing factors such as deformation, thermal exposure, pressure variations, and growth processes, as well as the surrounding thermodynamic conditions. It is well established that crystal defects can dramatically affect the electronic structure of a material. Even minor distortions in the crystal potential can cause shifts in electron energy levels, pushing them beyond the expected band structure of a defect-free crystal. Consequently, these defects can have far-reaching impacts on the material's physicochemical properties, including its reactivity, stability, and overall rheological behavior. Rheology, in particular, directly correlates a material's response to applied deformations with the fragility or plasticity of the structure, as described by the Mohr-Coulomb theory. However, the smaller these transformations occur, the more elusive they become, demanding sophisticated investigative techniques to capture them. Fortunately, advances in modern instrumentation have made it possible to probe materials at unprecedented resolutions. The latest generation of scanning transmission electron microscopes (S/TEM), dual beam scanning electron microscopes (SEM-FIB), and analytical tools such as energy-dispersive X-ray spectroscopy (EDX) and electron energy-loss spectroscopy (EELS) now enable nanoscale investigations, even down to the atomic level. These tools allow us to precisely identify and categorize crystal discontinuities. Through continuum mechanics analysis, we can not only detect but also measure, quantify, and map these defects throughout the material. Continuum mechanics, based on the continuum hypothesis—which states that no matter how small a material volume is subdivided, each element will still contain matter [1]—plays a critical role in understanding these phenomena. It provides a framework for analyzing and predicting the complex interplay between crystal defects and material properties, bridging the gap between nanoscale discontinuities and macroscale behaviors. References [1]. Irgens, F. Continuum Mechanics. Springer-Verlag Berlin, Heidelberg (2008). <https://doi.org/10.1007/978-3-540-74298-2>

1571078058: 4-Fluoro benzyl ammonium iodide passivated perovskite films for efficient perovskite solar cells

Afna Manaf, Bhabani Sankar Swain and Hiba Shahulhameed (UAE University, United Arab Emirates); Abdul Kareem Kalathil Soopy (United Arab Emirates University, United Arab Emirates); Adel Najjar (UAEU, United Arab Emirates)

Despite significant progress in perovskite solar cell research, surface defects like point defects, dangling bonds and grain boundary defects limits further enhancement of power conversion efficiency (PCE). Introducing organic ammonium halide passivating agents is a effective approach for passivating both surface and bulk defects. In this study, we used 4-Fluoro benzyl ammonium iodide (4FBAI) to passivate surface defect of MAPbI₃ perovskite films. This distinctive molecule possesses multiple functional groups, including a fluorine-containing ammonium salt and an aromatic benzyl group, which serve as a moisture barrier. We have analysed the passivated perovskite thin films using X-ray diffraction, photoluminescence spectroscopy, and UV-Vis absorption spectroscopy. The result indicates passivated perovskite films exhibit better crystallinity and absorbance compared to the pristine film. The synergistic passivation effect of R-NH₃⁺ and F⁻ from the passivating molecule on uncoordinated Pb²⁺ and halide defects of perovskite respectively, lead to decrease in defect density. As a result, the efficiency of the solar cells rises to 18.65% for 4FBAI, up from 17.03%.

1571078060: Passivation studies of organic- inorganic perovskite solar cells via amphiphilic quaternary ammonium halide molecule

Hiba Shahulhameed, Bhabani Sankar Swain and Afna Manaf (UAE University, United Arab Emirates); Abdul Kareem Kalathil Soopy (United Arab Emirates University, United Arab Emirates); Adel Najar (UAEU, United Arab Emirates)

Perovskite solar cells (PSC) have made substantial progress in renewable energy due to their exceptional efficiency and low production costs. Organic-inorganic halide perovskite solar cells provide a tunable bandgap, elevated absorption coefficient, and remarkable charge carrier mobility. Defects in the bulk or surface of perovskite films adversely affect their performance and stability. However, defects in the bulk/surface of perovskite films have an impact on their performance and stability. These defects reduce crystallinity and result in non-radiative recombination which are not desirable for efficient performance. We used an amphiphilic quaternary ammonium molecule, Dodecyl trimethyl ammonium bromide (DTAB) for passivation. The alkyl chains of these molecules and the robust chemical interactions between Br and Pb²⁺ minimize dangling bonds and grain boundary defects. We utilized various characterization techniques, including X-ray diffraction (XRD), photoluminescence (PL) spectroscopy, and ultraviolet-visible (UV-Vis) spectroscopy, to examine the passivated perovskite films. The passivation enhanced both crystallinity and absorbance. The initial findings indicate less non-radiative recombination and enhanced charge transfer at the interfaces. Consequently, efficiency increased from 16.28% for the control device to 18.76% for the DTAB-passivated device.

1571078951: Tackling the challenges of novel materials analysis: recent advances in transmission electron microscopy

Reza Zamani (Thermo Fisher Scientific, Germany)

Nowadays a great host of novel materials is developing to address the current challenges we face in our society. The interest in applications such as green energy production, CO₂ capturing, catalysis, and advanced electronics has skyrocketed in recent years. However, understanding the functionality of these materials is still challenging and often requires reliable characterization methodology which preserve the material's integrity while its properties are examined. In this context, transmission electron microscopy (TEM) offers a wide range of capabilities for studying the newly developed materials at the atomic scale. At Thermo Fisher Scientific we continuously develop innovative solutions, in order to (i) expand the capabilities to wider ranges of information, e.g. magnetic/electrical properties, phononics and plasmonics, chemical composition, and structures at the atomic level, (ii) expand the aforementioned capabilities to a wide range of specimens from robust to highly electron-beam-sensitive, e.g. polymers, zeolites and MOFs, and on the other hand, (iii) avail TEM to a broader group of researchers, by providing fully-integrated easy-to-use reproducible platforms with imbedded automated features. In this contribution, we present the most recent advances aimed for achieving these goals. In particular, we focus on newly developed integrated EELS solutions as well as Cs-corrected Lorentz TEM/STEM mode for high-resolution field-free imaging of magnetic materials. These are meant to provide the user-friendly all-in-one TEM platform the scientists need in order to explore the properties of novel materials at their native state.

1570981160: Utilizing Nanocoating Technology to Improve Compressed Earth Blocks

Aya Dkhil (ESPRIT School of Engineering, Tunisia)

This research investigates the application of nanocoating technology to enhance the durability of two traditional earth-based construction materials: compressed earth blocks (CEBs) and adobe blocks. These materials have long been recognized for their sustainability and low environmental impact. The study formulates and applies a specialized nanocoating, composed of carefully selected nano materials, to assess its impact on the structural integrity and longevity of both CEBs and adobe blocks. Through comprehensive testing and comparative analysis between coated and uncoated blocks, significant improvements are observed in multiple key parameters. The coated blocks exhibit heightened resistance to environmental factors such as weathering, erosion, and moisture ingress. Structural strength and load-bearing capacity are notably enhanced, showcasing the potential of nanocoatings to reinforce and extend the lifespan of these traditional earth-based materials in contemporary construction practices

1571079310: Advanced Transmission Electron Microscopy for In-situ Studies of Cement Reactions

Nouran Elmesalami (New York University, United Arab Emirates)

Reactive MgO cement (RMC) is a sustainable alternative to ordinary Portland cement (OPC), acting as a low-carbon binder. RMC reacts with water and absorbs CO₂ from the environment forming hydrated magnesium carbonates (HMCs) in the process. The final strength of RMC-based composites is affected by the specific HMC polymorphs that form, which are controlled by the CO₂ curing conditions and the RMC composition. This study explores the polymorphism of HMCs by examining the hydration and carbonation reactions of RMC through both ex-situ and specialized in-situ gas cell techniques using Transmission Electron Microscopy (TEM). The initial step in the experiments is the preparation of samples for both ex-situ and in-situ experiments. In ex-situ experiments, a carbonation chamber is used for sample exposure, and the sample is subsequently imaged and analyzed in the microscope after a set exposure period. In-situ experiments involve flowing gases at controlled concentrations and temperatures through the gas cell, capturing changes in sample morphology and phases via videos and images using in-situ TEM. Diffraction patterns and lattice images from TEM further provide insights into the various HMC phases that develop during the experiments. These findings offer valuable insights into the hydration and carbonation processes of magnesia, contributing to the assessment and improvement of RMC properties.

1571080369: Breaking boundaries

Rachid Sougrat (KAUST, Saudi Arabia)

The KAUST Imaging and Characterization Core Lab offers cutting-edge instrumentation and specialized expertise in a wide range of microscopy and spectroscopy techniques. This advanced facility includes powerful methods such as Nuclear Magnetic Resonance (NMR), Transmission Electron Microscopy (TEM), Scanning Electron Microscopy (SEM), X-ray Diffraction (XRD), Raman Spectroscopy, X-ray Photoelectron Spectroscopy (XPS), Secondary Ion Mass Spectrometry (SIMS), Atomic Force Microscopy (AFM), and optical microscopy. The diverse capabilities of the lab underscore the critical need for a multidisciplinary approach that seamlessly integrates insights from various scientific fields. These characterization techniques are essential for any research endeavor, embodying the synergy arising from diverse disciplines' convergence. Historically, research has often been compartmentalized into distinct fields. However, the challenges of today's scientific landscape require a collaborative, cross-disciplinary approach that harnesses advancements in physics, biology, chemistry, and engineering. In my upcoming presentation, I will explore the current challenges facing the scientific community, particularly the pursuit of high spatial resolution combined with accurate atomic identification. A prime example of this interdisciplinary collaboration is cryo-electron microscopy and electron tomography, revolutionary techniques combining physics and biology principles to expand the research frontiers. I will present examples that illustrate how the future of scientific inquiry is firmly rooted in the fusion of disciplines. Through collaboration and blending various scientific approaches, we can tackle complex research questions more effectively and pave the way for groundbreaking discoveries.

ORAL: AMN-A

1571057605: Film-forming Calcium Intercalated Graphene Oxide-Chitosan Nanocomposite: A Sustainable Solution for Healing Microcracks in Concrete

Abins Aziz, Shibil Abdul Gafoor, Bijily Balakrishnan, M Nithyadharan and Shihabudheen M. Maliyekkal (Indian Institute of Technology Tirupati, India)

Periodic repair and rehabilitation of concrete structures are essential to improve their service life and structural functions. Eco-friendly repairing materials with low embodied energy play a significant role in sustainable maintenance and reducing the environmental impact of the building during its life cycle. This paper describes the development of a calcium-intercalated graphene oxide-chitosan matrix (Ca-GO-CS) as a sealant for healing microcracks in concrete. A full factorial design approach was used to determine the relative proportions of chitosan, graphene oxide, calcium precursor, or magnesium precursors. The materials were characterized in detail to examine the chemical and mechanical properties of the composite films. The results reveal that adding graphene oxide nanosheets and calcium precursors can significantly enhance the mechanical properties of nanocomposite-formed film. The calcium ions in the nanocomposite matrix combine with the -NH₂ and -COOH groups of chitosan and graphene

oxide to form a complex, thus creating a highly cross-linked Ca-GO-CS network. Compared to pure chitosan film, the tensile strength and failure strain of Ca-GO-CS film were enhanced by 2.59 and 2.36 times, respectively. Because of their increased stiffness, Ca-GO-CS films had an elastic modulus 1.94 times higher than pristine chitosan films. The material has the desirable qualities of microcrack sealant and can solidify effectively in a concerned environment without any polymerizing agent. The work provides a viable avenue for creating sustainable and environmentally friendly buildings and repairing materials with low embodied energy.

1571057767: Fluorine free, mechanochemically robust Ag@SiO₂ core-shell/polysiloxane transparent superhydrophobic coating for self-cleaning and anticorrosion

Irfan Mohammad (Indian Institute of Technology Tirupati, India & IIT Tirupati, India)

Transparent coatings with self-cleaning and anticorrosion properties hold significant promise for various outdoor applications like solar cells, windshields, and automotive etc. However, their widespread use faces obstacles such as low transmittance and reliance on fluorinated materials. Therefore, the development of transparent, fluorine free, and cost-effective coatings is essential. This study presents a transparent superhydrophobic coating created through a simple and convenient two-step process. A suspension of Ag@SiO₂ core-shell nanoparticles and polysiloxane is spin-coated onto glass slide and mild steel substrates, followed by calcination at 400°C or above. The resulting hierarchical structure showed a water contact angle (WCA) above >150° and a sliding angle of less than <10°. It attained a good transmittance (%) in the visible light range (300-800 nm) as shown in the figure below and demonstrated impressive thermal stability (50-200°C). Furthermore, the coating maintained its functionality after exposure to strong acid and alkaline (pH ~1-9) solutions, as well as prolonged UVA irradiation, exhibiting excellent mechanical robustness in sandpaper abrasion and knife-scratch tests, along with effective self-cleaning capabilities. Additionally, Ag@SiO₂/polysiloxane superhydrophobic coating on mild steel substrate exhibit commendable anti-corrosion performance, with a reduced corrosion rate, rendering them a significant advancement for self-cleaning and anticorrosion applications in various outdoor settings.

1571057973: Performance Evaluation of Sulfur Modified Foamed Asphalt for local soil Stabilization

Waqas Rafiq (King Fahd University of Petroleum and Minerals (KFUPM), Saudi Arabia)

With the development in road construction techniques the foamed bitumen technology is considered a very effective, sustainable and improved engineering solution [1]. The worldwide formed bitumen recognition for asphalt production as cost effective and improved engineering properties. Furthermore, the utilization of sulfur in asphalt concrete has also been utilized successfully for building the test pavement sections on several highways worldwide. This research emphasized the locally available sulfur which is available in abundant quantities in Kingdom of Saudi Arabia to be used as raw material in the pavement construction [2]. The utilization of sulfur is economical and has many applications like in asphalt pavement which can reduce the asphalt binder usage by 30% [3]. The use of sulfur in foamed bitumen further reduces the binder content. Globally the ratio of 30 to 70 sulfur and bitumen is utilized to produce foamed bitumen. Saudia Arabia is a major producer of sulfur because of petroleum by product, the

production rate continuously increasing and currently is 6.5 million metric tons annually [4]. So, in the current study we explored the possibility of using foamed bitumen produced by ratio of 30 to 70 sulfur bitumen for the local soil stabilization. The locally available soils viz., marl, dune sand and sabkha were stabilized using foamed sulfur bitumen and were compared with the regular foamed asphalt. Keeping in mind the specification requirements, the designed asphalt mixtures using the soils were compared for evaluation in performance properties. The results of material properties, foamed bitumen, Marshall mix design, Indirect Tensile Strength for different percentages (3, 6, 9, 12 and 15) of the soils were evaluated. These results were analyzed for the suitability of using the foamed sulfur asphalt technology for road construction. Results indicated that the sulfur modified binder with different soils has more stability as compared to the regular foamed asphalt mixes.

1571068371: Nanocrystallization of metallic glasses at sluggish diffusion studied by in-situ atomic-scale high-resolution transmission electron microscopy

Dmitri V Louzguine (WPI Advanced Institute for Materials Research, Tohoku University, Japan)

Nanocrystallization of various Al-, Mg-, Ti- and Cu- based metallic glasses is studied on heating in-situ slightly below the glass-transition temperature when the atomic diffusion is restricted. The results reveal unusual crystallization mechanisms induced by the difference in diffusion coefficients of the atomic species. The resulting structure will be described in detail at high resolution by transmission electron microscopy (TEM) together with atomic-scale EDX mapping. These modern structural characterization techniques are essential in order to reveal the details of atomic structure. Owing to sluggish atomic diffusion of some alloying elements the kinetics of phase transformations studied by differential scanning calorimetry shall be interpreted only together with the results of TEM observation. The difference in the diffusion coefficients leads to the linear growth of primary crystals found in a Mg-based glassy alloy. The growth rate of nanocrystals in an Al-based metallic glass is significantly faster than suggested by viscosity and diffusion. A remarkable complexity of the crystallization process including heterogeneous nucleation on pre-existing particles is found in Cu-based alloy. The nature of the incubation period before nanocrystallization will also be discussed for a Ti-based metallic glass. Additionally, solid-state room-temperature mechanochemically-induced nanocrystallization of Fe- and Mg-based metallic glasses will be presented.

1571073663: Bulk nanostructured metallic materials for extreme environment

Bulk nanostructured metallic materials for extreme environment

To produce bulk nanostructured materials with ultrafine grains, a number of methods have been developed in recent years, of which the use of severe plastic deformation (SPD) combining the processing of materials by heavy deformations under high applied pressures is of particular interest [1, 2]. This report is focused on the principles of nanostructuring of various metallic materials by SPD processing related to the formation of ultrafine grains and the development of unusual phase transformations leading to the formation of grain boundary segregations and nano-sized precipitations of secondary phases. Nanostructuring allows for manufacturing the materials with advanced multifunctional properties that combine high mechanical (very high

strength and ductility, superplasticity) and functional properties (corrosion and radiation resistance, electrical conductivity, etc.). Special attention is paid to the examples of innovative application of multifunctional nanomaterials in medicine and engineering, particularly in extreme environment where materials are exposed to heavy loads, corrosion and erosion simultaneously.

Author acknowledges the support in part from the Ministry of Science and Higher Education of Russian Federation (Agreement No. 075-15-2022-1114 as of 06/30/2022).

[1] R.Z. Valiev, B. Straumal and T.G. Langdon, Using severe plastic deformation to produce nanostructured materials with superior properties, Annual Review of Materials Research 52 (2022) 357 [2] R.Z. Valiev, I.V. Alexandrov, M. Kawasaki, T.G. Langdon, Ultrafine-Grained Materials, SpringerNature, 2024

1571076327: Tetrapods based Smart Materials for Advanced Technologies

Yogendra Kumar Mishra (University of Southern Denmark, Denmark)

Considering the size dependent utilization complexities of nanoscopic dimensions in real technologies, the focus of nanomaterials community is converging to three-dimensional (3D) nanomaterials which are built out of interconnected nanostructures building blocks. This talk will briefly introduce the importance of tetrapod nanostructures towards smart 3D nanostructuring via a simple and single step flame-based approach for synthesis of zinc oxide tetrapods. These tetrapods have already demonstrated their potential roles in many different technologies. These zinc oxide tetrapods can be used as solid backbone or sacrificial templates to design hybrid or new tetrapods as smart materials. These smart 3D nanomaterials offer many applications in engineering and advanced technologies. Application examples of 3D tetrapods in nanosensing, composite engineering, antiviral candidates, water purification, piezotronics, agriculture, and in several other applications will be demonstrated [1-10]. The integration of tetrapods in electrospun fibers offers many advantages in biomedical engineering and few examples about nano-engineered electrospun fibers will be presented as recent developments.

References:

1. Chemical Engineering Journal 462, 141984, 2023
2. Progress in Materials Science 139, 101169, 2023
3. Progress in Polymer Science 101516, 2022
4. Materials Today 50, 533-569, 2021
5. Materials Today 48, 7-17, 2021.
6. Advanced Science 2100864, 2021
7. Advanced Functional Materials 31, 20007555, 2021
8. Materials Today 32, 108 -130, 2020
9. Advanced Functional Materials 1909725, 2020
10. Materials Today 6, 631-651, 2018

1571077470: The roles of nanostructures in improving the synergy of strength and ductility of near-alpha titanium alloys fabricated by thermomechanical powder and chip consolidation

Deliang Zhang (Northeastern University, China)

By thermomechanical consolidation of blended powders or prealloyed recycled chips, one can fabricate near-alpha titanium alloys with several nanostructural features in the microstructure including nanostructured alpha lamellar colonies, secondary alpha precipitates in beta matrix, grain boundary alpha plates and micro-texturing depending on compositions and post-fabrication heat treatments. A large amount of research undertaken by our own research group and other research groups has demonstrated that through manipulating these nanostructural features, the near-alpha titanium alloys not only achieve a high yield strength which can be 200-300 MPa higher than corresponding conventional near-alpha titanium alloys with same composition, but also very good tensile ductility of 10% or higher. It appears that the key is that the high flow stress sustained by a fraction of "hard" colonies during plastic deformation activates the $\langle c+a \rangle$ pyramidal dislocation slips which are essential to coordinate plastic deformation of different colonies and allow a large amount of straining prior to failure. This talk will review the findings and discuss underlying relationships which reflect the important roles played by the nanostructures played in improving the synergy of strength and ductility of near-alpha titanium alloys.

1571077476: Nanostructured particle strengthened high entropy alloys by powder metallurgy

Yong Liu (Central South University, China)

High entropy alloys (HEAs) have drawn wide attentions in structural applications due to their excellent combinations of mechanical and physical-chemical properties. In order to improve the high temperature strength of HEAs, nanostructured particles and oxides are very effective, and powder metallurgy is one of the promising ways in the introduction and controlling of these particles. In this presentation, various nanostructured particles in HEAs through powder metallurgy and subsequent thermomechanical treatment were introduced, including intermetallic phase, oxide particles and carbides. It was found that a high density of nanostructures can be formed in FeCoCrNi, WMoTaNb, WTaCrV and other newly-found HEA systems, and the formation mechanisms were discussed. The strengthening and irradiation-resistant mechanisms of the nanostructures in HEAs were also discussed. For examples, WTaCrV HEA indicated a strong structural stability, high strength as temperatures as high as 1500°C. After irradiation with various high energy ions, the HEA showed less formation of porosity, dislocations and other defects than pure W, and the hardening rate was only 1/5 of W. The high entropy effect and the existence of various nanostructures played significant roles in the irradiation resistance of HEAs. Our work indicates that the introduction of nanostructured particles in HEAs by powder metallurgy could be a promising technique for high-performance, high temperature and high irradiation-resistant structural materials.

1571077752: Self-Ordered Nanostructures: Elevating Austenitic Stainless Steel's Corrosion Resistance Through Anodization

Surya Prakash Gajagouni (Khalifa University, United Arab Emirates); Imad Barsoum (Khalifa University-ADAM Center, United Arab Emirates); Akram Alfantazi (Khalifa University, United Arab Emirates)

Electrochemical anodization has emerged as a promising technique to create protective nanoporous oxide layers on stainless steel, enhancing both corrosion resistance and functional properties like catalysis and biocompatibility, which are particularly valuable for energy and biomedical applications. This study explores the structural and corrosion behavior of anodized AISI 304 stainless steel using a two-step anodization process. Electron microscopy revealed well-ordered nanoporous oxide structures, with increased pore depth and layer thickness observed at higher voltages and longer anodization times. X-ray photoelectron spectroscopy indicated a surface enriched with Ni and Fe oxides while showing reduced Cr content. Electrochemical testing further demonstrated significant improvements in corrosion resistance in alkaline and seawater environments compared to untreated stainless steel. The formation of these oxide nanostructures offers tunable morphologies, which can be precisely tailored for a range of applications without compromising the inherent properties of stainless steel. These findings highlight anodization's potential to enhance the durability and functionality of austenitic stainless steels, particularly in aggressive environments.

1571077828: HPT-induced grain boundary transformation in Al-xCu alloys: composition, precipitation, segregation, and dislocations perspectives

Gang Sha (Nanjing University of Science and Technology, China)

Grain boundaries (GBs) play a crucial role in determining the stability and mechanical properties of ultrafine-grained materials. This research investigates how alloy compositions impacts GB evolution in Al-xCu alloys ($x = 1, 2$ and 4 wt%) under high-pressure torsion (HPT), examining the interplay between precipitation, segregation, and grain refinement. HPT processing induces dynamic precipitation of Al₂Cu (θ) and occasionally the unexpected formation of the AlCu (η_2) phase, while generating high-volume-fraction GBs and high-density dislocations with Cu segregation. Notably, GB misorientation angle evolves differently across the alloys with increasing HPT strain, in contrast to relatively stable GB segregation behavior. The study finds a strong correlation between reduced dislocation density and increased high-angle GBs (HAGBs), suggesting that dislocation annihilation at GBs facilitates the transformation of low-angle GBs into HAGBs during HPT processing. These findings demonstrate the potential to engineer GB characteristics in ultrafine-grained Al-Cu alloys by optimizing alloy composition and HPT processing parameters.

1571078341: Exploring Surface Disorder in spinel iron oxide hollow nanoarchitecture

Sawssen Simani (University of GENOVA, Italy)

A key factor for the novel physical chemical and magnetic properties of the nanoparticles compared to bulk counterparts is their large surface-to-volume ratio ($R=S/V$). The significant enhancement of R leads to an increase in the surface disorder and magnetic frustration. In fact surface disorder adds a new dimension to the design and function of magnetic nanoparticles particularly in biomedicine enhancing their therapeutic efficacy and responsiveness. By leveraging the disorder at particle surface researchers can develop advanced nanomaterials tailored to specific medical challenges improving patient outcomes in diagnostics and therapy. In this context hollow nanostructures offer grate advantages that make them ideal for a wide range of uses in nanomedicine due to the presence of both inner and outer surfaces. Here a comparative study of the morpho-structural and magnetic properties of full and hollow maghemite ($\gamma\text{-Fe}_2\text{O}_3$) nanoparticles (NPs) corresponding sizes 5.0(5) nm and 7.4(7) nm is presented. These systems have been thoroughly characterized by means of DC magnetization measurement and in field ^{57}Fe Mössbauer spectrometry. The in-field hyperfine structure analysis suggested the presence of non-collinear structure for hollow NPs originated from the increased surface role due to the hollow morphology. Interestingly an exchange bias effect was noted in the hollow structure which is demonstrated by the recorded shifted $M(H)$ hysteresis loop after field cooling. Monte Carlo (MC) simulations on assemblies of ferrimagnetic hollow nanoparticles unambiguously corroborate the critical role of the surface. MC simulation results show that the spins in the external thicker surface and at the interface of the hollow particle are strongly exchange coupled. This strong exchange coupling enhances the antiferromagnetic character of the hollow particle leading to the decrease of its M_s also it induces an exchange bias field and results in the enhancement of the coercive field in agreement with the experimental findings. In addition, a further investigation of hollow maghemite nanoparticles with high R value (1.5) and it's effect on the surface magnetism at nanoscale is discussed.

1571078564: Economic Viability of Functionally Enhanced Bio-based Noise Control Materials

Ashutosh Negi, Jonty Mago and Ms Sunali (Indian Institute of Technology Delhi, India); Adepu Kiran Kumar (University of Arkansas for Medical Sciences, USA); Ejaz Ahmad (Indian Institute of Technology (ISM) Dhanbad, India); M. Ali Haider and S. Fatima (Indian Institute of Technology Delhi, India)

Biorenewables offers sustainable alternatives to the growing demand for materials, chemicals, and energy products. Among the bio-based materials, a notable trend in the growth of bio-based noise control materials is driven by heightened awareness of the harmful effects of noise pollution and stringent regulatory frameworks aimed at keeping noise exposure within safe limits [1]. Additionally, rapid urbanization is boosting the expansion of commercial and residential spaces, which is expected to drive the global noise control material market to reach \$20 billion by 2028 [2]. In response to the need for sustainable alternatives to fossil-based synthetic noise control materials, we have developed sound absorbing materials from natural deep eutectic solvent (NADES) pretreated waste biomass. The morphological changes in the pretreated waste biomass enhance the dissipation of sound energy through frictional and viscous losses, resulting an improvement in the noise reduction coefficient of 0.55 compared to 0.41 for raw biomass [2]. Moreover, to assess the commercial viability of the developed sound absorbing materials, a techno-economic analysis (TEA) was conducted. The analysis evaluated the economic feasibility of producing noise control materials from waste biomass at a plant with an annual capacity of 300,000 m² (equivalent to 1,000 m²/day). Two scenarios were considered: a) establishing a new plant and b) repurposing an existing facility for production. The unit production cost, net present value (NPV), and internal rate of return (IRR) for fabricating sound absorbing materials in a new plant were estimated at \$14 per m², \$2.90 million, and 32%, respectively. In contrast, for the repurposed plant scenario, the NPV and IRR improved significantly to \$4.75 million and 64%. With the escalating concerns over climate change, adopting zero-waste processes using bio-based feedstocks is crucial to fulfill the rising global demand of materials in a sustainable manner. In this regard, the fabrication and techno-economic analysis of noise control materials from waste biomass can provide a reliable solution for growing demand in an eco-friendly manner.

References

[1] Malcom J. Crocker, Handbook of Noise and Vibration Control. Edited. John Wiley & Sons, Inc., 2007. [2] A. Negi et al., "Targeted Functionalization of Waste Lignocellulosic Biomass to Produce Sound Absorbing Materials," Waste Biomass Valorization, 2024, doi: 10.1007/s12649-024-02513-4.

1571079047: Poster Presentation Ultrafast laser structured silicon covered with non-spherical Au nanoparticles as a SERS substrate for ultralow-concentration detection

Amani Yassine, Ganjaboy Boltaev, Piotr Piatkowski and Ali Sami Alnaser (American University of Sharjah, United Arab Emirates)

Surface-enhanced Raman scattering (SERS) is a highly sensitive technique for molecular identification, particularly effective at low analyte concentrations, making it suitable for environmental monitoring, food safety testing and forensic analysis. This study investigates the impact of different shapes of gold nanoparticles on the SERS enhancement factor, with a focus on the plasmonic effects of non-spherical gold nanoparticles. We modified silicon substrates to create dome-shaped structures with diameter of 150 ± 50 nm, which were then covered with spherical Au nanoparticles measuring 14 nm in diameter and non-spherical Au nanoparticles (e.g., bipyramids, nanorods). The surface plasmonic resonance peaks for the spherical Au nanoparticles are located at a wavelength of 532 nm, while the non-spherical nanoparticles exhibit resonance at wavelength of 730 nm. This combination enhanced the surface properties and performance of the substrates, ensuring effective deposition and improved results. The morphology of the substrate surfaces was characterized by scanning electron microscopy (SEM) before and after nanoparticle deposition, allowing us to correlate morphological features with SERS performance. Next, we used these nanostructured silicon substrates for low concentration detection (10^{-6} mol/L, 10^{-9} mol/L, and 10^{-12} mol/L) of various analytes with excitation wavelength of 532 nm and 785 nm. We compared the Raman spectrum from the non-spherical Au nanoparticle substrate with that from a silicon substrate embedded with spherical gold nanoparticles. We obtained a high-contrast Raman signal from R6G at a concentration of 10-12 mol/L on substrates covered with non-spherical Au nanoparticles, compared to those with spherical 14 nm Au nanoparticles with an enhancement factor on the order of 10^9 . This demonstrates enhanced sensitivity and improved signal intensity with the non-spherical morphology, highlighting the significant advantages of using non-spherical Au nanoparticles in enhancing the Raman signal. The unique plasmonic characteristics of non-spherical gold nanoparticles on tailored laser-induced dome-shaped structures offer significant promise for improving SERS efficiency, with potential applications in environmental monitoring and forensic analysis.

1571080403: Electromechanical Characterization of Multifunctional Graphene-based Composites

Noora Mohamed Alahmed and Rehan Umer (Khalifa University, United Arab Emirates); Wesley James Cantwell (Khalifa University of Science and Technology, United Arab Emirates); Kamran Khan (Khalifa University, United Arab Emirates)

Fiber-reinforced polymer composites (FRPCs) are widely utilized in high-performance industries such as aerospace, marine, automotive, defense, and civil infrastructure due to their exceptional strength-to-weight ratio, stiffness, and corrosion resistance. A promising development in this field is the incorporation of 2D nanomaterials, such as carbon nanotubes (CNTs), graphene, and MXene, to enhance the multifunctionality of these composites. These nanomaterials introduce additional characteristics, including sensing capabilities, energy storage, electromagnetic interference (EMI) shielding, and mechanical property enhancements, making them ideal for advanced structural applications. Among these nanomaterials, reduced graphene oxide (rGO) shows promise in enabling self-sensing capabilities to glass fiber-reinforced polymers (GFRPs). The incorporation of rGO-coated glass fabric introduces a built-in sensing mechanism for structural health monitoring (SHM), enabling real-time damage detection without the need for external sensors. This approach addresses the limitations of traditional sensors, such as added weight, complexity, and potential points of failure. This study characterizes the effective electromechanical behavior, including both the mechanical response and self-sensing capabilities, of unidirectional (UD) GFRP laminate manufactured using vacuum-assisted resin transfer molding (VARTM) with rGO-coated glass fabric embedded in laminate, under tensile loading and investigate their time-dependent behavior through stress relaxation test. The results demonstrate that rGO-coated GFRPs have the potential to serve as integrated sensors for real-time SHM systems, representing a significant advancement in enhancing the manufacturability and reliability of structures in applications across various fields.

1571080421: Electromechanical performance of graphene based next-generation composite aerostructures

Israr Uddin (Khalifa University of Science and Technology, United Arab Emirates); Kamran Khan (Khalifa University, United Arab Emirates)

Graphene nanomaterials are usually embedded in matrix phase to enhance their mechanical properties and impart multi-functionality in composite materials as reported in literature [1,2]. However, graphene nanomaterials coated fabric-sensor embedded in fiber reinforced polymer composites (FRPCs) have found significant interest over the years in the development of high performance next-generation composite aerostructures. The introduction of these nanomaterials into composite structures not only enhance the mechanical properties such as stiffness, fiber/matrix interfacial strength but also can realize sensing capability in a distributed neuron-like network. Several researchers have demonstrated the usage of coated fabric-sensor in diverse applications such as sensor for crack growth monitoring, manufacturing process monitoring, etc. [3,4]. Sandwich composite structure which is one of the important load-bearing aerostructures was developed in this study having self-sensing capability. The Nomex™ core was sandwiched in between the self-sensing facesheets manufactured using the vacuum assisted resin transfer molding (VARTM) process. For the self-sensing capability, reduced graphene oxide (rGO) coated glass plain weave fabrics were embedded at the symmetric plane in each facesheet. The manufactured sandwich structures were tested at different loading conditions such as three-point bending, and compression at various loading rates. Fractional change in resistance (FCR) given by Eqn. (1) and load were recorded simultaneously in all the tests. $FCR = \frac{R - R_0}{R_0}$ (1) Where R is the instantaneous resistance recorded and R₀ is the initial resistance in the absence of any strain. The effects of geometrical parameters (length, width, thickness) of the rGO coated fabric-sensor was studied in detail. Moreover, the position of the rGO coated fabric-sensor and sensitivity variation was also experimentally investigated. It is concluded that rGO coated fabric-sensor can be effectively used for the self-sensing of the composite structures which can replace the conventional instrumentation for the strain and damage monitoring.

Nano-biomaterials, Nano-bionic and Biomedical Applications (NBBB-M)

1571041237: Synthesis of Zinc Oxide Nanoparticles and Potato Starch Composite film for Beans Packaging against Beans weevils and Fungi Infestation

Rabiat U Hamzah (Federal University of Technology Minna, Nigeria)

Beans (*Vigna unguiculata*) is one of the most important sources of human food, animal feed and industrial raw material. The entire production process (planting, harvesting and storage) of beans are points of contamination. The most severe infestation of beans is from weevil and fungi, at various stages of productions. Therefore, the aim of this study is to synthesize zinc oxide nanoparticles (ZnO-NPs) and potato starch composite film for beans packaging against beans weevils (*Acanthoscelides obtectus*). ZnO-NPs were produced through green synthesis method using aqueous extract of Neem (*Azadirachta indica*) leaf as reducing agent. The biosynthesized ZnO-NP was characterized using Uv-spectroscopy, Zeta-nanosizer and High-resolution scanning electron microscopy (HRSEM). Two films (A and B) were produced using various amount of potato starch, biosynthesized ZnO-NPs, 5% of acetic acid and glycerol. Film A was embedded with the biosynthesized ZnO-NPs, while film B was without nanoparticles. The study consists of six experimental groups (unpacked control, polythene, starch film, neem sprinkle, ZnO-NPs sprinkle and ZnO-NPs composite film) for shelf-life evaluation, proximate composition and fungi profile test was done on all groups. The proximate compositions of packaged and unpacked beans were done using AOAC method, while the fungi profile test was done using serial dilution techniques. The biosynthesized ZnO-NPs showed a maximum absorption peak at 293.8 nm and average particle size of 43.44 nm. Morphology of the biosynthesized ZnO-NP was hexagonal and spherical in shape. *Aspergillus fumigatus*, *Aspergillus niger*, *Aspergillus flavus*, *Mucors* sp. and *Penicillium* sp. were the identified fungi contaminations in the beans sample. The polythene, starch film, neem sprinkle, ZnO-NPs sprinkle package groups, developed weevils in packaged beans in the second week of study, while the ZnO-NPs composite films group was able to resist weevil infestation to the second month of packaging. The ZnO-NPs composite films group was able to preserve the physical morphology of beans by completely resisting weevil infestation, fungi contamination and maintain the nutritional quality of packaged beans compared to all other groups through the study period of two-months. Therefore, the ZnO-NPs composite films can be used as packaging material to preserve the physical and nutritional property of beans seeds.

1571049880: Synthesis, Characterization, and Preliminary Anticancer Evaluation of Iron-Based MIL-88B Nanostructures Incorporating Safranal

Alia Alkaabi and Khansa Ahsan (United Arab Emirates University, United Arab Emirates); Hesham El-Maghraby (United Arab Emirates University, United Arab Emirates); Nayla Munawar (United Arab Emirates University (UAEU), United Arab Emirates); Abdelouahid Samadi (United Arab Emirates University, United Arab Emirates); Amr Amin (University of Sharjah, United Arab Emirates); Yaser Greish (United Arab Emirates University, United Arab Emirates)

"To address the urgent need for innovative cancer therapies, this study explored the synthesis, characterization, and preliminary anticancer properties of MIL-88B(Fe), a biocompatible iron-based Metal-Organic Framework (Fe-MOF). This MOF nanostructure, comprising iron ions linked by terephthalic acid linkers, was loaded with Safranal, a natural compound derived from *Crocus sativus*, and evaluated for its effects on hepatic cancer, specifically HepG2 cells. The synthesis process involved preparing MIL-88B(Fe) using a facile solvothermal approach and incorporating Safranal into/onto its structure. Various characterization techniques, including XRD, FTIR, TGA, N₂-adsorption, ICP-MS and UV-Vis, were employed to confirm the material's composition and purity and observe its drug-release behavior. The morphology and uniformity were analyzed using SEM-EDX, and the successful incorporation of Safranal was verified by NMR. The study demonstrated that MIL-88B(Fe) and Safranal-loaded MIL-88B(Fe) exhibit significant anticancer activity, notably reducing cell viability and altering nuclear morphology in HepG2 cells. These results suggest that MIL-88B(Fe) loaded with Safranal holds promise as an anticancer agent and strongly recommends extending its application to non-hepatic cancers.

1571055785: Biosynthesis of in house Latent fingerprint developing powder using ZnO nanoparticles from neem extract and its characterization

Anas Abdul Samad, Amrutha Viswanathan Nambiar and Hardeep Kumar (Amity University Dubai, United Arab Emirates)

The toxicity of commercially available fingerprint development powders is a challenge in the LFP development field. Titanium dioxide-based powders are used commercially in crime scenes. In the current study, a biological synthesis-assisted powder development of Zinc oxide nanoparticles through Neem leaves is carried out. Zinc oxide nanoparticle is synthesized and characterized using UV-Visible spectroscopy, and FTIR, and the particle size were analyzed. The commercial and the synthesized powder are tested on various surfaces and the efficiency is compared based on the ridge development of the print.

1571056194: Sinapic acid-Pullulan based inflammation responsive nanoparticles for the local treatment of experimental inflammatory arthritis

Aneesh Ali (Institute of Nano Science and Technology, India)

Rheumatoid arthritis (RA) is a chronic inflammatory disorder of joints. RA is one of the major causes of disability and morbidity worldwide. Administration of conventional drugs through the systemic route restricts the bioavailability of drugs, systemic toxicity, and reduced efficacy. We have introduced Rebamipide (Reb)-loaded Sinapic acid (SA)-Pullulan (PL) nanoparticles (Reb@SA-PL NPs), a nanotechnology based drug delivery system for the treatment of inflammatory arthritis. PL is a polysaccharide obtained from the fungus *Aureobasidium pullulans*, and SA is a bioactive polyphenol found in various plants. Both are classified by US-FDA Generally Recognised as Safe (GRAS) materials. Reb@SA-PL NPs found to be cytocompatible. Subsequently, intra-articular administration of Reb@SA-PL NPs enhances the

anti-arthritic potential compared to free Reb drug in collagen-induced experimental inflammatory arthritis rat model. Reb@SA-PL NMs reduced the expression of RANKL receptor and Nf- κ B. Reb@SA-PL NPs, reverses the degradation of type II collagen, MMP-13, and inhibits the pro-inflammatory markers. Reb@SA-PL NPs suppressed joint swelling, synovial inflammation, cartilage damage, and bone erosion. The results of the study demonstrated that Reb@SA-PL NPs, an enzyme-responsive drug delivery system, has excellent potential for alleviating inflammatory arthritis by blocking MMP-13 and RANKL.

1571056641: Structural Characterization of PVP/Iodine-Based Nanofibers for Biomedical Applications

Haleema Khanzada (Kuanas University of Technology, Lithuania)

This study explores the fabrication of Polyvinylpyrrolidone (PVP) nanofibers with different levels of iodine concentration through electrospinning, with a focus on their potential medical applications, particularly in combating bacterial infections. PVP solutions at a concentration of 30% were prepared, and various iodine concentrations ranging from 0% to 5% were utilized. The resulting nanofibers were characterized using SEM analysis. The findings suggest that higher iodine concentrations led to the production of nanofibers with smaller diameters. These results indicate promising prospects for PVP/iodine nanofibers in the medical field.

1571056812: A facile rebridging approach to attain monoclonal antibodies-targeted nanoparticles

Bayan Alkhawaja (University of Bath, United Kingdom (Great Britain) & University of Petra, Jordan); Andrew Watts (University of Bath, United Kingdom (Great Britain))"Adopting conventional conjugation approaches to construct antibody-targeted nanoparticles (NPs) has demonstrated suboptimal control over the binding orientation or the structural stability of monoclonal antibodies (mAbs). Hitherto, the developed antibody-targeted NPs have shown proof of concept but lack product homogeneity, batch-to-batch reproducibility, and stability, precluding their advancement towards the clinic. A refined approach based on site-specific construction of mAbs-immobilised NPs will be looked over to avoid these limitations and advance towards clinical application. Initially, the conjugation of atezolizumab with polymeric nanoparticles was developed using bis-haloacetamide (BisHalide) rebridging chemistry (NP-Fab BisHalide Ab and NP-Fc BisHalide Ab). For comparison purposes, mAbs-immobilised NPs developed utilising conventional conjugation methods were included. Next, flow cytometry and confocal microscopy experiments evaluated the actively targeted NPs (loaded with fluorescent dye) for cellular binding and uptake. Our results demonstrated the superior binding and uptake of NP-Fab BisHalide Ab and NP-Fc BisHalide Ab into EMT6 cells by 19-fold and 13-fold, respectively.

Moreover, NP-Fab BisHalide Ab and NP-Fc BisHalide Ab were entrapped with cytotoxic payload and their cytotoxicity was evaluated. They showed significant enhancements in the

activity. This work will provide a facile conjugation method that could be implemented to actively target NPs with a plethora of approved therapeutic mAbs."

