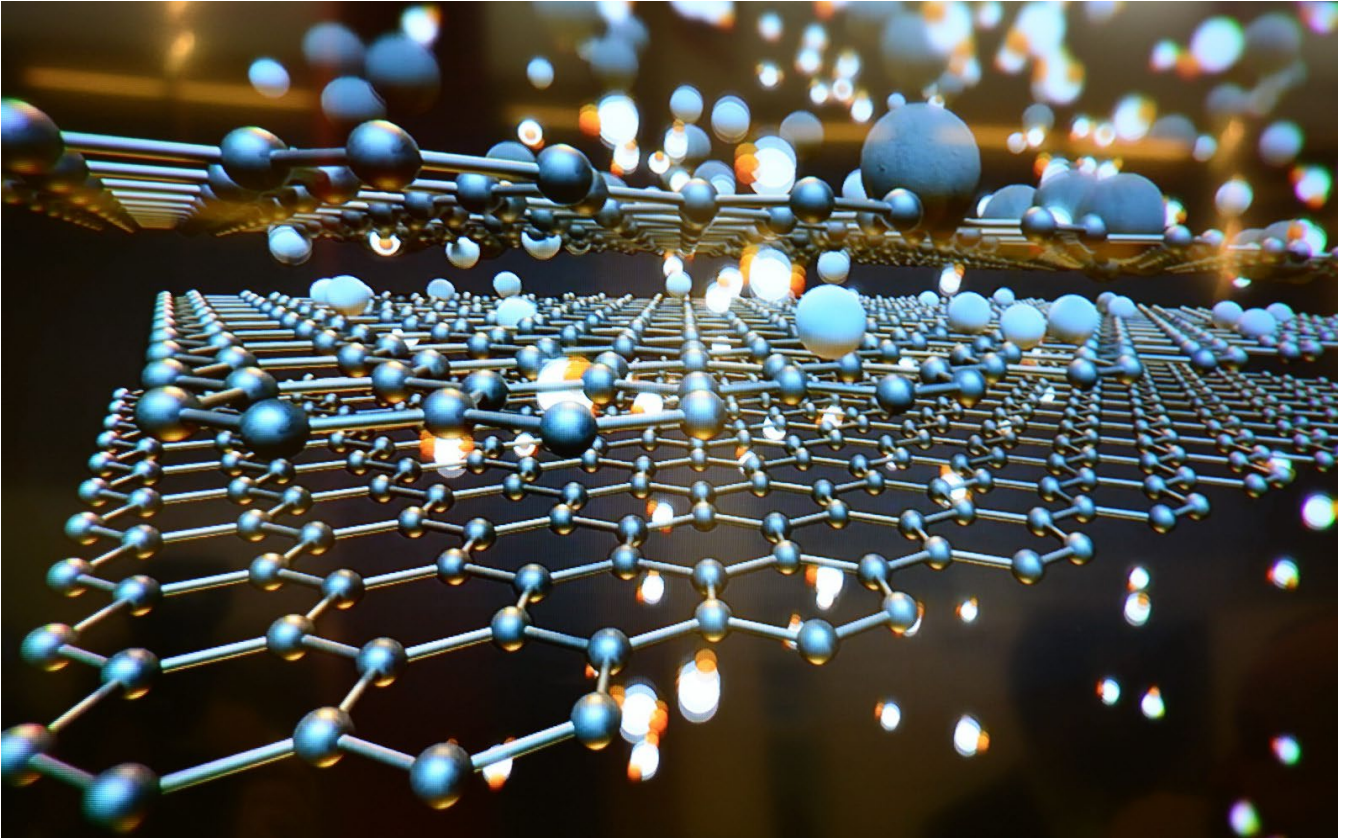


# Frontiers in Materials Science and Engineering (FMSE) | UAE 2024

## BOOK OF ABSTRACTS



February 13-15, 2024 | Main Building, AUS



# KEYNOTE ABSTRACTS | February 13–15, 2024

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## KEYNOTE ABSTRACTS

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# **Silicon nano structures and composites for high-tech device applications**