1571056903: Synergistic Enhancement of Physicochemical and Biomedical Properties in Microwave-Synthesized Copper-Doped Zinc Oxide Nanoparticles

Bibi Raza Khanam, Uma Reddy B, Khadke Udaykumar, Monica K J Nidhi and Nagaraja H (Vijayanagara Sri Krishnadevaraya University Ballari, India)

"Zinc oxide (ZnO) nanoparticles (NPs) are highly promising due to their broad applicability across numerous scientific and technological disciplines, including biomedical sciences [1]. The integration of metal into ZnO NPs significantly enhances their antibacterial, antifungal, antioxidant, and hemocompatible properties, crucial for biomedical applications such as infection control, wound healing, and medical implants [2,3]. This study investigates the impact of Copper (Cu) doping on both internal and surface characteristics of ZnO NPs. Microwave-assisted chemical combustion method is used to synthesize the pure ZnO (PZnO), calcinated ZnO (CZnO), and Cu-doped ZnO [$Zn_{1-x}Cu_xO$ ($x = 0.0385, 0.08, 0.115$ M)] (ZCu₂, ZCu₄, ZCu₆) NPs [4,5]. The influence of Cu doping on structural, optical, and zeta potential properties is examined by XRD, FT-IR spectroscopy, SEM, photoluminescence (PL) spectroscopy, and zeta potential (ZP) analysis. Biomedical applications including antibacterial, antifungal, antioxidant, and cytotoxicity against human RBCs were explored using in-vitro disc-diffusion, poisoned-food techniques, DPPH assay, and anti-hemolytic activity tests. It is found that the average crystallite size increased from 54.65 to 71.66 nm with ZCu₂, then decreased to 66.80 nm at ZCu₆, due to Cu²⁺ ion insertion causing lattice distortion, strain, and defects, as indicated by peak shifts and broadening. The FTIR spectra suggest that Cu doping causes a frequency shift in ZnO, confirming high purity without additional peaks. SEM images show that the average particle sizes are 122, 139, 197, and 128 nm for PZnO, ZCu₂, ZCu₄, and ZCu₆, respectively, with Cu doping causing an initial increase and then decrease in particle size, consistent with XRD analysis. PL spectroscopy reveals a blueshift in emission from 430 to 409 nm and an increase in the optical bandgap (E_g) from 3.30 to 3.47 eV in ZnO and ZCu NPs, corresponding to changes in particle size and increased surface defects with higher Cu doping. ZP analysis shows surface charges of 5.23, -2.94, -6.57, -23.27, and -12.78 mV for PZnO, CZnO, ZCu₂, ZCu₄, and ZCu₆, respectively, with ZCu₄ and ZCu₆ demonstrating superior colloidal stability, dependent on Cu doping concentration and particle size. Biomedical evaluation underscores the remarkable antibacterial, antifungal, antioxidant, and hemocompatible properties of both ZnO and Zn_{1-x}Cu_xO NPs, suggesting their promising utility in various biomedical applications, paving the way for further research in nanomedicine. The antibacterial activity of ZnO and Zn_{1-x}Cu_xO NPs against *E. coli* and *X. citri* showed that smaller ZnO NPs exhibited significant inhibitory properties, with inhibition zones ranging from 10.2 to 15.5 mm for ZnO NPs, while Cu doping increased inhibition with zones up to 13 mm for *E. coli* and 12.2 mm for *X. citri*, but also led to larger particle sizes, which may hinder bacterial membrane penetration and reduce effectiveness. ZnO and Zn_{1-x}Cu_xO NPs showed antifungal activity against *R. stolonifer* and *A. niger*, with mycelial growth inhibition rates for PZnO at 50.94% and 44.44%, for CZnO at 52% and 66.66%, and for ZCu₆ at 88.8% and 91.1% respectively, highlighting increased antifungal

efficacy with Cu doping but also noting a decrease in stability due to potential fungal resistance to copper. ZnO and Zn_{1-x}Cu_xO NPs demonstrated significant dose-dependent radical scavenging activity, with PZnO showing up to 92.27%, CZnO up to 90.73%, ZCu₂ up to 85.39%, ZCu₄ up to 87.24%, and ZCu₆ up to 89.45%, all with an IC₅₀ value of 50 µg/mL, comparable to the standard L-ascorbic acid. The erythrocyte hemolysis assay showed that ZnO and Zn_{1-x}Cu_xO NPs are hemocompatible up to 500 µg/mL, with PZnO and CZnO causing less hemolysis (2.15-3.12%) compared to higher Cu-doped samples (2.39-7.89%), due to Cu-induced toxicity. The biomedical evaluation underscores the antibacterial, antifungal, antioxidant, and hemocompatible properties of both ZnO and Zn_{1-x}Cu_xO NPs. Notably, the enhanced antibacterial and antifungal activities with Cu doping concentration suggest potential applications in combating microbial infections. The antioxidant activity and hemocompatibility further endorse their biomedical relevance. This multifaceted characterization underscores the promising utility of Zn_{1-x}Cu_xO NPs in various biomedical applications, offering avenues for further research and development in nanomedicine.

References

- [1]. Khanam, B.R. et al. (2023) 'The effect of reaction and annealing temperatures on physicochemical properties of highly stable ZnO nanoparticles synthesized via a green route using plumeria obtusa L.', *New Journal of Chemistry*, 47(41), pp. 19122-19137. doi:10.1039/d3nj02641h.
- [2]. Arshad, R. et al. (2023) 'Antimicrobial and anti-biofilm activities of bio-inspired nanomaterials for wound healing applications', *Drug Discovery Today*, 28(9), p. 103673. doi:10.1016/j.drudis.2023.103673.
- [3]. Hamimed, S. and Chatti, A. (2022) 'Photocatalytic Metal Bionanocomposites for Biomedical Applications', *Bionanotechnology: Emerging Applications of Bionanomaterials*, pp. 227-258. doi:10.1016/b978-0-12-823915-5.00011-3.
- [4]. Khanam, B.R., Kotresh, M.G. and Khadke, U.V. (2024) 'Enhanced crystallographic and physicochemical properties of chromium-embedded ZnO nanoparticles', *Chemical Physics Impact*, 8, p. 100518. doi:10.1016/j.chphi.2024.100518.
- [5]. Khanam, B.R. et al. (2024) 'Gamma radiation-induced modifications in the physicochemical features of ZnO nanoparticles synthesized using microwave technique', *Ceramics International*, 50(3), pp. 5552-5561. doi:10.1016/j.ceramint.2023.11.310."

1571056934 Detection of acetic acid for Fatty Liver diagnosis using Amorphous Tungsten Oxide (a-WO₃) Gas Sensors

Amal Alrebh (Khalifa University, United Arab Emirates)

"Wearable skin gas analyzers have gradually emerged as one of the central topics in the field of noninvasive diagnostic and health monitoring technologies. They provide a direct approach to evaluate health through monitoring of volatile organic compounds related to different physiological and pathological conditions produced from human skin and breath [1]. Trace

amounts of acetic acid found in human skin and breath can serve as a critical biomarker for monitoring potential health issues related to disturbances in the metabolism that is associated with metabolic syndrome and non-alcoholic fatty liver disease (NAFLD) [2]. Hence, the development of a sensitive, wearable gas sensor capable of detecting acetic acid at low concentrations is essential for proactive health management and noninvasive early detection of metabolic-related illnesses [3]. However, existing sensors are insufficient for detecting these biomarkers at low concentrations with the desirable sensitivity and selectivity in a complex and dynamic environment. In response to these challenges, tungsten oxide has promising potential because of its high sensitivity and selectivity for acetic acid detection.

The α -WO₃ micro-wire gas sensor operates based on interactions with acetic acid that alter resistance. When exposed to air, the sensor's surface adsorbs oxygen, forming oxygen ions that capture electrons from the conduction band, increasing the sensor's resistance. Upon exposure to acetic acid, the acetic acid molecules react with the adsorbed oxygen ions, releasing electrons back into the conduction band, which decreases the sensor's resistance. This change in resistance is proportional to the concentration of acetic acid, enabling its detection. The response of the α -WO₃ micro-wire gas sensor to a variation in the concentrations of acetic acid is presented in figure 1(a). The decrease in the resistance of the sensor with the increase in the concentration of acetic acid demonstrates sensor's high sensitivity at 200°C in air. Dynamic response and recovery of the sensor to acetic acid concentrations ranging from 100 ppb to 100 ppm in an air atmosphere is shown in Figure 1(b), whereby steady changes of resistance at each concentration level confirm the reliability and reproducibility of the sensor, which further validates its robustness. Figure 1(c) presents the the principal component analysis (PCA) results, highlighting that the sensor's high selectivity and potential to differentiate between acetic acid and other gases. These figures combinedly demonstrate that the α -WO₃ micro-wire gas sensor is not only sensitive but also selective and reliable, making it a potential candidate for the non-invasive monitoring the biomarkers of fatty liver disease. Figure 1 (a) sensor response to acetic acid concentrations in air, (b) Dynamic response and recovery in an air atmosphere, (c) principal component analysis (PCA) results showing the separation of acetic acid from other compounds.

Acknowledgements: This research is supported by Grant-in-Aid for Scientific Research No. 20H05651, JP22K18804, JP23H04099, and 21K14510 from the Japan Society for the Promotion of Science (JSPS), AMED under Grant Number JP22zf0127006, and JST CREST (JPMJCR22O2). Additional support was provided by the Khalifa University Summer Internship Program and in collaboration with the University of Tokyo.

Reference: [1]. Environ. Sci. Technol. 2022, 56, 8, 4838-4848. [2]. Giró Benet, J.; Seo, M.; Khine, M.; Gumà Padró, J.; Pardo Martínez, A.; Kurdahi, F. Breast Cancer Detection by Analyzing the Volatile Organic Compound (VOC) Signature in Human Urine. Sci. Rep. 2022, 12, 14873. <https://doi.org/10.1038/s41598-022-17795-8> [3]. Wilson, A.D. Application of Electronic-Nose Technologies and VOC-Biomarkers for the Noninvasive Early Diagnosis of Gastrointestinal Diseases. Sensors 2018, 18, 2613. <https://doi.org/10.3390/s18082613>

1571057904 In-situ development of glucose-responsive multifunctional hydrogels for drug release and wound healing applications

Akbar Ali (Khalifa University, United Arab Emirates)

Multifunctional hydrogels represent a significant advancement in the field of biomedical engineering, with several applications in drug encapsulation, sensing and wound healing mechanism. These systems, upon specific modifications, can be used to directly detect biochemical markers from body effluents, while their porous nature allows for the encapsulation of various therapeutic agents. The present study introduces a new approach for developing hydrogel composites based on PEGDA and conducting fillers. By embedding conductive materials, such as gold nanoparticles, Mxene (Ti_3C_2Tx), and poly(3,4-ethylene dioxythiophene): polystyrene-sulfonate (PEDOT: PSS) within the hydrogel network, these systems are found to detect and respond efficiently to changes in glucose concentration, consistent with blood and sweat glucose readings. Overall, the dual purpose of these hydrogels points to a path toward the creation of integrated systems that, when combined with safety, sustainable production at affordable prices, and innovative drug delivery technologies, can non-invasively detect specific analytes in wearable diagnostics for patients with chronic diseases like diabetes and chronic wound infections.

1571057977 Bio-ceramics for Thermal Management in Textiles

Muhammad Usman Munir (University of Milano-Bicocca, Italy); Massimiliano Darienzo (University of Milano Bicocca, Italy)

Infrared radiative textiles have gained much interest for their potential applications in health, sports, and everyday apparel. These textiles can enhance thermal regulation, providing both warmth and comfort. Bio ceramics, a class of materials known for their far-infrared (FIR) emission, offer promising solutions for functionalizing textiles. By integrating bio ceramics into textile fibers, we aim to develop fabrics that not only retain thermal energy but also promote health benefits such as improved blood circulation and muscle relaxation.

1571058151 Microwave-Assisted Green Synthesis of Iron Oxide Nanoparticles for Enhanced Germination of Cucumber Seeds

Godwin Joseph Nallathambi and Ankita Maria Paul (Amity University Dubai, United Arab Emirates); Henda Mahmoudi (Scientist, United Arab Emirates); Asha Madhavan (Amity University, United Arab Emirates)

"The escalating global population and the challenges posed by climate change necessitate innovative approaches to enhance crop production. Recent advancements in nanotechnology have demonstrated its potential to boost plant growth and development, thereby contributing to agricultural sustainability [1]. Integrating nanotechnology into agriculture has paved the way for improving crop productivity and nutritional value. Seed priming, a cost-effective and accessible method, has emerged as a promising approach to accelerate germination and

invigorate seedling growth [2]. Traditional methods often employ micronutrients, enzymes, or biopolymers for seed coating [3,4]. Integrating nanotechnology into seed priming has introduced a novel paradigm-nano-priming-which involves the application of nanoparticles to seeds and has shown remarkable potential in enhancing germination, nutrient uptake, and plant stress tolerance [5]. The current study reports the eco-friendly, microwave-assisted green synthesis of biocompatible iron oxide nanoparticles (FeO NPs) using Moringa (*Moringa oleifera*) leaves extract. The FeO nanoparticles were used a nano-priming agent to enhance the germination of cucumber (*Cucumis sativus*) seeds. The treated cucumber seeds were sown in plastic trays filled with black soil to investigate the effect of the nanoparticles on various growth parameters, including germination rate, leaf number, and seedlings height. Seed priming was performed using two concentrations (70 ppm and 100 ppm) of FeO nanoparticles and evaluated against a hydro-primed control (distilled water). The preliminary results indicated that the germination rates for the 70 ppm and 100 ppm treatments were significantly enhanced compared to the control group, with the higher concentration (100 ppm) demonstrating superior performance. Increased shoot length, accelerated germination rates, and a higher leaf number were observed, indicating more rapid seedling development under the 100 ppm treatment. The synthesized FeO NPs were characterized using UV-visible spectroscopy, dynamic light scattering (DLS), and X-ray diffraction (XRD). This study underscores the potential of phytochemical-capped FeO NPs as an effective nano-priming agent to stimulate cucumber seed germination, offering a promising approach for sustainably improving crop productivity.

References:

1. Elkhatib, E. A., Sherif, F. K., Fahim, S. F., Moharem, M. L., & Mahdy, A. M. (2020). Ameliorative Effect of Water Treatment Residual Nanoparticles on Seed Germination of Cucumber (*Cucumis sativus* L.) under Cd Stress. *Alexandria Science Exchange Journal*, 41(JANUARY-MARCH), 61-68.
2. Mahdy, A. M., Sherif, F. K., Elkhatib, E. A., Fathi, N. O., & Ahmed, M. H. (2020). Seed priming in nanoparticles of water treatment residual can increase the germination and growth of cucumber seedling under salinity stress. *Journal of Plant Nutrition*, 43(12), 1862-1874.
3. Abbasi Khalaki, M., Moameri, M., Asgari Lajayer, B., & Astatkie, T. (2021). Influence of nano-priming on seed germination and plant growth of forage and medicinal plants. *Plant growth regulation*, 93(1), 13-28.
4. Chandrasekaran, U., Luo, X., Wang, Q., & Shu, K. (2020). Are there unidentified factors involved in the germination of nanoprimered seeds?. *Frontiers in Plant Science*, 11, 832
5. Rhaman, M. S., Tania, S. S., Imran, S., Rauf, F., Kibria, M. G., Ye, W., ... & Murata, Y. (2022). Seed priming with nanoparticles: An emerging technique for improving plant growth, development, and abiotic stress tolerance. *Journal of Soil Science and Plant Nutrition*, 22(4), 4047-4062."

1571058162 Functionalization of Polyester using Nanoemulsion of Bioderived Gamma Decalactone and its Mosquito Repellency and Antimicrobial activity

Gulshita Alam and S. Wazed Ali (Indian Institute of Technology Delhi, India); M Ali Haider (Indian Institute of Technology Delhi Abu Dhabi, United Arab Emirates)

Development of human waste into the natural water resource has become the main cause of environment contamination. Contaminated water significantly contribute to the proliferation of mosquitoes and other pathogens resulting serious health and hygiene risks for human being. Therefore, it is a crucial need to develop sustainable solutions to control the proliferation of these insects and microbes. Various synthetic pesticides such as N, N-Diethyl-meta-Toluamide (DEET), picaridin, and permethrin are commercially available to protect human being from these pathogens. However, these products have adverse effects to the environment and human health, owing to their hazardous nature. In this regard, molecules derived from biomass are considered as a sustainable solution because of their remarkable medicinal value compared to synthetic pesticides. Additionally, multifunctional fabrics are a preferred material for protecting humans from mosquito bites and microbial attacks, as most of the body is covered by clothing. The present study deals with the functionalization of polyester fabric using an oil/water nano emulsion of biomass-derived gamma-decalactone for mosquito repellency and antimicrobial activity simultaneously. Fourier-transform infrared spectroscopy (FTIR) and Field Emission Scanning Electron Microscopy (FESEM) have been employed to analyze the functional and structural morphology of modified fabric. The results showed excellent mosquito repellency (>95%) against *Aedes* and *Anopheles* species, along with outstanding antibacterial effectiveness against gram-positive (*S. aureus*) and gram-negative (*E. coli*) bacteria (>98%). All the results are sustained even after 25 home laundering with slight decrement. Based on significant mosquito repellency and antimicrobial activity the functionalize fabric could be effectively employed as a biocompatible fabric in the fabrication of wearable textiles, mosquito repellent net and curtain.

1571058172 Pioneering HIV Prevention Through the Development of Mucoadhesive Biodegradable Nanoparticles for Effective Intravaginal Delivery of Efavirenz

Avichal Kumar (KLE College of Pharmacy, A Constituent Unit of KAHER-Belagavi, Bengaluru, India); Shivakumar H. N. (KLE College of Pharmacy, India)

HIV remains a pressing global health issue, with approximately 40.4 million individuals affected worldwide, and the number of new cases continues to rise. A promising strategy for HIV prevention is the use of pre-exposure prophylaxis (PrEP), which involves the administration of antiretroviral drugs. Among the various approaches to PrEP, topical vaginal formulations designed to inhibit viral transmission are gaining attention due to their potential efficacy. In this study, we developed Efavirenz (EFZ)-loaded nanoparticles (NPs) using poly(lactic-co-glycolic acid) (PLGA) via a modified emulsion-solvent evaporation technique, with Pluronic F-127 as a surfactant to enhance nanoparticle stability and performance. Various analytical techniques, including scanning electron microscopy (SEM), energy-dispersive X-ray analysis (EDAX), and atomic force microscopy (AFM), were employed to evaluate the nanoparticles' physical characteristics for vaginal delivery. These analyses confirmed that the nanoparticles had a spherical morphology and favorable surface properties. Fourier-transform infrared

spectroscopy (FTIR) indicated compatibility between Efavirenz and excipients, while differential scanning calorimetry (DSC) and powder X-ray diffraction (PXRD) analyses showed that Efavirenz existed in an amorphous state, enhancing its solubility and bioavailability. Characterization revealed an average particle size of 144.3 ± 2.13 nm, a polydispersity index (PDI) of 0.248 ± 0.14 , and a zeta potential of -17.52 ± 0.78 mV, indicating good stability and a high entrapment efficiency of $87.00 \pm 1.37\%$. In vitro dissolution studies in simulated vaginal fluid (SVF) demonstrated sustained release of Efavirenz over 12 hours. The nanoparticles exhibited good mucoadhesive properties, requiring a detachment force of 13 dyne/cm². Cytotoxicity assessments using the MTT assay showed reduced cell viability compared to free Efavirenz, supporting the potential of PLGA nanoparticles for effective HIV pre-exposure prophylaxis.

1571065263 Investigation on Antimicrobial Potential of Palladium-Gold Bimetallic Nanoparticles and its Alginate Entrapped Counterpart against Selected Respiratory Nosocomial Pathogens

Shwetha B Nagarajan, Ms. (NIMS University Rajasthan, India)

"Purpose: The development of nanoscale materials as an alternative means of combating infections is being driven by the concerns that antibiotic-resistant microbes are posing to public health. In the last ten years, biomedical domains have demonstrated the therapeutic potential of nanoparticles. Bimetallic nanoparticles (BNPs) have emerged as important technological components due to their biological properties, which include catalytic, antioxidant, antibacterial, antidiabetic, anticancer, hepatoprotective, and regenerative activity. The utilization of these substances in both healthcare and pharmacy has improved drastically over the last ten years.

Materials & Methods: This investigation attempts to synthesize a bimetallic nanoparticle made by combining palladium (1mM PdCl₂) and gold (1mM HAuCl₄) from a combination of two aqueous extracts of ajwain leaves (*Trachyspermum ammi*) and cloves (*Syzygium aromaticum*) at the ratio of 35:10:5 and was characterized using techniques like FTIR, XRD, DLS, UV-Vis, and HR-TEM (EDAX). Then the entrapment of the nanoparticle began by adding 1.5 ml of the sample into a small beaker containing alginate beads which are prepared by adding sodium alginate (4%) solution into calcium chloride (11.1g CaCl₂) solution drop-wise and kept for incubation and then was characterized using the same techniques with HR-SEM (EDAX). Antimicrobial susceptibility assay was performed with nanoparticle and the alginate entrapped counterpart against bacterial strains *K. pneumoniae* (ATCC13883), MRSA (ATCC43300), *S. pneumoniae* (ATCC6305), *H. parainfluenzae* (ATCC9796), *A. baumannii* (ATCC19606) and fungal strain *A. fumigatus* (ATCC204305) with standard antibiotics as positive controls.

Results and Discussion: The results revealed that pure Pd-Au shown increased inhibitory effect on MRSA, *K. pneumoniae*, *S. pneumoniae* and *A. baumannii* whereas same Pd-Au entrapped in alginate shown a slight decrease in inhibitory effect on mentioned strains but the same happened reverse in the case of *H. parainfluenzae*. In case of the fungus *A. fumigatus*, the pure

form of Pd-Au NPs didn't show any zone of inhibition whereas its alginate entrapped form showed a slight inhibition zone.

Conclusion: Further investigation is required in this short-term study to provide optimistic future scope to the field Nanotechnology in Biomedicine."

1571065284 Silver, nickel, and cobalt nanocomposites in a polymer-inorganic carrier SiO₂-g-PAAm for anti-microbial and anti-cancer treatment

Olga V. Akopova (Bogomoletz Institute of Physiology, Ukraine)

Metal nanocomposites of low-nanometer scale Me particle size (MeNC) with high anti-bacterial and anti-cancer activity were synthesised in situ in a polymer-inorganic matrix SiO₂-grafted polyacrilamide (SiO₂-g-PAAm). Mean particle diameters were evaluated by transmission electron microscopy. Obtained MeNC differed in their anti-bacterial and anti-cancer properties. AgNC exhibited high antibacterial activity against E. coli and S. aureus being least toxic to cancer cells (marmosets' leucocytes transformed by Barr-Epstein virus (B95-8) and Wish cell line with marker chromosomes of HeLa cells), while NiNC and CoNC exhibited high anti-cancer activity being non toxic for bacteria. Inhibition of cancer cell viability (IC₅₀) was inversely dependent on particle size: NiNC < CoNC < AgNC. Meanwhile MeNC exhibited low toxicity to control MDCK (Madin-Darby canine kidney) cells. Conclusion: developed method of synthesis in situ of Ag, Ni, and Co nanocomposites in SiO₂-g-PAAm matrix is a promising nanotechnology for the design of anti-bacterial and anti-cancer medicine.

1571066279 Patching Up the Puzzle: Nano-Biomaterials to the Rescue

Shabir Hassan (Khalifa University, United Arab Emirates)

The effects of self-oxygenation biomaterials on different aspects of regenerative medicine such as healing of the myocardium after MI or stem cell fate in cellularized hydrogels have not yet been studied. Additionally, decellularized hydrogels-based research is gaining attention, however, very little is known about their burn wound healing properties. Biomaterials were reinforced to give them oxygenating, antioxidative, and tissue-adhesive properties for three different applications: 1.) Better tissue regeneration in MI, 2.) Stem cell fate commitment for regenerative medicine such as bone regeneration, and 3) Complete healing of burn wounds (Figure 1). Alginate and silk fibroin (SF) based hydrogels were shown to continuously release stromal cell-derived factor (SDF) and oxygen for MI applications. This resulted in a significant improvement in vascularization, increasing the cardiomyocyte survival by 30% cardiomyocyte survival and reducing the fibrotic scar formation in an MI animal rodent model. In another study, bulk RNA-sequencing confirmed that MSCs with oxygenating particles (OMP) possessed a stronger expression of osteogenic gene transcript fingerprint than those with silicate NPs (SNPs) or SNPs with OMPs. OMPs also increased the number of vessels and potentially increased vessel diameter and thus vessel maturation. Decellularized caprine scaffolds encapsulating vitamin C and ZnO nanoparticles showed complete healing of a burn wound in a rabbit. Taken together, we present innovations in biomaterials in their oxygenating

capacity, bioadhesion, and antioxidating and wound healing properties to treat a wide variety of medical conditions in small and bigger animal models.

1571070460 Metal Free, Visible light mediated synthesis of tetracyclic benzimidazole: Regioselective C-H functionalization with in-vitro and computational study of anti-breast cancer compounds

Annu Abhishek Choudhary (Research Scholar (VNSGU), India)

Breast Cancer is responsible for the highest number of deaths worldwide. In the realm of anti-breast cancer drug design by several compounds docking studies, eight new N-containing nonsteroid tetracyclic derivatives have been synthesized via regioselective intramolecular C-H functionalization by visible light. The adopted methodology is highly efficient, green, and sustainable to unclash a new pathway in excellent yield, provides a cost-effective and catalyst-free protocol for the quick synthesis of biologically active compounds from readily available substrates. Synthesized compounds were characterized by spectroscopic techniques such as, HRMS, ¹HNMR, ¹³CNMR, and single-crystal XRD analysis. This study explores the antiproliferative potential of novel compounds against human MCF-7 breast cancer cells. This study includes in vitro experiments to assess the effect of our compounds on cells. These experiments include cytotoxicity assessment by MTT assay, apoptosis and cell cycle analysis by flow cytometry, ROS production assessment, etc. Among the novel compounds, compound 2e exhibited the most potent antiproliferative activity, with an IC₅₀ of 40 nM, surpassing the efficacy of established drugs like Exemestane (IC₅₀ 50 nM) and Tamoxifen (IC₅₀ 5.45 μM). Compound 2e also significantly induced G2/M phase cell cycle arrest and apoptosis, increasing the apoptotic cell population to 65.97%. Additionally, the compound led to a marked rise in reactive oxygen species (ROS) generation, implicating oxidative stress in its mechanism of action. Molecular docking and dynamics simulations further supported the strong anticancer activity of compound 2e, highlighting its potential as a promising therapeutic agent for breast cancer.

1571071619 Cell-Mediated Biointerfacial Phenolic Assembly for Probiotic Nano Encapsulation

Franco Luigi Centurion Rodriguez (The University of New South Wales, Australia); Md Arifur Rahim (Monash University, Australia)

The use of cell-mediated chemistry is an emerging strategy that exploits the metabolic processes of living cells to develop biomimetic materials with advanced functionalities and enhanced biocompatibility. Here, a concept of a cell-mediated catalytic process for forming protective nano-shells on individual probiotic cells is demonstrated. This process is leveraged by the cell environment to induce oxidative polymerization of phenolic compounds, and simultaneously these phenolic polymers assemble to form nano-coatings around individual cell surfaces. The detailed analysis reveals that the oxidation process is triggered by an essential nutrient (manganese) of the probiotic cells, which significantly increases the oxidation

rate of phenolic compounds. The phenolic coatings, encapsulating each cell in nanometre scale, demonstrate excellent biocompatibility and biodegradability. Additionally, the in situ encapsulated probiotic cells display an improved gastric tolerance of up to ≈ 1.4 times higher than the native cells and enhanced adhesion as high as ≈ 1.6 times onto a model of intestinal epithelial cells. Finally, the coated probiotic cells exhibit a high antioxidant activity as an advanced feature. Overall, this method provides a unique approach to improve the probiotic delivery using the cell machinery to engineer encapsulating nanocoatings with protective benefits and new functionalities.

1571072192 Niacin-Loaded Liquid Crystal Nanoparticles Ameliorate Prostaglandin D2-Mediated Niacin-Induced Flushing and Hepatotoxicity

Aaqib Javaid (Institute of Nano Science and Technology, India)

"Niacin plays a significant role in the therapy and management of mixed dyslipidaemia. Nevertheless, its administration in raw form is contraindicated due to potential adverse effects, including hepatotoxicity and cutaneous flushing. Prostaglandin D2 (PGD2) plays a crucial role in the signalling cascade of niacin-induced flushing. To address the potential adverse reactions linked to niacin therapy, we have developed a niacin-loaded lyotropic liquid crystal nanoparticle (NLCS) crafted explicitly for the oral administration of niacin. NLCSs were produced by disrupting the cubic gel of Glyceryl monostearate (GMS). The nanoparticles demonstrated notable drug-loading capabilities with a size of approximately 255 ± 31.6 nm. Furthermore, NLCS displayed a sustained release behaviour, indicating their potential for controlled and prolonged drug delivery. Efficient encapsulation and minimal interaction between niacin and other excipients were evidenced through Fourier transform infrared spectroscopy (FTIR) and X-ray diffraction (XRD) studies, establishing their high stability. In-vitro studies suggested that the nanoparticles had good antioxidant activity, swelling behavior, and biocompatibility. Additionally, compared to raw niacin, NLCS showed higher in-vivo therapeutic efficacy, lesser hepatotoxicity, a more refined lipid profile, and an improved complete blood count (CBC) profile. In addition, it was shown that animals treated with NLCS had lower PGD2 levels than those treated with raw niacin. In conclusion, our study highlights the potential of NLCS as a promising strategy to alleviate the side effects linked to the direct ingestion of pure niacin. These nanoparticles offer a solution to flushing-like symptoms and hepatotoxicity, positioning them as a viable therapeutic option for managing dyslipidemia.

References: Niacin-Loaded Liquid Crystal Nanoparticles Ameliorate Prostaglandin D2-Mediated Niacin-Induced Flushing and Hepatotoxicity, Aaqib Javaid, Abutwaibe K A, Krishana Kumar Sharma, Sherilraj P M, Anurag Verma, and Shyam Lal Mudavath. ACS Applied Nano Materials 2024 7 (1), 444-454; <https://doi.org/10.1021/acsanm.3c04649>"

1571073001 Recent advancements in lipid nanoparticles-based phytoactives delivery systems for neurodegenerative diseases

Mayssa Hachem and Amina Dirir (Khalifa University of Sciences and Technology, United Arab Emirates)

Neurodegenerative diseases including Alzheimer's and Parkinson's diseases pose a significant and continuous burden on the healthcare system internationally, urging the search for innovative therapeutical approaches targeting the central nervous system. Nowadays, no definitive treatment can effectively modulate the neuronal degeneration associated with such diseases. The current line of therapies is primarily symptomatic treatments and suffers from several drawbacks. Among these, phytoactives are emerging for their potential therapeutic effect in neurodegenerative diseases. Indeed, plants produce secondary metabolites that provide defensive functions against abiotic and biotic stresses. These metabolites can target the neurons and represent a promising therapeutic intervention for neurological disorders. However, the polar nature of phytoactives and their large size hinder their passage through the blood-brain barrier (BBB), a semi-permeable and very selective barrier separating blood and brain. More recently, evolving studies have showed that the therapeutic efficiency of phytochemicals has been enhanced following their encapsulation with different form of engineered nanoparticles including lipid nanoparticles [1-3]. Hence, the present paper highlighted the production and application of lipid nanoparticles as carriers for phytoactives for targeting the brain with the aim of neuroprotection, discussed the current challenges associated with such nanocarriers and provided insights into potential applications in the medical sector.

1571073342 Additive Manufacturing of Composite Contact Lenses

Said El Turk and Haider Butt (Khalifa University, United Arab Emirates)

"Gold nanoparticles (Au NPs) are nanomaterials with a wide range of uses in wearable technology and biomedicine. The potential applications of GNPs are vast, including medicine administration, laser protection, bacteria reduction, color blindness control, and detection/sensing. These applications could revolutionize contact lenses and their uses in various medical and technological fields. The Localized Surface Plasmon Resonance (LSPR) of nanoparticles is a unique property. An electron oscillation triggered by light contact is a plasmon. Surface Plasmon (SP) refers to the oscillation at a metal's outermost layer. When a surface plasmon is contained in a particle the size of a light wavelength, it is referred to as a localized surface plasmon (LSP). The LSP causes a dip in the nanoparticle's transmission spectra [1]. This dip can be used to block specific wavelengths. Color blindness, or color vision deficiency (CVD), is a medical condition in which one of the three types of cones in the human eye fails to function or is missing [2]. Around 200 million individuals worldwide are affected by color blindness. People who have color blindness find that their personal and professional lives are significantly negatively impacted [3]. Many types of color blindness can result from defects in or the absence of the human retina's long-, medium-, and short-wavelength-sensitive cones (L, M, and S cones). The two primary kinds of color blindness are red-green and blue-yellow vision deficits. There are two subtypes of red-green color blindness: Deutans and Protans. Deutans are further divided into two groups: those with deuteranopia have missing M cones,

while those with deuteranomaly have malfunctioning M cones. Similar to this, Protans can be further divided into protanomaly and protanopia, wherein individuals with Protanomaly have L cone malfunctions while those with Protanopia experience L cone absence [4]. The malfunctioning or absence of the cones causes their responses to overlap, and this overlap occurs in the range of 540 nm to 580 nm and needs to be blocked in order to enhance color perception in color-blind patients. Hence, in this study, Au NPs were fabricated in hydrogel-based 3D-printed contact lenses using a green synthesis technique. Using this method, the Carbonyl groups (C=O), Olefinic groups (C=C), and free radicals present in the lens material are responsible for reducing gold salts into nanoparticles in the lenses. In the 3D printed lenses, Au NPs were effectively developed, showcasing a novel method of synthesizing Au NPs in contact lenses to block problematic wavelengths for red-green color-blind patients. The blockage dips achieved were around 543 nm, 551 nm, and 560 nm, with increasing concentrations of gold precursor. Hence, the lenses are able to block wavelengths in the red-green color blindness overlapping range. The lenses were thoroughly characterized using scanning electron microscopy (SEM), Fourier transform infrared spectroscopy (FTIR), water content, contact angle, and leakage. SEM imaging confirmed the formation of Au NPs in the lenses, while FTIR confirmed the utilization of the carbonyl and olefinic groups in the synthesis process. The rest of the assessed properties were very comparable to the literature. The employed gold precursor solutions are reusable and do not get reduced into Au NPs. As a result, the innovative method can develop contact lenses for red-green color blindness management economically and rapidly."

1571073416 Biodegradable polyester-based hyperbranched nanocarrier-modified with N-acetyl glucosamine for efficient drug delivery to cancer cells through GLUTs

Aazam Shaikh (Agharkar Research Institute, India & Savitribai Phule Pune University, India)

Cancer, ranking just below cardiovascular diseases, is a leading cause of mortality worldwide. The key to enhancing survival rates among cancer patients lies in the early detection, removal, and treatment of tumors. However, the broad-spectrum nature of current treatments, including chemotherapy and radiation therapy, results in significant collateral damage to healthy cells and tissues. In this context, hyperbranched polymers present a promising avenue for more targeted therapy. These polymers can be loaded with chemotherapeutic drugs and modified with specific ligands to selectively target cancer cells via GLUT transporters, which are overexpressed in many cancer types. To enhance the delivery of drugs to cancer cells, we have engineered an N-acetyl glucosamine (NAG) conjugated version of this polymer. The characterization of these nanocarriers was evaluated using various techniques, including ¹H NMR, dynamic light scattering, and FTIR spectroscopy. Additionally, confocal microscopy was utilized to compare the accumulation of DOX in cancer cells using both the NAG-conjugated and unmodified versions of H40 Boltorn™. Our observations indicated a superior accumulation of DOX in cells treated with the modified H40-NAG polymer. Further evaluation of the drug-loaded nanocarriers was conducted on MDA-MB-231 and 4T1 breast cancer cell lines, focusing on their cytotoxic effects. This suggests that the targeted delivery of anticancer drugs using

the modified H40 Boltorn™ nanocarriers significantly enhances the ability to kill breast cancer cells, offering a more efficient and selective approach to chemotherapy that minimizes impact on healthy tissues and cells.

1571073786 Next-Generation Nanoparticles for Immune Modulation: A Versatile Approach to Cancer and Autoimmune Therapies

Alshayma Al-Thani (Qatar University, Qatar)

This review explores the potential of next generation nanoparticles for immune modulation in treating cancer and autoimmune diseases. It highlights the strategic design of dual-function nanoparticles to promote both pro- and anti-inflammatory response, offering a versatile platform for modulating the immune system. The review investigates the mechanisms of stimuli-responsive nanoparticle, which releases therapeutic agents in response to specific signals in the microenvironment, such as the shift of pH or levels of reactive oxygen species (ROS), increasing the delivery system's bioavailability and decreasing the drug material's side effects. Moreover, it investigates the application of nanoparticles in simultaneously delivering cytokines and immune checkpoint inhibitors, a novel approach designed to overcome patient resistance to traditional immunotherapies. Significant advancements in this field includes the capacity of nanoparticles to enhance the absorption of drugs, mitigate systemic toxicity, and tailor therapies to yield the best results possible based on patient-specific needs. Furthermore, the review discusses the ability of these multi-purpose nanoparticles to transform the treatment of both cancer and autoimmune disease by promoting accurate regulation of the immune system in conditions specific to each disease. The challenges of nanoparticle compatibility, safety, and long-term efficacy are also discussed, highlighting the importance of continued study in this rapidly growing field. The review finishes by outlining the future prospect of NP-based therapeutics in personalized medicine, emphasizing their ability to considerably improve therapeutic outcomes in immune modulation techniques.

1571074451 Green synthesis of silver nanoparticles using the UAE medicinal plant Tephrosia apollinea coated with chitosan and investigation of their anticancer activity on human colorectal cancer cells

Shifa Malik, Kareem A. Mosa and Khalid Bajou (University of Sharjah, United Arab Emirates); Rania Hamdy Hussein (UOS, United Arab Emirates)

Silver nanoparticles are widely used in various fields such as the environment, medicine and agriculture. Nanoparticle synthesis utilizing biological systems is cost-effective, safe and environmentally friendly compared to currently used chemical and physical methods. In this study, chitosan-coated *Tephrosia apollinea* silver nanoparticles (AgNPs) were biosynthesized. To synthesize AgNPs, UAE native plant *Tephrosia apollinea* shoot extracts were utilized as stabilizing and reducing agents, then coated with 1% chitosan using the ionic gelation method. Using energy-dispersive X-ray spectroscopy, Fourier transform infrared & ultraviolet-visible spectroscopy, GC-MS and scanning electronic microscopy (FESEM-EDS) the green synthesized

T. apollinea AgNPs were characterized. The anticancer activity of the synthesized AgNPs was assessed on human colorectal cancer cell line SW480, using 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT), apoptosis and cell cycle assays. The average sizes of the synthesized nanoparticles were 20-35 nm, spherical, cubical, and aggregated in shape. The IC50 of T. apollinea-AgNPs 50µg/ml were found to be more cytotoxic due to the significant induction of apoptotic activity and cell cycle arrest in G1 phase, than the 80µg/ml T. apollinea shoot extract against the malignant human colorectal cancer cell line SW480 after 24 hours of treatment. According to the findings in this research, using T. apollinea shoot extract to synthesis AgNPs may be an effective approach to treat colorectal cancer.

1571074877 Advancements in Nanomaterials and Nanofabrication of Conduits for Nerve Regeneration

Utpal Bora (Indian Institute of Technology Guwahati, India)

"Nerve regeneration, particularly after spinal cord or peripheral nerve injuries, poses significant challenges that often necessitate conduit implantation depending on the grade of the injury. Recent advancements in nanofabrication and nanomaterials have substantially improved nerve conduit designs, enhancing both structural and functional recovery.

In my talk, I will cover our research and recent progress in nanofabrication methods for nerve conduits, including electrospinning, dip coating, and additive manufacturing, while addressing their advantages and limitations [1, 2]. For instance, traditional silk fibroin, though useful in implants, lacks essential properties like electrical conductivity. This limitation has been addressed by integrating metallic nanoparticles and conducting polymers through nanofabrication techniques like electrospinning. These methods have proven effective in creating precisely controlled nanofiber-based conduits, leading to significant improvements in nerve regeneration, particularly with Schwann cell integration.

Our laboratory has developed silk-gold nanocomposite conduits with embedded gold nanoparticles, which show superior Schwann cell adhesion and proliferation compared to existing materials [3]. We have also created polyaniline-silk fibroin (PASF) conduits through electrospinning, significantly enhancing nerve regeneration and myelination [4].

Research efforts by others have focused on conduits made from silk fibroin and single-walled carbon nanotubes (SF/SWNT) with fibronectin, which improve nerve repair through enhanced conductivity and cell adhesion [5]. Bionic conduits combining silk fibroin/silk sericin (SF/SS) with a poly(lactic-co-glycolic acid) (PLGA) sheath replicate native nerve architecture, providing mechanical support and promoting regeneration with outcomes comparable to nerve autografts.

Additionally, I will discuss recent advances in 3D bioprinting, which enable the creation of customized nerve conduits that closely mimic natural nerve structures. These nanofabrication innovations offer promising solutions for more effective nerve repair and regeneration, underscoring the need for continued research to further enhance functional recovery."

1571074882 Green synthesis of copper oxide nanoparticles by using aqueous extract of *Oxalis corniculata* for the control of charcoal rot of mung bean

Arshad Javaid (University of the Punjab Lahore, Pakistan); Aqsa Zafar (University of the Punjab, Lahore, Pakistan); Aneela Anwar (University of Engineering and Technology, Lahore, Pakistan)

Macrophomina phaseolina is a highly destructive soil-borne fungal pathogen because it causes diseases in hundreds of plant species including charcoal rot disease in mung bean. Control of this pathogen through chemical fungicides is difficult as it forms sclerotia. This study was undertaken to synthesize copper oxide (CuO) nanoparticles by using aqueous shoot extract of an herbaceous weed *Oxalis corniculata* and evaluation of their antifungal potential against *M. phaseolina*. Characterization of these nanoparticles was carried out through UV-visible spectroscopy, measuring particle size, X-ray diffraction (XRD) analysis, FTIR spectrometry and scanning electron microscopy (SEM). These particles were of 73 nm in diameter, rod shaped and having crystalline structure. In vitro antifungal potential of these nanoparticles was assessed in 10-mL volume test each containing 1.0 mL malt extract broth (MEB) as growth medium. CuO nanoparticles were dissolved in DMSO and their eight concentrations (0.01562, 0.03125, 0.0625, ..., 2 mg mL⁻¹) were prepared in MEB. Findings of this antifungal bioassay revealed that these concentrations can decrease the fungal biomass by 16-43% over control. In vivo study was carried out in pots where mung bean plants were grown in *M. phaseolina* inoculated soil. Solutions of nanoparticles having 10, 20 and 30 ppm concentrations were applied to the pots and their efficacy was compared with a commercial fungicide mancozeb. *M. phaseolina* inoculation (positive control) reduced shoot and root biomass by 87% and 86% over negative control, respectively. Mencozeb and nanoparticles applied mung bean plants showed marked increase in shoot and root dry biomasses over positive control. However, the plant biomasses were still lower than the negative control. The highest increase in shoot biomass was recorded due to 30 ppm nanoparticle solution that was 356% higher than the biomass in positive control treatment. This study shows that the green synthesized CuO nanoparticle have the potential to suppress growth of *M. phaseolina* and to improved the crop growth of mung bean under the stress of this pathogen.

1571075043 Design of Nano-, Micro-particles for Efficient Delivery of Proteins to Macrophages

Fatima Ba Fakhri and Aya Shanti (Khalifa University of Science and Technology, United Arab Emirates); Dong-Wook Lee (Technology Innovation Institute & Advance Materials Center, United Arab Emirates); Nitul Rajput (Colleague, United Arab Emirates); Tadzio Levato (Technology Innovation Institute, United Arab Emirates); Sung Mun Lee (Khalifa University of Science and Technology, United Arab Emirates)

"Oxidative stress, excessive production of reactive oxygen species (ROS), plays an important role in the pathogenesis of inflammatory diseases such as cardiovascular diseases, cancer, and

neurodegenerative diseases. An emerging area of interest is the role of ROS in COVID-19-induced lung inflammation. Catalase, an antioxidant enzyme, has a great therapeutic potential; however, its efficacy is limited by its delivery to target cells or tissues. In order to design efficient drug delivery nanoparticles, many factors should be considered such as size of nanoparticles, drug distribution, and drug activity. Here, two different types of nanoparticles will be designed and deliver the catalase to macrophages. First, three dimensional (3D) microcubes were printed by Nanoscribe Photonic Professional GT2, a high-resolution 3D printer. Second, various sizes or shapes of gold nanoparticles (AuNPs) were synthesized as a delivery system.

The size of 3D-printed microcubes was 800 nm in the length of square and 600 nm in height. Catalase was loaded on 3D-printed microcubes by non-specific adsorption, and catalase on 3D-printed microcubes (CAT-MC) retained 83.1 ± 1.3 % activity of intact catalase. More than 80% macrophages were infected by AuNPs when treated with spherical AuNPs (100, 200, or 400 nm), cube or bean shape. Both 3D-printed microcubes and AuNP delivered catalase to RAW 264.7 macrophages and they protected macrophages from the cytotoxicity of H₂O₂. We anticipate numerous applications of 3D-printed microparticles and AuNP for delivering therapeutic proteins."

1571075057 A comprehensive study on Synthesis, Characterization, and Cytotoxic Effects of Glutathione (GSH) coated Magnetite (Fe₃O₄) nanoparticles to target and eliminate cancerous cells

Nadiya N Patel, Jr. (D. Y. Patil Education Society, Kolhapur, Maharashtra, India)

Nanoparticle-based therapies have garnered significant interest in cancer treatment due to their potential for targeted drug delivery and enhanced therapeutic efficacy. The present study emphasizes the synthesis of Magnetite (Fe₃O₄) nanoparticles by the coprecipitation method and their subsequent functionalization with Glutathione (GSH) by oxidative polymerization method to improve biocompatibility and facilitate targeted drug delivery. Characterization techniques includes X-ray diffraction (XRD), Dynamic light scattering (DLS), Zeta potential (ζ -potential), Scanning electron microscopy (SEM), Transmission electron microscopy (TEM), and Fourier-transform infrared spectroscopy (FTIR) were employed to assess the structural, morphological, and chemical properties of the synthesized nanoparticles. The magnetic properties of synthesized nanoparticles were analyzed using a vibrating magnetometer (VSM) and zero field cooled (ZFC)-field cooled (FC). The results show that the synthesized nanoparticles are superparamagnetic, with saturation magnetization (M_s) values of approximately 60 and 49 emu/g at room temperature for Fe₃O₄ and GSH-coated Fe₃O₄ nanoparticles, respectively. The antioxidant activity was ascertained through a DPPH (1, 1-diphenyl-2, picrylhydrazyl) free radical scavenging assay. The antioxidative capabilities of GSH are principally responsible for the 63.00% free radical scavenging activity of the GSH-coated Fe₃O₄ nanoparticles at a concentration of 100 μ g/mL. Furthermore, the cytotoxic effects of GSH-coated Fe₃O₄ nanoparticles were studied on fibroblast cell lines (L929) and Breast cancer cell lines (MDA-MB-231) using a 3 (4, 5 dimethylthiazol 2 yl) 2, 5 diphenyl tetrazolium bromide

(MTT) cell viability assay. The findings show that the synthesized nanoparticles are minimally harmful to healthy cells (L929) but display dose-dependent moderate cytotoxicity toward cancer cells (MDA-MB-231). Also, the hemolysis assay was used to evaluate the impact of synthesized particles on the red blood cell membrane, preventing lysis under stress conditions. When doxorubicin (DOX) was loaded into Fe₃O₄ and GSH coated Fe₃O₄ nanoparticles, a maximum drug entrapment capacity of 85% was seen after 48 hours of loading. UV-visible spectroscopy was used to assess the in vitro drug releases. The results show that extracellular glutathione spiking facilitates drug release under acidic conditions (pH-4.5). The magnetic induction study shows that the generated magnetic nanoparticles reach therapeutic temperature (42-45°C) during the first 10 minutes of being exposed to an alternating current (AC) magnetic field. This extensive study highlights the potential of Fe₃O₄ and GSH-coated Fe₃O₄ nanoparticles as promising agents for targeted cancer treatment and offers insightful information for clinical translation.

1571075675 Metformin Loaded Zein Polymeric Nanoparticles to Augment Antitumor Activity against Ehrlich Carcinoma via Activation of AMPK Pathway: D-Optimal Design Optimization, In Vitro Characterization, and In

Yasmina Elmahboub (Misr University for Science and Technology, Egypt)

Metformin (MET), an antidiabetic drug, is emerging as a promising anticancer agent. This study was initiated to investigate the antitumor effects and potential molecular targets of MET in mice bearing solid Ehrlich carcinoma (SEC) as a model of breast cancer (BC) and to explore the potential of zein nanoparticles (ZNs) as a carrier for improving the anticancer effect of MET. ZNs were fabricated through ethanol injection followed by probe sonication method [1]. The optimum ZN formulation (ZN8) was spherical and contained 5 mg zein and 30 mg sodium deoxycholate with a small particle size and high entrapment efficiency percentage and zeta potential. A stability study showed that ZN8 was stable for up to three months. In vitro release profiles proved the sustained effect of ZN8 compared to the MET solution [2]. Treatment of SEC-bearing mice with ZN8 produced a more pronounced anticancer effect which was mediated by upregulation of P53 (Table 1) and miRNA-543 (Figure 1) as well as downregulation of NF-κB (Table 1) and miRNA-191-5p gene expression (Figure 1). Furthermore, ZN8 produced a marked elevation in pAMPK (Table 1) and caspase-3 levels as well as a significant decrease in cyclin D1, COX-2, and PGE2 levels. The acquired findings verified the potency of MET-loaded ZNs as a treatment approach for BC.

1571075800 Ion concentration modulation induced by nanoscale membrane in a nanofluidic confinement

Hiba Al Jayyousi and Serdal Kirmizialtin (NYUAD, United Arab Emirates); Yong-Ak Song (New York University Abu Dhabi, United Arab Emirates)

"Ion Concentration Polarization (ICP) is an electrokinetic phenomenon that occurs near a nanoscale permselective membrane under the influence of an applied voltage. It is widely

utilized for preconcentrating biomolecules in microfluidic devices. Given the nanometer-scale nature of this phenomenon, experimental probing of ICP for fundamental studies presents substantial challenges. In this context, our study employs molecular dynamics simulation to explore ICP inside and adjacent to the membrane, focusing particularly on the nanoscale processes. We developed a simulation framework that investigates two distinct systems within a nanoscale channel measuring 20 nm x 20 nm x 6 nm (height x length x width), subjected to different ionic concentrations (0.05 M, 0.1 M, and 0.5 M) and electric field strengths (0.05 V/nm, 0.1 V/nm, and 0.5 V/nm). The reference system consisted of a crosslinked Poly(2-Acrylamido-2-Methylpropanesulfonic Acid) PAMPS network, a cation-selective membrane created with acrylamide propyl sulfonic acid (AMPS) and of N, N'-methylenebis(acrylamide) (MBAA), all contained in an ionic aqueous solution. Extending this setup, the main system incorporated RNA molecules to simulate and observe how the local RNA concentration changed in the vicinity of the membrane under various conditions, offering more profound insights into the dynamics of ICP formation. Our findings indicated significant impacts of ionic concentration and electric field strength on the distribution and behavior of ions and RNA within the PAMPS network. At the lower ionic concentration of 0.05 M, ion and RNA localization was minimal. However, as the ionic concentration increased to 0.1 M and 0.5 M, we observed the formation of a pronounced ion depletion region, which actively displaced ions and RNA molecules away from the cation-selective membrane. Furthermore, varying electric field strengths critically influenced ions' and RNA's localization and movement. These findings were validated experimentally inside a microfluidic channel. In summary, our molecular dynamics simulation not only recapitulated experimental studies on the ICP phenomenon but also elucidated the atomic details of the mechanism of biomolecular concentration. These findings pave the way for significant advancements in the sensitivity and speed of cation-selective polymer membranes for applications in bioanalytical fields, offering promising prospects for the future."

1571076428 Nano-Liposomal Beetroot Phyto-Pigment in Photodynamic Therapy as a Prospective Green Approach for Cancer Management: In Vitro Evaluation and Molecular Dynamic Simulation

Doaa A Abdel Faddel and Maha Fadel (Cairo University, Egypt)

"Photodynamic therapy (PDT) is an effective, non-invasive strategy for treating various malignant and nonmalignant conditions. PDT is a photochemical interaction between a photoactive molecule (photosensitizer), light energy, and molecular oxygen in the tissue. When a photosensitizer absorbs the light energy, it gets excited to higher energy levels. It transfers this acquired energy to suitable substrates. This reaction finally results in the generation of reactive oxygen species (ROS) and free radicals (type I) or singlet oxygen (type II) that irreversibly devastate the cells [1]. In recent years, endeavors have been made to search for green photosensitizers derived from plants as their high bioavailability and high biodegradability characterize them. Using plant extracts as photosensitizers in photodynamic therapy (PDT) represents a significant green approach toward sustainability [2]. Beetroot extract (*Beta vulgaris* L.) has gained popularity as a potential "functional food" as it is rich in

micro-nutrients and bioactive phytoconstituents. Betanin is the main pigment in beetroot that is mainly employed as a colorant agent in the food industries and was reported to possess several biomedical activities as an antioxidant, anti-inflammatory, and anticancer agent [3]. Nevertheless, the use of betanin in the biomedical field is limited due to its rapid degradation and high susceptibility to changes in the surrounding conditions such as temperature, pH, oxygen, enzymes, and light. These drawbacks can be resolved by encapsulating betanin in an appropriate nanocarrier, such as liposomes [4]. This study investigates beetroot juice (BRJ), betanin, and their liposomal formulations (Lip-BRJ, Lip-Bet) as photosensitizers in cancer PDT. BRJ was prepared, and its betanin content was quantified via HPLC. A molecular dynamic simulation study was performed to examine the mechanism of selective interaction of betanin with Bcl-2 proteins. The characterization of liposomes is summarized in Table 1. The (RNO)/imidazole technique monitored the singlet oxygen formation. BRJ and betanin decreased the RNO absorbance at 440 nm by 12% and 9% after 45 min of irradiation, respectively. The cytotoxicity results revealed that irradiation significantly enhanced the cytotoxicity of Liposomal Betanin on HEK 293 cells (20% cell viability at 2000 µg/mL) and A549 cells (13% cell viability at 1000 µg/mL). For Lip-BRJ, irradiation significantly enhanced the cytotoxicity on HEK 293 cells at lower concentrations and on A549 cells at all tested concentrations (Figure 1,2). These results proved the positive effect of light and liposomal encapsulation on the anticancer activity of betanin and BRJ, suggesting the efficiency of liposomal beetroot pigments as green photosensitizers."

1571077213 Highly Porous PVDF-HFP Membranes via Mixed Solvent Phase Separation (MSPS) for Enhanced Membrane Oxygenation

Reham Al Nuaimi (KAUST, Saudi Arabia & King Abdullah University of Science and Technology, Saudi Arabia); Zhiping Lai (King Abdullah University of Science and Technology, Saudi Arabia)

"Extracorporeal membrane oxygenation (ECMO) is a key therapy for patients suffering from severe cardiopulmonary failure, playing a vital role in supporting heart and lung function. This technology is particularly crucial given that acute respiratory distress syndrome (ARDS) affects approximately 3 million people worldwide annually, accounting for about 10% of all intensive care unit (ICU) admissions [1]. The central component of the ECMO system is the membrane, which facilitates oxygen transfer into the blood without allowing the gas to come into direct contact with the blood. Specifically, the membrane acts as a barrier between the oxygen-deficient blood and the gas stream, allowing oxygen to return to the blood and carbon dioxide to be removed due to the concentration gradient across the membrane. Membrane oxygenators function as specialized membrane contactors. It is crucial that their pores remain dry and not become penetrated by blood. Pore wetting can significantly reduce the gas transfer efficiency, potentially compromising the effectiveness of the treatment, and in some cases pose a risk to the patient's life. Therefore, the membranes used for ECMO must be highly hydrophobic. The priming volume is another critical factor in the blood oxygenation process, as large volumes could risk hemodilution. Employing a membrane with a highly porous, uniform structure could decrease the area required for gas transfer, thus reducing the amount

of priming liquid required. Currently, commercial membrane oxygenators employ either polypropylene (PP), or polymethylpentene (PMP) membranes. Despite the high gas permeance of PP membranes, their applicability to long-term operation is limited due to their large pore size. Furthermore, the main limiting factors of PMP membranes is their higher material cost as well as their more challenging processability due to the brittle nature of the polymer. Recently, reports of employing fluoropolymer materials for membrane oxygenators have emerged, owing to their simple processability, high hydrophobicity, and structure tunability [2]. This study presents the development and characterization of a nanoporous polyvinylidene fluoride-hexafluoropropylene (PVDF-HFP) membrane for ECMO applications. The performance of the membranes were tested for pure gas permeability as well as in an ECMO-simulated gas-liquid circulation device. The PVDF-HFP membranes were fabricated through the mixed solvent phase separation (MSPS) method [3], a technique which utilizes a system comprising of a polymer, solvent, and de-solvent which are miscible at a critical temperature. The MSPS method is a unique combination of two consecutive processes. Initially, temperature-induced phase separation between the solvent and de-solvent takes place, which creates a high density of uniform pores on the surface of the membrane. Next, non-solvent induced phase separation (NIPS) between the solvent and the non-solvent (coagulation bath) occurs, generating an asymmetric, interconnected, and porous bulk structure. The fabricated PVDF-HFP membranes displayed an average pore size of 53 ± 3 nm, and a surface porosity of 24.79%. The nanoporous structure and asymmetric configuration of the highly porous MSPS PVDF-HFP membrane endow it with exceptional gas permeability while maintaining water impermeability. This results in high gas permeation units of up to 1.0×10^5 for O₂ and 7.4×10^4 for CO₂. In addition, due to the membrane's low surface energy, it exhibited promising results in hemolysis and cytotoxicity inhibition when tested with real mice blood, establishing it as a strong candidate for membrane oxygenation applications. To study the performance of the fabricated membrane in a gas-liquid membrane contactor system, a simulated circulation device was designed in which the liquid and gas were circulated counter-currently in the membrane module. The driving force for oxygen transfer was the partial pressure difference across the membrane. During the simulated liquid oxygenation, the concentration of the oxygen was monitored continuously until it reached steady-state. Specifically, at liquid and gas flow rates of 50 mL min⁻¹ and 25 atm cm³ min⁻¹, the average O₂ transfer rate was 256 mL min⁻¹ m⁻², which is five times higher than reported membranes under similar testing conditions. Furthermore, with increasing liquid flow rate, the gas transfer rate increased which implies that the pores were impermeable to liquid, since a decrease in the gas transfer would signify wetting of the pores (Figure 2b). The hydrophobicity of the membrane is endowed by the property of the material used, as well as its morphology. A high liquid entry pressure is achieved not only by a high contact angle, but also a smaller maximum pore size [4]. In particular, the nanoporous rough structure on the surface enhance the resistance to wetting, which is the case for the MSPS PVDF-HFP membrane.

[1] Acute Respiratory Distress Syndrome (ARDS), Cleveland Clinic. <https://my.clevelandclinic.org/health/diseases/15283-acute-respiratory-distress-syndrome-ards>, 2023.

[2] A.L. McGaughey, P. Karandikar, M. Gupta, A.E. Childress, Hydrophobicity versus Pore Size: Polymer Coatings to Improve Membrane Wetting Resistance for Membrane Distillation, *ACS Appl. Polym. Mater.* 2 (2020) 1256-1267.

[3] R.L. Thankamony, X. Li, X. Fan, G. Sheng, X. Wang, S. Sun, X. Zhang, Z. Lai, Preparation of Highly Porous Polymer Membranes with Hierarchical Porous Structures via Spinodal Decomposition of Mixed Solvents with UCST Phase Behavior, *ACS Appl. Mater. Interfaces* 10 (2018) 44041-44049.

[4] M.T. Rauter, S.K. Schnell, S. Kjelstrup, Cassie-Baxter and Wenzel States and the Effect of Interfaces on Transport Properties across Membranes, *J. Phys. Chem. B* 125 (2021) 12730-12740."

1571077583 Suspended DNA nanofibers as scaffolds for nucleic acids covalent alteration studies

Monica Marini and Bruno Torre (INRiM, Italy); Marco Allione and Enzo di Fabrizio (Politecnico di Torino, Italy)

"Covalent modification to the double helix can occur upon the exposure of nucleic acids to environmental solicitations i.e., the administration of drugs such as chemotherapeutic compounds or the activation of epigenetic mechanisms. The assessment of epigenetic alterations such as DNA methylations is of crucial importance in the regulation of gene expression and is involved in the outbreak and progression of pathological states as immune-related disease and cancer [1]. Also, DNA methylation is strongly connected to other epigenetic variations such as the ones on histone proteins and its profound understanding is fundamental. To this end, the use of a novel strategy for an accurate profiling of the DNA chemistry and structure at specific biologic sites is needed and currently missing. Here we report the use of DNA nanofibers with three main advantages (i) providing a background free platform for electron microscopy and spectroscopy studies (ii) allow characterizing the chemical modification on a confined area of the fibers (iii) combine the effect of the chemical alteration with the biological meaning. From the experimental point of view, microfabricated superhydrophobic devices [2] were used for the autonomous suspension of long double strand molecules of DNA over the micropillars of the device. The thorough optimization of the suspension process allows obtaining self-sieved, ordered and oriented fibers carrying the chemical modification [3]. In this work, different percentages of methylations affecting the double helix were considered, preliminary screened through scanning and high-resolution transmission electron microscopy, and the spectral fingerprint acquired through microRaman spectroscopy. The spectral analysis allowed distinguishing a hypermethylated DNA from a non-methylated one through the study of the contribution of the methyl group to the conformation of the double helix, OPO vibrations, adenine and guanine residues, therefore identifying global helical methylations alterations. Also, the proposed methodology allows studying molecules at low concentration and without the need of crystallization. The flexibility of this methodology paves the way to multiple application of this research spanning from biomedical to material sciences applications.

- [1] R. Liu, E. Zhao, H. Yu, C. Yuan, M. N. Abbas, H. Cui, *Sig Transduct Target Ther* 2023, 8, 310.
- [2] M. Marini, A. Falqui, M. Moretti, T. Limongi, M. Allione, A. Genovese, S. Lopatin, L. Tirinato, G. Das, B. Torre, A. Giugni, F. Gentile, P. Candeloro, E. Di Fabrizio, *Science Advances*, DOI: 10.1126/sciadv.1500734.
- [3] M. Marini, B. Torre, M. Allione, T. Limongi, F. Legittimo, A. Giugni, C. Ricciardi, C. F. Pirri, E. di Fabrizio, *Journal of Raman Spectroscopy* 2022, 53, 1352."

1571077825 An unexplored medicinally significant Chromone derivative released on employing abiotic elicitor-biofabricated ZnO nanoparticles - in in vitro callus culture of *Curcuma aeruginosa* Roxb

Ahlam Abdul Aziz III and Rehna Augustine (Kerala Agricultural University, India)

"Plant tissue cultures especially callus cultures are very good targets for achieving enhanced commercial production of plant secondary metabolites. Elicitation is one of the process used in plant tissue culture which cause defense responses in a plant finally improving the synthesis of metabolites [1]. Nanoparticles (NP) are emerging abiotic elicitors and among them metal oxides like ZnO-NPs have attracted considerable attention due to its multifaceted properties. Present study focussed to explore the impact of biogenic ZnO-NPs as an elicitor in the callus culture of ethnomedicinal plant *Curcuma aeruginosa* Roxb. It is a stemless, aromatic rhizomatous plant in Zingiberacea family, usually blooming during the wet and rainy seasons with extensive biological activity such as anticancer, antioxidant, antimicrobial, anti-dengue, anthelmintic, anti-inflammatory, anti-androgenic, immune-stimulating, anti-nociceptive, antipyretic activity, and uterine relaxant effect [2]. ZnO nanoparticles was biosynthesized employing aqueous extract of *Hemigraphis colorata* leaves (HcLZnONPs). The average size of HcLZnONPs calculated from XRD (X-ray diffraction) and SEM (Scanning Electron Microscopy) data is 28.45 nm and the EDAX (Energy Dispersive X-ray Spectroscopy) spectrum clearly shows the inorganic particle is purely ZnO (Figure 1). The physico-chemical parameters required for the induction of callus from young rhizome part of the plant was optimized through various trial and error method. The plant growth regulator, 2,4-dichlorophenoxyacetic acid (2,4- D) found to be the best hormone for callus induction and proliferation. The same conditions were also provided with and without HcLZnONPs for the purpose of elicitation study in callus cultures. Interestingly, NPs alone itself without 2,4-D can accelerate the callus proliferation and also shows their presence enhance regeneration potential in *C.aeruginosa* (Figure 2). The screening of secondary metabolites were procured by Gas Chromatography Mass Spectrometry (GC-MS) analysis and shows the presence of an unexplored secondary metabolite - 5-Hydroxy-6,7,8-trimethoxy-2,3-dimethyl-4H-chromen-4-one - from nano-elicited callus. The drug-likeness and ADME properties revealed the phyto compound is a good drug candidate. Molecular docking analysis explained its interaction with cancer and viral related protein targets depicting their anticancer(lung and breast cancer) and antiviral (Covid and Nipah) potential(Figure 2). This is the first report on the biomedical aspect of this chromone derivative as well as the elicitation study of HcLZnONPs on *C.aeruginosa*"

1571078042 Poly(acrylic acid) conjugated Eu-doped BiGd₂O₃ nanoparticles as an efficient multimodal imaging agent for spectral photon-counting CT, magnetic resonance, and Fluorescence imaging of cancer cells

Yusuf Olatunji Ibrahim (Khalifa University, United Arab Emirates)

Nanomaterials have over time become a promising diagnostics tool for diseases. They are used as contrast agents in imaging modalities such as computed tomography. High-Z nanomaterials such as Au and Gd are mostly used in CT imaging due to the advantage of K-edge imaging. In our study, novel Eu-doped BiGd₂O₃ nanoparticles coated with Poly (acrylic acid) are designed and characterized using different analytical techniques such as TEM, SEM, XRD, PL spectroscopy, and XPS, their imaging capability and biosafety were examined in in-vitro studies. The cytotoxicity of the as-prepared nanoparticles with an average size of 24 nm investigated on A549 cell lines proves the system is not toxic up to a concentration of 250 µg/ml. The system of nanoparticles is found to exhibit a strong x-ray attenuation property with a slope of 60.785 HU mL/mg, obtained from the plot of the HU against the concentration of the nanoparticles in a spectral photon-counting CT and It proves excellent T1-relaxivity for magnetic resonance imaging capability with r1 value of 11.77 mM⁻¹s⁻¹. The material exhibited a strong attenuation in gadolinium's k-edge region, employing the k-edge imaging principle. Furthermore, the effective delivery of the system into A549 cells and the study of fluorescence imaging capability were performed using fluorescence microscopy imaging. The result shows that the system has red fluorescence properties accredited to the presence of Europium. Conclusively, based on the result obtained from the in-vitro experiment, the Eu-BiGd₂O₃-NPs system has an important capability for imaging of cancer cells in spectra photon-counting CT, magnetic resonance, and fluorescence imaging.

1571078499 Lymph node targeting novel cationic niosomes delivered via dissolvable gelatin microneedle for enhanced long-term immunity

Jayakumar Rajendran (Indian Institute of Technology, Hyderabad, India)

"Using biomolecules such as proteins and nucleic acid for vaccination has gained significant interest. However, their inherent fragility and susceptibility to degradation during long-term storage present formidable challenges in preparing the vaccine delivery system without needing a cold chain, maintaining therapeutic efficacy, and providing enhanced immune response. In the case of vaccination, the efficient delivery of vaccines to draining lymph nodes and the induction of robust local immune responses are crucial for immunotherapy. The antigen encapsulated and delivered via the nanoparticle system to protect the antigen from hydrolytic degradation must reside in the lymph for a long time and facilitate higher uptake of immune cells, mimicking native antigens. Transdermal-based skin vaccination has been evidenced to facilitate the delivery of ingredients to lymph nodes rich in antigen-presenting cells (APCs), such as Langerhans cells (LCs) in the epidermis and other dendritic cells (DCs) in the dermis. The barrier effect of stratum corneum on macromolecules such as antigens

necessitates invasive delivery methods such as subcutaneous injections to achieve vaccination, which poses disadvantages such as poor patient compliance, difficulty in autonomous administration, and cross-contamination. Microneedle technology can directly overcome the skin barrier and deliver macromolecules into all skin layers. Microneedle vaccine patch is expected to reduce cold chains and non-invasive, economical, and high patient compliance with the potential of mass vaccination. In this study, we overcome the challenges of inefficient delivery and rapid clearance of antigens from lymph nodes using novel cationic niosomes delivered via a protein microneedle system. The niosomes were made from the FDA-approved pluronic and chemically modified to bear the positive charge of +25 mv with a uniform size of 180nm. Cationic niosomes were used for antigen (Ovalbumin)/adjuvant (Resiquimoid) encapsulation with an encapsulation efficiency of more than 50%, providing higher cellular uptake (<15 minutes) with low cellular toxicity (up to 2mg/ml). These cationic niosomes made from FDA-approved pluronic surfactant are highly stable at 40C and 25oC and overcome the lipid-based toxicity of the conventional lipid nanoparticle system. These were integrated with gelatin-dissolving microneedles to investigate their effects on immune responses. The microneedles were easily inserted into rat skin with a fracture force of more than 95N and achieved the local release of niosomes into the dermis through rapid dissolution within 5 minutes. Further, niosomes release 100% of the encapsulated antigen within 48 hours and 100% of the adjuvant within 24 hours. The high concentration of stabilizing agent (trehalose of 5% w/v) in niosomes and microneedle matrix provides stability to the Ovalbumin (OVA) for more than 3 months at 40C and 25oC with no apparent change in the secondary structure confirmed with circular dichroism and SDS page. Further, the in vivo distribution of the niosomes released from the microneedle shows the long residing of cationic niosomes in the lymph node for more than 5 days, whereas the control and native antigen showed no/low intensity. The storage stability potential of niosomes loaded microneedle was checked by storing niosomes loaded microneedle at 25oC for 6 months and in vivo immune response of the niosomes loaded microneedle was compared with 6 month stored samples at 25oC in rats. There was no apparent change in the IgG and IgE antibody between the stored and the as prepared samples. Further the long-term cellular immunity was checked by the splenocytes proliferation index as well the inflammatory cytokines released from the splenocytes culture after reactivation with the antigen shows the successful memory T cell activation."

1571078758 Nanoceria laden polymeric nanocomposites for biomedical applications

Shiv Dutt Purohit, Hemant Singh and Peter Corridon (Khalifa University, United Arab Emirates); Narayan Chandra Mishra (Indian Institute of Technology Roorkee, India)

The incidence of burn injury, skin, and bone damage increased globally owing to rise in traumatic and accidental cases. Current treatments for wound and bone repair are slow and often do not lead to full functional recovery. During the slow healing process, free radicals are generated at the damaged site, causing further delays in healing. To address these issues, tissue engineering approaches using polymeric scaffolds loaded with free radical scavenging capabilities appear to be a promising choice. Cerium oxide nanoparticles (nanoceria, NC)

demonstrate excellent free radical scavenging capabilities. In this study, nanoceria was added to gelatin-alginate (GA) blend and decellularized ECM based natural hydrogel. The GA based scaffolds were tested for bone regeneration related applications. Whereas decellularized ECM based scaffolded were evaluated for their potential applications in wound healing. The obtained results are promising and depict antioxidant properties of nanoceria aid in cell proliferation and reduce wound healing time.

1571078983 Enlightening C-DoTs embedded hydrogel system for theranostic applications

Hemant Singh, Rukshana Mangattu Veettil and Shahd Badr Alshehhi (Khalifa University, United Arab Emirates); Salama Ali Suhail Ali Aldhaheeri (Khalifa University of Science and Technology, United Arab Emirates); Shabir Hassan (Khalifa University, United Arab Emirates)

Carbon biomaterial in the nano range with unique fluorescent properties, abundant functional groups, electron mobility, effective antioxidant and antibacterial properties, good biocompatibility, cheap and high stability make them suitable asset for theranostic applications. Hence, we synthesize the carbon quantum dots (C-DoTs) from a new herbal source widely available in Arab Countries using simple microwave-assisted technology, as demonstrated in Figure 1. The synthesized C-DoTs in the nano range show intense red fluorescence emission under the UV light at 365nm. The red fluorescence emission intensity also varied with pH and excitation intensity parameters. Synthesized C-DoTs further depict efficient antibacterial, free radicals scavenging capability, good hemocompatibility, biocompatibility, and a significant uptake by Normal Human Dermal Fibroblasts (nHDF) and HepG2 cells, highlighting their ability as a diagnostic and therapeutic agent. After that, the synthesized Illuminating C-DoTs are embedded in a hydrogel system to manage the controlled delivery for diagnosis and therapeutic applications. These outcomes imply that the biosynthesized enlightening C-DoTs with hydrogel system possess the meaningful capability for theranostic applications that can act as a robust benchmark for scientists towards advancing sustainability.

1571079031 Biochemical Effects of Cinnamon Extract and Its Nanoparticles on Experimentally Induced Diabetic Rats

Mostafa Sliem (Qatar University, Qatar)

"Diabetes mellitus, a metabolic disorder characterized by hyperglycemia, presents a significant global health challenge. Cinnamon, known for its potential anti-diabetic properties, has garnered attention in traditional medicine. However, its efficacy and mechanism of action, particularly in nanoparticle form, remain underexplored. In this study, diabetic rats were induced with streptozotocin (STZ) and treated with either Cinnamon extract or its nanoparticle formulation for a specified duration. Therefore, the present study investigated the effect of the anti-diabetic activity of Cinnamomum cassia (C. cassia, Cc) and silver nanoparticles (CcAgNPS) extract on experimentally induced diabetic rats. Twenty-five male's albino rats were divided

into five groups (five rats in each group). The first group served as the normal control group, while the other groups had diabetes induced by a single injection of streptozotocin (STZ, 50 mg/kg). The 2nd group served as diabetic control group, the 3rd diabetic rats group were treated with Glibenclamide drug, the 4th diabetic rats group were administered orally Cc extract and 5th diabetic rats group were administered orally CcAgNPS. Fasting blood glucose, HbA1c, and insulin levels, with biochemical parameters including lipid profile, liver and kidney function, cytokines markers, and oxidative stress parameters were assessed. Histopathological examination of pancreatic tissue, kidney, and liver organ cells was also performed. Our findings reveal that neither Cinnamon extract nor Cinnamon nanoparticles exerted significant anti-diabetic effects, as evidenced by the reduction in blood glucose and HbA1c levels, and increased insulin levels. There was an improvement in the biochemical parameters, compared to diabetic control rats. Additionally, histological analysis showed restoration of pancreatic architecture, and kidney and liver organ cells in the treated groups. Furthermore, nanoparticle formulation exhibited enhanced efficacy, potentially attributed to improved bioavailability and targeted delivery. These results underscore the therapeutic potential of Cinnamon and highlight the utility of nanoparticle technology in enhancing its efficacy for diabetes management. Further research elucidating the underlying mechanisms and long-term effects is warranted to establish its clinical relevance."

1571079068 Deep learning-based classification of macrophage polarization from label-free holotomography images

Dong-Wook Lee (Technology Innovation Institute & Advance Materials Center, United Arab Emirates); Hoibin Jeong (Korea Basic Science Institute, Korea (South)); Sung Mun Lee (Khalifa University of Science and Technology, United Arab Emirates); Seon Ju Park (Korea Basic Science Institute, United Arab Emirates)

"The role of immune cells, particularly macrophages, within the disease is very important to understand the progression and treatment of diseases like cancer. It is very important to differentiating between their M1 (anti-tumour) and M2 (pro-tumour) states for effective therapy. Accurately distinguishing these states in live cells is challenging using traditional methods. Holotomography, a label-free imaging technique, offers a solution by capturing high-resolution, 3D images based on cells' intrinsic optical properties, preserving their natural morphology and behaviour. However, the complexity of data generated by holotomography requires advanced computational tools for analysis. To address this, the study uses deep learning method such as convolution neural network to analyse holotomography images of polarized macrophages. This method enables non-invasive, real-time classification of macrophage phenotypes without disruptive labelling techniques, addressing a key challenge in immunological research. The findings suggest that combining holotomography with machine learning can provide an effective, label-free method for assessing immune cell states, which could be valuable for studying the tumour microenvironment and other diseases where macrophages play a crucial role."

1571079282 Facile synthesis of Carbon-dot nanoparticles (CD) embedded on Zeolitic Imidazole metal organic framework (ZIF-8) nanocomposites suppress cariogenic Streptococcus mutans biofilm formation

Saba Naseem (Aligarh Muslim University, United Arab Emirates)

"Metal-organic frameworks (MOFs) have emerged as promising materials in various fields due to their unique properties, including high surface area, tunable pore size, and exceptional adsorption capabilities. The use of MOFs for drug delivery in biological applications has gained more interest in recent years. These nano-MOFs (nano-MOFs) can function as effective nanocarriers to carry drugs for imaging, chemotherapy, photothermal therapy, or photodynamic therapy when the size of MOF particles is reduced to the nanoscale. Carbon dots inherent antimicrobial properties due to their ability to generate reactive oxygen species (ROS) upon exposure to light. When incorporated with ZIF-8, which possess antimicrobial properties as well, the synergistic effects can enhance the overall antimicrobial activity. ZIF-8 also provides a stable framework that can protect the c-dots from degradation, thereby enhancing their longevity and effectiveness as antimicrobial agents. In the realm of dentistry, MOFs have shown potential in addressing the prevalent issue of dental caries, commonly known as tooth decay. This study shows that incorporating nanomaterials in MOFs is an effective way to tune the material properties while preserving the overall structure and stability. Dental caries result from the demineralization of tooth enamel by acids produced by bacterial metabolism of dietary carbohydrates. MOFs, with their ability to absorb and release molecules selectively, offer an innovative approach to combatting this dental condition. MOFs exhibit potential as diagnostic tools for detecting and monitoring dental caries. Functionalized MOFs (Au/ZIF-8 and CDs/ZIF-8) can selectively capture cariogenic bacteria or their metabolic by products from saliva or dental plaque samples. This selective adsorption can aid in the early detection of caries risk and facilitate targeted preventive interventions, thereby contributing to improved oral health outcomes. Oral biofilms play a crucial role in the development of dental caries and other periodontal diseases. Streptococcus mutans is one of the primary etiological agents in dental caries. Implant systems are regularly employed to replace missing teeth. Oral biofilms accumulate on these implants and are the chief cause of dental implant failure. In the present study, the potential of ZIF-8 nanocomposites (Au-Np/ZIF-8 and Carbon dots-Np/ZIF-8) against the cariogenic properties of Streptococcus mutans was explored. Streptococcus mutans is known to produce biofilm which is one of the primary causes of dental caries. Acid production and acid tolerance along with exopolysaccharide (EPS) formation are major virulence factors of S. mutans biofilm. The in vitro studies revealed 64.31 % (Au/ZIF-8) and 68 % (CDs/ZIF-8) reduction in biofilm formation. The results showed a reduction of almost 51% in EPS production on treatment with sub-MIC concentrations of CDs/ZIF-8. This is the first study where CD/ZIF-8 has been investigated as a potential coating material for dental implants. CD/ZIF-8 coated acrylic tooth surfaces successfully inhibited S. mutans biofilm (95%) formation. Furthermore, the decreased toxicity of the nanocomposite makes it an effective coating agent for dental implants."

1571083690 A Deep Learning-Based Ensemble Framework for Precision Diagnosis of Multiple Sclerosis Utilizing Transfer Learning on Embedded Systems

Saiakhil Chilaka (NC State University & Enloe High School, USA)

Multiple Sclerosis is a chronic autoimmune condition characterized by an attack elicited through an immune response in the central nervous system. Affecting over 1.8 million people worldwide. The condition leads to a range of neurological symptoms, including limited mobility, impaired vision, and cognitive deficits. Although the exact causes of multiple sclerosis remain unclear, a combination of genetic, environmental, and immunological factors is believed to play an important role over multiple years. In such cases, an early and accurate diagnosis through MRI scans remains crucial for timely intervention and proper treatment. Leveraging a meticulously curated ensemble model, this approach integrates optimized convolutional layers with customized transfer-learning models, combining the strengths of both frameworks for enhanced performance. The obtained dataset contains sagittal and axial magnetic resonance scans (n=3427) in greyscale, obtained through a prior study that studied 131 subjects in 2021. In the pre-processing stage, all images were resized to 128 by 128 pixels for computational efficiency and converted to RGB, followed by two 80-20 splits, resulting in training, validation, and final testing sets. A final ensemble model consisting of an optimized VGG19 achieved an average 97.5% accuracy, and a receiving operating characteristic (ROC) of 97.8%. Subsequent analyses were directed towards intricate multiclass stratifications, elucidating avenues for nuanced diagnostics and treatment planning for multiple sclerosis.

1571085708 Electrically Conductive GelMA-MWCNT-Bioactive Glass Bone Biomaterials

Kibret Mequanint and Rebeca Arambula Maldonado (University of Western Ontario, Canada)

Gelatin methacryloyl (GelMA) is a promising biopolymer widely used in tissue engineering due to its biocompatibility, tunable mechanical properties, and ability to support cell attachment. However, GelMA lacks intrinsic electrical conductivity, a key property for enhancing cellular communication and tissue regeneration, particularly in bone tissue engineering. To address this, the incorporation of multi-walled carbon nanotubes (MWCNTs) and bioglass particles into GelMA matrices has been explored. MWCNTs impart electrical conductivity, which can enhance osteogenic differentiation and support electrochemical signaling in bone regeneration. Bioglass, known for its bioactivity, facilitates bone bonding and mineralization. The combination of GelMA, MWCNTs, and bioglass aims to create a multifunctional scaffold that mimics the native bone microenvironment, supporting both the structural and electrical cues required for effective bone tissue regeneration. Studies show that such composite biomaterials exhibit improved mechanical properties, enhanced cell proliferation, and differentiation when compared to GelMA alone. The integration of MWCNTs and bioglass also promotes electrical conductivity, crucial for stimulating bone tissue formation and accelerating the healing process. This innovative approach holds significant potential for improving outcomes in bone regeneration therapies, offering a versatile and efficient scaffold for clinical applications in bone tissue engineering.

Nanomaterials and Nanotechnologies for Environmental Applications (NNEA 2024-K)

Invited: Highly Efficient Plasmonic-Assisted Platforms: Flexible SERS Biosensors and Photocatalytic Systems for Organic Dye Degradation

Mounir Gaidi, University of Sharjah

(UAE)

Optical detection strategies have garnered significant attention for their potential in rapid and ultrasensitive biomolecule detection, particularly for clinical applications. Surface-enhanced Raman spectroscopy (SERS) has emerged as a powerful analytical tool for noninvasive, ultra-sensitive analysis of organic and biomolecules, offering potential breakthroughs in detecting disease-specific biomarkers from bodily fluids, such as blood or saliva, which could transform medical treatments. Meanwhile, plasmonic metal-assisted photodegradation has gained interest as a reusable, low-cost approach for environmental applications. This study explored the photocatalytic potential of bimetallic silver-gold functionalized silicon nanowires as reusable systems for degrading organic pollutants. Silicon nanowires, fabricated through metal-assisted chemical etching and further modified via silver and gold electroless deposition, were characterized to assess their morphological, optical, and catalytic properties. We examined the effect of the nanowire aspect ratio on catalytic performance, finding that tuning the deposition of plasmonic metals optimized photocatalytic efficiencies. Over 85% degradation efficiency was achieved for organic dyes such as methylene blue and methyl orange, positioning these hybrid nanowire systems as promising candidates for contaminant degradation. Additionally, the reproducibility and efficiency of the nanofabricated structures were assessed for biosensing applications, with optimized sensors demonstrating excellent sensitivity to biomolecules at low concentrations.

Invited: Nano-structured functional surfaces for enhanced water harvesting and treatment

Hongxia Li, TII

(UAE)

Nanoengineering material is transforming condensation processes for environmental applications such as water harvesting, desalination, and wastewater treatment. This work explores nanoengineered surfaces to enhance condensation efficiency and passive droplet removal. Functionalized surfaces with nanostructures demonstrated significant improvements in vapor condensation and collection by reducing contact angle hysteresis (CAH) and increasing surface hydrophobicity. Together with the micro-scale features, we also show a functional surface for long-distance, directional transport of water droplets. This capillary-driven motion, coupled with frequent droplet coalescence, significantly enhanced water collection efficiency. The combination of these nanoengineering strategies offers promising advancements for sustainable water production and environmental management.

1570990971: Beyond Boundaries: Harnessing Graphene for Self-Healing and Thermal Energy Storage Advancements

Abdullah N Mustapha, Maitha Almheiri, Nujood Seed Mohammed, Alshehhi, Nitul Rajput, Zineb Matouk and Natasa Tomic (Technology Innovation Institute, United Arab Emirates)

Tung oil (TO) microcapsules (MCs) with a poly(urea-formaldehyde) (PUF) shell were synthesized via one-step in situ polymerization, with the addition of graphene nanoplatelets (GNPs) (1–5 wt. %). SEM images then displayed an increased shell roughness for of the TO-GNP MCs in comparison to the pure TO MCs due to the GNP species on the shell. At the same time, high-resolution Transmission electron microscopy (TEM) images also confirmed the presence of GNPs on the outer layer of the MCs, with the stacked graphene layers composed of 5–7 layers with an interlayer distance of ~0.37 nm. Cross-sectional TEM imaging of the MCs also confirmed the successful encapsulation of the GNPs in the core of the MCs (As seen in Figure 1). Micromanipulation measurements displayed that the 5% GNPs increased the toughness by 71% compared to the pure TO MCs, due to the reduction in the fractional free volume of the core material. When the MCs were dispersed in an epoxy coating and applied on a metallic substrate, excellent healing capacities of up to 93% were observed for the 5% GNP samples, and 87% for the pure TO MC coatings. The coatings also exhibited excellent corrosion resistance for all samples up to 7 days, with the GNP samples offering a more strenuous path for the corrosive agents. Furthermore, to tackle the challenge of supercooling in organic microencapsulated phase change materials (MPCMs), three groups of graphene-based materials derivatives were utilised in a novel way to perform as nucleating agents and to initiate the crystallization process much quicker. Graphene dispersions, graphene nanoplatelets (GNPs) and graphene oxide (GO) were used as additives in urea-formaldehyde microcapsules (MCs) with a paraffin core material. It has been observed that the graphene dispersion reduced the supercooling phenomena in the MPCMs by approximately 13 °C, followed by GNP with 12 °C, and GO with a reduction of 5 °C.