Munir H. Nayfeh

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Due to several fundamental characteristics, semiconductor silicon and its compounds/composites commends highly unique Earth and space importance. Those characteristics include a two-bandgap nature, one is UV direct, and the other is infrared indirect. Moreover, it exhibits high density of valence electrons, high chemical reactivity with oxygen, metal solubility via charge acceptance/donorship, ability to exchange charge with salts, and unique novel quantum confinement characteristics induced by miniaturization to the nano scale. Silicon-based compounds such as silica/silicates/concrete and computer chips have been pivotal in sustainability and improvement of lifestyle on Earth, while re-cycled interstellar nano silica/silicate dust/grain has been key to the formation of new stars and rocky planetary systems in the far corners of the cosmos. Moreover, additional unique characteristics at the nano scale enable/afford a wide range of optical and plasmonic characteristics in the UV/visible, infrared, radio, and microwave regimes affording high-tech applications as well as hold keys, signatures, and secrets of the universe. In this talk, we present methods for Earth and space production of the Si-based structures, and present a selected bouquet of recent unique applications, including electronics, plasmonic/photonics, biosensing, climate change, quantum computing and networking, hence sampling some of the recent emerging high-tech functionalities and applications.

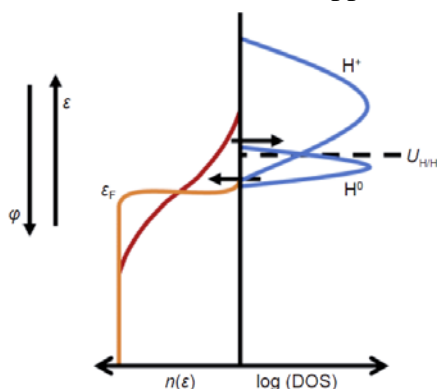
# FEMTOSECOND LASER INDUCED PHYSICOCHEMICAL PROCESSES

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Ultrafast pulse laser energy deposition in solids is reviewed. It takes place faster than the electron-phonon-relaxation followed by processes, such as e.g. phase changes, leading to ultraprecise machining results, but also new classes of physical, chemical and biological reactions, in which directed, deterministic motions of atoms play a key role [1].

Hot electrons in thermal nonequilibrium with a metal lattice can be generated with low-energy photons from a fs-pulse laser [2]. Electrons are emitted into an adjacent acidic electrolyte as giant current pulses (up to  $2 \times 10^6 \text{ A cm}^{-2}$ ) with durations of the order of the electron-phonon relaxation time. They reduce protons to hydrogen thus recharging the electrochemical double layer. The reduction product, hydrogen in *statu nascendi*, can re-inject electrons into the metal because the Fermi distribution has returned to its equilibrium state (Figure 1). The strongly superlinear dependence of the emitted charge on the laser fluence is supported by the thermoemission model.



**Figure 1.** fs-laser generation of hot electrons at the metal-electrolyte interface. Schematic electronic Fermi-Dirac distribution  $n$  on the metal and density of states (DOS) as function of the electronic energy  $\varepsilon$  of  $\text{H}_3\text{O}^+$  and  $\text{H}^0$  [2].

Apertureless scanning near-field optical lithography can extend the lithography resolution. A scanning probe microscope tip was illuminated by a focused fs-laser beam and strongly enhanced the electromagnetic field in the vicinity of the tip's apex [3]. This generated nano-modifications on a solid surface in close proximity with the tip.

Femtosecond laser generation of binary metallic oxide nanoparticles for applications in medical imaging diagnosis can be based on Liquid-Assisted Pulsed Laser Ablation (LA-PLA). Thus multimodal imaging contrast agents (MCAs) combining magnetic  $\gamma\text{-Fe}_2\text{O}_3$  or  $\text{Fe}_3\text{O}_4$ , and W, Ta and Bi capable of responding to both X-ray radiation and magnetic fields could be generated [4].