1570990972: Heal & Seal: Breaking Ground with Self-Healing and Self-Sensing Microcapsules in Anti-Corrosion Microcapsules

Nujood Seed Mohammed, Alshehhi and Abdullah N Mustapha (Technology Innovation Institute, United Arab Emirates); Nitul Rajput (Technology innovation institute); Natasa Tomic (Technology Innovation Institute, United Arab Emirates); Fatima Montemor (Centro de Quimica Estrutural, Portugal)

This study introduces a novel approach to enhance the durability and longevity of anti-corrosion coatings by incorporating fluorescent microcapsules. These microcapsules serve a dual purpose as indicators for microcrack formation and carriers of self-repair healing agents. The innovative design facilitates real-time monitoring of coating integrity, with automatic healing mechanisms triggered upon microcapsule rupture. The released fluorescent dye,

visible under ultraviolet (UV) light, clearly indicates microcrack locations. Leveraging the unique properties of fluorescent microcapsules, this crack-probing methodology provides an efficient and visually accessible means for assessing material integrity. The characterization methods used in the experiment were SEM, EDS, and fluorescent microscope. Integrating self-repair capabilities ensures timely maintenance, promising extended performance and resilience in anti-corrosion coatings across various applications.

1571042712: Photodegradation of Methylene Blue by CeO₂/NiO Modified Silicon Nanowires

Brik Afaf (Crtse, Algeria)

In this work is to deposition of CeO₂/NiO on SiNWs which present a high specific surface and to evaluate its catalytic activity for the degradation of blue methylene (BM) under Visible light irradiation. The silicon nanowires were elaborated by metal assisted chemical etching and the Cerium and Nickel was deposited by methods Hydrothermal. The samples were analyzed by scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy (EDX). The samples showed a high efficiency for the BM photodegradation especially, under visible light irradiation where a degradation rate of 98% was obtained after 90 min.

1571056389: Comparative catalytic performance of hydrogen peroxide-responsive Pt/hematite micromotors and fully platinum-coated hematite particles

Faizan Khan (Indian Institute of Technology Ropar India, India)

Recent advancements in fuel-responsive micromotors have demonstrated significant potential for various environmental applications. However, reaction losses due to particle agglomeration have become a notable issue. In the present study, we compared the reactions of two types of particles: passive ones with a full platinum nanoparticle coating and active ones with platinum partially decorated on their surfaces. The selective decoration of platinum on the hematite core was confirmed using a range of techniques, including energy-dispersive X-ray spectroscopy (EDX), field emission scanning electron microscopy (FESEM), transmission electron microscopy (TEM), and X-ray photoelectron spectroscopy (XPS). These techniques provided a detailed understanding of the micromotors' surface morphology engineered with Pt nanoparticles. The decomposition of hydrogen peroxide (H₂O₂) by Pt nanoparticles, when selectively decorated on one side of the hematite particles, generates thrust, causing the particles to propel in a single direction. This active mobility offers significant advantages in terms of interacting with pollutant molecules, allowing the micromotors to navigate effectively within the bulk phase. Microscopy images revealed that agglomeration occurs during the Fenton-like reaction in both passive and active particles. In the case of passive particles, swift agglomeration was observed over time due to magnetic dipolar attraction. However, studies

with Janus particles/micromotors suggest that fuel-powered self-propulsion (using H_2O_2) can counteract these attractive forces, preventing the formation of irregular 3D clusters and enhancing the efficiency of the micromotors.

1571056431: Enhancing Cloud Seeding with AgI Nanoparticles: An Effective Solution for Water Scarcity

Shiva Shafiei Khosroshahi (UNESCO UNISA Africa Chair in Nanoscience & Nanotechnology, South Africa & University of South Africa (UNISA), South Africa)

Water scarcity is a growing worldwide issue that requires innovative solutions. One promising approach is cloud seeding using ice nucleating agents like silver iodide (AgI) [1] nanoparticles. These nanoscale agents, based on their high surface area to volume ratio, enhance the efficiency of ice nucleation processes [2], making them superior to typical micro-sized particles. The application of nanoparticles not only boosts the effectiveness of cloud seeding but also potentially reduces the environmental and health impacts of chemical usage in weather modification. In this study, the synthesis and application of AgI nanoparticles for cloud seeding is investigated. The research focuses on optimizing the physical properties, including size, of these nanoparticles to maximize their ice nucleation capabilities. Comprehensive optical and structural characterizations were conducted, including UV-Vis spectroscopy, scanning electron microscopy (SEM), transmission electron microscopy (TEM), and Raman and FTIR spectroscopy, to assess the morphology and composition of the nanoparticles. The average size of the synthesized NPs is 16 nm based on zetasizer analysis. Laboratory-based ice nucleation experiments demonstrated a marked improvement in ice formation efficiency using these synthesized nanoparticles. These findings underscore the potential of AgI nanoparticles to enhance cloud seeding techniques, offering a scalable solution to mitigate environmental problems and water shortages.

1571057209: Polyaniline (PANI) Supported 2D Nanomaterial for Efficient Iodine Capture and Accelerated Fluorescent Heavy Metal Detection

Amjad Mumtaz Khan, Sr. (Aligarh Muslim University, India)

Iodine is critical element for various industrial and environmental applications, including medical imaging, water treatment, and nuclear waste management. The increasing concern over iodine contamination necessitates the development of efficient capturing materials. This work outlines the potential of PANI/LDH nanocomposites for iodine capture, highlighting their unique structural and functional properties, and the underlying mechanisms involved in the adsorption and removal of iodine. PANI/LDH (Polyaniline/Layered Double Hydroxide) nanocomposites have demonstrated high adsorption capacities and selectivity for iodine capture. While the LDH (Layered Double Hydroxide) component in the nanocomposite offers

a high surface area and ion exchange capabilities, further enhancing the iodine capture efficiency, while PANI's conductive properties allow for rapid iodine uptake, making it an ideal candidate for environmental remediation. Zn (M 2+) and Pr (M 3+) metals are used for LDH synthesis using a hydrothermal process. The formation of nanocomposite of PANI and LDH was confirmed by characterization techniques such as XRD, FTIR, SEM, TEM, TGA and Raman spectroscopy. The highest iodine uptake of more than 90% was observed using PANI and 2:1 Zn/Pr LDH nanocomposite. In order to address heavy metal detection, we incorporated fluorescent probes into the PANI/LDH matrix, enabling real-time monitoring of different metal ions such as Cr 6+, Mn 7+, Al 3+, Fe 3+, & Pb 2+. The resulting PANI/LDH nanocomposite demonstrates exceptional sensitivity and selectivity for heavy metals, with fluorescence intensity correlating directly with metal concentration. This work highlights the potential of PANI/LDH nanocomposites as a sustainable solution to environmental problems while also showcasing its multifunctional capabilities. Through the integration of heavy metal detection and iodine capture, this study reveals the significance of innovative nanotechnology and its role in developing sustainable materials for environmental protection, opening up new avenues for the development of advanced materials in environmental monitoring and remediation.

1571057674: Development and characterization of Pectin/Starch/Lignin/Graphene hybrid bio nanocomposite film for advanced food packaging applications

Vishnuvarthanan Mayakrishnan (Kalasalingam Academy of Research and Education, India)

The quest for sustainable and advanced food packaging materials has led to the exploration of hybrid bio nanocomposites. This study focuses on the development and characterization of pectin/starch/lignin/graphene hybrid bio nanocomposite films aimed at enhancing food packaging applications. The films were fabricated using a solution casting method, incorporating varying concentrations of graphene to optimize their mechanical and functional properties. The thickness measurements confirmed uniform film formation, while Fourier Transform Infrared Spectroscopy (FTIR) revealed successful interactions among pectin, starch, lignin and graphene, indicating strong intermolecular bonding. Scanning Electron Microscopy (SEM) provided detailed surface morphology, showing well-dispersed graphene within the polymer matrix, which is crucial for enhancing mechanical and barrier properties. Surface color and opacity tests demonstrated that the films maintained acceptable transparency and aesthetic qualities suitable for packaging. Porosity analysis indicated a dense structure with minimal voids, contributing to improved barrier properties. The tensile strength of the films was significantly enhanced with the addition of graphene, demonstrating superior mechanical robustness. Oxygen Transmission Rate (OTR) and Water Vapor Transmission Rate (WVTR) measurements showed a substantial decrease in permeability, indicating excellent barrier properties against gases and moisture, essential for prolonging the shelf life of packaged foods. The antimicrobial properties of the hybrid films were evaluated against common foodborne pathogens, revealing effective microbial inhibition due to the presence of graphene.

and lignin. Biodegradability tests confirmed that the films are environmentally friendly, decomposing efficiently under natural conditions without leaving harmful residues. Overall, the incorporation of graphene into pectin/starch/lignin matrices results in hybrid bio nanocomposite films with enhanced mechanical strength, barrier properties, antimicrobial activity and biodegradability. These characteristics make them promising candidates for advanced food packaging applications, offering a sustainable alternative to conventional plastic packaging and contributing to environmental conservation.

1571057693: Comparative Analysis of physicochemical and catalytic properties of lysozyme silver nanocatalyst immobilized on various 2D nanomaterials for degradation of Hazardous dyes

Jinan Alhariry (Indian Institute of Technology Roorkee, India)

The increasing prevalence of hazardous dyes in industrial effluents poses a critical environmental challenge, necessitating the development of effective and reusable catalytic systems for their degradation. This research presents a comprehensive comparative analysis of the physicochemical properties and catalytic activity of three distinct 2D nanomaterials loaded with lysozyme silver nanocatalysts (LSNC). Multiwalled carbon nanotubes (CNT), halloysite nanotubes (HNT), and boron nitride nanosheets (BNN) were used to immobilize the nanocatalyst (LSNC), generating different reusable nanocatalytic platforms for efficient degradation of organic dyes. The fabricated nanocatalyst-loaded nanomaterials were meticulously characterized using sophisticated techniques, including Field Emission Scanning Electron Microscopy (FESEM), Energy-Dispersive X-ray Spectroscopy (EDX), Transmission Electron Microscopy (TEM), Attenuated Total Reflectance Fourier-Transform Infrared Spectroscopy (ATR-FTIR), Powder X-ray Diffraction (PXRD), and Thermogravimetric Analysis (TGA). These techniques provided in-depth insights into the structural, compositional, morphological and stability properties of each nano catalytic system. As evident from EDX and TEM analysis, LSNC of 6 - 12 nm was successfully immobilized on the nanomaterials. The catalytic activity of LSNC and the three loaded nanomaterials were compared for the degradation of congo red (CR), methyl orange (MO), and methylene blue (MB) following pseudo-first-order kinetics. The findings indicated that certain nanocatalytic platforms exceedingly enhanced the catalytic performance of nanocatalyst, offering a potential approach for applications in wastewater treatment. Furthermore, the reusability of the nanocatalytic platforms was evaluated over several degradation cycles, assuring high catalytic activity across repeated uses and rendering them excellent candidates for sustainable environmental remediation activities. This work intensifies the understanding of nanomaterials-based catalysis and emphasizes the necessity of tailored nanostructure selection in boosting the catalytic performance for environmental applications.

1571057760: Preparation and characterization of PVA/Nanochitosan/Nanocurcumin bio nanocomposite films for food packaging applications

Asha Madhavan (Amity University, United Arab Emirates); Vishnuvarthanan Mayakrishnan (Kalasalingam Academy of Research and Education, India); Saket Anuj Bharadwaj (Amity University, United Arab Emirates); Godwin Joseph Nallathambi (Amity University Dubai, United Arab Emirates)

The increasing environmental concerns and demand for sustainable packaging solutions have propelled the development of bio nanocomposite films for food packaging applications [1,2]. The films derived from natural biopolymers and reinforced with nanoparticles offer enhanced mechanical strength, barrier properties and antimicrobial activity [3,4]. Bio nanocomposite films provide an eco-friendly alternative to conventional plastic packaging, aiming to extend the shelf life of food products while reducing environmental impact [5]. This study explores their potential in creating more sustainable and effective food packaging solutions. The development of biodegradable and environmentally friendly packaging materials has garnered significant attention in recent years. This study focuses on the preparation and characterization of polyvinyl alcohol (PVA) based bio nanocomposite films reinforced with nanochitosan and nanocurcumin for potential food packaging applications. The bio nanocomposite films were synthesized via the solution casting method, incorporating varying concentrations of nanochitosan and nanocurcumin to enhance their mechanical and functional properties. Fourier Transform Infrared Spectroscopy (FTIR) was utilized to analyze the molecular interactions and confirm the successful incorporation of nanochitosan and nanocurcumin into the PVA matrix. Scanning Electron Microscopy (SEM) provided insights into the surface morphology and dispersion of nanoparticles within the polymer matrix, revealing a uniform distribution with minimal agglomeration. The tensile strength of the films was measured to assess their mechanical properties, demonstrating a significant improvement in strength and flexibility compared to pure PVA films. Oxygen Transmission Rate (OTR) and Water Vapor Transmission Rate (WVTR) tests were conducted to evaluate the barrier properties of the bio nanocomposite films. The results indicated a substantial reduction in both OTR and WVTR, suggesting enhanced barrier properties against gases and moisture, which are critical for food packaging applications. Additionally, the antimicrobial activity of the films was tested against common foodborne pathogens, showing effective inhibition of microbial growth, attributable to the presence of nano chitosan and nanocurcumin. Overall, the incorporation of nano chitosan and nanocurcumin into PVA not only improved the mechanical and barrier properties but also endowed the films with antimicrobial properties, making them promising candidates for sustainable food packaging applications. This study highlights the potential of these bio nanocomposite films to extend the shelf life of food products while reducing environmental impact.

1571057782: Fabrication and Characterization of PVA/Nanochitosan/ Nanocellulose Reinforced Biodegradable Packaging Films

Asha Madhavan (Amity University, United Arab Emirates); Vishnuvarthanan Mayakrishnan (Kalasalingam Academy of Research and Education, India); Shruti Arivazhagan and Ankita Maria Paul (Amity University Dubai, United Arab Emirates)

The shift towards sustainable practices has increased interest in biodegradable packaging films as an eco-friendly alternative to traditional plastics [1,2]. The films from natural biopolymers decompose naturally, reducing environmental impact [3]. They offer comparable mechanical and barrier properties, making them suitable for food packaging applications [4, 5]. This study investigates the fabrication and characterization of biodegradable packaging films reinforced with nanocellulose derived from date palm waste. The nanocellulose was extracted using a mechanical and chemical treatment process and then incorporated into a biodegradable polymer matrix via solution casting to form nanocomposite films. Fourier Transform Infrared Spectroscopy (FTIR) was employed to analyze the chemical interactions between the nanocellulose and the polymer matrix, confirming successful integration. Scanning Electron Microscopy (SEM) provided detailed images of the film's surface morphology, illustrating a uniform distribution of nanocellulose within the polymer, which is crucial for enhancing the mechanical properties. Tensile strength tests revealed a significant improvement in the mechanical robustness of the nanocomposite films compared to the pure polymer films, demonstrating their potential for practical application. The barrier properties of the films were evaluated through Oxygen Transmission Rate (OTR) and Water Vapor Transmission Rate (WVTR) measurements. The results indicated that the inclusion of nanocellulose evidently reduced both OTR and WVTR, enhancing the film's ability to protect against oxygen and moisture, which is vital for food packaging. Additionally, the antimicrobial properties of the films were assessed against common foodborne pathogens, showing promising results in inhibiting microbial growth due to the inherent properties of nanocellulose. It has been proved that the incorporation of nanocellulose into biodegradable polymer matrices not only improves the mechanical and barrier properties but also imparts antimicrobial capabilities, making these films highly suitable for sustainable packaging applications. This research underscores the potential of utilizing agricultural waste, such as date palm residues, to produce high-performance, eco-friendly packaging materials, contributing to waste reduction and environmental sustainability.

1571057871: Multifaceted Advances of Non fluorinated Functionalized Materials: Environmental Remediation to Corrosion Protection & Emulsion Separation

Narendra Singh (Indian Institute of Technology Tirupati, India)

Oil-water separation remains a critical environmental challenge due to frequent oil spills and industrial discharge of organic pollutants. In this talk, innovative materials and methods will be explored to enhance oil-water separation efficiency and material durability. A novel non-fluorinated coating, Metal oxide composites (MOCs)-PDMS, was synthesized using a one-pot

hydrothermal technique on metallic foams (MFs). The resulting MOCs-PDMS-MFs coating exhibited superhydrophobicity with a water contact angle (WCA) exceeding $>152^\circ$, combined with mechanical robustness, thermal stability (50-200°C), and acid-alkaline resistance (pH 1-9). This coating demonstrated superior oil-water separation efficiency and exceptional anti-corrosion performance, making it suitable for marine applications. Further advancements included the successful application of PDMS/functionalized-SiO₂ composite coatings on IN617 substrates via spin coating. These coatings maintained a WCA of 135° even after ten abrasion cycles and achieved an ASTM grade 3B rating. The coatings demonstrated excellent corrosion resistance, with a corrosion rate three orders of magnitude lower than the uncoated substrate, highlighting their potential for enhanced corrosion protection. Polyurethane sponges modified with ZnO-decorated reduced graphene oxide (rGO) and PDMS were designed for oily wastewater treatment. These sponges displayed superhydrophobicity (WCA $\sim 152.4^\circ$) and high sorption capacities for various oils and solvents, alongside good chemical stability and temperature resistance, proving effective in treating oily wastewater. In addition, a functionalized superhydrophobic nanofibrous membrane was developed by electrospinning a to remove traces of moisture from oil-rich emulsion.

1571057905: A Novel Cu(II) Mediated Synthesis of Porous Organic Polymers for the Sustainable CO₂ Capture

Princy Deni Raju (University of Kerala, India)

Materials with porosity may be used in a variety of disciplines and open up new avenues for scientific inquiry. The design and synthesis of porous organic polymers using a very simple process might speed up the use of these materials in a variety of applications, such as the adsorption of gases, energy storage, light emittance (PLEDs) and photocatalysis [1]. There exist many conventional and non-conventional methods to synthesise POPs, making them a key platform for developing new porous organic polymers [2]. Different types of porous organic networks have been produced, including conjugated microporous polymers (CMPs), covalent organic frameworks (COFs), polymers of intrinsic microporosity (PIMs), hyper-crosslinked polymers (HCPs), and covalent triazine frameworks (CTFs) [3]. Synthetic methods for preparing POPs involve Sonogashira, Heck, Suzuki, Oxidative coupling, Yamamoto and Cyano cyclotrimerization, which requires expensive noble metal catalysts. Recently, Cu-promoted azide-alkyne click reaction gained much attention in synthesizing CMPs [1]. In this work, a unique Cu (II)-mediated oxidative coupling polymerization yielded porous organic polymers with comparable yields relative to the reported POP networks. Herein, we present an inexpensive synthetic method that can integrate electron-rich aromatics into porous organic polymers while also streamlining the reaction conditions. One electron transfer from the electron-rich centres to the oxidizing agent generates cation radical intermediates and further facilitates the polymerization reaction. FT-IR, XRD, SEM, EDS, XPS, and TGA were used to evaluate the synthesized polymeric networks, while N₂ sorption analysis was used for the porosity and surface area measurements. We observed that the synthesized polymers could

adsorb carbon dioxide at room temperature. Porous Organic Polymers containing nitrogen may have an increased affinity for CO₂ due to the dipole-quadrupole interaction between nitrogen atoms and CO₂; this would boost the adsorption capacity. We anticipate that by adjusting the pore size and surface area and adding nitrogen-rich functional elements, the porous organic polymeric adsorbents' ability to adsorb CO₂ may be improved. Furthermore, this methodology may attain tremendous interest in the future, along with the drastic development of applications of POPs in the environmental sector.

References: [1] J. M. Lee and A. I. Cooper, "Advances in conjugated microporous polymers" *Chemical reviews* 120(4), 2171-2214 (2020). [2] W. Zhang, H. Zuo, Z. Cheng, Y. Shi, Z. Guo, N. Meng, A. Thomas, and Y. Liao, "Macroscale conjugated microporous polymers: controlling versatile functionalities over several dimensions" *Advanced Materials* 34(18), 2104952 (2022). [3] N. Naz, M. H. Manzoor, S. M. G. Naqvi, U. Ehsan, M. Aslam and F. Verpoort, "Porous organic polymers; an emerging material applied in energy, environmental and biomedical applications" *Applied Materials Today* 38, 102198 (2024).

1571058210: Biosynthesis of MoO₃ nanoparticles using Henna leaf extract for seed germination

Claire Mary Savio (Politecnico di Milano, Milan, Italy); Shwetha Sajeev (Amity University Dubai, United Arab Emirates); Meby Susan Johnson (Amity University, United Arab Emirates); Henda Mahmoudi (Scientist, United Arab Emirates); Asha Madhavan (Amity University, United Arab Emirates)

Developing sustainable and innovative methods for synthesis of nanoparticles is vital for making advancements in the field of materials science. MoO₃ nanoparticles have been gaining attention due to their unique properties, including their potential enhancement of agricultural processes [1]. Henna leaves have a rich phytochemical profile comprising of proteins and antioxidants, hence it behaves as a natural source for the synthesis of nanoparticles [2]. Researchers proved that a chemical compound in henna known as apiin helps synthesize nanoparticles with exceptional surface properties and desired sizes. The carbonyl group of apiin allows it to bind to metal ions and form a coating over the nanoparticles, thus preventing the accumulation of nanoparticles [2]. Additionally, the use of henna extract as a reducing agent offers a cost-effective and sustainable alternative to the traditional synthesis methods. The current study investigates a novel and sustainable approach to synthesize molybdenum trioxide nanoparticles from ammonium molybdate using henna leaf extract and studies their effect on seed germination. MoO₃ nanoparticles were synthesized by furnace heating and its properties were analyzed by UV-visible spectroscopy, DLS and SEM. UV-visible peaks in the range of 224 to 260nm were observed for the nanoparticles and nano-rods having an average width of 240 nm and a length of approximately 580 nm with a narrow size distribution. Our observations are in agreement with the work of Ama et al. [3]. The stability of the synthesized

nanoparticles was analyzed by time dependant UV studies and the MoO₃ nanoparticles were found to be stable. The bandgap of the synthesized nanoparticles was analyzed using a Tauc plot and it had bandgaps in the range of 3.3eV to 3.6eV which is larger than the recorded bandgap of bulk MoO₃ by Singh et al., which is 2.9eV [4]. The effect of the MoO₃ nanoparticles on seed germination will be tested on foxtail millet seeds at the International Center for Biosaline Agriculture (ICBA) using hydroponic system.

References [1] J. Nanda, et al., "Effect of molybdenum trioxide nanoparticle-mediated seed priming on the productivity of green gram (*Vigna radiata* L.)," (2023). [2] J. Kasthuri, et al., "Biological synthesis of silver and gold nanoparticles using apiin as reducing agent," *Colloids and Surfaces B: Biointerfaces* 68(1), 55-60 (2009). [3] O.M. Ama, et al., "Efficient and Cost-effective Photoelectrochemical Degradation of Dyes in Wastewater over an Exfoliated Graphite-MoO₃ Nanocomposite Electrode," *Electrocatalysis* 9(5), 623-631 (2018). [4] M. Singh, et al., "Size and shape effects on the band gap of semiconductor compound nanomaterials," *Journal of Taibah University for Science* 12(4), 470-475 (2017).

1571064189: Enhancing Iodine Capture with Electrospun Nanofiber-Supported Nano/Mesoscale Covalent Organic Frameworks

Abul Hasnat (Indian Institute of Technology Mandi, India); Prem Felix Siril (Indian Institute of Technology, India); Sumanta Chowdhury (Indian Institute of Technology Mandi, India)

Nuclear power offers a low-carbon electricity source, contributing approximately 10% of global energy needs.[1] However, radioactive gas emissions (131I and 129I) from nuclear fuel reprocessing and accidents pose serious environmental risks and health hazards.[2] Covalent organic frameworks (COFs) have emerged as state-of-the-art sorbents for iodine capture, demonstrating exceptional sorption capacities exceeding 10 g/g with rapid kinetics and excellent recyclability.[3] This intriguing behavior often stems from their high surface areas, controllable pore-interface and structural tunability.[4] Despite advancements, the influence of particle size and morphology control in COFs has been overlooked in the literature. Recognizing the research gap, we developed a series of imine-linked isostructural COFs with distinct particle sizes and morphologies (mesospheres, nanoflowers and bulk-sheets) to enhance their iodine sorption behaviour. Our study demonstrates that solid-state aggregation in powdered form limits the sorption efficacy of nano/mesoCOFs while passivating their external surfaces. To overcome this challenge, we supported these COFs on electrospun nanofibrous membranes with an in-situ growth strategy. This strategy, coupled with rapid mass transfer, faster sorption kinetics, accessible binding sites, improved processability, and enhanced chemisorption, guiding the development of next-generation iodine sorbents.

Reference: [1] D. Horikami et al., 'The effect of exposure on cattle thyroid after the Fukushima Daiichi nuclear power plant accident', *Scientific Reports* 2022 12:1, vol. 12, no. 1, pp. 1-13, Dec. 2022, doi: 10.1038/s41598-022-25269-0. [2] G. Mushkacheva et al., 'Thyroid abnormalities associated with protracted childhood exposure to ¹³¹I from atmospheric emissions from the Mayak weapons facility in Russia', *Radiat Res*, vol. 166, no. 5, pp. 715-722, Nov. 2006, doi: 10.1667/RR0410.1. [3] Y. Xie et al., 'Ionic Functionalization of Multivariate Covalent Organic Frameworks to Achieve an Exceptionally High Iodine-Capture Capacity', *Angewandte Chemie International Edition*, vol. 60, no. 41, pp. 22432-22440, Oct. 2021, doi: 10.1002/ANIE.202108522. [4] T. Pan, K. Yang, X. Dong, and Y. Han, 'Adsorption-based capture of iodine and organic iodides: status and challenges', *J Mater Chem A Mater*, vol. 11, no. 11, pp. 5460-5475, Mar. 2023, doi: 10.1039/D2TA09448G.

1571068529: Blue Plumbago-Derived Silver-Doped Zinc Oxide Nanoparticles: A Leap Forward in Nanoremediation

Khalida Mahmediqbal Bloch (RK. University, India); Sougata Ghosh (RK University, India)

The rapid expansion of dyeing and textile industries has led to the uncontrolled release of heavy metals and dyes into the environment. These industries discharge harmful dyes such as methylene blue, methylene orange, Congo red, and rhodamine B directly into water bodies, causing severe damage to both human health and aquatic ecosystems [1]. While various physicochemical methods exist for removing these toxic pollutants from water, they often lack eco-friendliness [2]. Therefore, nano-remediation approaches are gaining attention for their potential benefits [3]. This study presents the synthesis of zinc oxide (ZnO) [4] and silver-doped zinc oxide nanoparticles (ZnOAg1Ps, ZnOAg10Ps, and ZnO10Ag1Ps) [5] using the leaf extract of *Plumbago auriculata*. Gas chromatography-mass spectroscopy (GC-MS) and phytochemical analysis revealed the presence of several beneficial compounds in the leaf extract, including phenols, reducing sugars, flavonoids, and plumbagin. The synthesized composites were characterized using UV-vis and photoluminescence (PL) spectroscopy, high-resolution transmission electron microscopy (HRTEM), energy dispersive X-ray analysis (EDX), X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), dynamic light scattering (DLS), and zeta potential measurements. Photocatalytic degradation of methylene blue was conducted using these composites, with ZnO10Ag1Ps achieving a 95.7% degradation rate and a rate constant of 0.0463 s^{-1} . The results demonstrate the effective remediation of toxic dyes, highlighting silver-doped ZnO nanoparticles as a promising strategy for eliminating hazardous pollutants from wastewater.

Acknowledgment KB acknowledges the financial support from the Student Startup & Innovation Policy (SSIP) of the Government of Gujarat and RK University (U-0647/SSIP/RKU/SOS/2021-22/13). The authors thank the Sophisticated Analysis Instrumentation Facilities (SAIF) at IIT Bombay for providing TEM and SEM access. They also

acknowledge the Department of Pharmaceutical Sciences at Saurashtra University, Rajkot, for using DLS and FTIR facilities. References [1] M. I. Din, R. Khalid, J. Najeeb, and Z. Hussain, "Fundamentals and photocatalysis of methylene blue dye using various nanocatalytic assemblies-A critical review," *J. Clean. Prod.* 298, 126567 (2021). <https://doi.org/10.1016/j.jclepro.2021.126567> [2] S. Gautam, G. Kaithwas, R. N. Bharagava, and G. Saxena, "Pollutants in tannery wastewater, their pharmacological effects and bioremediation approaches for human health protection and environmental safety," in *Environmental Pollutants and Their Bioremediation Approaches*, edited by R. N. Bharagava (CRC Press, Taylor & Francis Group, Boca Raton, FL, USA, 2017), pp. 369-396. <https://doi.org/10.1201/9781315173351-14> [3] Mandeep and P. Shukla, "Microbial nanotechnology for bioremediation of industrial wastewater," *Front. Microbiol.* 11, 590631 (2020). <https://doi.org/10.3389/fmicb.2020.590631> [4] M. Naseer, U. Aslam, B. Khalid, and B. Chen, "Green route to synthesize zinc oxide nanoparticles using leaf extracts of *Cassia fistula* and *Melia azadarach* and their antibacterial potential," *Sci. Rep.* 10, 9055 (2020). <https://doi.org/10.1038/s41598-020-65949-3> [5] D. Thakur, A. Sharma, D. S. Rana, N. Thakur, D. Singh, T. Tamulevicius, et al., "Facile synthesis of silver-doped zinc oxide nanostructures as efficient scaffolds for detection of p-nitrophenol," *Chemosensors* 8, 108 (2020). <https://doi.org/10.3390/chemosensors8040108>

1571071134: Multifunctional mesostructured silica-based materials as sorbents and catalysts for pollutant removal and CCU technologies

Francesca Perra, Valentina Mameli, Fausto Secci, Chiara Busonera, Alessandra Fantasia and Nicoletta Rusta (University of Cagliari, Italy); Mauro Mureddu (SotaCarbo S.p.A., Italy); Daniela Meloni, Elisabetta Rombi and Carla Cannas (University of Cagliari, Italy)

In recent years, water pollution derived from heavy metals and global warming due to the increasing levels of CO₂ concentration have become worldwide environmental concerns. Both these issues are included in the 17 goals of the Agenda 2030, in particular the goal number 6 regarding "clean water and sanitation" and the goal number 13 regarding "climate action". The aim of this study is the synthesis of multifunctional materials that can act as sorbents for the removal of metals/metalloids from water and as sorbents and/or catalysts for the CO₂ capture and/or conversion. The current work focuses on the synthesis and functionalization with aminosilanes of mesostructured silicas (specifically MCM-41 and MCM-48) for the development of amine-silica sorbents with potential applications in Cd²⁺ removal from aqueous solutions and in Carbon Capture and Utilization (CCU) technologies. Due to their highly ordered mesoporous structure and large surface area, along with nitrogen's ability to donate lone pairs to Cd²⁺ and the strong affinity of amines for CO₂, amine-silica sorbents are well-suited for these applications. Furthermore, silica-based mesostructured composites have been developed by incorporating oxidic phases of copper, zinc and zirconium (CZZ) into MCM-41, aiming at their potential use in the catalytic hydrogenation of CO₂ into methanol [1]. Mesostructured silica was synthesized via the sol-gel technique employing a templating agent,

a siliceous alkoxide precursor and two distinct solvent systems: water alone (yielding MCM-41) and a combination of water and ethanol (yielding MCM-48). Various amine-silica sorbents were obtained from post-synthesis grafting with aminopropyltriethoxysilane [2] and tested for Cd²⁺ removal and CO₂ capture. To lower both environmental and economic impact of the grafting procedure, an eco-friendly solvent was used: butanol instead of the commonly used toluene. The CZZ@MCM-41 composites were prepared through a wet impregnation method followed by auto-combustion starting from nitrate salts of copper, zinc and zirconium. In addition, for the development of sorbents for cadmium removal and CZZ-based catalysts, mesostructured silica from an industrial waste (hexafluorosilicic acid, FSA) [3] was also tested. All sorbents were characterized by XRD, TEM-EDX, TEM, N₂-physisorption, thermogravimetric-analysis and FTIR-ATR. MCM-48 was obtained by adding ethanol as co-solvent, keeping all the other experimental conditions equal to the MCM-41's synthesis, confirming its key role among others synthesis parameters in tuning the mesophase. The replacement of the alkoxide precursor with FSA allowed the production of MCM-41 with comparable textural properties, avoiding the discharge in water or the storage in dangerous conditions of FSA and consequently reducing environmental and economic impacts. On the other hand, the same amino groups' concentration (~2 mmol/g) was obtained for MCM-41 functionalized with either toluene or butanol. Amino-silica sorbents were tested for Cd²⁺ sorption showing a removal percentage of 98-99% and an adsorbed amount of cadmium (q_e) around 40-45 mgCd(II)/gsorb for MCM-41 obtained both from TEOS and FSA. This preliminary study suggests that the replacement of TEOS with FSA doesn't influence the performances in terms of removal and that amine-silica materials can be good sorbents for cadmium removal. On the other hand, the use of butanol instead of toluene in the grafting procedure led to a decline in CO₂ adsorption performances (1120 μmolCO₂ ads/gsb with toluene vs. 571 μmolCO₂ ads/gsb with butanol), indicating the need to improve functionalization process. Nevertheless, a comparison revealed that toluene-functionalized MCM-41 is more efficient than SBA-15, emphasizing the crucial role of the support's surface area in the distribution of the amino-groups inside the mesopores.

1571073898: Harnessing Temperature-Dependent Breathing Behavior in Aluminium-Based MOFs for Enhanced Congo Red Dye Removal

Ahmed Radwan (Ain Shams University, Egypt & University of North Texas, Egypt)

This study delves into the temperature-dependent breathing behavior of aluminium-based metal-organic frameworks (Al-MOFs) and its profound impact on the adsorption of Congo red (CR) dye. Synthesized via a hydrothermal method, the Al-MOFs exhibit high crystallinity, porosity, and thermal stability, as confirmed by comprehensive characterization techniques, including PXRD, FESEM, TEM, FTIR, BET surface area analysis, and XPS. These structural properties are key to understanding the material's exceptional adsorption performance. Our findings reveal that the temperature-dependent breathing effect of Al-MOFs, characterized by

reversible structural transformations between narrow-pore (NP) and large-pore (LP) phases, significantly enhances the material's adsorption capacity. As temperature increases, Al-MOFs undergo phase transitions that expand their pore volume, facilitating greater adsorption of CR dye, with a maximum capacity of 223.8 mg/g. This temperature-induced flexibility not only improves adsorption efficiency but also allows the material to accommodate larger dye molecules (Figure 1). Thermodynamic analysis highlights the endothermic and spontaneous nature of the adsorption process, driven by positive ΔH° and ΔS° values and negative ΔG° values. The breathing behavior plays a critical role in overcoming pore size limitations, making Al-MOFs highly effective for dye removal under varied conditions. Adsorption isotherms and kinetics follow a Langmuir model and pseudo-second-order kinetics, indicating that monolayer adsorption and chemisorption are the rate-limiting steps. The study also demonstrates the reusability of Al-MOFs, maintaining 90% of their adsorption efficiency after five cycles, further solidifying their potential for practical applications. This research underscores the importance of the breathing effect in enhancing adsorption performance, positioning Al-MOFs as promising candidates for advanced environmental remediation technologies. These insights into the tunable breathing behavior of MOF-based materials open new avenues for their development in addressing environmental challenges.

1571076022: Exploring Moringa concanensis Mediated Synthesis of Ag-MgO Nanoparticles for Antioxidant Potential, phytotoxicity and Chromium (VI) Remediation in Tannery Effluents

Vedant Bhargava (Vellore Institute of Technology, India & VIT School of Agricultural Innovations and Advanced Learning (VAIAL), India)

Moringa concanensis belongs to the Moringaceae family and is native to India. It is renowned for its rich phytochemical content, including potent antioxidants and bioactive compounds, this indigenous tree species serves as a valuable resource in nutrition and traditional medicine. In this study, *Moringa concanensis* bark plant profiling is examined using qualitative and quantitative analysis which indicates the presence of alkaloids, phenols, flavonoids, tannins, saponins, glycosides, and triterpenes using various solvents (Ethyl acetate, Ethanol, Methanol, and Aqueous). The total phenolic content and total flavonoid content of different bark extracts was examined. Green synthesis of Ag-MgO nanoparticles using *M. concanensis* bark extract was achieved and characterized using UV, XRD, FTIR, and SEM analysis. Antioxidant properties of plants and biosynthesized nanoparticles were evaluated using DPPH assay, and metal chelating assay. The Ag-MgO nanoparticles are subjected to phytotoxicity assessment analyzing various parameters using *Vigna radiata* seeds. Chromium (VI), a toxic element commonly found near tanneries and industrial sites, poses substantial risks to the environment and human health. The green synthesized Ag-MgO nanoparticles are subjected to chromium degradation in tannery effluents. The objective of this study summarizes the green synthesis of Ag-MgO nanoparticles for significant antioxidant activity and heavy metal degradation

which underscores the potential to enhance environmental sustainability and human well-being.

1571077053: Study and synthesis of a nanocomposite prepared from cullet for microwave absorption application

Younes Lamri (University M'Hamed Bougara of Boumerdes, Algeria); Bachir Eddine Messaid and Farouk Mebtouche (University of Boumerdes, Algeria); Fayrouz Benhaoua (Université M'hamed Bougera of Boumerdes, Algeria)

Exposure to electromagnetic waves from modern electronic devices, such as mobile phones and wireless equipment, can negatively affect human health. As a result, research into protective nanomaterials against microwaves has become a highly active field. Simultaneously, the increasing demand for raw materials, alongside declining resources, drives the need for recycling. In this study, glass foam nanocomposites were developed using recycled glass waste (cullet) and metal waste as absorbers for electromagnetic waves. The materials-cullet, metal waste (0% to 20wt.%), and limestone (CaCO_3) as a foaming agent-were ground and heated at 800°C for 20 minutes in a heat-resistant mold. The resulting foam composites displayed a homogeneous structure. Their absorption properties were measured across the 8-12 GHz frequency range using a vector network analyzer (Rohde & Schwarz, ZNB 20). Results demonstrated that absorption varied with filler content and foam density. The best-performing composite exhibited an attenuation of 0.83 at 9.45 GHz with a density of 0.34 g/cm^3 . Furthermore, the composite containing 12% metal waste showed low reflection, reaching -35.97 dB at 11.44 GHz. These promising results indicate that the developed glass foam composites are highly effective for electromagnetic wave absorption.

1571077906: DC magnetometry as direct probe for the the study of removal process of AsV species by nanoakaganeite

Valentina Mameli (University of Cagliari, Italy); Marco Sanna Angotzi (Italy); Alessandra Fantasia (University of Cagliari, Italy); Cesare Atzori (European Synchrotron Radiation Facility, Italy); Giovanni Bertoni and Vincenzo Grillo (Istituto Nanoscienze Consiglio Nazionale delle Ricerche, Italy); Martin Kalbac (JH Institute of Physical Chemistry, Academy of Sciences, Dolejskova 3, Prague, Czech Republic); Jana K Vejpravova and Dominika Zakutna (Charles University, Czech Republic); Carla Cannas (University of Cagliari, Italy)

Iron oxides and oxihydroxides are effective sorbents toward aqueous AsIII/AsV species, thanks to the formation of complexes of the inner sphere of surface Fe atoms by exchange of surface OH_2 and OH^- with the arsenic species.[1] Although the affinity of arsenic species toward iron

oxides and oxihydroxides are known from decades, we recently started a comprehensive comparison of their arsenic uptake. In particular, among the tested sorbents (akaganeite (β -FeOOH), ferrihydrite ($\text{Fe}_5\text{HO}_8 \cdot 4\text{H}_2\text{O}$), maghemite (γ - Fe_2O_3 , as single phase or embedded into porous silica)), [2] akaganeite was proved to be the best sorbent for arsenate anions (89 mg g⁻¹ at pH 3, 52 mg g⁻¹ at pH 8) and also an effective one for neutral arsenite species (91 mg g⁻¹ at pH 3-8). A careful chemical-physical characterization revealed the role of both surface and textural properties depending on the specific arsenic speciation under specific pH conditions. The high positive surface charge (measured by Electrophoretic Light Scattering, ELS, ≈ 30 mV) and high surface area (determined by N₂ physisorption, ≈ 200 m² g⁻¹) were found to be responsible for the AsV and AsIII uptake, respectively. In this context, since the arsenic uptake is generally determined indirectly by measuring the arsenic concentration, a further investigation on the "after usage" sorbent was undertaken by different techniques with the aim of revealing changes in the sorbent with respect to its pristine state. Among the adopted methods (e.g., powder X-ray diffraction (PXRD), infrared spectroscopy (FTIR-ATR), transmission electron microscopy also in high resolution (HRTEM) and coupled with chemical probes (EDX-EELS), X-ray photoelectron spectroscopy (XPS), X-ray absorption (XAS)) DC magnetometry was able to detect remarkable changes in the akaganeite magnetic properties upon adsorption of arsenate species. In particular, a second band in the temperature profile of the magnetisation measured through the Zero Field Cooling protocol appeared after the removal process, with a clear dependence on the increasing adsorbate amount. This work demonstrates the possible application of DC magnetometry in studying the adsorbate/adsorbent interactions in the field of environmental chemistry.

1571078141: Application of nanotechnology to produce smart filter fabrics for Environmental Sustainability

Ola Mohsen Darwish, Sr (Helwan University & Faculty of Applied Arts, Egypt); Aliaa Abdelfatah (Cairo University, Egypt)

There are many uses of fabrics, including the use of multi layers cloth in filters to purify the rising fumes to preserve the environment. The problem of the search is producing woven fabrics in a multi-layered with the effect of the two factors: first, textile construction (thread number, yarn density in units of measure) Which directly affects the suitability of the final functional performance of the textile product for use as filters to isolate some gases polluting the environment from the air and emitted from food factories. The second factor is the use of nano particles in fabric treatment to increase control over the permeability of fumes rising from food factories. The research aims to design a fabric that has the ability to purify the fumes from factories by controlling the size of the interspaces in the cloth. This cloth acts as a unit of the filter matrix used. By changing the building factors of the fabric and the and nano particles mechanism, a high rate of purification of the emitted fumes can be obtained. These fabrics, when tested by exposing them to carbon dioxide, were able to filter the gas by 98%. By changing the size of the interstitial spaces, other harmful particles can be filtered, so the fabrics are an effective part of the filter matrix. Air purification can be enhanced through

nanotechnology in various ways. Nanoparticle enhances the CO₂, SO₂, CO absorption which has a high specific area and a high degree of orientation of fiber.

1571078303: Development and Evaluation of Porous Adsorbent for CO₂ Capture

Aqeel Ahmad (Interdisciplinary Research Center for Refining and Advanced Chemicals, KFUPM, Saudi Arabia); Masooma Nazar (Center for Integrative Petroleum Research (CIPR) KFUPM, Saudi Arabia); Azmi Bustam (Universiti Teknologi PETRONAS, Malaysia); Othman Sadeq Al Hamouz (King Fahd University of Petroleum and Minerals, Dhahran, Saudi Arabia)

The swift increase in carbon dioxide (CO₂) levels in the environment has a major effect on global warming. To mitigate CO₂ emissions and achieve industrial decarbonization, carbon capture (CC) is essential. For this, metal-organic frameworks (MOFs) are optimal for CO₂ capturing due to their large surface area. In this work, the solvothermal approach was employed to synthesize MOF-74, which was produced in pellet and powder form. The pelletizing process was carried out using the extrusion technique with 5 wt% polylactic acid (PLA). The PXRD, BET, TGA, and CO₂ adsorption tests were employed to assess how well the manufactured MOF-74 powder and pellets performed. The synthesis of MOF-74 was confirmed by PXRD, and TGA results demonstrated that the thermal stability of pelletized MOF-74 was enhanced from the powdered MOF by 10 °C. The powdered MOF-74 provided 18.37% more BET surface area than pelletized MOF-74. The CO₂ absorption capacity of powdered and pelletized MOF-74 was 5.48 mmol/g and 4.38 mmol/g, respectively. The Dual Site Langmuir-Freundlich isotherm model, which exhibited the regression coefficient (R^2) value of 0.999987, provided the most accurate match to the adsorption data. It seems from these results that the suggested strategy is quite efficient and a viable option in lowering atmospheric CO₂ levels. Furthermore, to boost the CO₂ uptake capability, the primary point of future studies should be on surface modification of the synthesized MOF-74.

1571078472: PDMS-Based magnetic nanocomposites

Sawssen Simani (University of GENOVA, Italy)

Polymer- based magnetic nanocomposites (PMNCs) have attracted considerable interest in recent years as a new class of multifunctional materials. In this framework the design of a suitable synthetic approach represents a key point to obtain a PMNCs with optimized physical properties for biomedical and environmental applications. A key step in the synthesis of PMNCs is definitively the molecular functionalization of magnetic nanoparticles . This work we report an investigation of morpho-structural and magnetic properties of 10 nm CoFe₂O₄ nanoparticles, bare (B-MNPs) and coated with oleic acid (OA-MNPS) then embedded in polydimethylsiloxane (PDMS) matrix. Then PMNCs were synthesized embedding B-MNPS and OA-MNPS in a PDMS matrix using the electrospinning technique. A complete characterization

was carried out via a combination of morpho-structural (X-ray diffraction XRD) and magnetic (Vibrating Sample Magnetometer, VSM) measurements, providing a detailed understanding of physico-chemical properties. Furthermore, additional techniques (Fourier Transform Infrared Spectroscopy FTIR Thermogravimetric Analysis TGA and Dynamic Light Scattering) were employed to confirm the magnetic nanoparticles coating and their stability in the working solvent. The magnetic investigation at room temperature of both particles nanocomposites allow revealing the key role of the particles functionalization in tuning the morpho-structural properties of the PMNCs. Interestingly the presence of the CoFe₂O₄ nanoparticles significantly the aging time of the PDMS from 72 hours to 24 hours. This indicates that by embedding magnetic nanoparticles into the PDMS matrix the resulting nanocomposites exhibit dual functionality magnetic responsiveness and catalytic activity. This unique combination of these properties offers a promising and sustainable solution for environmental application.

1571079374: Molecular insights on Hierarchical Carbon-based adsorbent materials for CO₂ Capture

Daniel Bahamon, Maryam Khaleel and Lourdes Vega (Khalifa University, United Arab Emirates)

In the last two decades, adsorption with porous solid materials has become an alternative option for capturing CO₂ at a large-scale. By eliminating the liquid phase, such process overcomes the typical drawbacks found in the absorption technology with aqueous amines [1], like evaporation losses and high energy requirements for regeneration. Nanoporous materials such as Metal-Organic Frameworks (MOFs) and zeolites have been previously explored in the literature, however, the adsorption process is often limited by poor performance at low CO₂ partial pressures [2], especially important if the feed stream has a low concentration of carbon dioxide. Hence, functionalization appears as an alternative to obtain better-performing CO₂ adsorbents, taking advantage of the two above-mentioned technologies. Carbon-based adsorbents have been studied in this contribution due to their thermal and mechanical stability, as well as providing a wide variety of pore sizes and geometries. Moreover, the possibility of functionalizing them with amino molecules that can tightly bind with CO₂ (chemisorption process)[3] makes them promising supports to be further explored. In this regard, molecular simulations can be applied as a robust and complementary tool to design and/or fine-tune novel materials for specific applications. Therefore, in this contribution, we present results based on Molecular Dynamics (MD) and Monte Carlo (MC) simulation techniques to study the CO₂ physisorption and predict the chemisorption performance [4][5] by analyzing the accessibility and orientation of blended amine chains inside different hierarchical structures (i.e., including both micro and mesopores) obtained from activated carbons and zeolite templated carbons (see Figure 1). Functionalization includes primary and secondary multiamines such as ethylenediamine (EDA) and diethylenetriamine (DETA). Up to a ten-fold enhancement in the adsorption capacity has been obtained for functionalized materials when compared to their parent structures. Particularly important is the role of the hierarchical features in avoiding pore blockage after functionalization, hence proving the potential of these materials to enhance the CO₂ capture

performance at typical industrial conditions, while reaching comparable performance with existing commercial absorption processes [6]. Financial support for this work has been provided by Khalifa University under the Research and Innovation Center on CO₂ and Hydrogen (RICH) RCII-2019-007.

References [1]. C.H. Yu, C.H. Huang, C.S. Tan. A Review of CO₂ Capture by Absorption and Adsorption. *Aerosol Air Qual. Res.*, 2012, 12, 745. <https://doi.org/10.4209/aaqr.2012.05.0132> [2]. Z. Wu, D. Zhao. Ordered mesoporous materials as adsorbents. *Chem. Commun.*, 2011, 47, 333. <https://doi.org/10.1039/C0CC04909C> [3]. B. Singh, J. Na, M. Konarova, T. Wakihara, Y. Yamauchi, C. Salomon, M.B. Gawande. Functional Mesoporous Silica Nanomaterials for Catalysis and Environmental Applications. *Bull. Chem. Soc. Jpn.*, 2020, 93, 1459. <https://doi.org/10.1246/bcsj.20200136> [4]. S. Builes, P. López-Aranguren, J. Fraile, L.F. Vega, C. Domingo. Analysis of CO₂ Adsorption in Amine-Functionalized Porous Silicas by Molecular Simulations. *J. Phys. Chem. C*, 2012, 116, 10150. <https://doi.org/10.1021/acs.energyfuels.5b00781> [5]. H. Al Araj, D. Bahamon, K.S.K. Reddy, L.F. Vega, G.N. Karanikolos. A Systematic Approach to Understanding and Optimizing the CO₂ Capture Performance of Triamine-Functionalized Mesoporous Silica with Amine Blends Using Molecular Simulations. *J. Phys. Chem. C*, 2023, 127, 7410. <https://doi.org/10.1021/acs.jpcc.2c08453> [6]. L.F. Vega, D. Bahamon. Importance of Bridging Molecular and Process Modeling to Design Optimal Adsorbents for Large-Scale CO₂ Capture. *Accounts Chem Res*, 2023, 57, 188-197. <https://doi.org/10.1021/acs.accounts.3c00478>

1571083404: Innovative 2D Nanocomposite Aerogels for Efficient Lithium Recovery from Brine Water

Nour Abdelrahman (Khalifa University, United Arab Emirates)

With the rising demand for lithium in sectors such as electric vehicles and renewable energy, concerns about the depletion of lithium reserves and the environmental impact of traditional mining practices have intensified. This study targets the recovery of lithium from various water sources, including brine, wastewater, and seawater, to promote more sustainable lithium production methods. The research aims to develop a high-efficiency adsorbent and integrate it into advanced lithium recovery technologies, contributing to a circular economy within the lithium-ion battery industry. One of the key strategies explored involves the use of nanocomposite aerogels made from 2D materials, with modified cellulose- the most abundant polymer globally-serving as the main structural framework. These cellulose-based aerogels offer substantial benefits, particularly in simplifying the recovery and handling of adsorbent materials, making them more practical than using nanomaterials alone. In this study, different variations of modified cellulose-based aerogels were synthesized and assessed as lithium-ion-selective adsorbents, including those enhanced with MXene, graphene oxide, ionic liquids, and DES. The successful evaluation of these aerogels' performance in lithium-ion adsorption

demonstrates their promise in lithium recovery technologies. These findings could play a crucial role in reducing the environmental impact of lithium extraction while improving the cost-efficiency of recovery processes, supporting the sustainable growth of the lithium-ion battery industry.

1571084894: Bifunctional FeEDTMPs Catalyst for CO₂ Utilization: Enhanced Cyclic Carbonate Yields through Epoxide Activation

Naveen Naveen, Sr (Malaviya National Institute of Technology Jaipur, India & NIT, India); Pawan Rekha (Malaviya National Institute, India)

The optimal conditions 30 mg catalyst, 100 °C, and 7 bar CO₂ pressure resulted in complete epoxide conversion and 99% yield of cyclic carbonates within 24 hours. Kinetic analysis reveals a slow reaction rate in the early stages, accelerating after 14 hours as polycarbonate intermediates convert into cyclic carbonates. Temperature influences the reaction significantly, with higher values improving mass transfer by increasing gas diffusivity and reducing liquid viscosity. However, selectivity declines at 120 °C due to side-product formation. FeEDTMPs display remarkable efficiency even at moderate CO₂ pressures, reducing the need for expensive high-pressure reactors, making the catalyst promising for industrial applications. The catalyst's versatility was further demonstrated by testing different epoxides, with smaller substrates achieving near-complete yields, while bulkier epoxides showed lower conversion due to steric hindrance. Electron-withdrawing substituents facilitated nucleophilic ring-opening, enhancing reactivity and product formation.

This study underscores the potential of FeEDTMPs as a sustainable catalyst for CO₂ fixation, providing crucial insights into the relationship between catalyst structure and reaction conditions. The findings offer valuable guidance for the development of advanced catalytic systems for cyclic carbonate synthesis, advancing the field of carbon capture and utilization.

ORAL: 2D Materials & Applications (2D 2024-P)

Invited: Functionality Transformed Memory Devices

Nazek El-Atab, KAUST

(Saudi Arabia)

The convergence of sensing, computation, and actuation within unconventional material geometries is ushering in a new era of electronics. 2D materials, with their exceptional properties, offer a promising avenue for developing transformative devices. This talk explores the emergence of multi-functionality in 2D material-based smart memory devices, focusing on charge trapping memory and memristor technologies. We delve into their ability to sense various stimuli, store information, and perform complex tasks like image recognition and denoising. By integrating these capabilities into a single device, we can achieve significant advancements in power

efficiency, speed, and fabrication cost. This paves the way for a more sustainable and efficient electronics future.

1571056891: Electrostatic Self-Assembled V4C3/Protonated g-C3N4 heterostructures: High Photosensitivity and Photophysical Insights

Muhammad Abiyu Kenichi Purbayanto, Madhurya Chandel and Agnieszka M. Jastrzębska (Warsaw University of Technology, Poland)

Graphitic carbon nitride (g-C₃N₄) is a promising semiconductor for optoelectronic applications due to its visible light bandgap energy of 2.7 eV and large excitonic binding energy.¹ However, g-C₃N₄ suffers from poor electrical conductivity and fast recombination of electron and hole pairs, limiting its practical applications.² Additionally, only limited fundamental studies of the photophysics and carrier recombination process of g-C₃N₄ based heterostructures have been studied so far, which needs further investigation as they are vital for developing optoelectronic devices.^{3,4} In this study, we fabricate V₄C₃ MXene/protonated g-C₃N₄ (PCN) 2D/2D van der Waals heterostructures via facile electrostatic self assembly. Using the combination of temperature-dependent photoluminescence (PL) and time resolved PL spectroscopy, we explain the photophysics behind the effective charge transfer in V₄C₃/PCN heterostructures. V₄C₃/PCN heterostructures showed higher photosensitivity towards white light than PCN or V₄C₃ due to low charge transfer across 2D/2D interfaces. We observed a PL quenching and prolonged charge carrier lifetime in optimized V₄C₃/PCN at the wide temperature of 70 - 370 K. In particular, 2.3-fold lifetime enhancement was observed at an elevated temperature of 370 K. Our results are essential to understanding the charge transfer mechanism and achieving highly photosensitive g-C₃N₄ based heterostructures for optoelectronic applications.

1571058252: Talk

Exploring the role of Cl- and F- and OH- terminal groups in the synergistic CO₂ reduction on Ti₂CT_x MXene supported TiO₂ nanocrystals for selective ethanol formation

Malavika Sunil S, B M Jaffar Ali Jaffar Ali, Ramanathan Padmanaban and Thamarainathan Doulassiramane (Pondicherry University, India)

This study delves into the selective photocatalytic reduction of CO₂ to ethanol utilizing TiO₂ nanocrystal-supported Ti₂CT_x MXene. MXenes are a group of 2D materials that are created by selectively removing A layers from MAX phases by techniques such as the MILD (minimally intensive layer delamination) procedure. The 2D materials, such as carbides, nitrides, and carbonitrides, demonstrate notable characteristics such as elevated electrical conductivity, adjustable surface chemistry, and exceptional mechanical qualities. Titanium-based MXenes, such as Ti₂CT_x, have been extensively researched because of their exceptional stability and adaptability in several applications. Titanium-based MXenes are utilized in several fields such as energy storage, sensors, and catalysis. Among them, Ti₂CT_x exhibits considerable promise in

photocatalytic applications, particularly in the reduction of CO₂. Ti₂CTx possesses tuneable surface functional groups that augment its capacity to absorb and activate CO₂, rendering it a highly efficient catalyst for sustainable chemical processes [1]. Specifically, we examine the influence of terminal groups such as Cl, F-, and OH- on photocatalytic CO₂ reduction performance. CO₂ reduction products like methane and carbon monoxide are useful for energy and chemical feedstocks. Due to their increased value and wider use in fuels, chemicals, and polymers, C₂ products like ethanol and ethylene are more commercially attractive. Ethanol sells for \$2.50 to \$3.00 per gallon, making it a profitable target for CO₂ conversion technology that might reduce carbon emissions and produce sustainable chemicals [2], [3]. Photocatalyst was prepared by in-situ growth of TiO₂ nanocrystals, on Ti₂CTx MXene to form heterojunction by co-polymerization precipitation followed by a hydrothermal process. This process offers larger surface areas and improved light absorption, boosting photocatalytic activity. The formed nanocrystals appear to be in rice crust form which is seen in SEM images. (Fig.1a) The identification of terminal group elements was by using X-ray photoelectron spectroscopy (XPS) (Fig.1b), and the formation of (001) anatase phase TiO₂ nanocrystals is evident from XRD (Fig.1c & d). Density Functional Theory (DFT) studies provided detailed insights into the reaction mechanisms and the role of terminal groups, revealing that specific groups significantly influence electron transfer dynamics and CO₂ reduction efficiency. The findings indicate that only OH- groups involve in the reaction mechanism by H transfer to intermediates, suggesting a new pathway leading to selective ethanol formation. Combining Ti₂CTx MXene and TiO₂ nanocrystals' surface oxygen vacancies, Ti³⁺ sites, hydroxyl groups, reactive edge, and corner sites enhance CO₂ adsorption and activation, and their efficient charge carrier energy dynamics improve charge separation and transport, resulting in higher conversion rates and selectivity towards C₂ hydrocarbons namely ethanol, attributed to the balance between hydrogenating ability and C-C coupling in the reaction mechanism. The hydrothermal synthesis method played a significant role in enhancing catalytic activity by producing nanocrystals with high crystallinity and fewer defects, ensuring consistent performance. The DFT studies offered a comprehensive understanding of the reaction pathways, guiding the rational design of future photocatalytic systems to overcome kinetic barriers in CO₂ reduction [4]. This research underscores the importance of terminal group engineering and nanostructured supports in optimizing photocatalytic systems for sustainable CO₂ conversion. The study demonstrates the potential of Ti₂CTx MXene supported on TiO₂ nanocrystals as an effective photocatalyst reducing CO₂ more effectively, paving the way for advanced photocatalysts with enhanced efficiency and selectivity, contributing to mitigating climate change through efficient CO₂ utilization.

Acknowledgment: Part of this research was performed using facilities at CeNSE, Indian Institute of Science, Bengaluru.. We acknowledge Central Instrumentation Facility, Pondicherry University for characterization work.

References: [1] F. Shahzad, A. Iqbal, H. Kim, and C. M. Koo, "2D Transition Metal Carbides (MXenes): Applications as an Electrically Conducting Material," *Advanced Materials*. 2020, doi: 10.1002/adma.202002159. [2] H. Zhang, J. Gao, D. Raciti, and A. S. Hall, "Promoting Cu-Catalysed CO₂ Electroreduction to Multicarbon Products by Tuning the Activity of H₂O," *Nature Catalysis*. 2023, doi: 10.1038/s41929-023-01010-6. [3] D. Gao, W. Li, H. Wang, Q. Wang, and R. Cai, "Heterogeneous Catalysis for CO₂ Conversion Into Chemicals and Fuels," *Transactions of Tianjin University*. 2022, doi: 10.1007/s12209-022-00326-x. [4] T. K. Todorova, M. W. Schreiber, and M. Fontecave, "Mechanistic Understanding of CO₂ Reduction Reaction (CO₂RR) Toward Multicarbon Products by Heterogeneous Copper-Based Catalysts," *Acs Catalysis*. 2019, doi: 10.1021/acscatal.9b04746

1571072652: Talk

COMPARATIVE ANALYSIS OF STEADY STATE CREEP IN SUS-ZrO₂ AND Al-ZrO₂ FUNCTIONALLY GRADED PRESSURIZED CYLINDERS WITH ITS IMPLICATIONS

Manoj Sahni, Sr. (Pandit Deendayal Energy University, India))

This paper focuses on secondary creep analysis in functionally graded (FG) rotating cylinders subjected to internal and external pressure. For a prolonged period of time, when the material undergoes a steady magnitude of load, it experiences a time-dependent deformation which is irreversible and is known as a creep deformation. This paper analyses secondary creep stresses and strains in functionally graded cylinders under different volume reinforcement profiles with different material combinations. Anisotropic cylinder with varying nonlinear volume reinforcement of ceramic in metal matrix is considered and closed-form results are obtained for the creep stresses and creep strains in radial and tangential directions. The results are plotted graphically, and the implications of the results are discussed using the numerical values over the radial dimension of the functionally graded cylinder

1571073964: Construction of 2D-2D face to face S-scheme Mxene-based dual heterojunction with enhanced visible light driven photocatalytic H₂ generation and CO₂ reduction

Muhammad Ahmed (National University of Sciences & Technology (NUST) Islamabad, Pakistan)

Compelling research has been directed for hydrogen (H₂) generation through photocatalysis and carbon dioxide (CO₂) reduction by virtue of increasing need of sustainable energy solutions. Ti₂C Mxene based dual heterojunction with Nickel Telluride (NiTe) was fabricated via facile solvothermal technique. Etched and delaminated Ti₂C Mxene 1 was added during Ni BDC MOF synthesis 2, and it was further used via another solvothermal synthesis route 3 to prepare 2D face to face S-scheme Ti₂C Mxene based NiTe heterojunction. Material prepared was characterized via powder X-Ray Diffraction (XRD), Scanning Electron Microscopy (SEM), Energy Dispersive X-Ray Spectroscopy (EDX), Transmission Electron Microscopy (TEM), Raman Spectroscopy, UV-VIS Diffuse Reflectance Spectroscopy (DRS), X-Ray Photoelectron Spectroscopy (XPS) & Brunner-Emmett-Teller (BET). TEM reveals that the needle like entities of NiTe seem to protrude from the 2D sheets of Ti₂C Mxene surface indicating strong interfacial interaction that leads to the successful formation of heterojunction. The PEC performance of this heterojunction 4 was checked via linear sweep voltammetry (LSV), chopped chronoamperometry (CA), electrochemical impedance spectroscopy (EIS), and Mott-Schottky (M-S) analysis. 2D Ti₂C Mxene based dual heterojunction with NiTe showed a photocurrent density difference of 318 μA

cm⁻² which was almost double than the pristine NiTe material. At 400 °C, maximum amount of CO produced via photothermal carbon dioxide reduction was 3.4487 mmol·g⁻¹·h⁻¹ while no reduction was observed via pristine sample. This work offers an environmentally friendly and cost-efficient way to create a remarkable heterojunction for hydrogen production and carbon dioxide reduction using solvothermal technique.

1571056120: Multifunctional Electronic Devices Based on Van der Waals 2-Dimensional Black Phosphorous (BP)

Yasir Hassan¹, Pawan Kumar Srivastava², Budhi Singh², Changgu lee², Minsup choi¹

¹Department of Material science, Chungnam National University, Daejeon South Korea. ²School of Mechanical Engineering Sungkyunkwan University, Suwon 16419, South Korea.

Two-dimensional (2D) semiconductors and their heterostructures are at the forefront of some of the most transformative device innovations in recent decades. Particularly, heterostructures based on atomically thin 2D materials herald a new era of understanding and exploring enhanced properties for applications in light-emitting diodes, tunneling field-effect transistors, resonant tunneling transistors, quantum well lasers, logic circuitry, bipolar junction devices, and many others. Here in this presentation, I will show a clear conception on how tuning the Fermi level, as a function of the tunability of the black phosphorus (BP) work function (Φ_{BP}) with variations in flake thickness, across black phosphorus (BP)/rhenium disulfide (ReS₂) broken-gap (type-III) heterojunctions yields diverse current-transport characteristics. These include gate-tunable rectifying p-n junction diodes, Esaki diodes, backward-rectifying diodes, and non-rectifying devices, resulting from the varied band-bending at the heterojunction. The multifunctionality arising from this band-bending is illustrated by a p+-n-p junction consisting of BP (38 nm)/ReS₂/BP (5.8 nm) in applications such as binary and ternary inverters, and also demonstrates the behavior of a bipolar junction transistor with a common-emitter current gain of up to 50. Additionally, based on the anisotropic nature of black phosphorus, electronic transport in a homostructure based on black phosphorus will be presented, showcasing the extraordinary degree of control the relative stacking twist angle between anisotropic layers has on vertical transport behavior. The orthogonally stacked trilayer homojunction based on BP exhibits characteristics of resonant tunneling through quantum well states without the need for any physical tunneling materials. This approach achieves the largest tunneling conductance and peak-to-valley ratio in negative differential resistance (NDR) characteristics among van der Waals materials.

[1] Pawan Kumar Srivastava, Yasir Hassan, D. J. P. de Sousa, Yisehak Gebredingle, Minwoong Joe, Fida Ali, Yang Zheng, Won Jong Yoo, Subhasis Ghosh, James T. Teherani, Budhi Singh, Tony Low, Changgu Lee; *Nature Electronics* 4, 269 (2021). [2] Yasir Hassan, Pawan Kumar Srivastava, Budhi Singh, A. M. Sabbtain, F. Ali, W. J. Yoo, Changgu Lee; *ACS Applied Materials and Interfaces*, 12, 14119 (2020). [3] Pawan Kumar Srivastava, Y. Hassan, Y. Gebredingle, J. Jung, B. Kang, W. J. Yoo, Budhi Singh, Changgu Lee; *ACS Applied Materials and Interfaces*, 11, 8266 (2019). [4] Min Sup Choi, Myeongjin Lee, Tien Dat Ngo, James Hone, and Won Jong Yoo, *Adv. Electron. Mater.* 2021, 7, 2100449. [5] Pawan Kumar Srivastava, Yasir Hassan, Yisehak Gebredingle, Jaehyuck Jung, Byunggil Kang, Won Jong Yoo, Budhi Singh, and Changgu Lee. *Small* 2019, 15, 180488.

1571058240: Scalable Liquid Phase Exfoliation of Layered and 2D Materials

Mariam Mohamed Yehia Badawi (Khalifa University, United Arab Emirates); Muhammad Faizan (Khalifa University of Science and Technology Abu Dhabi, United Arab Emirates); Yarjan Abdul Samad (Cambridge, United Kingdom (Great Britain)); Imran Afgan (Khalifa University, United Arab Emirates)

Liquid phase exfoliation (LPE) methods are becoming increasingly significant in the exfoliation of graphene and other 2D materials due to their easiness and high production rates compared to other mechanical or chemical methods [1]. Inks produced by LPE are required in a wide range of applications including but not limited to flexible electronics [2], conductive coatings, and composite materials. The scalability of these processes is still a challenge, particularly due to limited flake sizes [1]. Current LPE methods that are widely investigated by researchers include sonication [2], shear mixing [3], and high-pressure homogenization [4]. Sonication is a cavitation-dominated process, while shear-mixing and high-pressure homogenization are shear-dominated forces accompanied with cavitation and collision effects. The cavitation and collision effects involved in these methods can induce significant defects in the resulting material, as well as the long process time for sonication limit the scalability of these methods [5]. In this work, a new LPE method is introduced, in which exfoliation occurs due to high shear forces developed among successive stationary and high-speed rotating discs. CFD simulations are performed for the device to evaluate the resulting shear forces acting on the fluid. A structured hexahedral mesh is employed in the simulations with k- ω SST turbulence model. Simulations are performed in the transient regime with a timestep of 810-6 s. Figure 1 shows the pressure, velocity and strain-rate contours for the flow domain at 5000 rpm with the strain rate reaching a maximum value of 4.5106 s-1 and an average value of 5.4*104 s-1, which exceeds the minimum shear-rate required for graphene exfoliation (104 s-1) [3]. Different rotational speeds are investigated in this work and the effect of each on the flow behavior and shear rate will be presented. Overall, this method has the potential to produce larger flakes with minimum defects, which facilitates the efficient scalable production of graphene and 2D materials inks to be used in different applications

1571084422: Enhancing the Vibrational Sensitivity of Graphene via Substitutional Doping

Kalpanadevi P (BITS Pilani, United Arab Emirates); Aiswarya Thekkedath (BITS Pilani Dubai Campus, United Arab Emirates); Adarsh Ganesan (BITS Pilani, Dubai Campus, United Arab Emirates); K K singh (BITS Pilani Dubai Campus, United Arab Emirates)

Graphene, in its pristine form, is a zero-bandgap material. This means it does not have a natural energy gap between its valence and conduction bands, unlike conventional semiconductors like silicon. Graphene's honeycomb lattice structure leads to a peculiar energy dispersion relationship. At the Dirac points, the energy levels form a conical shape, known as the Dirac cone, and there is no gap between the bands. This characteristic allows electrons to move freely, making graphene an excellent conductor. However, the absence of a bandgap limits graphene's use in digital electronics, where a semiconductor material with an "on-off" switching behavior is required [1]. Therefore, it is essential to establish a band gap, consequently decreasing graphene's electron mobility. In graphene, techniques such as surface modification or chemical doping have been shown to induce a band gap [2]. In this respect, the transition metals can be

considered for doping. The combination of graphene and transition metals creates a distinctive arrangement that boosts sensor sensitivity, primarily due to graphene's high surface area [3]. Graphene's large surface area, combined with its exceptional electronic and electrochemical properties, renders it particularly advantageous for biosensing applications. Very recently, we reported a computational study to showcase the possibility for direct sensing of β -D glucose using metal-doped graphene, explored through simulation approaches [4]. We found that the physisorption of glucose molecule causes high-variations in conductivity in the case of metal doped graphene sheets, except for Ni. While we studied conductivity variations in [4], this work explores the variations in vibrational frequencies of both pristine and metal-doped graphene sheets.

1571084422: Enhancing the Vibrational Sensitivity of Graphene via Substitutional Doping

Kalpanadevi P (BITS Pilani, United Arab Emirates); Aiswarya Thekkedath (BITS Pilani Dubai Campus, United Arab Emirates); Adarsh Ganesan (BITS Pilani, Dubai Campus, United Arab Emirates); K K singh (BITS Pilani Dubai Campus, United Arab Emirates)

Graphene, in its pristine form, is a zero-bandgap material. This means it does not have a natural energy gap between its valence and conduction bands, unlike conventional semiconductors like silicon. Graphene's honeycomb lattice structure leads to a peculiar energy dispersion relationship. At the Dirac points, the energy levels form a conical shape, known as the Dirac cone, and there is no gap between the bands. This characteristic allows electrons to move freely, making graphene an excellent conductor. However, the absence of a bandgap limits graphene's use in digital electronics, where a semiconductor material with an "on-off" switching behavior is required [1]. Therefore, it is essential to establish a band gap, consequently decreasing graphene's electron mobility. In graphene, techniques such as surface modification or chemical doping have been shown to induce a band gap [2]. In this respect, the transition metals can be considered for doping. The combination of graphene and transition metals creates a distinctive arrangement that boosts sensor sensitivity, primarily due to graphene's high surface area [3]. Graphene's large surface area, combined with its exceptional electronic and electrochemical properties, renders it particularly advantageous for biosensing applications. Very recently, we reported a computational study to showcase the possibility for direct sensing of β -D glucose using metal-doped graphene, explored through simulation approaches [4]. We found that the physisorption of glucose molecule causes high-variations in conductivity in the case of metal doped graphene sheets, except for Ni. While we studied conductivity variations in [4], this work explores the variations in vibrational frequencies of both pristine and metal-doped graphene sheets.

1571084764: Ibuprofen Removal from Water Using the IB-COF Covalent Organic Framework

Salama Rashed Ali Almeqbaali

The contamination of water bodies by pharmaceuticals, particularly ibuprofen, poses a significant threat to environmental and public health. This study introduces IB-COF, a novel covalent organic framework designed specifically for the extraction of ibuprofen from aqueous

solutions. Objective: The primary goal of this research is to develop and evaluate the effectiveness of IB- COF in removing ibuprofen from water, addressing the challenges posed by pharmaceutical pollutants. Methods: IB-COF was synthesized via a solvothermal method using N1-(4- aminophenyl)benzene-1,4-diamine and 4',5'-bis(4-formylphenyl)-[1,1':2,1''-terphenyl]-4,4''- dicarbalddehyde as linkers. The synthesized material was characterized using FT-IR spectroscopy, powder X-ray diffraction (PXRD), and nitrogen sorption isotherms to confirm its structural and functional properties. The adsorption performance of IB-COF was assessed through batch adsorption experiments, evaluating its capacity, kinetics, and recyclability. Major Findings: IB-COF demonstrated exceptional adsorption performance, reaching equilibrium within 60 minutes and achieving a maximum adsorption capacity of 512 mg/g. The adsorption kinetics followed pseudo-second-order and Langmuir models, indicating efficient monolayer adsorption. The material also exhibited robust recyclability, maintaining high adsorption efficiency over multiple cycles. Additionally, IB-COF showed high selectivity for ibuprofen in the presence of competing pharmaceuticals, highlighting its potential for practical water treatment applications. Significance: The development of IB-COF as an advanced adsorbent represents a significant advancement in water purification technology. Its high efficiency, stability, and selectivity make it a promising candidate for mitigating pharmaceutical pollution in water sources. This research contributes to the broader efforts of environmental purification and water pollution mitigation, offering a sustainable and effective solution to a pressing global issue.

1571047752: Electrical sensing studies on bare and doped Boron Nitride Nanosheets with Melphalan drug

Aiswarya Thekkedath (BITS Pilani Dubai Campus, United Arab Emirates); Kalpanadevi P (BITS Pilani, United Arab Emirates); K K singh (BITS Pilani Dubai Campus, United Arab Emirates)

Since anticancer medication delivery avoids secondary adverse effects and permits localised drug release close to the tumour cell, it is increasingly acknowledged as a significant scientific achievement. The current study evaluated bare boron nitride nano sheet (BNNS) and Au doped boron nitride nanosheets (BNNSAu) efficacy in drug delivery for the anti-cancer medication melphalan (Mln). To investigate the efficacy of BNNS and BNNSAu as a drug-delivery system, the ground electrical properties of BNNS, BNNSAu, melphalan, BNNS-Mln and BNNSAu-Mln were estimated. This study uses Density Functional Theory (DFT) to investigate the encapsulation of Melphalan, a commonly used chemotherapeutic drug, within BNNS as well as gold doped BNNS nano-carrier. Using theoretical simulations, the study thoroughly investigates the structural, electrical, and energetic characteristics of the BNNS-Mln drug-carrier combination. The LANL2DZ basis set and the B3LYP technique were used for all computations. Through the examination of stabilising energy and frontier molecular orbitals, the interaction between Melphalan and bare as well as doped BNNS were confirmed. Additionally, studies of Molecular Electrostatic Potential (MEP), Total Dipole Moment (TDM) and studied the transfer of charge from the Melphalan to the BNNS and gold doped BNNS. The drug target exhibits adsorption energies of -0.3164 eV and -0.937 eV with the bare BNNS and BNNSAu surface in the gas phase, respectively. Melphalan with BNNS and doped BNNS interact significantly, as indicated by their respective band gaps of 5.08, 5.04 and 1.74 eV respectively. The recovery time for bare and doped BNNS results in 0.22 μ s and 6.89 secs. From the change in bandgap values refers that doped BNNS interacted with melphalan drug shows more sensitive than bare BNNS. The

thermodynamic analysis refers that the reaction in both complex systems behave like exothermic and stable structure. This thorough investigation clarifies the complex mechanism of interaction between Melphalan and doped BNNS, highlighting the latter's potential as a viable delivery system for the anticancer medication Melphalan.

1571058098: Theoretical insights of silicene as C - reactive protein biosensors for cardiac vascular applications using Density Functional Theory/ Kalpanadevi P (BITS Pilani, United Arab Emirates);

K K singh and Aiswarya Thekkedath (BITS Pilani Dubai Campus, United Arab Emirates); Neeru Sood (BITS Pilani- Dubai Campus, United Arab Emirates); Vilas H Gaidhane (Birla Institute of Technology and Science Pilani, Dubai Campus, UAE, India)

Nanotechnology has rapidly transformed the field of biosensing by providing remarkable sensitivity and selectivity in detecting biomolecules. C-reactive protein (CRP) has become recognized as a prominent predictor of inflammation linked to cardiovascular problems. Higher levels of CRP are directly associated with a greater risk of heart attack, stroke, and peripheral artery disease, making it an essential target for bio-sensing applications. Silicene, a single layer of silicon atoms structured in a honeycomb lattice-like graphene, has emerged as a highly promising candidate for biosensing applications. Density Functional Theory (DFT) is a highly effective computational framework used to comprehend the electronic characteristics and molecular interactions that underlie the operation of biosensors. In this Study, we theoretically analysed the sensing properties of nickel doped silicene with CRP as the target molecule using DFT. Ni-Si interacts with CRP resulted with adsorption energy (ΔE) as -0.7216 eV with the binding distance as 2.01 Å which lies in the optimal range. Therefore Ni-Si sheet would be excellent candidate for reusable CRP sensor due to its strong but not excessively strong interactions with CRP molecule. For Ni-Si sheet interacts with CRP produced the negative enthalpy, Gibbs free energy and entropy values which predicts that adsorption is exothermic and spontaneous process. The change in the energy gap upon adsorption of CRP indicates that nickel doping alters the electronic properties of silicene substantially. Nickel-doped silicene sheets offer a promising platform for the development of highly sensitive CRP sensors. The material's stability, substantial change in electronic properties upon target adsorption, and strong charge transfer interactions underpin its effectiveness.

1571077624 Talk

Single-Step Fabrication of Composite Materials by Inducing Heteroatom-Doped Graphene onto Porous Organic Polymers through Femtosecond Laser Writting and Their Application in VOC Detection and Capture

Rasha Diab (Materials Science and Engineering Program, American University of Shar, United Arab Emirates); Ganjaboy Boltaev (American University of Sharjah, United Arab Emirates); Mahmoud M. Kaid (Virginia Commonwealth University, USA); Ahmad Fawad (American University of Sharjah, United Arab Emirates); Hani M. El-Kaderi (Virginia Commonwealth University, USA); Mohammad

Al-Sayah and Ali Sami Alnaser (American University of Sharjah, United Arab Emirates); Oussama El-Kadri (American University of Sharejah, United Arab Emirates)

Due to their remarkable electrical, chemical, and mechanical characteristics, graphene, a two-dimensional material made of sp²-hybridized carbon atoms arranged in a honeycomb structure, have sparked significant research interest. Among other techniques, laser-induced graphene (LIG), recognized for its simplicity, efficiency, and cost-effectiveness, has revolutionized the fabrication of graphene from various commercial and natural sources. This study presents a novel approach to creating a composite material exclusively from a porous organic polymer (POP) via one-step femtosecond laser direct writing on a naphthalene-based imide-linked POP substrate. The resulting hybrid structure, denoted as LIG@NI-POP, comprises few-layered, N and O co-doped conductive graphene layers integrated onto the microporous polyimide surface. A range of characterization techniques verified the formation of a hierarchical porous hybrid material, with substantial heteroatom self-doping within the graphene framework. By leveraging these combined properties, namely its conductivity and porosity, LIG@NI-POP was employed for volatile organic compound (VOC) sensing as a proof of concept application, demonstrating its dual functionality as both a sensor and an adsorbent for VOCs. Fine-tuning laser parameters and selecting optimal starting materials for the desired applications open new possibilities for extending laser direct writing to various porous polymers, thus broadening their potential as hybrid materials.

1571077631 Talk

Enhanced Oxygen Evolution Reaction Using Hydrothermally Synthesized V₂C MXene composites

Hamzeh Sabouni, Anum Iqbal and Nasser Hamdan (American University of Sharjah, United Arab Emirates)

The oxygen evolution reaction (OER) is a critical step in water splitting for hydrogen fuel production, underpinning sustainable energy technologies. This study investigates the catalytic performance of iron phthalocyanine (FePc), vanadium-based V₂C MXenes synthesized via hydrothermal (MX-HT) and hydrofluoric acid etching (MX-HF) methods, and their composite (FePc-MX) as OER electrocatalysts. FePc, with its central Fe ion capable of Fe²⁺/Fe³⁺ redox transitions and stable macrocyclic ligand structure, offers efficient adsorption and activation of oxygen-containing species. V₂C MXene provides a highly conductive, large-surface-area, and layered structure that enhances electron transfer and offers abundant catalytic sites. Our findings demonstrate that MX-HT not only circumvents the use of hazardous hydrofluoric acid but also shows enhanced catalytic properties over MX-HF. Linear sweep voltammetry (LSV) results indicate that the FePc-MX composite exhibits the lowest onset potential and highest current density among all tested materials, including the benchmark RuO₂, signifying superior OER activity. The composite also presents the lowest Tafel slope, reflecting the most efficient reaction kinetics. Electrochemical impedance spectroscopy (EIS) reveals that the FePc composite has the lowest charge transfer resistance (RCT) of 1.91 Ω. Stability tests confirm the composite's robustness, retaining 99.6% of its performance over 50 hours, compared to 68.7% for RuO₂,

highlighting its suitability for long-term applications. The composite's electrochemical surface area of 152.1 cm^2 shows a slight improvement over FePc alone which effectively combines the 2D nature of MXene with the rod-shaped morphology of FePc, enhancing active site availability. The FePc-MX composite emerges as a highly efficient and stable OER electrocatalyst, outperforming both its individual components and the benchmark RuO_2 .

1571058190 Talk

Mechanical properties of freestanding cellular lattices made of pristine $\text{Ti}_3\text{C}_2\text{T}_x$ MXene/
Abdallah Kamal Hamouda and BaoSong Li (Khalifa University, United Arab Emirates);
Abdullah Solayman (Researcher, United Arab Emirates); Lianxi Zheng (Khalifa University,
United Arab Emirates); Kin Liao (Aerospace Engineering, United Arab Emirates)

Two dimensional (2D) materials, such as graphene and MXenes, exhibit multifunctionality due to their wide range of outstanding properties. Thus, they represent appropriate solutions for many technological challenges [1]. Investigating the various properties of such materials in various freestanding three dimensional (3D) architectures is essential. The mechanical properties of rGO lattices showed high sensitivity toward the relative density, lattice's form and the number of unit cells [2]. Similarly, gyriodal cellular lattices made of $\text{Ti}_3\text{C}_2\text{T}_x$ MXenes exhibit ultrasensitive micromechanical sensing applications [3]. High sensitivity (139 Pa^{-1}) was achieved by refining the dip coating process which makes it an appropriate candidate for multifunctional application. Additive manufacturing (AM) of customized architecture, made of freestanding 2D materials, showed high capability to acquire preferable properties [4]. Accordingly, investigating the mechanical performance of such lattices is of interest. Additionally, optimizing the structural parameters to get robust lattices for multifunctional applications. In this study, the mechanical properties of gyriodal architected cellular lattices made of pristine $\text{Ti}_3\text{C}_2\text{T}_x$ MXene are experimentally investigated. The parameters of dip coating process are optimized to acquire robust lattices. Figure 1a illustrates the fabrication approach of MXene lattices. Additionally, the influence of number of unite cell (Figure 1c) and the lattice's relative density on the compression strength are investigated. X-ray diffraction (XRD) and Raman spectroscopy were used to prove complete etching of MAX phase (Ti_3AlC_2) and confirm successful synthesis of $\text{Ti}_3\text{C}_2\text{T}_x$ MXene. Scanning electron microscope (SEM) was used to examine the nanoflakes' alignment after thermal etching of castable wax scaffold as shown in Figure 1b. The results show that the fabrication approach, lattice's geometry and lattice's parameters have impact on the compression strength of the obtained MXene lattices.

1571058134 Talk

Mechanical properties of freestanding cellular lattices made of pristine $\text{Ti}_3\text{C}_2\text{T}_x$ MXene
Abdallah Kamal Hamouda and BaoSong Li (Khalifa University, United Arab Emirates);
Abdullah Solayman (Researcher, United Arab Emirates); Lianxi Zheng (Khalifa University,
United Arab Emirates); Kin Liao (Aerospace Engineering, United Arab Emirates)

Two dimensional (2D) materials, such as graphene and MXenes, exhibit multifunctionality due to their wide range of outstanding properties. Thus, they represent appropriate solutions for many

technological challenges [1]. Investigating the various properties of such materials in various freestanding three dimensional (3D) architectures is essential. The mechanical properties of rGO lattices showed high sensitivity toward the relative density, lattice's form and the number of unit cells [2]. Similarly, gyroidal cellular lattices made of Ti₃C₂T_x MXenes exhibit ultrasensitive micromechanical sensing applications [3]. High sensitivity (139 Pa⁻¹) was achieved by refining the dip coating process which makes it an appropriate candidate for multifunctional application. Additive manufacturing (AM) of customized architecture, made of freestanding 2D materials, showed high capability to acquire preferable properties [4]. Accordingly, investigating the mechanical performance of such lattices is of interest. Additionally, optimizing the structural parameters to get robust lattices for multifunctional applications. In this study, the mechanical properties of gyroidal architected cellular lattices made of pristine Ti₃C₂T_x MXene are experimentally investigated. The parameters of dip coating process are optimized to acquire robust lattices. Figure 1a illustrates the fabrication approach of MXene lattices. Additionally, the influence of number of unite cell (Figure 1c) and the lattice's relative density on the compression strength are investigated. X-ray diffraction (XRD) and Raman spectroscopy were used to prove complete etching of MAX phase (Ti₃AlC₂) and confirm successful synthesis of Ti₃C₂T_x MXene. Scanning electron microscope (SEM) was used to examine the nanoflakes' alignment after thermal etching of castable wax scaffold as shown in Figure 1b. The results show that the fabrication approach, lattice's geometry and lattice's parameters have impact on the compression strength of the obtained MXene lattices.

1571057670 Talk

Basic Characterization of SiCN ceramics

Adam Otabil (Khalifa University, United Arab Emirates)

Polymer derived ceramics (PDCs) are highly sought after for a wide range of applications, such as aerospace, defense, electronics, photonics, and biological purposes. PDCs can be synthesized using the process of pyrolysis, which involves subjecting preceramic polymers (PCP) to high temperatures in an inert atmosphere. In this study, SiCN ceramics was synthesized according to Dory et al.,[1]. 5 ml of cyclosilazane were put to a beaker and dissolved in 5 ml of trimethoxysilylpropylmethacrylate (TMSPM) while stirring. To initiate the sol-gel procedure for grafting of the TMSPM 200 µl of a 2 M solution of HCl were added. The reaction time was adjusted to 12 hours while being stirred magnetically at ambient temperature. The photoactive preceramic polymers were obtained after a 12-hour period. The material was subjected to UV curing for a duration of 10 minutes, followed by thermal curing for a period of 16 hours, and then pyrolyzed at a temperature of 1300 oC. No visible cracks or defects were seen in the cured and pyrolyzed sample as shown in Figure 1. The pyrolysis of pre-ceramic resulted in SiCN ceramic with 33% yield and 18% shrinkage. As seen in Figure 2(a), the XRD pattern of the pyrolyzed sample depicted phases of SiO₂, β-SiC and carbon. The carbon phases were confirmed with the Raman analysis. As shown in Figure 2(b), the Raman spectra exhibited two characteristic attributes of disordered graphitic carbon at 1332 cm⁻¹ and 1620 cm⁻¹, which correspond to the D and G bands, respectively. [2]

1571080134 Talk

MoS₂ / conducting polymer hybrid electrodes for enhanced electrochemical sensing

Sara Awni Alkhatib, Mohammad Moeaz Barazi and Nabila Yasmeen (Khalifa University, United Arab Emirates); Kishore K Jena (Research Scientist, United Arab Emirates); Sagar Arya and Vincent Chan (Khalifa University, United Arab Emirates); Kin Liao (Khalifa University of Science Technology and Research, United Arab Emirates); Leontios J. Hadjileontiadis (Khalifa University, United Arab Emirates & Aristotle University of Thessaloniki, Greece); Anna Maria Pappa (Khalifa University, United Arab Emirates); Kyriaki Polychronopoulou (Khalifa University of Science and Technology, United Arab Emirates)

Artificial biocatalysts, if designed properly can be more stable and cost-effective as compared to actual enzymes. 2D materials are indeed particularly promising in electrochemical and biocatalytic sensing due to their high surface area, sensitivity, and ion-intercalation surface morphologies [1]. In this study, we report on the development of a hybrid molybdenum disulfide / poly(3,4-ethylenedioxythiophene) polystyrene sulfonate (MoS₂/PEDOT: PSS) nanocomposite electrode, for enhanced electrochemical sensing performance. By combining the high surface area and catalytic activity of MoS₂ nanosheets with the superior conductivity of PEDOT: PSS [2], [3], we create a platform that exhibits improved sensitivity and selectivity for the detection of electroactive biomolecules including ascorbic acid (AA), Dopamine (DA), and hydrogen peroxide (H₂O₂).

MoS₂ nanosheets were synthesized via a hydrothermal process, and the composite films were deposited on screen-printed carbon electrodes (SPCE) via spin-coating to form a uniform MoS₂/PEDOT: PSS hybrid layer. The resulting electrodes were characterized using SEM, TEM, and Raman spectroscopy to confirm the morphology and structure of the nanocomposite (Fig. 1b). The detection mechanism at the MoS₂/PEDOT: PSS hybrid electrode begins with the diffusion of analytes such as H₂O₂, DA, and AA towards the electrode surface (Fig. 1a). Once adsorbed, the analytes undergo electrochemical reactions, facilitated by the large surface area of MoS₂. The integration of PEDOT: PSS significantly enhances electron transfer kinetics by providing an efficient pathway for charge transport, improving conductivity and reducing resistance. The hybrid electrode exhibited a stable and reproducible electrochemical response, with enhanced electron transfer kinetics compared to MoS₂ alone as depicted in figure 1d.

For H₂O₂, the MoS₂/PEDOT: PSS electrode displayed a clear reduction peak at approximately -0.4 V vs Ag/AgCl, with increasing peak currents correlating with higher H₂O₂ concentrations (5 nM to 10 μM). Similarly, DA detection was achieved over a wide concentration range (from 1 fM to 1 mM), showing a strong linear relationship between current and concentration, highlighting the enhanced sensitivity of the hybrid film. AA detection was also demonstrated, with distinct anodic peaks in the DPV curves that increased in magnitude with increasing concentration ranging from (100 aM to 100 μM), confirming the capability of the electrode to detect AA (Fig. 2).

These results highlight the potential of MoS₂/PEDOT: PSS hybrid electrodes for clinical biosensing applications, offering high sensitivity, stability, and selectivity for the simultaneous detection of H₂O₂, DA, and AA. This methodology establishes the groundwork for subsequent investigation of two-dimensional materials combined with conducting polymers for electrochemical biosensing technologies.

1571076045 Talk/

Sulfonated Polyethersulfone/Montmorillonite Nanocomposite Cation Exchange Membrane for Enhanced Salinity Gradient Power

Randa Ibrahim Fathy (Khalifa University, United Arab Emirates); Emad Alhseinat (Professor of Chemical Engineering, United Arab Emirates)

Reverse Electrodialysis (RED) demonstrates the potential for power generation utilizing salinity gradients, offering the distinct advantage of direct conversion of salinity gradients into electricity, termed Salinity Gradient Power (SGP). Consequently, RED holds promise for providing a sustainable and clean energy source while facilitating the treatment of intricate wastewater with elevated salinity levels. However, challenges such as low energy efficiency and substantial membrane costs have impeded the widespread adoption of this technology. Addressing these challenges necessitates the development of high-performance and cost-effective Ion Exchange Membranes (IEMs), crucial for the scalable implementation of RED in harvesting energy from salinity gradients in water. The amalgamation of nanocomposite structures has attracted considerable attention in scholarly investigations due to the synergistic outcomes arising from the distinctive characteristics of both inorganic and organic constituents. The initial proposal for nanocomposite structures designed specifically for IEMs in RED applications was introduced by Hong and Chen in 2014 [1]. Clays have undergone examination as potential additives to enhance the properties of conductive polymers [2], [3]. Various clay minerals, including Montmorillonite (MMT), kaolinite, illite, and chlorite, have gained widespread application across diverse domains due to their abundant availability, versatility, cost-effectiveness, high surface area-to-volume ratio, environmentally friendly characteristics, robust thermal and chemical stability, suitability across a broad pH range, and facile modification or functionalization possibilities [4]. These clay minerals also exhibit electrical conductivity [5]. MMT, a 2:1 layered silicate mineral, comprises layers (~1 nm) consisting of two O-Si-O tetrahedral sheets enveloping one O-Al (Mg)-O octahedral sheet, with adjacent layers connected through van der Waals and electrostatic forces [6]. Consequently, MMT not only influences the electrochemical attributes of ion exchange membranes, such as ion conductivity and permeability, but also impacts their thermal and mechanical stability [5]. This work extensively investigates the development of innovative nanocomposite cation exchange membranes (CEMs) designed for RED, emphasizing membrane materials to overcome economic barriers impeding the widespread commercialization of RED technology. The study explores the incorporation of MMT to enhance the selectivity and electrical properties of Sulfonated Polyethersulfone (SPES) membranes. Furthermore, various analytical methods, including Fourier-transform infrared (FTIR) and X-ray Powder Diffraction (XRD),

as well as atomic force microscopy (AFM), were employed to investigate the properties of MMT and SPES polymer and their interactions within the nanocomposite membrane. It has been observed that hydrogen bonding interactions between the -OH groups of the sulfonic moiety in the SPES polymer and the -OH groups of MMT significantly contribute to enhancing the open circuit potential, resulting in an impressive cation transference number of 97% under 10-fold. This interaction also brings about a substantial decrease in internal resistance. Consequently, a notable tenfold increase in power density is achieved. These outcomes emphasize the potential of incorporating MMT as a viable strategy for fabricating nanocomposite CEMs with advanced performance characteristics, particularly well-suited for applications in RED.

1571056069/Talk

Investigation of Tunable Bilayer Structures in rGO/SiO₂ Memristors for Enhanced Neuromorphic Applications

Harsh Ranjan, Chandra Prakash Singh and Vivek Pratap Singh (Indian Institute of Technology Patna, India); Saurabh Pandey (IIT Patna, India)

This study investigates hybrid memristors that integrate Silicon di Oxide (SiO₂) and graphene oxide (GO) to leverage their respective benefits. While SiO₂ offers stability and durability, GO, on the other hand, provides significant tunability for simulating synaptic functions but may face stability issues. Combining these materials aims to create a versatile memristor that enhances performance across various neuromorphic computing applications

1571058202/Talk/

Alkylated chitosan nanomaterials for enhanced antimicrobial activity and delivery of fusidic acid: Preparation and preliminary in vitro investigation

Aisha Salam (Al Ain University, UAE)

Nanomaterials manufactured of amphiphilically-altered polysaccharides have sparked a great deal of interest due to their capability to elevate drug transport across the skin. The study presents the fabrication of alkylated chitosan through 2-tert-butoxymethylloxirane alteration (alkylation degree 29.7%), that was typified by spectroscopic, chromatographic, and thermal analysis approaches before being constructed into nanomaterials for the analysis of their capability in governing fusidic acid diffusion percutaneously. The nanomaterials were constructed via the ionic interaction of positively charged chitosan and negatively charged cross linker sodium tripolyphosphate, with a loading degree of fusidic acid of ca. 20% reported. Fusidic acid release was slower in nanomaterials constructed of alkylated chitosan than in neat chitosan. Under application-relevant conditions, in vitro incubation with HaCaT cells exhibited insignificant toxicity. Using Franz diffusion cells, the alkylated chitosan nanomaterials induced fusidic acid to infiltrate the Strat-M[®] membrane at a 2-fold greater rate than the neat chitosan nanomaterials. Based on the agar diffusion test, fusidic acid was shown to have better antimicrobial activity when loaded into alkylated chitosan nanomaterials than when loaded into neat chitosan nanomaterials. Ultimately, the in vitro results revealed that alkylated chitosan nanomaterials offer a great deal of potential for percutaneous delivery, which merits greater analysis. KEYWORDS chitosan, fusidic acid, nanomaterials, percutaneous delivery, polymer alkylation

1571078789/Talk/

CONDUCTING POLYMER SCAFFOLDS BASED ON PEDOT: PSS and MXENE COMPOSITES FOR DRUG DELIVERY IN WOUND HEALING APPLICATIONS/

Khulood Hasan AlShehhi, Charalampos Pitsalidis and Shahd Badr Alshehhi (Khalifa University, United Arab Emirates)

Conducting polymers have emerged as promising materials for tissue engineering and biomedical application due to their unique electrical, chemical, and mechanical properties. Recent developments have demonstrated the engineering of conducting polymer into various forms, including films, hydrogels, and nanofibers, providing versatile bioelectronic platforms for interfacing living tissues. We herein investigate the synthesis and characterization of conducting composite scaffolds based on poly(3, 4-ethylenedioxythiophene)(styrenesulfonate) (PEDOT: PSS) and MXene. Scaffolds are prepared with varying ratios of MXene to PEDOT: PSS to examine their influence on structural properties, drug release, and antibacterial efficacy. Tetracycline hydrochloride (TCH) is incorporated into the scaffolds to develop drug-loaded systems. The TCH release profile is monitored at multiple time points to evaluate the impact of scaffold composition on release kinetics. Additionally, the antibacterial efficacy of the TCH-loaded scaffolds is tested against two different bacteria strains; *Pseudomonas aeruginosa* and *Escherichia coli* via both agar plate diffusion and bacterial growth inhibition assays. The results demonstrate that the ratio of MXene to PEDOT: PSS significantly affects the scaffold's morphology, swelling behavior, drug release profiles, and antibacterial activity. Scaffolds with different compositions show varied performance, providing insights into optimizing these materials for targeted drug delivery and infection control. This study suggests that MXene and PEDOT: PSS scaffolds have significant potential as multifunctional platforms for controlled drug release and antibacterial applications, contributing to the development of more effective and tailored therapeutic strategies.

1571085060/Talk/

Engineering Lead-Free BiFeO₃-BaTiO₃ Ceramics for Large Piezoelectric Performance Through A/B Site Ion Replacement/

Tauseef Ahmed (King Fahad University of Petroleum and Minerals Saudi Arabia, Saudi Arabia)

Developing high-temperature lead-free piezoelectric ceramics with exceptional electromechanical properties at low fields and room temperatures is challenging. Lead-free BiFeO₃-BaTiO₃ ceramics doped with B-site donors (BF-BT(1-x)Tax) and A-site isovalent (BF-B(1-y)CayT) have been investigated for use in piezoelectric actuators. B-site donor doping significantly enhanced the ceramics piezoelectric performance, achieving a strain (S) of ~0.2982% at a low field of ~3.5 kV/mm, d₃₃ ~851 pm/V at room temperature (RT), and S ~0.358%, d₃₃ ~1023 pm/V at 90 °C. In contrast, A-site isovalent doping resulted in lower S ~0.2632% at 5.0 kV/mm, d₃₃ ~526 pm/V at RT, and S ~0.3041% with d₃₃ =871 pm/V at 90 °C). Furthermore, the B-site donor yielded a higher d₃₃ (~201 pC/N at RT and ~230 pC/N at 90 °C) than A-site isovalent doping (~192 pC/N at RT and ~223 pC/N at 90 °C). This exceptional piezoelectric performance can be attributed to the optimal grain size, high density, enhanced domain switching, reduced oxygen vacancy, local structural heterogeneity, and maximum lattice distortion. This study highlights the critical role of A/B site doping in enhancing BF-BT ceramic performance, particularly with donor elements. These findings provide valuable insights into the future design of high-performance piezoceramic materials.

1571074535/Talk

Multifunctional Sustainable Nanofibrous Membranes and Their Applications in Filtrations

Juraj K (United Arab Emirates University & College of Engineering, United Arab Emirates); Akmal Nazir and Yaser Greish (United Arab Emirates University, United Arab Emirates); Prasanna Kumar S Mural (Indian Institute of Technology Bombay, India); Muhammad Zafar Iqbal (UAE University, United Arab Emirates)

Abstract

Due to the detrimental effects and environmental persistence of traditional polymers, sustainable polymer materials are emerging as the next-generation materials in the filtration sector [1]. Electrospinning is a robust method to fabricate electrospun nanofibrous membranes (ENMs) from polymer solution or melt with high porosity for filtration applications [2]. In this presentation, we will present ENMs from polymer blend for switchable premix membrane emulsification/demulsification and water filtration applications. From the various blend ENMs, optimization was done based on the average fiber diameter, porosity, pore size, and morphology analysis. Compared to the polylactic acid (PLA) nanofibers, the developed blend nanofibers showed a smaller fiber diameter in the range of 150 -200 nm with the incorporation of the poly (ethylene furanoate) (PEF), whereas PEF nanofibers showed the least fiber diameter of 110 nm. The optimized 2:3 PFLA (PEF/PLA) ENM exhibited better chemical, mechanical, thermal, and permeation properties compared to neat PEF and PLA ENMs. The presence of two glass transition temperatures (T_g) with a significant shift in their position in the optimized blend ENM was attributed to the homogenization effect of electrospinning to form a partially miscible blend ENM. Furthermore, tunable hydrophilic wettability of PEF-based ENMs was observed using trifluoroacetic acid (TFA) solvent. The optimized PFLA ENM exhibited hydrophilicity with a static contact angle of 66° , and superhydrophilicity was confirmed with a dynamic contact angle of 0° after 5 s. A remarkably higher water flux of $15 \times 10^4 - 72 \times 10^4 \text{ L m}^{-2} \text{ h}^{-1}$ was observed at various pressures (1 -5 bar). Theoretically, the antifouling nature of the developed membranes was investigated by Hermia fouling models. PEF and optimized ENMs were not the best fit with any Hermia fouling models, whereas the PLA ENM was best fitted with the cake formation model. The optimized 2:3 PFLA ENM showed switchable emulsification and demulsification by controlling surfactant to oil ratio in the oil-in-water (O/W) coarse emulsion and exhibited significant emulsification and demulsification efficacy comp

ORAL: MN-D

1571075856: Boosting the performance of magnetic nanoparticles: magnetic field-assisted assembly and magnetic functionalization

Jana K Vejpravova (Charles University, Czech Republic)

The magnetic properties of single-domain nanoparticles are primarily determined by three key factors: phase composition, particle size, and lattice/spin disorder. At the individual

nanoparticle level, these properties are relatively straightforward, but when nanoparticles interact, collective effects such as dipolar interactions begin to play a significant role. These interactions alter the magnetic behavior, providing opportunities to engineer materials with tailored magnetic properties.

One of the most exciting advancements in this field is the organization of nanoparticles into anisotropic structures, a bottom-up approach that enables precise control over magnetic anisotropy at the mesoscopic scale. By assembling nanoparticles into specific geometries, researchers have been able to create highly anisotropic magnetic materials, which have wide-ranging applications in drug delivery, bioanalysis, data and energy storage, sensing technologies, and catalysis. The ability to manipulate magnetic properties at this level is particularly attractive for applications that require highly specific magnetic behaviors.

An important method for achieving such organized nanostructures is magnetic field (MF)-assisted self-assembly. This approach has drawn significant attention due to its ability to organize magnetic colloids into well-defined structures such as fibers, chains, tubes, and circles. These architectures offer enhanced control over magnetic properties and have opened up new possibilities for creating materials with customizable magnetic characteristics.

In this presentation, I will explore some of the most promising strategies for MF-assisted organization of magnetic nanoparticles. In addition to reviewing current techniques, I will introduce a novel concept known as MF-assisted click chemistry. This technique is based on the thermoreversible Diels-Alder reaction, which, when conducted in the presence of an external magnetic field, allows for the creation of highly anisotropic assemblies of nanosized magnets. These assemblies can be reversibly decomposed through thermal treatment, offering a flexible and innovative approach to designing magnetic materials.

Finally, I will discuss the development of hybrid nanoparticles functionalized with magnetic molecules. These hybrid systems represent a frontier in nanoparticle research, combining the unique properties of both inorganic and organic magnetic materials. Such functionalized nanoparticles could lead to breakthroughs in various fields, from medical diagnostics to advanced data storage systems. Overall, the advances in MF-assisted self-assembly and hybrid nanoparticle design are pushing the boundaries of what can be achieved with magnetic nanomaterials.

1571077221: Tuning Magnetic Properties in Core/Shell Nanoarchitectures: Shell Thickness Effects on Anisotropy and Interparticle Interactions

Davide Peddis (Università di Genova, Italy & CNR-ISM, Italy)

In this study, we explore the impact of shell thickness on the magnetic characteristics of core/shell magnetic nanoarchitectures (MNAs), using semi-hard cobalt ferrite (CoFe_2O_4) cores encased in soft nickel ferrite (NiFe_2O_4) shells [1]. These materials were selected as model hard and soft magnetics due to their magnetic anisotropy constants differing by two orders of

magnitude [2]. We synthesized CoFe₂O₄ cores with an average diameter of ~9 nm and systematically varied the NiFe₂O₄ shell thickness (~1, 3, and 6 nm) using a seed-mediated high-temperature decomposition method [3-5] (Figure 1a-d). The resulting MNAs are compositionally-graded single crystals, exhibiting crystallographic coherence between core and shell without a discernible interface at the atomic level (Figure 1f). Our findings reveal that these core/shell MNAs behave as single magnetic units in the rigid exchange coupling regime (Figure 1e). Notably, we observed a non-monotonic relationship between coercivity and shell thickness, which we attribute to the interplay of various magnetic anisotropies (e.g., magneto-crystalline and surface) and interparticle dipolar interactions. To support our experimental results, we conducted Monte Carlo simulations using a mesoscopic model that incorporates both nanoparticle morphology and interparticle interactions. The simulation outcomes show good qualitative agreement with our experimental data, providing insights into the underlying mechanisms governing the magnetic behavior of these MNAs.

1571075554: Thin-Film Heterostructures Based on Co/Ni Synthetic Antiferromagnets on Polymer Tapes: Toward Sustainable Flexible Spintronics

Mariam Hassan (CNR-ISM & University of Augsburg, Italy); Sara Laureti (CNR - ISM, Italy); Davide Peddis (Università di Genova, Italy & CNR-ISM, Italy); Christian Rinaldi and Federico Fagiani (Politecnico di Milano, Italy); Gianni Barucca (Università Politecnica Delle Marche, Italy); Francesca Casoli (CNR-IMEM, Italy); Alessio Mezzi, Eleonora Bolli and Saulius Kaciulis (CNR-ISMN, Italy); Aladin Ullrich (University of Augsburg, Germany); Manfred Albrecht (Universität Augsburg, Germany); Gaspare Varvaro (National Research Council, Italy)

Synthetic antiferromagnets with perpendicular magnetic anisotropy (PMA-SAFs), consisting of two ferro(i)magnetic layers separated by a non-magnetic spacer, have caught big interests for both conventional and advanced spin-based applications [1]. Although great progress of PMA-SAF spintronic devices on rigid substrates has been achieved, only few examples on flexible thin film heterostructures, all containing platinum group metals (PGMs), are reported in the literature [2-4]. In this regard, Co/Ni system can offer additional advantages (e.g., low damping, high spin polarization) for the development of advanced spin-based devices [5]. Moreover, decreasing the content of critical PGM elements is responsible for relieving the demand for strategic raw materials (CRMs) and reduce the environmental impact of related technologies, thus contributing to the transition towards a more sustainable future [6]. In this work [7], we delve into the pioneering fabrication of sustainable and flexible Co/Ni-based PMA-SAFs and magneto-resistive (MR) spin-valves (SVs) containing a SAF reference electrode (RL) and a Co/Ni free layer (FL) deposited on flexible polyethylene naphthalate tapes. Diverse combinations of buffer (BL) and capping (CL) layers, including critical (Pt, Pd) and non-critical (Cu/Ta) elements were explored with the aim of further reducing the CRMs' content. High-quality flexible SAFs with a fully compensated AF region and SVs with a sizeable MR ratio (up to 4.4%), in line with the values reported in the literature for similar systems on rigid substrates, have been obtained in all cases. However, due to the different interdiffusion mechanisms occurring at the interface between the metallic layers, we demonstrated that while PGMs allow obtaining the best results when used as BL, Cu is the best choice as CL to optimize the properties of the stacks. To explore the possibility to integrate such flexible systems on curved surfaces, MR measurements under a bending angle of 180° were performed (curvature $\kappa = 1/r = 0.4 \text{ mm}^{-1}$, $\sigma \cong 8.5 \text{ GPa}$). Compared to the planar structure, the MR curves of flexible spin valves show very similar features and a slight reduction (<15%) of the maximum MR ratio demonstrating the high robustness of the samples' properties against bending. The results indicate that complex and bendable Co/Ni-based heterostructures with reduced content of PGMs can be obtained on flexible tapes, allowing for the development of novel flexible and sustainable spintronic devices for applications in many fields including wearable electronics, soft robotics, and biomedicine.

1571062889: Hexagonal Diamond Synthesis with Cobalt Nanowires Using Porous Alumina Template

Mohammed Bin afif (Khalifa University, United Arab Emirates); Daniel Choi (Khalifa University of Science and Technology, United Arab Emirates); Faisal A AlMarzooqi (Khalifa University & Masdar Institute, United Arab Emirates)

By electrolysis of organic solution containing methanol an attempt is made to synthesize hexagonal diamond. The process involved electrodeposition of cobalt nano wires on an

anodized alumina template, followed by electrodeposition of organic solution containing methanol resulting in synthesis of hexagonal diamonds. Following deposition etching was performed to remove Ag, Al, and Co using different etchants. The samples were investigated by SEM and TEM, and it was found that they included impurities. Presence of Ag and Co was confirmed by EDS, the etching process did not entirely remove, these substances.

1571077887: Disentangling Anisotropy Contributions in Mn-mixed Ferrite Nanoparticles

Marianna Gerina (Charles University, Czech Republic); Marco Sanna Angotzi (Italy); Valentina Mameli (University of Cagliari, Italy); Michal Mazur (Charles University, Czech Republic); Nicoletta Rusta (University of Cagliari, Italy); Elena Balica (Universita di Firenze, Italy); Pavol Hrubovčák (P.J. Šafárik University, Slovakia); Carla Cannas (University of Cagliari, Italy); Dirk Honecker (ISIS Neutron and Muon Facility, United Kingdom (Great Britain)); Dominika Zakutná (Charles University, Czech Republic)

Tailoring magnetic nanoparticles (NPs) by choosing a suitable combination of size, shape, and material is the basis for realizing various technological (data storage, spintronics)[1], biomedical (magnetic hyperthermia, drug delivery)[2], or environmental applications. The macroscopic physical properties of magnetic NPs rely on magnetic anisotropy, and their understanding is fundamental to the design of magnetic materials for different applications. Nevertheless, magnetic anisotropy is influenced by the shape, crystal structure, surface effects, and interactions. To understand these properties comprehensively, it is essential to investigate all the factors contributing to the total effective magnetic anisotropy. Conventional magnetic measurements like DC magnetization and AC susceptibility provide an overview of the macroscopic physical properties but do not reveal the detailed microscopic phenomena that drive these properties. This is where small-angle polarized neutron scattering (SANS POL) comes into play, offering sub-atomic resolution and serving as a powerful tool for studying surface anisotropy[3] and microscopic phenomena. In this contribution, we will show the impact of the Mn-doping level in cobalt ferrite NPs (10 nm) on their magnetic properties. Nevertheless, the macroscopic magnetic responses of the Mn-mixed cobalt ferrite NPs were inconclusive and inconsistent with changing Mn content. However, we will demonstrate the versatility of SANS POL and disentangle all anisotropy contributions of the total magnetic anisotropy of a series of Mn-mixed Cobalt ferrite NPs with different Mn content but the same shape, size, and surfactant and correlate it with their macroscopic response[4]. Ultimately, our work aims to clarify the complicated picture of magnetic anisotropy and offer insights into the design of magnetic materials.

Acknowledgments The authors thank ISIS Neutron and Muon Source for providing the beamtime (RB2220620- 1). The authors acknowledge the assistance provided by the Advanced Multiscale Materials for Key Enabling Technologies project, supported by the Ministry of Education, Youth, and Sports of the Czech Republic. Project No. CZ.02.01.01/00/22_008/0004558, Co-funded by the European Union. DZ has been supported by Charles University Research Centre program No. UNCE/24/SCI/010, and MG by the Grant Agency of Charles University: GAUK 267323.

References [1] P. Bender and et al. J. Phys. Chem. C 122 (2018) 3068. [2] A. Lak, S. Disch and P. Bender Adv. Science 8 (2021) 2002682. [3] M. Gerina, D. Zákutná and et al., Nanoscale Adv. 5

(2023) 4563-4570. [4] M. Gerina, D. Zákutná and et al. ArXiv (2024). <https://doi.org/10.48550/arXiv.2409.03736>

ORAL: NPO-F

1571075619: Processing of Si-Er-O Nanostructures by Energetic Ar⁺ Beam Irradiation for Efficient Light Emission at the Light at the 4f Intraband Transition

Sufian Abedrabbo (Khalifa University, United Arab Emirates); Mohammad M. Zeidan (Higher Colleges of Technology, United Arab Emirates); Ali Abdullah (Khalifa University of Science and Technology, United Arab Emirates); I. A. Qattan (Khalifa University, United Arab Emirates); Jamal Hassan (Khalifa University of Science and Technology, United Arab Emirates); Anthony T. Fiory (Integron Solutions LLC., United Arab Emirates)

In the pursuit of developing cost-effective optically active media for silicon-based infrared emitters, we employed a multi-step fabrication process to create silicon films doped with erbium (Er) and oxygen (O). The process involved physical vapor deposition (PVD) followed by ion beam surface modification (IBM) and oxygen incorporation that are facilitated by Ar⁺ and O₂⁺ implantation, and thermal annealing techniques. The resulting silicon films, denoted as Si-Er-O, demonstrated efficient room-temperature emission, indicative of 4f transitions. Notably, the observed photoluminescence manifests Stark-split 4I_{13/2} - 4I_{15/2} transitions characteristic of Er³⁺ impurity centers mimicking that of Er in optical fiber materials. The concentration distributions of the dopants within the films were determined utilizing Rutherford backscattering spectrometry (RBS). The main finding of this study is the correlation between Er concentration, oxygen presence, and optical activity in Si-Er-O films. Results demonstrate that the optical activity of Er³⁺ ions rise with the O/Er atomic concentration ratio, peaking at a specific ratio; corroborating with earlier results from other researchers including the notable work of Coffa et al. Elevated Er concentration correlates with decreased photoluminescence (PL) signals, confirming that Er-O association enhances optically active Er³⁺, while Er-Er association inhibits it. This optimal balance suggests potential improvements in LED manufacturing via PVD. More importantly, the efficacy of IBM is evident in its role in enhancing Er thermal diffusion and achieving optimum optical activation. Furthermore, the study highlights the importance of controlling processing conditions to achieve desired composition and properties, with implications for enhancing LED efficiency, especially in the infrared spectral range.

1571078739: Non-Volatile Phase Trimming of Silicon Photonics Using 2D InPSe Integration in Microring Resonators

Mahmoud Rasras (NYU AD, United Arab Emirates); Ghada Dushaq (New York University, United Arab Emirates); Srinivasa Reddy Tamalampudi (New York University Abu Dhabi, United Arab Emirates)

This study introduces a novel approach for enhancing silicon photonics by integrating a two-dimensional (2D) In₄/3P₂Se₆ (InPSe) layer into silicon microring resonators (Si-MRRs). The integration mitigates laser power sensitivity while enabling non-volatile phase trimming through applied bias voltage. Achieving a non-volatile blue phase shift ranging from -3 to -9 pm/V and effective index modulation of 2.29×10^{-3} , the platform demonstrates a wavelength trimming rate

of -24.0 pm/min under a -10V bias. With minimal optical losses of ~0.051 dB/phase shifter, this method improves data transmission and operational stability, advancing high-power applications within compact photonic designs.

1571076441: Investigating Chemical Bonding and Photonic Performance in Erbium-Doped Silica Films

Ali Abdullah (Khalifa University of Science and Technology, United Arab Emirates); El Mostafa Benchafia (New Jersey Institute of Technology, USA); Daniel Choi (Khalifa University of Science and Technology, United Arab Emirates); Sufian Abedrabbo (Khalifa University, United Arab Emirates)

Erbium-doped silica films are pivotal in advancing photonic and optoelectronic technologies due to their unique light-emitting properties [1]. Rare earth doping, particularly with Erbium, has emerged as a critical strategy for enhancing the optical performance of silica-based materials. Erbium ions (Er^{3+}) are well known for their ability to emit in the 1.5 μm wavelength range [2], making them especially valuable for telecommunications, where this wavelength corresponds to the low-loss window of optical fibers [3]. Moreover, the 4f electronic transitions of rare earth ions, such as erbium, are shielded by outer 5s and 5p electrons, which makes them less sensitive to the surrounding host matrix and more stable under varying environmental conditions [4]. This shielding ensures sharp emission lines and long-lived excited states, ideal for applications in lasers and amplifiers. In this study, erbium-doped silica films were synthesized via a two-step acid-base-catalyzed sol-gel method, with doping concentrations ranging from 0.2% to 6% and annealing temperatures between 500°C and 900°C. The films exhibited significant photoluminescence, particularly at 3% and 6% doping levels when annealed at 800°C and 900°C, revealing dominant 4f transitions of Er^{3+} ions. These transitions are critical as they allow for efficient energy transfer and light emission. X-ray Photoelectron Spectroscopy (XPS) provided detailed insights into the chemical bonding within the films, revealing distinct erbium-oxygen and silica bonds. Shifts in binding energies highlighted a clear interaction between erbium and the silica matrix, suggesting that erbium plays a stabilizing role, further enhancing the material's optical properties. Rare earth ions, such as erbium, tend to form strong chemical bonds with oxygen, which in turn modifies the local electronic environment, enabling better control over the optical output of the doped silica films. Complementary structural analysis using X-ray diffraction (XRD) revealed the amorphous nature of the films, with subtle phase changes detected at higher doping concentrations. The emergence of erbium silicate phases such as $\text{Er}_2\text{Si}_2\text{O}_7$ and Er_2SiO_5 contributed to the enhanced photoluminescence, demonstrating a strong correlation between doping levels, annealing temperatures, and optical performance. These phases are important because they help maintain the distribution of erbium ions, preventing clustering and ensuring uniform emission. This characteristic is crucial for achieving high efficiency in light-emitting devices. These findings provide new avenues for tuning the chemical and structural properties of erbium-doped silica films, with promising applications in high-performance photonic devices, pushing the boundaries of modern optoelectronics.

1571070375: Additive Manufacturing of Photonic Devices from Nanocomposite Materials

Haider Butt (Khalifa University, United Arab Emirates); Fahad Aalam (King Fahd University of Petroleum & Minerals, Saudi Arabia); Dileep Chekkaramkodi, Murad Ali and Israr Ahmed (Khalifa University, United Arab Emirates)

Additive manufacturing (3D printing) is a disruptive method that enables fabrication of complex and multifunctional optical devices that can be utilized for sensing and biomedical applications. Advancements in the development of a diverse range of 3D printable materials, from biocompatible to metallic materials, including polymers, hydrogels, and their composites, have paved the path to broaden the prospects of sensing and optical devices for research as well as for commercial purposes. The capability of open-source 3D printers allows for the usage of customized materials for printing according to the requirements of the targeted applications. In the current work, we have demonstrated the fabrication of biocompatible and stimuli-responsive hydrogel-based optical fibers, Fresnel Lenses, and Contact Lenses via 3D printing for sensing applications. Methods: Reversible thermochromic powder in the form of micro-powders were utilized to add stimuli-responsive functionality into the customized 3D printable hydrogel material. Fabrication of the hydrogel-based optical devices was performed in a single step using the masked stereolithography apparatus (MSLA) 3D printer. The optical devices were manufactured using a variety of geometries and printing parameters. Results: The thermal response of the developed fibers was carried out by recording their reflection spectra upon increasing and decreasing the temperature from 25 to 32 °C. Significant measurable changes in the reflection spectra were observed in response to temperature changes, which were reversible, and the relationship between the temperature and the output signals was established. The 3D-printed optical devices were inherently mechanically flexible, and their strain-sensing capabilities were also investigated. The changes in their optical losses in response to different bending angles (45° and 90°), demonstrated the ability of strain sensing. This work may pave the way toward low-cost, repeatable, and direct fabrication of biocompatible, soft, flexible, and tunable thermochromic sensors and wearable devices. The developed stimuli-responsive hydrogel optical fibers may have remote temperature and strain sensing applications in biomedical and healthcare environments.

1571057586: Two-dimensional integration design of carbon nanotube sensor for realizing visualization of long wavelength information

Ryoga Odawara, Minami Yamamoto, Yukio Kawano and Kou Li (Chuo University, Japan);
Yoshihiro Watanabe (Tokyo institute of technology, Japan)

INTRODUCTION In the field of non-destructive inspection, ultra-broadband electromagnetic wave imaging measurements using carbon nanotube (CNT) film photo-thermal (PTE) sensors have been attracting attention in recent years[1-2]. This sensor can detect ultrabroadband photo-irradiation in infrared, THz, and millimetre waves regions at room temperature[3]. Furthermore, the sensor has flexible characteristics. Therefore, the sensor has the potential to inspect for any shape. The vital matter of non-destructive inspections is speed and accuracy. In higher-speed operations, the integration time of signal readout is shorter. As a result, the normal mode noise increases. In addition, 2D integration of the sensor is necessary to realize higher-speed imaging rather than single elements or 1D integration setups. Therefore, it is essential to select device materials that can withstand the noise of higher-speed operations and integrate optical sensors in higher density for achieving superior performances of CNT film imagers. This study reports the physical and chemical composition optimization of CNT film broadband imagers beyond the speed-sensitivity trade-off for augmented reality (AR) non-destructive inspection. In general, functional inspections with AR techniques such projection mapping requires both high-speed and sensitive operations[4].

II . EXPERIMENT First, this study compared two-type single element CNT film PTE sensor of adopting conventional CNT and high conductivity CNT. These sensors perform XY imaging at three different readout speeds to confirm the noise at each speed. Second, this study fabricates two-dimensional integration design CNT film PTE imager and tests imaging performance the device.

III . RESULTU Figure. 1 shows a comparison of PTE images (target: metallic pattern marked as "10") obtained by the CNT film PTE sensor. In the conventional study, the noise in PTE images (dominantly derived from electrical resistance) increased significantly as the operation speed became faster. This tradeoff between noise and speed is a critical problem for an image sensor. For this reason, this study adopts the high conductivity of the CNT film to solve this tradeoff. As a result, this study succeeds in decreasing the noise at higher-speed operation time. It turns out the CNT film utilized in this study can reduce noise more than that in the conventional study. Thus, the operation speed of the sensor is available at over five times faster than that of the conventional study. In Figure. 1, this work employed the single element CNT film PTE sensor for those images. Owing to the single-element configuration, the imaging time is extended. Hence, this study focused on the imager design of 2D integration to reduce imaging time. Figure. 2 shows the design of the CNT film imager and the imaging result with that device. This design succeeds in an 8×8 integration by the original design. Image sensor pixels consist of the interface portion between CNT films and electrodes. As shown in Figure. 2, the successful integration of pixels maintained 2.4 mm spacing. The CNT solution printing technique produced this design. This imager achieved five times shorter imaging time rather than that of the single element.

1571078770: Scalable 2D Semiconductor-Based Field Effect Transistor Sensor for Emerging Contaminants Detection

Md Mohidul Alam Sabuj (New Jersey Institute of Technology, USA); Mariam Naseer (New Jersey Institute of Technology, United Arab Emirates); Viviana Nunez (New Jersey Institute of Technology, USA); Sufian Abedrabbo (Khalifa University, United Arab Emirates); Meng-Qiang Zhao (New Jersey Institute of Technology, USA)

Two-dimensional (2D) materials such as Graphene and transition Metal dichalcogenides (TMDs, e.g., MoS₂) are promising candidates for sensor applications due to their large surface-to-volume ratio, nanometer thickness, and significant response to external environmental changes. However, sensors based on these 2D materials always require proper chemical functionalization with a probe molecule or receptor to achieve the selective recognition of target molecules and ions, which always involves a complex and difficult process. Here, we developed a hexagonal boron nitride (hBN)-assisted functionalization process for the fabrication of highly scalable, back-gated 2D materials-based field-effect transistor (FET) nanosensors through a single chemistry. The basic idea is to use an hBN layer as an intermediate layer and a pyrene-based molecules as the linker to facilitate the bonding with different type of probe molecules. Given the multiple choice of pyrene-based molecular chemistry, we successfully fabricated arrays of 2D MoS₂-based FET sensors for the sensitive and selective detection of different emerging contaminants, such as organic (e.g. per- and polyfluoroalkyl substances, PFAS) and inorganic (e.g. Pb²⁺) contaminants of concerns. The results show that low limit-of-detection values of 0.001 ppb and 0.07 ppb have been achieved for the detection of PFAS and Pb²⁺ ion, respectively, which also exhibit promising selectivities. The approach could be easily applied to any other 2D materials, therefore providing a universal pathway towards nanosensor fabrication.

1571075103: Investigation of The Optical Band Gap Change of Zinc Oxide Depending On Cerium Concentration for Optical Applications

Yusuf Özpolat, Gökhan Algün and Namık Akçay (Istanbul University, Turkey)

This study includes the investigation of the optical band gap change of zinc oxide (ZnO) nanostructured thin film depending on the cerium (Ce) doping concentration. ZnO and Ce doped ZnO (CZO) nanoparticles were synthesized using the sol-gel method. Ce doping concentration in ZnO was adjusted as 0, 1, 2, 3, 4, 5 and 10 mol%. ZnO and CZO nanostructured thin films were produced on glass substrates by spin coating technique. According to x-ray diffraction analyses, all nanostructures have hexagonal wurtzite crystal structure and preferential orientation along the (002) plane. The presence of zinc, oxygen and cerium elements in the nanostructures was confirmed by energy dispersive x-ray spectroscopy. It was determined by scanning electron microscope micrographs that the surfaces of the nanostructures contained uniform and homogeneously distributed nano-sized grains and capillary nanopores. UV-Vis spectroscopy revealed that all CZO nanostructures have high optical transmittance in the visible region. The increase in the Ce concentration in the ZnO lattice led to a decrease in the optical band gap of CZO nanostructures. The lowest optical band gap value was calculated as 3.16 eV in the 10 mol% Ce doped ZnO nanostructure. The results emphasize that the optical band gap of ZnO nanostructure can be changed depending on the amount of Ce doping concentration. This situation reveals the potential of CZO nanostructures for optical applications. Based on this result, the next step will be to investigate the suitability of these structures for UV shielding and the effect of the change in optical bandgap on this suitability.

1571057706: Micro-wave-based non-destructive monitoring by photo thermoelectric sensors with carbon nanotube films beyond the diffraction limit

Qi Zhang, Asumi Sano, Yukio Kawano and Kou Li (Chuo University, Japan)

his study includes the investigation of the optical band gap change of zinc oxide (ZnO) nanostructured thin film depending on the cerium (Ce) doping concentration. ZnO and Ce doped ZnO (CZO) nanoparticles were synthesized using the sol-gel method. Ce doping concentration in ZnO was adjusted as 0, 1, 2, 3, 4, 5 and 10 mol%. ZnO and CZO nanostructured thin films were produced on glass substrates by spin coating technique. According to x-ray diffraction analyses, all nanostructures have hexagonal wurtzite crystal structure and preferential orientation along the (002) plane. The presence of zinc, oxygen and cerium elements in the nanostructures was confirmed by energy dispersive x-ray spectroscopy. It was determined by scanning electron microscope micrographs that the surfaces of the nanostructures contained uniform and homogeneously distributed nano-sized grains and capillary nanopores. UV-Vis spectroscopy revealed that all CZO nanostructures have high optical transmittance in the visible region. The increase in the Ce concentration in the ZnO lattice led to a decrease in the optical band gap of CZO nanostructures. The lowest optical band gap value was calculated as 3.16 eV in the 10 mol% Ce doped ZnO nanostructure. The results emphasize that the optical band gap of ZnO nanostructure can be changed depending on the amount of Ce doping concentration. This situation reveals the potential of CZO nanostructures for optical applications. Based on this result, the next step will be to investigate the suitability of these structures for UV shielding and the effect of the change in optical bandgap on this suitability.

571056546: Exploring the Influence of Surface Defects on Third-Order Nonlinearity Characteristics of Zn-Doped NiO Nanostructure Thin Films

Ramseena Thundiyil (Manipal Institute of Technology, India & MANIPAL ACADEMY OF HIGHER EDUCATION, India); Poornesh P (M I T Manipal, India)

We investigated the role of surface defects in the third-order nonlinearity characteristics of spray-pyrolyzed zinc-doped NiO nanostructure thin films using the Z-scan experiment. Various characterizations were performed to examine the impact of Zn doping on the NiO lattice. XRD analysis reveals that the FWHM values of the peaks increase upon Zn doping, while the crystalline size of the films decreases from 8.26 nm to 7.53 nm. The broadening of peaks is due to the ionic radii difference between Zn and Ni ions, inducing strain and dislocations in the lattice. The well-defined occurrence of the LO mode in Raman spectra indicates the presence of nickel vacancies due to the parity-breaking Ni-O bond. The increment in peak intensity, variation in peak position, and broadening of the LO peak confirm that Zn doping introduces disorder into the nanostructures, such as oxygen vacancies and nickel defects. Gaussian deconvolution fitting on photoluminescence spectra reveals defect-related emission originating from intrinsic defects such as nickel and oxygen interstitials and vacancies. The core level spectra of O1s from XPS analysis show a one-fold enhancement in oxygen vacancy defects upon Zn doping, corroborating the PL study findings. The open aperture Z-scan technique suggests that the enhanced nonlinear absorption is due to increased defect densities in the lattice, stimulating the nonlinear optical processes of excited state absorption and free carrier absorption induced by two-photon absorption. The self-defocusing property of the films is attributed to the thermal lensing effect caused by the continuous wave laser. Altering Zn doping concentrations results in a substantial rise in third-order susceptibility from 0.54×10^{-2} to 3.32×10^{-2} esu. The remarkable improvement in third-order nonlinear parameters with Zn doping makes these materials promising candidates for optoelectronic applications.

1571078805 Synthesis, Characterization and Comparative Study of SiO₂, ZnO, and ZnO-SiO₂ nanocomposite powders

Allen Stephen (National Institute of Technology, India); Ali Abdullah, Gigi Xavier and Sasi Stephen (Khalifa University of Science and Technology, United Arab Emirates); Mohammad M. Zeidan (Higher Colleges of Technology, United Arab Emirates); Daniel Choi (Khalifa University of Science and Technology, United Arab Emirates); Sufian Abedrabbo (Khalifa University, United Arab Emirates)

To investigate the potential uses of metal oxide nanocomposites, we synthesized and characterized silicon dioxide (SiO₂), zinc oxide (ZnO), ZnO-SiO₂ nanocomposite powders. Silicon dioxide (SiO₂) is widely employed as a catalyst support due to its high surface area and thermal stability. In contrast, zinc oxide (ZnO) has notable uses in gas sensors, UV-blocking coatings, and as an antimicrobial agent in biomedical contexts. ZnO also excels in photocatalysis, particularly for degrading organic pollutants under UV light, making it effective for environmental cleanup. Recent studies show that ZnO-SiO₂ composites enhance photocatalytic activity, improve mechanical stability, and hold promise for optoelectronic devices, including LEDs and advanced gas sensors. Utilizing processes such as sol gel, the powders were synthesized and then characterized to explore the structural, morphological and functional properties of these materials. One of the major goals was to determine if there would be any interactions between the SiO₂ and ZnO. Various techniques, including X-Ray Diffraction (XRD), Scanning Electron Microscopy with energy-dispersive X-Ray Spectroscopy (SEM-EDS), and Attenuated total reflectance-Fourier Transform Infrared Spectroscopy (ATR-FTIR) were used to analyse particle structure, molecular interactions, elemental composition and particle size. For the composite, we were able to achieve a 90:10 composite of SiO₂-ZnO respectively. SEM-EDS characterization confirmed the presence of both SiO₂ and ZnO in the composite. From the FT-IR results, we were able to confirm the presence of Si-O-Zn bonds, corroborating with the notable work of H. Helmiyati et al. The composite of ZnO-SiO₂ could have huge implications in hydrogen storage due to the high surface area of SiO₂ for hydrogen adsorption followed by the catalytic properties of ZnO that can enable interaction with Hydrogen molecules at a nanoscale.

1571057202: Microstructural characterization of sol-gel fabricated Silica coatings for enhanced bandgap-emission of Silicon

Inas Taha, Sufian Abedrabbo and I. A. Qattan (Khalifa University, United Arab Emirates); El Mostafa Benchafia (New Jersey Institute of Technology, USA); Mohammad Khaled Shakfa and Dalaver Anjum (Khalifa University, United Arab Emirates)

Silicon is a crucial semiconductor in electronic applications due to its affordability, stable dielectric properties (SiO_2), and bandgap value of 1.1 eV, making it ideal for detectors and integrated circuits (ICs). As device speed and functionality demands increase, a shift towards on-chip and chip-to-chip optical data transmission drives the IC industry to explore Si-photonics devices. However, silicon's indirect bandgap makes it a weak light emitter, dominated by non-radiative recombination paths such as Auger recombination. Despite this, theoretical quantum efficiency suggests that light-harvesting from Si is possible with high carrier injection. Researchers, including Abedrabbo et al., have sought to enhance Si light emission by circumventing its indirect bandgap limitations. Techniques like ion-beam mixing have introduced Si-Ge structures and GeO_2 nanostructures in Si, achieving enhanced optoelectronic properties and rare-earth impurity centers for C-band emission at 1.5 microns. Since 2009, Abedrabbo's group has employed an innovative approach of coating Si with sol-gel-based erbium (Er)-doped SiO_2 , significantly boosting bandgap-related emission intensity. These studies focused on factors such as film thickness, annealing temperature, and Er doping, all critical to understanding the enhanced Si bandgap emission. Despite extensive research, the structural exploration of sol-gel-based silica on Si is limited, hindering comprehension of how processing methodologies affect interfacial states and structural properties, particularly for bandgap-enhanced emission. This study addresses this gap by using Transmission Electron Microscopy (TEM) to analyze sol-gel-based SiO_2/Si structures, revealing microstructural properties that enhance bandgap emission. Silica films were synthesized via a sol-gel method using TEOS, ethanol, deionized water, and phosphoric acid. The solution was stirred, heated, filtered, and spin-coated onto p-type Czochralski silicon wafers, then dried at 120°C. The wafers were scribed into substrates, with one as-deposited reference sample and the others annealed at 900°C. Room-temperature photoluminescence (PL) studies used a Fluorolog Quanta Master spectrofluorometer. For TEM analysis, thin slices of SiO_2/Si were prepared with a dual beam FIB tool and examined with a Titan 80-300 ST TEM. Bright-field and high-resolution TEM (BF-TEM and HRTEM) assessed stack integrity, morphology, and defect density. The room temperature PL spectra for both as-deposited samples and those annealed at 900°C are presented.

Generally, the results indicate that the annealed samples exhibit superior optical properties to the as-deposited samples, notably enhanced bandgap emission. The increase in PL intensity for the annealed samples can be attributed to several factors. Annealing reduces point defects, typically non-radiative recombination centers, thus enhancing band-to-band recombination. Additionally, point defects can sometimes facilitate radiative recombination, but their impact on light emission in Cz-Si substrates is minimal. However, annealing-induced dislocations act as deep-level impurities, creating sub-bandgap states that contribute to improved light emission.

1571079024: Growth of InGaN/GaN quantum-disks-in-nanowires on multiple-monolayer graphene

Mohammad Khaled Shakfa and Dalaver Anjum (Khalifa University, United Arab Emirates)

Group III-nitride vertically aligned nanowires are highly promising for optical devices such as light-emitting diodes, laser diodes, photodetectors, and photovoltaic cells due to their tuneable wide band gaps and nanostructure, which enhance device performance. The transparency and high electrical conductivity of monolayer or few-layer graphene films make them ideal candidates for use in nanowire-based devices. Furthermore, the flexibility and ease of transferring graphene onto various substrates facilitate the development of flexible devices and enable the seamless integration of group III-nitrides with other material systems, advancing innovations in optoelectronics. Here, we present our work on the growth of InGaN/GaN quantum-disks-in-nanowires on graphene/SiO₂/Si substrates using plasma-assisted molecular beam epitaxy. Several characterization methods have been used and demonstrated that the nanowires were of high structural and optical quality. Interestingly, the nanowires grown on MLG show a relatively broad linewidth emission of about 160 nm, independent of the excitation intensity.

1571077607: In-situ Synthesis and Integration of Gold Nanoparticles into 3D Printed Optical Fiber Probes

Dileep Chekkaramkodi and Haider Butt (Khalifa University, United Arab Emirates)

This work uses the polymeric reduction method to explore the in-situ synthesis of gold nanoparticles (AuNPs) within 3D-printed optical fiber probes (OFPs). Digital light processing (DLP) 3D printing is employed to fabricate the OFPs using a resin consisting of hydroxyethyl methacrylate (HEMA) and polyethylene glycol diacrylate (PEGDA). After printing, OFPs were immersed in a boiling gold precursor solution to facilitate the synthesis of AuNPs inside the polymer matrix. We produced single material (HEMA/PEGDA) and multimaterial (HEMA/PEGDA + Dentaclear) OFPs loaded with AuNPs at different concentrations. Transmission electron microscopy revealed spherical AuNPs around 30 nm in size. Scanning electron microscopy analysis confirmed the effective distribution and dispersion of AuNPs within the polymer matrix. The optical properties, including reflection and transmission spectra, are comprehensively measured using customized setups. The localized surface plasmon resonance of the embedded AuNPs created a distinct dip in the 500-600 nm wavelength range. Higher AuNP concentrations and longer dipping times enhanced light absorption, reducing reflection and transmission intensities. Multimaterial OFPs also exhibited tunable wavelength filtering capabilities based on the AuNP concentration. The AuNP-loaded OFPs demonstrated stable optical performance across varying temperatures and pH environments, highlighting their potential for diverse applications.

ORAL: NE-E

1571074663/INVITED Talk:Wearable reconfigurable metamaterials and origami-inspired implantable sensors for human-machine interfaces

Firat Guder(Imperial College London, UK)

Although not known widely, the field of soft robotics was born out the research in microfluidics which developed the initial methods for transport of fluids (liquids or gasses) along micron or millimeter-sized channels. We have recently discovered that when silicone-based millifluidic devices are worn as sleeves, they can be pressured with gasses to change their material properties, including their geometry and hardness acting as a metamaterial. We have exploited this phenomenon to build wearable devices that can be used in prosthetic sockets as an interface to improve the use and comfort of prosthetic limbs and tested this idea in human trials. Our research also extends beyond wearable robotics. We have been developing flexible origami-inspired implantable sensors that can be inserted into the body with a syringe and unfold like a satellite in orbit to allow minimally invasive physiological monitoring of biometrics from within the body.

1571078895/Impact of Hafnium Doping on the Properties of Germanium Telluride Thin Films

Haila AlDosari (UAE Univerity, United Arab Emirates); Latifa Al Mheiri, Asma Al Ghaithi, Mahra Alblooshi and Hajar Alshehhi (United Arab Emirates University, United Arab Emirates)

Germanium telluride (GeTe) is a promising phase change material widely used in various applications, including resistive switching random access memories, due to its unique electrical and optical properties. Doping GeTe with transition metals, such as hafnium (Hf), can enhance its performance by modifying its structural and electronic characteristics. This study investigates the impact of doping GeTe with Hf using the co-sputtering technique with doping concentrations of 5 at.% and 10 at.%. The thin films were sputtered and annealed at different temperatures: room temperature, 300 °C, and 500 °C for 24 h. X-ray diffraction analysis revealed that all Hf-doped GeTe thin films are amorphous except for those annealed at 500 °C, exhibiting polycrystalline characteristics with the rhombohedral crystal structure. Raman spectroscopy demonstrated the emergence of sharp peaks in the spectra of the annealed samples, indicating structural changes associated with crystallization. Furthermore, the indirect optical bandgap (E_g) value of the amorphous Hf-doped GeTe thin films was higher than that of the crystalline thin films. E_g is found to be 0.85 and 0.95 eV of the amorphous 5 at.% and 10 at.% Hf-doped GeTe films, respectively. In contrast, the 500 °C annealed thin films exhibit E_g values of 0.60 and 0.63 eV with an increasing trend in E_g energy correlated with higher doping concentrations. Furthermore, the 5 at.% Hf-doped GeTe film annealed at 500 °C showed enhanced electrical properties with an average sheet resistance of 300 Ω^{-1} . These findings suggest that Hf doping significantly increases the crystallization temperature, improves thermal stability, and influences the structural and optical properties of amorphous GeTe, paving the way for the development of their envisioned applications.

1571079020/ Magnetorheological Actuator with Permanent Magnet for Mechanical Characterization of Hydrogels

Solomon Terwase Apuu (King Abdullah University of Science and Technology (KAUST), Saudi Arabia)

The characterization of hydrogels and soft tissues is essential for several reasons, particularly in biomedical engineering, materials science, tissue engineering and clinical applications [1]. Understanding their mechanical properties is crucial for designing and developing medical devices, treatments, and synthetic materials that interact with biological tissues. Despite recent advances, the characterization of hydrogels and soft biological tissues still poses a challenge [2]. The existing methods for this task (microrheology, atomic force microscopy (AFM) etc.) are currently expensive, slow, sometimes require a prolonged fabrication duration and consume large amounts of the hydrogel samples [3]. In this work, we propose a magnetically controlled robot based on magnetorheological elastomer (MRE) to measure the mechanical properties of soft polymers (hydrogels). The actuator is made from a smart stimuli-responsive composite material, which is a combination of a polymer (Ecoflex 0030) and micro/nano ferromagnetic particles (iron particles), thereby enabling active control over both the mechanical properties and actuating motions of the device through magnetic field manipulation [4]. Consequently, the magnetic composite actuator can dynamically adjust its viscoelastic properties, including stiffness and damping. Scanning electron microscopy (SEM) and Vibrating Sample Magnetometry (VSM) were performed for the MRE composite to study the material morphology, particle distribution and magnetic behavior. The operational schematic is presented in Figure 1. Using the commercial finite element software COMSOL Multiphysics and the mechanical properties of MREs from [5], we simulated the stiffness of the prepared MRE to be 25.3 N/m, see Figure 2. Moreover, we can control the stiffness of the MRE by adjusting the magnetic particle volume fraction and the strength of the magnetic field. Given the highly tunable properties of hydrogels, we prepared hydrogels with Young's modulus compatible with the MRE for optimal performance. The piezoresistive and magnetostrictive nature of MREs are used to enable accurate sensing and investigation of hydrogel normal and shear stresses. This approach introduces significant advantages over well-established wafer-based technologies or microfluidics, such as having the flexibility and stretchability needed for sophisticated environments. Therefore, featuring high performances such as low-cost, fast actuation design, simplicity in fabrication, low sample consumption, biocompatibility, and scalability, the proposed magneto-controllable device can be promising for a wide range of applications. Additionally, using MREs minimizes mechanical vibrations, enabling its use in various fields compared to existing actuators.

1571079382/ Star-shaped triazine -conjugated structures: synthesis and liquid crystalline properties

Lokman Torun (Yildiz Technical University, Esenler, Istanbul, Turkey)

Six- and three-armed star-shaped macromolecule series were prepared. This series has a benzene or triazine structure at the centre, which were connected by acetylene bridges to the side groups containing dialkoxy triazine groups. Thus, a series of electron rich macromolecules with conjugated and planar skeletons, and flexible side groups were obtained. Since these macromolecules were liquid at room temperature, they were mixed with 4-(dodecyloxy)benzoic acid in a one-to-one ratio resulting the corresponding solid materials formed by ionic interaction between the benzoic acid and triazine nitrogens, which exhibited a phase transition at low temperature. Such ionic liquid crystals are important class of mesomorphic materials and have considered as sealants due to their very low vapour pressure which demonstrated a proficient electrolyte systems for their anisotropic phase such as high ionic conductivity and diffusion along with excellent thermal stability. All the intermediate compounds and final compounds were confirmed by spectroscopic techniques (^1H NMR, ^{13}C NMR, FT-IR, and HRMS). The presentation will include synthesis of the star-shaped macromolecules and their liquid crystalline properties.

1571081252/Convergence of Piezoelectric-Triboelectric Transduction for Highly Efficient Biomechanical Sensing

Nadeem Tariq Beigh (Khalifa University, United Arab Emirates); Sandeep Singh Chauhan (Amrita School of Engineering, Bangalore, Amrita Vishwa Vidyapeetham, India); Dhiman Mallick (Indian Institute of Technology Delhi, India); Nouha Nouha Alcheikh ep Allouch (Khalifa University, United Arab Emirates)

Nanomaterials have accelerated the progress of self-powered sensors into the field of smart healthcare, smart automation, smart agriculture, etc. [1]. A subclass of nanomaterials called nanocomposites is capable multidimensional, hybrid, self-powered sensing. The interplay of polymer-dopant combination in a nanocomposite gives rise to interesting phenomena and applications. The phenomenon of dual transduction emerges from the polymeric nature of the base matrix and the ferroelectric nature of dopants, resulting in an alternate energy route for sensing/energy harvesting applications [2]. Though there are a few works that provide analysis of the underlying mechanism of dual transduction, nevertheless the concept is intriguing[3]. This work presents the concept of "triboelectric shift" in a well-known piezoelectric polymer called poly (vinylidene fluoride-trifluoro ethylene) (P(VDF-TrFE)) by a controlled barium titanate (BTO) doping. The tunability of piezoelectric/triboelectric behavior is advantageous in designing low-cost nanosensor/generators with a wide variety of contacting materials. This opens avenues for flexible nano sensors/generators with applications in self-powered biomechanical sensing [4]. In this work, we employ 20% P(VDF-TrFE) polymer as the base matrix and vary the BTO %weight ratio from 0-20%. Figure 1a outlines the hybrid sensor design with a "flip-chip" structure. The nanocomposite is integrated to have distinct piezoelectric and triboelectric outputs after being spin-coated on a polyethylene terephthalate (PET)/molybdenum (Mo) substrate. The nanocomposite with varying %weight ratio is studied for structural, morphological, piezoelectric and triboelectric properties. Among all, the 15% BTO in 20% P(VDF-TrFE) shows excellent surface/cross-sectional dopant distribution and uniformity with minimal clustering and agglomerations (Figure 1(b-f)). The absence of clustering and short circuit paths with an optimum BTO content results in a high normalized piezoelectric coefficient of $\sim 10\text{mV/V}$ in comparison to other variants (Figure 1g). The addition of optimum BTO dopants enhance the piezoelectric polarization of P(VDF-TrFE) and improve the β -phase without the need to external poling (Figure 1h). In the same context, the presence of BTO dopants elevate the surface charges by increasing the number of dangling bonds, free electrons and

charged particles. Thereby, adding to the surface charge density and modulating the net surface potential from a "tribo-negative" to a "tribo-positive" (Figure 1(i-l)). This phenomenon is called "triboelectric shift". The 15% BTO in P(VDF-TrFE) projects an excellent surface morphology, mild surface roughness, high piezoelectric and triboelectric responsiveness. Finally, the dual sensor based on the optimum nanocomposite is tested for a simulated biomechanical excitation (Figure 2a). The sensor achieves the sensitivities of 21mV.Kpa-1 and 13mV.KPa-1 for the triboelectric and piezoelectric modes, respectively. The sensor shows a linear operational range of 60Kpa at 4Hz excitations. The initial analysis suggests that the dual transduction sensor based on optimum design nanocomposites has excellent potential in multitude of sensing applications including tactile sensing and smart health monitoring.

References: [1] Hasan, M. A. M., Wang, Y., Bowen, C. R., & Yang, Y. (2021). 2D nanomaterials for effective energy scavenging. *Nano-Micro Letters*, 13, 1-41. [2] Beigh, N. T., Singh, S., Goswami, A., & Mallick, D. (2022). Dual piezoelectric/triboelectric behavior of BTO/SU-8 photopatternable nanocomposites for highly efficient mechanical energy harvesting. *Advanced Electronic Materials*, 8(10), 2200338. [3] Beigh, N. T., Beigh, F. T., & Mallick, D. (2023). Machine learning assisted hybrid transduction nanocomposite based flexible pressure sensor matrix for human gait analysis. *Nano Energy*, 116, 108824. [4] Zhou, Y., Zhang, J. H., Wang, F., Hua, J., Cheng, W., Shi, Y., & Pan, L. (2024). Recent Advances in Flexible Self-Powered Sensors in Piezoelectric, Triboelectric, and Pyroelectric Fields. *Nano energy Advances*, 4(3), 235-257

ORAL: Nano Water

1571077845: Silver Nitroprusside Nanoparticles Grafted Antibacterial Membrane with Antifouling Properties for Water Purification and Bio-Separations

Manideep Pabba (Khalifa University, United Arab Emirates); Bhoga Arundhathi (CSIR-Indian Institute of Chemical Technology, India); Srinivas Mettu (Assistant Professor, United Arab Emirates); Sundergopal Sridhar (CSIR-Indian Institute of Chemical Technology, India)

Metal nanoparticles, especially silver nanoparticles (AgNP's), have garnered significant interest for their potential in antimicrobial applications. Recently, silver metal complex nanomaterials, such as Silver Nitroprusside, have gained substantial attention, particularly within medical contexts due to their notable antibacterial properties. Polymeric membranes are susceptible to fouling, particularly when processing surface water polluted with natural organic matter and microbial entities. The challenge of fouling can be mitigated through surface modification, which imparts antifouling and antibacterial characteristics to the membrane. In this investigation, polysulfone (PS)-based membranes were synthesized utilizing the phase inversion method, incorporating polyvinylpyrrolidone (PVP) as a pore-forming agent. A polydopamine (PDA) coating, followed by the immobilization of silver nitroprusside (Ag), was applied to the PS + PVP composite membrane to enhance its wettability and antibacterial functionality. Four distinct membrane variants were fabricated: pristine PS (M1), PS integrated with polyvinylpyrrolidone (M2), polydopamine (PDA) + PS + PVP (M3), and silver nitroprusside + PDA + PS + PVP (M4). The membranes underwent extensive characterization to evaluate their physical morphology, contact angle, pure water permeability (PWP), rejection efficiency for humic acid (HA), Bovine Serum Albumin (BSA) protein rejection, and antibacterial effectiveness. The pristine PS

membrane (M1) demonstrated a 45% rejection of HA, while the incorporation of PVP into the matrix resulted in a decrease of HA rejection to 41% for M2. The PDA coating on M3 significantly enhanced the rejection rate to 59.8%, a result attributed to the formation of an additional layer that reduced the size of the membrane pores. Remarkably, the Ag nitroprusside immobilized on M4 exhibited complete eradication of *Escherichia coli*, *Staphylococcus aureus*, and *Mycobacterium smegmatis*, alongside the highest antibacterial activity and HA rejection, recorded at 80.66% among all membranes. These findings indicate that Ag-modified PDA membranes possess exceptional antibacterial and antifouling properties, rendering them highly appropriate for environmental applications. Also, the M4 membrane demonstrated superior filtration performance, characterized by increased water flux and an elevated flux recovery ratio (FRR%) in comparison to pristine M1 membranes. Under similar conditions, the M4 membrane's pure water flux of $350 \text{ L}\cdot\text{m}^2\cdot\text{h}^{-1}$ at 4 bars remarkably exceeded the M1 membrane's $142 \text{ L}\cdot\text{m}^2\cdot\text{h}^{-1}$. Furthermore, the incorporation of NPs enhanced the antifouling capabilities of the PS membranes. The FRR of the M1 membrane was 63%, which improved to 82% in the M4 membrane. The antibacterial characteristics of Ag-modified membranes also contributed to the inhibition of biofouling by impeding microbial proliferation on the membrane surface. From all these research findings, this modification not only enhances filtration efficiency but also prolongs membrane longevity and reduces maintenance and cleaning demands, thereby contributing to more sustainable membrane operations. The developed membrane holds potential for further optimization aimed at applications in bio-based separation industries.

1571027238: Polydopamine-modified 2D niobium carbide MXene/poly(lactic acid) (PLA) composite membranes for wastewater treatment

Ravi P. Pandey and Shadi Wajih Hasan (Khalifa University of Science and Technology, United Arab Emirates)

Ultrafiltration (UF) membrane technology is considered as a promising alternative because of simple operating principle, environmental impact and cost-effective treatment of pathogens based on size and charges. Herein, we synthesised a two-dimensional (2D) niobium carbide MXene modified with polydopamine (PDA) (PDA-Nb) nanomaterials as a promising nanofiller. The UF membranes were developed by solution blending of PDA-Nb nanomaterials with poly(lactic acid) (PLA) polymer matrix via phase inversion method. The top performing membranes with highest loading of PDA-Nb into PLA exhibited highest porosity and mean pore size among all the PDA-Nb/PLA developed membranes. The PDA-Nb/PLA-6 membrane had the ~4-fold more pure water permeability as compared to the pristine PLA membrane. The PDA-Nb/PLA-6 membrane offered 1.64-fold higher FRR (%) in compared to the pristine membrane. The developed UF membrane, specifically PDA-Nb/PLA-6, can be recommended for wastewater treatment.

1571057660: Sand-supported Antimicrobial Film-forming Nanocomposite (SAFe): A point-of-use water disinfection system

MSV Naga Jyothi, Uthradevi Kannan and Shihabudheen M. Maliyekkal (Indian Institute of Technology Tirupati, India)

Nanotechnology-enabled disinfectants like silver nanoparticles (AgNPs) are effective against a broad spectrum of bacteria and viruses due to their excellent oligodynamic properties. Unlike conventional disinfectants such as chlorine and ozone, AgNPs are safe and do not produce harmful disinfection by-products. However, large-scale deployment of silver-based disinfection systems is hampered due to the possible interaction of silver nanoparticles with natural organic matter and other ions, such as chloride, in water. Besides, there must be a robust support matrix to hold the AgNPs and improve their practical use. In this context, this conference paper describes the in-situ synthesis and encapsulation of the AgNPs on surface-modified sand particles. A reduced graphene oxide-biopolymer matrix was used for in-situ synthesis and effective encapsulation of AgNPs, and this system acts as a silver reservoir. The film-forming nanocomposite is effectively coated on citrate-functionalized sand particles, and a point-of-use disinfection system, namely SAFe Water Disinfector, was developed. The SAFe is hydraulically stable and can release silver ions, an active disinfectant, at a controlled and sustained rate into water. The mechanistic details of the surface coating and formation of the SAFe are also proposed. ATR-IR analysis confirmed the interaction of citrate with silanol and siloxane groups and the presence of the carbonyl functional group of the citrate compound on the modified sand particles. The nanocomposite forms a stable coating on the modified sand through the electrostatic interaction of free carboxyl functional groups of modified sand with amine and hydroxyl functional groups of the nanocomposite. The disinfection ability of the antimicrobial sand is assessed in continuous mode operations, and a simple back-washing strategy has been developed to enhance the service life of media and the effective utilization of the AgNPs. The SAFe water disinfection unit can provide microbial-safe water at a treatment cost of 0.12 - 0.24 USD/1000 L. Briefly, this work presents the performance evaluation of the resource-efficient antimicrobial sand for the disinfection of water that treats water at a low cost.

1571075160: Synthesis of MXene@MOF composite mixed matrix membranes for the removal of Per- and polyfluoroalkyl substances (PFAS) from Wastewater

Sana Ahmad Minhas (Khalifa University, United Arab Emirates)

Per- and Polyfluoroalkyl substances (PFAS) are considered as persistent emerging contaminants of industrial origin, which are of major concern due to their adverse effects on human health and ecosystem. Their physicochemical properties and unique molecular structures make the conventional water treatment methods ineffective for their removal. Membrane technology is one of the prominent separation processes in water applications. Moreover, the incorporation of nanomaterials in membranes can enhance their properties and hence has the capacity to become a potential candidate in PFAS removal. In this work, four different compositions of novel nanocomposite are synthesized with iron-based metal organic framework (MOF(Fe)) and MXene by in-situ growth method. The synthesized nanocomposites are characterized and analyzed using XRD, FTIR, SEM, zeta potential, XPD and EDS. Moreover, nanocomposite mixed matrix membranes were fabricated by incorporating the synthesized nanocomposites into Cellulose Acetate (CA) membrane via phase inversion method. The membranes show 92% removal of PFOA and also show an increase in water flux. The fouling studies demonstrates good flux recovery ratio in nanocomposite membranes.

1571057076: Highly-dispersible graphene oxide-based ultrafiltration membrane for enhanced water flux, anti-biofouling, and mechanical properties

Vajitha G (Indian Institute of Technology Tirupati, India); Kritika Jashrapuria and Swatantra Pratap Singh (Indian Institute of Technology Bombay, India); Shihabudheen M. Maliyekkal (Indian Institute of Technology Tirupati, India)

The use of activated carbon and other carbon derivatives in water purification is well documented. Recently, nanoscale carbon, especially graphene, and its derivatives have gained significant interest in water treatment due to their unique physicochemical properties and ability to resolve various water quality issues. However, their use in mass and down-to-earth applications like water purification is limited for various reasons, including the high cost of production, lack of affordable methods for industrial-scale production, and poor solvent dispersibility. This paper describes the bulk and relatively rapid production of a highly dispersible graphene oxide (HDGO) from graphite through combustion synthesis. The HDGO is 8-10 times less costly and consumes 7-10 times less synthesis time than Hummer's graphene oxide. The application of the HDGO in manufacturing mixed matrix ultrafiltration membranes is demonstrated. The HDGO and composite membranes are thoroughly characterized, and its performance under various experimental conditions is established. Unlike conventional graphene oxide, the HDGO formed a homogeneous and stable dispersion in the membrane matrix, preventing the leaching of GO into water. The HDGO content and membrane composition were optimized based on the selectivity and permeability trade-off. HDGO-modified UF membrane showed enhanced flux due to increased hydrophilicity and porosity of the membrane. Furthermore, the anti-microbial properties of HDGO lead to the inactivation of bacteria, thereby reducing the risk of biofouling. Compared to the pristine membranes, the modified membranes show ~64% and ~18% enhancement in protein rejection and flux, respectively. Also, the improved flux recovery ratio of ~20% and high BSA rejection of ~60% indicate the anti-fouling potential of the modified UF membrane. The HDGO's low cost of production and high dispersibility in solvents make HDGO a potential candidate for building with enhanced performance and durability.

1571053781: Rapid and Eco-Friendly Fabrication of Dendritic BiVO₄ Mesocrystals using Curcumin for enhanced photocatalytic degradation of 2,4-D

Harshita Chawla (University of Szeged, Hungary & Amity University, India); Seema Garg (Amity University, India); Jyoti Rohilla (Indian Institute of Technology, Delhi, India); Ákos Szamosvölgyi and Anastasiia Efremova (University of Szeged, Hungary); Pravin P. Ingole (Indian Institute of Technology, India); Andras Sapi and Zoltán Kónya (University of Szeged, Hungary)

As an important photocatalytic semiconductor, dendrite mesocrystals of bismuth vanadate are typically prepared in pH and temperature-controlled strategies in the presence of various solvents using hydrothermal method for longer duration, which possess potentially environmental implication. Herein, we demonstrate a fast and simple method using bio-organic Curcumin extract via hydrolysis route at 60 °C for 1 hour, for eco-friendly synthesizing dendrite like BiVO₄. The possible reaction mechanism and growth process of the crystals is proposed based on the experimental results. Morphological and Structural Analysis (XRD, TEM, SEM, SAED, EIS) reflected successful fabrication of heterojunction between Curcumin and BiVO₄. The as-fabricated dendrites of BiVO₄ (BVO-cur) reflected highly efficient photocatalytic fragmentation of 2,4-dichlorophenoxy acetic acid [2,4-D (70.25%)], on comparison with pristine BiVO₄ [2,4-D (45.94%)] within 120 mins. of visible-light-irradiation. Further, optical studies including photochemical responses and radical-quenching showed that h⁺, ·O²⁻ and ·OH were responsible for the fragmentation of these recalcitrant herbicides. Based on in-situ High Performance Liquid Chromatography (HPLC) and Liquid Chromatography Mass Spectroscopy (LCMS) analysis, degradation pathways were designed. This work provides an in depth understanding of bio-fabrication of photocatalyst by enhancing the active sites of the reactants and hindering the recombination of photogenerated charge carriers.

1571078987: Solar-driven brine management using biochar-derived photothermal foam: towards zero liquid discharge and pure water generation

Sumina Namboorimadathil Backer (University of Sharjah, United Arab Emirates)

Brine management is a critical challenge due to its harmful environmental impact. The most effective solution for RO brine disposal is zero liquid discharge (ZLD). However, conventional membrane filtration methods face limitations in treating high-salinity brine because of severe fouling and salinity levels [1]. In response, we developed a sustainable and cost-effective photothermal nano based biofoam using biochar derived from macadamia shells, harnessing renewable solar energy [2], [3]. This photothermal bi-layer foam was engineered to maximize solar energy absorption and heat generation through interfacial solar heating. The top layer, acting as the photothermal component, was fabricated using biochar at different concentrations (80 mg, 160 mg, and 300 mg), which provides broadband solar absorption. Beneath it lies a sodium alginate foam layer for water transport. The biochar was uniformly dispersed in a 1% sodium alginate solution, and the mixture was poured into a mold containing crosslinked sodium alginate gel. A 5% CaCl₂ solution was used for crosslinking, and the resulting hydrogel was freeze-dried to create the bi-layer biofoam aerogel, designated as Biofoam 0-3 based on biochar concentration in the top layer. The nano characteristics of biochar allowed for excellent dispersion in the sodium alginate matrix, ensuring the fabrication of a floatable biofoam. Biofoam optimization was monitored by evaluating solar spectral irradiance utilization, thermal conversion efficiency, water evaporation efficiency, and water production rate. Among the samples, Biofoam 2 achieved an evaporation rate of 1.93 kg m⁻² h⁻¹ under a solar simulator (0.89 kW m⁻²), 2.5 times greater than pure water. In real-time testing, Biofoam 2 demonstrated a high evaporation efficiency of 93.8% for real RO brine. Quantitative water analysis confirmed the production of pure water via sustainable photothermal desalination, with salts and impurities concentrated in the residual brine. The condensed water (permeate) showed significantly reduced salinity compared to the feed RO brine. While, ion concentration in the brine concentrates increased, highlighting the potential for pure water production and zero liquid discharge from real RO brine.

References. [1] S. Backer et al., *Sustain.*, vol. 14, no. 11, 2022, doi:

<https://doi.org/10.3390/su14116752>. [2] S. Namboorimadathil Backer, A. M. Ramachandran, A.

A. Venugopal, A. P. Mohamed, A. Asok, and S. Pillai, *ACS Appl. Nano Mater.*, vol. 3, no. 7, pp.

6827-6835, 2020, doi: <https://doi.org/10.1021/acsanm.0c01207>. [3] X. Hou, H. Sun, F. Dong, H.

Wang, and Z. Bian, *Chemosphere*, vol. 315, p. 137732, 2023, doi:

<https://doi.org/10.1016/j.chemosphere.2022.137732>.

1571078986: Synergistic Enhancement of Ciprofloxacin Degradation in Aqueous Solutions Using Simultaneous and Sequential Applications of Nano Zerovalent Iron and UV Light

Sefeera Sadik (University of Sharjah, United Arab Emirates)

Pharmaceuticals are a class of emerging contaminants in aquatic ecosystems that have raised significant concerns about their impact on ecological systems and human health. Ciprofloxacin (CPX), a fluoroquinolone antibiotic, is frequently detected in wastewater and natural water bodies due to its extensive use in treating bacterial infections in humans and animals. Traditional wastewater treatment methods do not fully remove these chemical compounds, so it leads to their buildup in aquatic environments, where they can undergo biological transformations, bioaccumulate in organisms, and contribute to the emergence of antibiotic-resistant microorganisms [1-3]. Due to the limitations of conventional treatment techniques, more efficient methods are needed to address these persistent contaminants. In recent years, advanced oxidation processes (AOPs) and nanomaterial-based treatment approaches have shown significant potential for the removal of a wide range of organic and inorganic contaminants from water. AOPs, which involve the generation of highly reactive species (e.g., hydroxyl radicals), are effective at targeting and degrading organic molecules like CPX. Meanwhile, nanomaterials, such as nanoscale zerovalent iron (nZVI), offer high surface area and high reactivity with organic molecules via redox reactions that can enhance contaminant degradation[4]. However, limited information is available on the efficacy of using AOPs such as UV and nanomaterial-based degradation as a combined treatment scheme. This study investigates the synergistic application of an advanced oxidation process, specifically UV light, with nano zerovalent iron to enhance the degradation of ciprofloxacin in aqueous solutions. This research evaluates the efficacy of both simultaneous and sequential applications of nZVI and UV light for the degradation of ciprofloxacin. The study aims to optimize the conditions for these processes while comparing the performance of three treatment schemes: simultaneous nZVI-UV application, sequential applications of UV followed by nZVI, and sequential application of nZVI followed by UV. The methodology comprised four main stages: First, nano zero-valent iron(nZVI) particles were synthesized using a wet chemical reduction method with iron sulfate hepta-hydrate and potassium borohydride under nitrogen. Second, the nZVI particles were characterized using high-resolution scanning electron microscopy, X-ray diffraction, and zeta potential measurements to determine their morphological and physicochemical properties. Third, batch experiments tested ciprofloxacin degradation at an initial concentration of 30mg/L under various conditions: nZVI alone, UV alone (covering the spectrum for UV-A and UV-C), simultaneous application of nZVI and UV, and sequential application of nZVI followed by UV, and also UV followed by nZVI. Finally, degradation products were analyzed by measuring total organic carbon (TOC) with a Tekmar Fusion TOC analyzer, fluoride release with an Extech FL 700 meter, and transformation products using liquid chromatography-mass spectrometry (LC-MS) with a Waters Acquity UPLC H-Class-Xevo Triple Quadrupole system, revealing differences in mass spectra and insights into the transformation mechanisms. The study results concluded that the simultaneous combination of nZVI and UV light offers a promising approach to the degradation of ciprofloxacin in aqueous solutions compared to individual treatment methods. In sequential application, UV followed by nZVI shows effective enhancement compared to nZVI followed by UV. The findings of this research emphasize the potential of integrating advanced oxidation technologies for mitigating pharmaceutical contaminants in water systems, addressing the limitations of traditional wastewater treatment methods, and contributing to environmental protection and public health. Further optimization and scaling up of these processes could offer practical solutions for removing persistent microcontaminants from aquatic environments.

Reference: [1] T. An, H. Yang, G. Li, W. Song, W. J. Cooper, and X. Nie, *Applied Catalysis B: Environmental*, vol. 94, no. 3-4, pp. 288-294, 2010. [2] J. Deng et al., *Chemical Engineering Journal*, vol. 330, pp. 1390-1400, 2017. [3] S. K. Mondal, A. K. Saha, and A. Sinha, *Journal of cleaner production*, vol. 171, pp. 1203-

1214, 2018. [4] M. Liu, Y. Ye, L. Xu, T. Gao, A. Zhong, and Z. Song, *Nanomaterials*, vol. 13, no. 21, p. 2830, 2023.

ORAL: AIN-L

1571058072: Predicting NMR Chemical Shifts with Graph Neural Networks

Dong-Wook Lee (Technology Innovation Institute & Advance Materials Center, United Arab Emirates); Seon Ju Park (Korea Basic Science Institute, United Arab Emirates); Hengjo An (Kumoh National Institute of Technology, Korea (South)); Sung Mun Lee (Khalifa University of Science and Technology, United Arab Emirates)

Nuclear magnetic resonance (NMR) spectroscopy is one of the essential techniques to understand complex molecular arrangements and bonding. The distinct chemical shifts in NMR spectrum come from each atom's local chemical environment and interactions with other atoms. Recently, machine learning technique such as graph neural network successfully has been applied to predict NMR chemical shift. In this work, we developed several different graph neural networks and train them to predict ^{13}C chemical shift from popular NMR database such as NMRShiftDB2. And they are tested to predict ^{13}C chemical shift from 303 natural chemical compounds. Our models show very accurate predictions.

1571043783: Exploring Van der Waals Materials with High Optical Anisotropy Using Graph Neural Networks

Liudmila Bereznikova, Jr., Ivan Kruglov and Georgy Ermolaev (Emerging Technologies Research Center, XPANCEO, United Arab Emirates)

One of the relevant tasks of modern materials science is the search for optical functional materials with unique properties such as birefringence, characterizing their optical anisotropy [1]. These properties are interesting due to their performance in a wide range of science and technology: including waveplates, photonic chips and switching nanolasers. This work considers how geometric representations of crystal structure and machine learning methods can be applied to select van der Waals (vdW) materials with desired optical anisotropy characteristics [2]. Computational materials science plays a key role in the search for new materials with desired properties, and some of the proposed methods already avoid costly experiments. Machine learning is actively used to predict various properties of materials based on their structure and chemical composition. Currently, graph neural networks (GNNs) are one of the most effective methods for this task. Our work applies Atomistic Line Graph Neural Network (ALIGNN) to predict the optical coefficient Δn (in-plane and out-of-plane), characterizing optical anisotropy of the material. Initially, training set, containing crystal structures and birefringence coefficient values was formed from the NOEMD database [3]. In order to select from the NOEMD database the most similar structures to the target vdW materials, they were classified into groups, based on their compositional and structural features. In addition, an algorithm for determining the geometric anisotropy of layered materials was developed. The application of the described methods allowed us to discover a number of interesting, previously under-researched van der Waals materials characterized by high values of geometrical and optical anisotropy. The results obtained in the course of the study were confirmed by density functional theory (DFT) calculations using the PBE functional and for the most interesting materials optical properties were verified in the experiment.

1. Ermolaev, G. A. et al. Giant optical anisotropy in transition metal dichalcogenides for next-generation photonics. *Nat Commun* 12, 854 (2021).
2. Slavich, A. S. et al. Exploring van der Waals materials with high anisotropy: geometrical and optical approaches. *Light Sci Appl* 13, 68 (2024).
3. C. Xie, E. Tikhonov, D. Chu, M. Wu, I. Kruglov, S. Pan, and Z. Yang, A Prediction-Driven Database to Enable Rapid Discovery of Nonlinear Optical Materials, *Sci. China Mater.* (2023)

1571067851: Sustainable additive manufacturing through recycled and reinforced thermoplastic composites: A state-of-art

Jatinder Singh and Rakesh Kumar (Dr B R Ambedkar National Institute of Technology Jalandhar, India)

Converting plastic waste into useful products presents a formidable challenge for society at large. However, a promising solution lies in the emerging melt extrusion-based Fused Deposition Modeling (FDM) approach which is an additive manufacturing or 3D printing process. Although, multiple recycling of the waste thermoplastics through melt-extrusion leads to significant changes in the properties still it is a promising solution to cater for the waste plastics. In the realm of 3D printing applications, the incorporation of additives has shown promise as an effective means to uplift the performance of recycled materials. Thus, the objective of this study is to provide a comprehensive overview of the repurposing of plastic waste with the addition of reinforced material for FDM-based 3D printing. This review encapsulates the existing information regarding how processing impacts the properties of recycled plastic FDM components. Furthermore, it involve the utilization of diverse additives to enhance the overall quality. Moreover, the review presents two case studies sourced from open literature to illustrate the application of FDM and related technologies in plastic recycling scenarios. This innovative FDM technique holds the potential to create a diverse range of functional and practical products from recycled and reinforced filament material characterized by robust strength, high quality, and cost-effectiveness which represents a significant step towards a more sustainable and circular economy.

1571076305: Artificial Intelligence and Machine Learning Algorithm of Corrosion Behavior of X42 Pipe Grade Steel with and without Fluoropolymer Nano Composite Coatings for Oil and Gas

Hussain Saleh Ahmad Saheli (Jazan University, Saudi Arabia); Khalid Ali Hakami (Jazan University, Saudi Arabia); Ali Ahmed Al Salem, Mohsen Ahmed Omaysh, Nawaf Ismail Dallak, Mohammed Ahmed Mathmi, Haitham Hadidi and Rajasekaran Saminathan (Jazan University, Saudi Arabia)

Corrosion is nearly a 2.2 trillion \$ problem worldwide especially in oil and gas industries in recent decade. Hence corrosion mitigation is of utmost priority in oil and gas industries in gulf countries¹. Steel pipes are given coatings like ceramic coating, metallic coatings and polymer coatings in order to improve the life time of the oil transporting pipe line systems². In recent times, polymer coatings are promising in corrosion control of steel pipeline systems used in oil and gas industries due its improved performance in aggressive corrosion inducing environments and leading to increased durability of the pipeline systems³. Further advancement in surface coatings for steels relates to the nano particle reinforced polymeric coatings showing improved strength in addition to excellent corrosion resistance⁴. In recent times the artificial intelligence and machine learning software's are used in obtaining criticality factors and interdependency of corrosion parameters in formulating efficient corrosion monitoring systems⁵. This work concentrates on applying a poly tetra fluoroethylene (fluoropolymer)/graphene oxide nano composite coating on X42 pipe grade steel. This is achieved by cold spray technique. The poly tetra fluoroethylene in powder form purchased from nanochemzone (99.96 % purity) and graphene oxide nano particles purchased from Techinstro (99.65 % purity) are mixed in 95:5 percentile namely to prepare an emulsion using isopropyl alcohol and aforementioned powder mixture. Eventually 20% emulsion of powder mixture in isopropyl alcohol is prepared and sprayed on the polished X42 steel specimens. The experimental setup to carry out the weight loss measurements consists of an electric motor of controllable rpm. The specimen attached to one end of rod (specimen holder) by means of screw setup. The rpm of the motor is maintained at 100 while immersing specimen in crude oil collected from the refineries. Every specimen is exposed to fresh 500 ml of crude oil. The rotating surface of the X42 steel specimen with and without coating in oil simulates the condition of oil transportation in pipe lines of oil and gas industries. The test is continued for time periods namely 10 days to 100 days. The weight loss calculations are used in determining the corrosion rate and durability of the steel specimens. Similarly, the corrosion of steel specimens with and without polymer composite coating are tested in soil too. ASTM G-162-18 for soil corrosion on steel and ASTM G-205-10 for corrosion test of metallic specimens in crude oil are followed. In addition, potentiodynamic polarization measurements were carried out using CH instruments in order to compare the corrosion rates obtained in weight loss measurements. JEOL scanning electron microscope and JEM 1400 transmission electron microscopes were used analyzing the metallography of the specimens. The SEM microstructure of fluoropolymer coating on X42 steel indicating islands like formations of composite polymer over the surface of the steel. More over the TEM microstructure clearly show the presence of Graphene oxide particles in the fluoropolymer matrix. The first observation corrosion test results shows the corrosion rate of the X42 steel in crude oil increases as the number of hours of exposure. The same is observed in the case of fluoropolymer composite (FPC) coated steel specimens. But the corrosion rate of X42 steel is vastly decreased by the fluoropolymer coating and hence the durability of the steel increases to a greater extend. The artificial intelligence and machine learning algorithm obtained by the WEKA machine learning software. The algorithm identifies the primary focusing parameters as the corrosion rate of the specimens. Further the time of exposure and the durability are related as the interdependent parameters. The critical range of corrosion rate is categorized from 0.41 and 0.95. The corrosion rate equivalent and above to 0.95 has severity level of 10 as per the algorithm. More over the time of 600 hours has been identified as the critical time by the machine learning algorithm. Durability of structures having a critical value of 33.36 or less show a severity level of 9. It can be concluded that the corrosion behavior of X42 steel specimen with and with out fluoropolymer coating in crude and soil conditions are comprehensively determined. It is observed that the corrosion rate of the pipe grade X42 steel has greater tendency to corrode in crude oil than the exposure to the soil conditions. When the X42 steel is coated with poly tetra fluoroethylene by spray coating, its durability increases nearly 5 times since there exists a greater reduction in corrosion rate. The machine learning algorithm identifies the critical corrosion rate as 0.95 mm/year and above having a severity level of 10. 600 hours of time of exposure happens to be the critical limit while 33.36 years or less of durability is termed as critical range. The AI and machine learning algorithm computes the critical ranges of corrosion behavior of the X42 steel with and without fluoropolymer coating in addition to interdependent parameters so that the efficient corrosion monitoring system is designable.

1571056628: Exploring Surface Properties: A Multi-Frequency AFM Approach

Lamiaa Elsherbiny and Matteo Chiesa (Khalifa University, United Arab Emirates)

Our study investigates the characterization of thin films and two-dimensional materials using atomic force microscopy (AFM), with a focus on van der Waals interactions to elucidate sample properties, structure, and functions. This research emphasizes the critical role of AFM in growing, characterizing, and analyzing two-dimensional materials. The experimental setup involves a microcantilever with a sharp probe interacting with the sample surface, recording atomic forces. Incorporating multifrequency AFM, enhances resolution, allowing for quantitative assessment of weak forces in bimodal and trimodal AFM. This sophisticated technique scans surfaces and quantifies material properties by externally stimulating multiple eigenmodes, observing amplitude, phase, or frequency shifts. Material properties are extracted using transforms based on these variables. A data-driven approach utilizing machine learning algorithms predicts the force profile from AFM observables for each scanned point using synthetic data. By feeding the dataset into machine learning algorithms, we accurately predict force profiles, enabling multifrequency spectroscopy formalism to derive material properties. This integration of AI and machine learning presents a comprehensive methodology for predicting the power of the force profile of the surface. This methodology can give information about the sharpness of the tip, the quality of the 2D material and the dominant forces that exist within a specific distance.

ORAL: [NF 2024-N \(Nanofluidics\)](#)

1571078315: A Eulerian-Eulerian Approach for Investigating Thermofluidic behaviour of Nanofluids in a Ribbed Heated Microchannel with Variable Drag Coefficients

Abdullah Aziz (Khalifa University, United Arab Emirates)

This study presents a theoretical investigation into the flow dynamics and heat transfer performance of Al₂O₃ nanofluid through a heated microchannel with ribbed bottom surfaces using a two-phase Eulerian-Eulerian model. Unlike conventional models that assume the fluid and nanoparticles move at the same velocity, this research examines the impact of "slip velocity," where nanoparticles travel at different velocities than the base fluid, ranging from 0 to 0.3 m/s. The volume fraction of nanoparticles is varied between 0.01 wt.% and 0.05 wt.%, and the effect of uniformly spaced ribs, with heights ranging from 1% to 5% of the channel height, on heat transfer and pressure drop is analyzed. The results reveal that slip velocity has a profound effect on heat transfer, particularly in the presence of ribbed structures. Increasing the slip velocity enhances the mixing between the nanoparticles and the fluid, leading to improved local heat transfer rates but also increases the drag force and pressure drop. As the volume fraction of nanoparticles increases, the Nusselt number rises, indicating a higher heat transfer efficiency. However, at higher Reynolds numbers, the effect of nanoparticle concentration diminishes as the flow becomes more turbulent. Additionally, the Euler number, which reflects pressure losses, decreases with increasing Reynolds number, suggesting reduced pressure losses at higher flow rates. The study concludes that the presence of ribs and slip velocity offers a complex interaction that enhances heat transfer but requires careful optimization to manage increased pressure drop. This research provides valuable insights into

the behavior of nanofluids in microchannels, highlighting potential avenues for future experimental studies and technological developments in heat transfer applications.

POSTER: MN-D

1571062454: Hydrophilic Magnetic COFs: The Answer to Photocatalytic Degradation and Removal of Imidacloprid Insecticide

Muneb Mukhtar and Hamad HK Alblooshi (United Arab Emirates University, United Arab Emirates); Shaikha Alneyadi (UAEU, United Arab Emirates); Sultan A. Jama (United Arab Emirates University, United Arab Emirates)

The widespread use of imidacloprid (IMI) in pest control presents significant environmental challenges due to its persistence and low removal efficiency. This study introduces magnetic Covalent Organic Frameworks (COFs) functionalized with Fe_3O_4 nanoparticles (Fe_3O_4 @HMN-COF, Fe_3O_4 @MANCOF, and Fe_3O_4 @SIN-COF) as efficient adsorbents for IMI removal from water. These COFs, engineered with nitrogen-rich structures and extensive π -electron systems, achieve superior adsorption through π - π interactions, hydrophobic interactions, and hydrogen bonding. Characterization via FT-IR, XRD, and nitrogen sorption isotherms confirmed their high hydrophilicity, stability, and large surface areas. The magnetic properties of the COFs facilitated easy separation from water, enhancing practicality. Kinetic studies for all COFs indicated a pseudo-second-order model, suggesting chemisorption, with adsorption capacities of 600 mg/g for Fe_3O_4 @HMN-COF, 480 mg/g for Fe_3O_4 @MAN-COF, and 375 mg/g for Fe_3O_4 @SIN-COF. Thermodynamic analyses revealed spontaneous and endothermic adsorption processes. Reusability tests showed minimal capacity loss over multiple cycles, underscoring their practical applicability. Practical tests in honey and fruit samples confirmed high efficacy, demonstrating the COFs' versatility. The study also optimized the photocatalytic degradation of imidacloprid using these COFs, with Fe_3O_4 @HMN-COF achieving 98.5% efficiency under optimal conditions (10 mg/L IMI, 0.01 g catalyst dose, pH 11, 30°C, UV light) (Fig 1). These findings highlight the potential of magnetic COFs for sustainable environmental remediation of pesticide-contaminated water.

Acknowledgements: The Research Affairs Sector of UAE University (grant number. G00004741) is gratefully acknowledged by the authors as providing substantial financial assistance

References:

Thuyet, D.Q., H. Watanabe, and J.-h. Ok, Effect of pH on the degradation of imidacloprid and fipronil in paddy water. *Journal of Pesticide Science*, 2013. 38: p. 223-227.

Patil, P.N., S.D. Bote, and P.R. Gogate, Degradation of imidacloprid using combined advanced oxidation processes based on hydrodynamic cavitation. *Ultrasonics Sonochemistry*, 2014. 21(5): p. 1770-1777.

Yari, K., et al., A comparative study for the removal of imidacloprid insecticide from water by chemical-less UVC, UVC/TiO₂ and UVC/ZnO processes. *Journal of Environmental Health Science and Engineering*, 2019. 17: p. 337-351.

Wang, S., et al., Type- I hetero-junction of BiOI-BiO₂-x anchored on Ni foam accelerating charge separation and transfer for efficiently purifying hazardous wastewater. *Journal of Photochemistry and Photobiology A: Chemistry*, 2022. 426: p. 113705.

POSTER: NPO-F

1571056738: All-solution-processable ultrasensitive terahertz-infrared detectors with printable nanocarbon-inorganic hybrid structures

Yuto Matsuzaki, Minami Yamamoto, Leo Takai, Yukio Kawano and Kou Li (Chuo University, Japan)

As the structures of various industrial products become increasingly complex with improved functionality, non-destructive testing techniques are indispensable to obtain detailed internal structural and defect information. In particular, non-destructive image measurement with electromagnetic waves ranging from infrared (IR) to terahertz- and millimeter-waves (THz, MMW) enables both structural reconstruction and material identification based on the difference in permeability of these wavelengths bands. In this context, carbon nanotube (CNT) films are suitable for omni-directional non-destructive imaging devices for three-dimensional multilayered objects owing to their excellent physical durability and high absorption characteristics for ultrabroad IR-MMW bands [1]. Here, these photo-thermoelectric (PTE) effect devices including CNT film-type sensors utilize photo-induced heating and associated thermoelectric (TE) conversion for photo-detection [2]. Whereas the CNT films have excellent photo-absorption properties, the low Seebeck coefficient remains an issue in improving their sensitivity as PTE devices. In contrast, this work proposes the hybrid structure ultrasensitive sensors combining the superior photo-detection performance of CNT films and the thermoelectric conversion performance of bismuth composite materials with the high Seebeck coefficients. This work fabricated bismuth composite pastes by effectively mixing bismuth composite powders with conductive solvents and surfactants. This technique enables easy-to-handle use of bismuth composite materials in representative bulky configurations such as chips and pellets. In addition to the above, this work implements these pastes into devices by the screen-coating method [3]. By employing bismuth composite materials, the Seebeck coefficients of p- and n-type pastes exceed those of the CNT films, respectively. Through these efforts, this work proposes the hybrid structure device with significantly improved sensitivity while maintaining the excellent performance of existing broadband photo-detection and facilitating non-destructive testing techniques. In addition to the above, this work will comprehensively report the optimized mixing conditions of the bismuth composite pastes, the detailed fabrication process of the proposed broadband imaging device, and the demonstration of applied non-destructive imaging measurements at the conference.

1571057574: Two-dimensional high-yield printable integration of carbon nanotube pixels for real-time, large-area, and broadband non-destructive inspection camera applications

Leo Takai, Yuto Matsuzaki, Minami Yamamoto, Yukio Kawano and Kou Li (Chuo University, Japan)

I . INTRODUCTION This study aims to develop a carbon nanotube (CNT) film type broadband imaging device and applies it to non-destructive inspection technology by taking advantage of the optical and mechanical properties of CNT thin films[1]. The presenting device has ultra-broadband absorption properties and flexibility compared to existing solid-state detectors. The principle of this device is the photo-thermoelectric (PTE) effect[2]. Specifically, first, certain electromagnetic waves irradiated on CNT films are absorbed into local heating. Then, heat generates the voltage by the Seebeck effect. Relatedly, previous works mostly fabricated single pixel and one-dimensional array devices by using CNT films. However, these devices need to spatially scan a subject when imaging. Therefore, it is necessary to two-dimensionally integrate CNT film type devices as a camera structure[3, 4]. This work employed a desktop auto dispenser (available in uncooled atmospheric conditions) to print the entire structure on a flexible/stretchable thin substrate for fabricating the above imaging device. This study succeeded in developing a high yield CNT film type 2D camera device and real-time non-destructive imaging by mechanical alignment of each pixel by using the auto dispenser.

II . METHOD This study employed the auto dispenser (Fig. 1a) as the printing equipment. CNTs can be utilized in ink form, called CNT solution. Other materials, n-type chemical carrier dopant (for forming pn junctions) [5], conducting paste (electrode), and solder resist (insulator), are also ink forms. These liquid materials show high compatibility with existing printing technology. The device printing with a fully automated dispenser enables high yield micro-integration and three-dimensional wiring structures, leading to the realization of a CNT film type 2D camera device.

III . RESULT The fabricated 2D camera device in this study has 49 pixels (Fig. 1b). The n-type dopant applies to the upper right half of the CNT film. This camera device uses the PTE effect as its operating principle. The device is able to perform ultra-broadband optical detection with low noise under normal temperature and pressure due to the PTE operation of the CNT film. Fig. 1c indicates the measurement of the PTE response value by irradiating a near-infrared laser ($\lambda=1.55 \mu\text{m}$) at the pn junction of each pixel. As shown in this figure, this camera device is high yield. This represents that the camera printing is highly accurate.

1571057577: Multi-wavelength computer vision for structure restoration with a carbon nanotubes imager

Daiki Shikichi, Miki Kubota, Yukio Kawano, Kou Li and Ryoga Odawara (Chuo University, Japan)

This study demonstrated complete non-destructive restoration of three-dimensional (3D) composite material structures by using multi-wavelength computer vision techniques with a carbon nanotubes (CNT) film photo-thermoelectric (PTE) imager. The IoT society whose people and objects interact closely with each other, is expanding in recent years. With that background, high-quality, non-destructive inspection technology is attracting much attention, such as detecting impurities and defects in industrial products and daily necessities. Electromagnetic wave imaging plays a core role in non-destructive imaging techniques. Notably, during those electromagnetic wave imaging techniques, material identification and structural reconstruction are important inspection sections. Because of the lack of in-depth information on the structures, long-wavelength optical measurements that allow the material identification cannot achieve detailed restoration. On the other hand, computer vision techniques that lead to structural reconstruction have an issue with expanding longer wavelengths. In response, this study demonstrated the material-identified structural restoration that has never been achieved before by combining long-wavelength optical measurements and computer vision techniques with a CNT imager, one of the nanomaterial devices that makes it possible (Figure. 1). This study employs a Single-Walled CNT film PTE array detector. It absorbs ultra-broadband electromagnetic waves in visible light to millimeter-wave range and detects them effectively as electrical signals based on the PTE effect [1]. As the computer vision techniques, this work uses the visual hull evaluation [2] and the computed tomography (CT). Visual hull evaluation enables specifying the arrangement and general shape of structures using 3D images made from bi-directional silhouette images. The CT identifies the exact shape and materials of the structures. Therefore, by combining the complementary information obtained by these two methods, detailed structural reconstruction and material identification of 3D structures can be achieved. As a result of the multi-wavelength computer vision imaging with the CNT film PTE imager for a structure consisting of the first layer (a 1 mm diameter metal bar) and the second layer (a 10 mm width silicon outer wall), the visual hull reconstructed the shape of the second layer, and the CT restored the whole structure including the size and the thickness of each layer by transmitting the far-infrared through the silicon (Figure. 2). The combination of these results clarifies the structural information, including material identification. The material identification and structural reconstruction of more layered and composite material structures by wide-band, multi-wavelength computer vision imaging will be presented at the upcoming conference.

1571077960: Novel Microscope Based on simultaneous utilization of Third Harmonic Generation (THG) and Photoluminescence (PL) Microscopy for Thin Film Analysis and Molecular Detection

Mostafa Ahmed Nasr, Ganjaboy Boltaev, Piotr Piatkowski and Ali Sami Alnaser (American University of Sharjah, United Arab Emirates)

We report on the development of new microscope that allows for rigorous analysis of thin films and other transparent samples based on simultaneous utilization of Third Harmonic Generation (THG) Microscopy and Photoluminescence (PL) Microscopy, known as the THG-PL Microscope. Microscopic techniques in general have been developing quite rapidly since the advent of modern optics that lead to the development of Fluorescence Labelling, Fluorescence Microscopy and Light Profilometry [1]. In addition to that, with the development of nonlinear optics such as Second Harmonic Generation (SHG) and THG microscopy in what is known as Multi Photon Microscopy [2]. All these microscopic techniques revolutionized the field of microscopy and spectroscopy, as they allowed for characterizations that were simply not possible by the previous techniques [1][3]. Nevertheless, whilst these techniques have their own specialties, their own respective limitations provide a base for which THG-PL can prove its utility. For example, it is known that Fluorescence labelling techniques, require for labelling agents to be able to perform the spectroscopy of the material, rendered the samples altered, thus the desire for a label free and contact free technique is crucial [4]. Furthermore, Fluorescence Microscopy and SHG Microscopy both are limited to the range of materials they can investigate, as not all materials emit the relevant signals to the microscopic technique [5]. Another disadvantage that was of interest to improve upon, is the fact that techniques such Light Profilometry requires considerable time to generate images and is sensitive to the random movements of the background surfaces, which compromises the quality of the topography maps generated by the device. For these reasons, the THG-PL Microscope was developed to address those limitations and was tested on relevant transparent samples. Perovskite thin films of varying qualities and composition were analyzed using the newly developed THG-PL microscope. The microscope displays both signals from THG microscope component and the PL microscope component simultaneously on the camera screen. This allows for observing extent of smoothness on the film and detection of defects. The principle of having both the PL signal and the THG signal both shown together allows for the different morphological features to be compared as both signals are related in terms of the physics of their generation. In addition to that, the microscope has the capability to also act as a profilometer that is able to identify the topography of the sample's surface by converting the image maps to 3D spectrograms digitally. This functionality was tested by placing samples that have nanogrooves and comparing the results with a light profilometer. From understanding the topology, the smoothness, the composition of the sample, as well as having a map created for the sample, allows for the quality of films to be conveniently and rapidly be discerned using this innovative instrument. The microscope also has the option to replace its lenses such that magnification can be increased to allow for higher resolution that has the possibility of examining molecular samples.

1571078334: Effects of surface morphology and composition on saturable absorption and charge carrier dynamics of oxidized Si nanocrystal thin layers

Namitha Brijit Bejoy, Piotr Piatkowski and Ali Sami Alnaser (American University of Sharjah, United Arab Emirates)

Silicon, the cornerstone of modern electronics, takes on unique properties when engineered at the nanoscale, making it promising for a variety of applications, including energy storage, sensors, photonics, and nanoelectronics. Among the most interesting forms of nanosilicon are thin layers, which have garnered significant attention due to their enhanced physical and chemical properties compared to bulk silicon. Nanocrystal semiconductor thin films have intriguing applications, including their use as saturable absorbers (SAs) in mode-locked fiber lasers and as versatile photovoltaic material. A critical factor influencing the optical and charge transport properties of these thin layers is their surface morphology and composition. Understanding these effects is therefore essential for advancing the design and development of future devices. This study reports findings from Z-scan measurements, as well as time-integrated and time-resolved spectroscopic and microscopic analyses, on thin layers of silicon nanoparticles (Si NP) deposited on a glass substrate through the slow evaporation of Si NP colloidal solutions. These colloidal solutions were derived from the femtosecond laser ablation of silicon wafer in water, at two different pulse energy levels; 20 μJ and 240 μJ . Stationary spectroscopic and microscopic analyses were used to characterize the SiNPs, which consisted of an amorphous silicon phase and an oxidized mesoporous SiO_x layer surrounding a crystalline silicon core. Saturable absorption (SA) was observed in both sets of thin film samples during open aperture Z-scan measurements. For the 20 μJ thin film sample, the saturation intensity was determined to be 32.8 MW/cm², while for the 240 μJ sample, it was significantly lower at around 1.58 MW/cm². This SA behavior suggests the presence of localized trap states between the valence and conduction bands. Factors affecting the saturation intensity include (1) the thickness of the thin films, (2) the lifetime of the trap states, and (3) the density of the trap states. Raman mapping and profiling of the thin films showed that both samples had comparable thicknesses, approximately 2 μm . Time-resolved transient absorption (TA) spectra and dynamics revealed that excitons initially photoinduced in the crystalline silicon core are transferred to shell-related trap states within about four picoseconds. The trapped charges are then redistributed among localized states over tens of picoseconds. Finally, depopulation of the trap states into the valence band occurs on a nanosecond timescale, much longer than the experimental timescale, confirming the extended lifetimes of the trap states. These long lifetimes allow the trap states to be easily filled with low input intensities. XPS measurements revealed that the thin films prepared with higher pulse energy exhibited stronger oxidation and a reduction in crystalline core size, which likely contributed to an increase in the density of trap states. These results underscore that surface morphology and composition are crucial factors to consider in the design and development of Si NP-based optoelectronic devices.

1571062970: Synthesis and characterization of Multiwalled Carbon Nanotube /Iron Oxide nanocomposite for Electromagnetic Shielding

Mariam Siddiq Mansouri (Khalifa University & ADEC, United Arab Emirates)

MWCNT/Fe₃O₄ nanocomposites are assembled in the shapes of free-standing bucky paper with various wt% Fe₃O₄ on the copper foils. They are characterized by transmission electron microscopy, X-ray diffraction, and Raman spectroscopy. The EMI shielding was investigated in X-band frequencies (8.2 - 12.4 GHz). The nanocomposite of 30wt% Fe₃O₄ shows 42 dB SET, 27 dB SEA, and 15 dB SER, the best candidates for EMI shielding and microwave absorption.

1571063471: Functionalization of three-dimensional printed micro-containers with ferromagnetic nanomaterials for biomedical applications

Abhishek Lokhande (Khalifa University, United Arab Emirates); Daniel Choi (Khalifa University of Science and Technology, United Arab Emirates)

Three-dimensional (3D) printing technology has attracted interest in a various field of applications. However, most of the previous studies were focused on additive materials for 3D printing or developing new printable materials to functionalize the printed structures. Those approaches obviously have shown some progresses, but any solution has not been achieved to functionalize original ink materials for 3D printing that are supplied. In this study, we report a feasible 3D printing technique of fabricating micro-containers coated with Ni-Au coreshell nanowires that have a multi-functional properties. The surfaces of the polymer-based micro-containers are modified with thiol groups and confirmed by FT-IR. Then Ni-Au nanowires are directly attached without further treatment. Our approach expands direct applications of polymeric 3D printing materials to biomedical and pharmaceutical technology as a utilized platform for functional nanostructures.

1571078565: Compositional Effects on Superconducting Transitions in TiZrNbSn Shape Memory Alloys

Tahir Nawaz, Mehmet Egilmez and Wael Abuzaid (American University of Sharjah, United Arab Emirates)

Shape memory alloys (SMAs) exhibit superelasticity and/or shape memory effect, depending on their composition and thermal treatment. NiTi-based SMAs are widely studied due to their high superelastic strain (up to 10%) and shape memory functionality. Consequently, TiNb-based SMAs, particularly TiNbZr, have emerged as promising alternatives due to their similar mechanical properties and enhanced biocompatibility. TiNbZr alloys exhibit tunable superelasticity and stability, with elements like Mo, Ta, and Sn improving phase stability. Zr enhances superelasticity at room temperature, while Sn stabilizes transformation stress under cyclic loading. The combination of superelasticity and superconductivity in this material makes it a candidate for high-current superconducting wires and electronic applications. While research on TiNb based SMAs has predominantly focused on their metallurgical, mechanical, structural, and phase transformation properties, our study explores the influence of composition on the superconducting characteristics of biocompatible TiZrNbSn SMAs. Here, we studied the electrical and magnetic properties of $\text{Ti}_{67}\text{Zr}_{19-x}\text{Nb}_{11.5}\text{Sn}_{2.5}\text{X}_x$ (at%) SMAs (X represents Al, Si, and C). The desired compositions of the $\text{Ti}_{67}\text{Zr}_{19-x}\text{Nb}_{11.5}\text{Sn}_{2.5}\text{X}_x$ (in at. %) were prepared using vacuum arc melting furnace in inert environment. Highly pure (>99.5%) metal chunks were measured in the desired concentration to produce a total of 15g of each alloy. The produced ingots were further homogenized at 1100°C for 24h in a muffle furnace filled with Argon. The homogenized ingots were cold rolled down to 90-95% thickness reduction and were solutionized at 950°C for 30min, followed by water quenching. The solution treatment resulted in a BCC single phase material. Physical properties were measured through a Physical Properties Measurement System. We observed a superconducting phase transition in the base alloy $\text{Ti}_{67}\text{Zr}_{19}\text{Nb}_{11.5}\text{Sn}_{2.5}$ ($x=0$) at a critical temperature T_c 4.65K. Furthermore, we investigated the effect of the Al, Si, and C incorporation into the TiZrNbSn alloy on its superconducting phase transition temperature T_c . Our findings underscore the impact of compositional adjustments on the superconducting properties of SMAs, offering crucial insights for the development of advanced cryogenic electrical devices.

1571084230: Electrical and Piezoelectric Properties of the Flexible PZT/CNT Composite Films in Robot Actuator Application

Andrew B. Lee (American Community School of Abu Dhabi, United Arab Emirates); Abhishek Lokhande (Khalifa University, United Arab Emirates); Daniel Choi (Khalifa University of Science and Technology, United Arab Emirates)

(Prefer Poster Presentation) One of the most commonly used piezoelectric materials, PZT ($\text{Pb}(\text{Zr}_{0.52}\text{Ti}_{0.48})\text{O}_3$, lead zirconate titanate), offers a high piezoelectric response and is used in practical applications to make robot actuators and ultrasound transducers, while it has one of notable drawbacks such as brittleness, and can cause performance degradation. While, carbon nanotube (CNT) has remarkable properties, exceptional tensile strength and thermal conductivity because of their nanostructure and strength of the bonds between carbon atoms. Four PZT/CNT composite films are fabricated by a tape-casting process to study the role of CNT to the piezoelectric moment in PZT/CNT composite. Electrical properties are evaluated by measurement resistance and conductivity. Brittleness is measured by Stress/Strain Test. Material characterizations are also confirmed by both X-ray Diffraction (XRD) and microstructure and electrical properties through Field Emission Scanning Electron Microscope (FESEM) images depending on voltage variations. The PZT(300 mg)/CNT(80mg) composite shows the optimal CNT concentration that offers highest conductivity while preserving the mechanical integrity and piezoelectric performance of the composites.

POSTER: Nano Water

1571071621: Ceramic membrane fabrication techniques: A review

Mohamed Abbas (Qatar University & Center for Advanced Materials, Qatar); Rawia Abdullahi Mohammed and Besan Alja'oni (Center for Advanced Materials - Qatar University, Qatar); Maryam Al-Ejji (Qatar University, Qatar); Rayane Akoume (Center for Advanced Materials - Qatar University, Qatar)

Ceramic membranes have garnered significant attention for their diverse applications in separation processes. This review explores various fabrication methods employed in the production of ceramic membranes, including phase inversion, sol-gel, electrospinning, dry pressing, slip casting, and extrusion. Each method is scrutinized for its unique mechanisms, influencing factors, advantages, and drawbacks. The review also highlights the applications of ceramic membranes across different industries, emphasizing their role in water purification, gas separation, catalysis, biofiltration, membrane reactors, the pharmaceutical industry, the food industry, and bioengineering. A comprehensive evaluation of the pros and cons of ceramic membrane fabrication methods provides insights into their suitability for various scenarios. Finally, strategies for overcoming the limitations of ceramic membranes are discussed, addressing cost mitigation, enhancing mechanical strength, pore size control, and fouling challenges. This review aims to provide a concise yet comprehensive overview of ceramic membrane technology.

1571078594: Lignocellulosic Nanofibril Crosslinking for Oil/Water Separation: Enhancements using Femtosecond Laser

Muhammad Qasim and Ali Sami Alnaser (American University of Sharjah, United Arab Emirates)

Oil/water separation is a critical issue across several industries. Extensive growth and developments in the oil and gas, mining, textile, food, and metallurgical industries have resulted in generation of large quantities of oily wastewater. Also, activities such as oil exploration, production, and transportation can cause accidental release of oil into the oceans [1]. Both oily wastewater and oil spills have the potential to impose serious impacts on the marine and coastal environment and human health. Conventionally, oil/water mixtures are separated using techniques such as gravity settling, adsorption, and flotation. These techniques are known to exhibit low separation efficiency and/or have high operational costs [2]. As a result, development of efficient and cost-effective oil/water separation techniques is of extreme significance. Recently, it has been reported that oil/water separation can be performed by turning lignocellulosic waste into hydrophobic membranes through crosslinking of the nanofibrils using metal ions [3]. Lignocellulosic waste, such as paper and food packaging materials, is available in large quantities (~1.3 billion tons/year [4]) and can be employed as a low-cost and biodegradable material for oil/water separation after effective hydrophobization. To impart hydrophobicity, crosslinking of the nanofibrils present within the lignocellulosic wastes can be performed such that coordination interactions are created between the surface polar groups of nanofibrils and some suitable metal ion [5]. These interactions reduce the number of surface polar groups and lower the surface energy, thereby, imparting surface hydrophobicity. However, the hydrophobicity imparted in this case remains limited (water contact angle: ~130°) which, in turn, limits the oil/water separation efficiency. Herein, we report an enhanced methodology for converting lignocellulosic waste to highly hydrophobic membranes. Waste lignocellulosic waste was immersed in a dilute solution of ferric chloride (FeCl₃) followed by surface texturing using a femtosecond laser (Figure 1). The laser surface texturing produced crevices through laser ablation that, in turn, provided open pockets for the entrapment of air. The resulting surface was, thus, converted to a highly hydrophobic membrane that exhibited a water contact angle as high as 153°. The hydrophobic membrane was also found to be highly effective in separating oil/water mixtures.

References: [1] S. Rasouli, N. Rezaei, H. Hamed, S. Zendejboudi, and X. Duan, *Mater Des*, vol. 204, p. 109599, 2021, doi: <https://doi.org/10.1016/j.matdes.2021.109599>. [2] J.-J. Li, Y.-N. Zhou, and Z.-H. Luo, *Prog Polym Sci*, vol. 87, pp. 1-33, 2018, doi: <https://doi.org/10.1016/j.progpolymsci.2018.06.009>. [3] X. Wang, M. Chen, R. M. O. Nayanathara, Z. Zhang, and X. Zhang, *Carbohydrate Polymer Technologies and Applications*, vol. 6, p. 100377, 2023, doi: <https://doi.org/10.1016/j.carpta.2023.100377>. [4] M. Bilal and H. M. N. Iqbal, *Current Sustainable/Renewable Energy Reports*, vol. 7, no. 3, pp. 100-107, 2020, doi: <https://doi.org/10.1007/s40518-020-00153-5>. [5] R. M. Oshani Nayanathara et al., *Chemical Engineering Journal*, vol. 459, p. 141596, 2023, doi: <https://doi.org/10.1016/j.cej.2023.141596>.

POSTER: AIN-L

1571086363: Data-driven approach for Time-Resolved Photoluminescence Modeling of Perovskite Solar Cells

Salah Ahmad Shaito (University of Sharjah, United Arab Emirates & DEWA, United Arab Emirates); Ahmer A.b. Baloch (DEWA, United Arab Emirates); Nouar Tabet (University of Sharjah, United Arab Emirates)

The performance of solar cells is critically influenced by carrier dynamics within the active layer and at the interfaces, particularly regarding recombination mechanisms and carrier extraction processes. Time-resolved photoluminescence (TRPL) spectroscopy serves as a pivotal tool for probing these dynamics; however, traditional analyses often rely on fitting experimental decay curves with simplistic exponential functions that lack physical justification. Moreover, solving the numerical models that describe TRPL with complex boundary conditions is computationally intensive and time-consuming.

In this work, we present a data-driven approach employing a Variational Autoencoder (VAE) to model and analyze TRPL spectra of perovskite solar cells. We generate a comprehensive dataset using validated model by systematically varying eight key physical parameters influencing carrier dynamics: film thickness, diffusion constant, Shockley-Read-Hall (SRH) recombination rate, radiative recombination rate, doping density, injection level, and surface recombination velocities at interfaces [1]. Each unique combination of these parameters is used to simulate TRPL signals using an established physical model, resulting in a rich dataset that encapsulates the interplay between material properties and photoluminescence behavior. VAE is trained on the simulated TRPL spectra to learn a latent representation of the underlying physical parameters. This approach enables us to tackle both the forward problem-predicting TRPL spectra from given physical parameters-and the inverse problem-inferring the physical parameters from experimental TRPL data. By mapping complex, high-dimensional TRPL data into a lower-dimensional latent space, the VAE facilitates rapid and accurate reconstruction of TRPL spectra and extraction of material parameters without the need for iterative numerical solutions. Our methodology offers several advantages over traditional modeling techniques. Firstly, it provides a physically interpretable framework for analyzing TRPL data, linking observed photoluminescence dynamics directly to material properties and interface characteristics. Secondly, it significantly reduces computational overhead, allowing for swift predictions that are essential for high-throughput screening and real-time diagnostics.

This work underscores the potential of machine learning techniques, specifically generative models like VAEs, in advancing the analysis of complex spectroscopic data in photovoltaics research. By bridging the gap between experimental observations and theoretical models, our approach contributes to a deeper understanding of the factors limiting PSC performance and opens avenues for the optimization of device architectures

1571005676: A practical Guide In Water Quality Prediction using Artificial Intelligence Algorithms

Dlayel Aluhaideb, Danah Algarni, Fatema Alamoodi, Shahd Aljaafari and Zainab Alsafwani
(Imam Abdulrahman Bin Faisal University, Saudi Arabia)

The ability to access potable water is a privilege that every human being should have. As pollution levels increase, water quality has been significantly impacted. In addition to the high demand for accessing potable water. Potable water is the term that describes water that is safe for human consumption. Therefore, predicting water potability before consumption will eventually reduce the influence of high pollution rates. Previous studies have significantly shown promising results in terms of accuracy and low error rates. However, based on the literature survey outcomes, previous studies were to have a relatively small dataset. In this research, the Jupyter Notebook tool is used with the machine learning algorithms Support Vector Machine, Decision Tree and K-Nearest Neighbor to predict water potability. The reason for choosing these algorithms in particular is that they perform well in binary classification models. In this research, the data is split using the `train_test_split` method with 70% subset used for the training and 30% used for the testing. However, there was an issue of having an imbalanced dataset. Thus, Synthetic Minority Oversampling Technique (SMOTE) is applied. Moreover, the Stratified Cross-Validation algorithm is used in the GridSearch for the purpose of hyperparameter tuning, having the value of k as 10. While the Sequential Feature Selection is used for feature selection purposes. Furthermore, the ensembled process is used to get a better generalization of the model. Lastly, the results of evaluating the model were based on the testing split taken from the initial split of the dataset. Results of the study demonstrated that the highest accuracy is achieved by the DT as it achieved %73.75 accuracy.

Poster: Nano-biomaterials, Nano-bionic and Biomedical Applications (NBBB-M)

1571077705 Analysis of Adsorbed Serum Proteins on Polymer Brush Films

Ayano Nomura and Tomohiro Hayashi (Institute of Science Tokyo, Japan)

When biomaterials are in contact with blood, serum proteins are rapidly adsorbed onto their surface and influence their performance. Understanding protein adsorption on biomaterial surfaces is crucial for the development of improved medical and biotechnological devices. However, adsorbed proteins and adsorption mechanism remain unclear because of the limitations of methods and the complexity of data analysis. In this work, we used six different types of polymer brush films with nanometer-scale thickness as a model to investigate how proteins adsorb onto material surfaces. Over 200 adsorbed proteins were identified and their quantities determined by using nano LC-MS/MS analysis. Furthermore, we found that the composition of the adsorbed proteins is not simply governed by their isoelectric points and molecular weights. To clarify factors that promote protein adsorption, especially onto protein resistant films, we analyzed the composition of amino acids on the "surface areas" of the proteins. Our analysis revealed that arginine residues, which facilitate protein-protein interactions, are crucial for distinguishing between adsorbing and non-adsorbing proteins.

This finding contributes to the understanding of the longstanding questions including the condensation of vitronectins and fibronectins on various materials."

1571080552 Eco-Friendly Synthesis of Zinc Oxide Nanoparticles Using Peppermint Extract: Characterization and Antimicrobial Evaluation

Muhammad Shahid (Sultana Qaboos University, Oman) Shahira Al-Reisis¹, Arshad Ali², Maryam Al-Zadjali¹, Ali-Al-Subhi¹, Muhammad Shafiq Shahid^{1,*}

¹Department of Plant Sciences, College of Agricultural and Marine Sciences, Sultan Qaboos University, Al-Khoud 123, Oman

²Earth Sciences Research Centre, Sultan Qaboos University, Al-Khod 123, Oman

*Correspondence at: mshahid@squ.edu.om

Summary: This study explores the green synthesis of zinc oxide nanoparticles (ZnONPs) using peppermint (*Mentha Piperita*) extract as a reducing and stabilizing agent. The synthesized ZnONPs were characterized using various techniques including SEM, TEM, EDXS, XRD, FTIR, and UV-Vis spectroscopy. The particles displayed a size range of 20-50 nm with a well-defined crystalline structure. Antimicrobial testing demonstrated significant bacterial inhibition, showing promise for applications in antibacterial technologies and other industrial uses.

Materials and Methods: Peppermint Extract was prepared from *Mentha Piperita*, this extract served as the reducing and stabilizing agent due to its bioactive compounds, including flavonoids, terpenoids, and polyphenols. The peppermint extract was mixed with an aqueous solution of zinc nitrate hexahydrate under controlled conditions. The bioactive components in the peppermint extract reduced zinc ions to form ZnONPs and capped them to prevent aggregation, facilitating the eco-friendly synthesis process. SEM, TEM, EDXS, XRD, FTIR and UV-Vis Spectroscopy were used to determine morphology, particle size, shape, elemental composition, crystalline structure, functional groups and optical properties of the NPs (Chowdhury et al., 2021). Antibacterial properties were evaluated using the well diffusion method. ZnONPs at concentrations of 35 mg/ml, 25 mg/ml, and 15 mg/ml were tested against bacterial strains, and inhibition zones were measured to determine antimicrobial efficacy.

Results: SEM revealed triangular-shaped ZnONPs with well-defined morphology. TEM showed NPs with spherical shapes, with sizes ranging from 20-50 nm. EDXS confirmed a composition of 80.4% zinc and 19.6% oxygen, indicating the formation of ZnO. XRD analysis indicated the wurtzite crystalline structure, which is a stable phase of ZnO. FTIR identified the presence of biomolecules, such as hydroxyl and carbonyl groups, from the peppermint extract responsible for NP stabilization. UV-Vis spectroscopy displayed an absorption peak at 220 nm, characteristic of ZnONPs. The antimicrobial tests demonstrated significant bacterial inhibition, with zones of inhibition measured at: 0.2 mm for 35 mg/ml ZnONPs, 0.1 mm for 25 mg/ml ZnONPs, and 0.05 mm for 15 mg/ml ZnONPs. The antibacterial activity was concentration-dependent, with the highest ZnONP concentration producing the largest inhibition zone.

Discussion: This study successfully demonstrates an eco-friendly synthesis of ZnONPs using peppermint extract, contributing to the field of green nanotechnology. The bioactive components in peppermint played a crucial role in reducing and stabilizing the NPs, offering a sustainable alternative to conventional chemical synthesis methods. The characterized ZnONPs exhibited desirable properties, including a well-defined crystalline structure and excellent antibacterial performance. The findings support the potential of ZnONPs for applications in antibacterial technologies, such as in medical devices, coatings, and packaging. The ability to synthesize ZnONPs in an environmentally conscious manner is highly relevant in nanostructured material applications, particularly in energy, bio, photonics, and electronics sectors. These particles may be further explored for their catalytic, optical, and electronic properties, expanding their utility in various industrial applications.

Conclusion: The eco-friendly synthesis of ZnONPs using peppermint extract offers a sustainable and effective method for producing NPs with significant antibacterial properties. The well-defined ZnONPs exhibited excellent antimicrobial activity, making them suitable for a range of applications in biomedicine and materials science. This green synthesis method aligns with the broader goals of sustainability and opens new avenues for the use of ZnONPs in diverse fields, including energy and electronics (Malik 2023).

References: Chowdhury, R. A., Hassan, M. M., Das, S., Dhar, S. A., Moniruzzaman, M. (2021). IOP Conference Series: Materials Science and Engineering.

Malik, S., Muhammad, K., Waheed, Y. 2023. Nanotechnology: A revolution in modern industry. Molecules 28(2), 661."

POSTER: 2D Materials & Applications (2D 2024-P)

1571077761/Poster

Desani Ramadhan and Shashikant P. Patole (Khalifa University, United Arab Emirates)

Perforated MXene, a novel variant of the two-dimensional (2D) transition metal carbide, has emerged as a promising material for water purification. This work explores the unique properties and potential applications of perforated MXene in water purification. By introducing controlled perforations into the MXene structure, researchers have significantly enhanced its surface area and porosity. This increased surface area-to-volume ratio allows for more efficient adsorption and filtration of contaminants from water. Additionally, the perforations can be tailored to specific applications, enabling selective removal of various pollutants. This review summarizes the methods used to fabricate perforated MXene and the factors influencing its performance. It also highlights the potential advantages of perforated MXene over traditional MXene in terms of adsorption capacity, filtration rate, and selectivity. Applications of perforated MXene in water purification include the removal of heavy metals, dyes, organic pollutants, and even salts for desalination. The ability to selectively target specific contaminants makes perforated MXene a valuable tool for addressing complex water quality issues. In conclusion, perforated MXene represents a significant advancement in water purification

technology. Its unique properties and versatility offer promising solutions to the challenges posed by water scarcity and pollution. Further research and development in this area are expected to lead to even more innovative and effective applications of perforated MXene in water treatment.