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## Semiconducting Polymers for Electronics, Optoelectronics, and Energy Storage Technologies

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Our laboratory has been investigating conjugated polymers for applications in organic electronic and energy conversion/storage devices, including organic light-emitting diodes, thin film transistors, electrochemical transistors, organic photovoltaics, thermoelectric devices, etc for more than three decades. Nevertheless, the underlying mechanisms of how molecular and supramolecular factors influence the electronic structure, charge transport, optoelectronic, and electrochemical properties of semiconducting and conducting polymers in most of these applications remain to be fully elucidated. In this talk, I will highlight some examples of our recent work in addressing this knowledge gap for both n-type and p-type conjugated polymers. Our studies in one area have investigated how polymer molecular weight influences the charge transport properties in two topologically distinct classes of n-type conjugated polymers – those with rigid-rod chain topology and those with semi-flexible chain topology – and found that the chain length dependence of carrier mobility and mechanism of electron transport depend on the polymer chain topology.

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# 2D Graphene Oxide Liquid Crystal for Post-AI Era: Smart Fibers, Soft Robotics, Single Atom Catalyst

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## **Abstract**

Graphene Oxide Liquid Crystal (GOLC) is an intriguing 2D carbon based soft material, which exhibits nematic type colloidal discotic liquid crystallinity with the orientational ordering of graphene oxide flakes in good solvents, including water. Since our first discovery of GOLC in aqueous dispersion at 2009, this interesting mesophase has been utilized over world-wide for many different application fields, such as liquid crystalline graphene fiber spinning, highly ordered graphene membrane/film production for water treatment, nanoporous graphene assembly for energy/environmental applications and so on. Interestingly, GOLC also allow us a valuable opportunity for the highly ordered molecular scale assembly of functional nanoscale structures. This presentation will introduce our current status of GOLC and other 2D material research particularly focusing on the nanoscale assembly of functional nanostructures, including highly oriented 1D fibers, 2D films and 3D nanoporous structures. In particular, human muscle inspired graphene based nanocomposite fiber actuators will be highlighted along with its interesting demonstration for biomimetic behaviors. Besides, relevant research works associated to the nanoscale assembly and chemical modification of various low dimensional materials, including 2D TMDs and MXene, will be presented particularly aiming at energy and environmental applications. In the last part of presentation, our first discovery of single atom catalyst will be introduced, including other relevant research efforts exploiting the customized heteroelement doping of graphene based structures.

## Additive Manufacturing – Towards Smart and Sustainable Manufacturing

Marwan Khraisheh

Texas A&M University at Qatar

Additive manufacturing (AM) is an advanced manufacturing process that involves layer-by-layer fabrication of three-dimensional objects from digital designs. With its remarkable growth and potential, AM is poised to revolutionize the manufacturing industry. It enables on-demand fabrication of components, eliminating the need for extensive inventory and reducing waste. It also promotes cost-effective utilization of materials, enhances resiliency, improves efficiency, increases design flexibility, and provides overall agility. With the transition towards digital manufacturing and smart communities, AM is expected to be an integral part of the future. AM has already found applications in almost all major industries including energy, utilities, infrastructure, transportation, biomedical and agriculture. Despite substantial progress and developments, AM still faces challenges; among them are the limited predictive capabilities of material defects during the fabrication process and the difficulty to optimize the many highly interrelated process parameters to produce defects-free components. The research activities at the smart and sustainable manufacturing lab at Texas A&M University at Qatar that aim to advance the utilization of additive manufacturing will be presented including the development of a framework for constructing printability maps.



## **An overview of strength and ductility in additively manufactured metals**

Yinmin (Morris) Wang

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The rising impacts of additive manufacturing (AM, aka 3D printing) on various industries have propelled materials scientists and mechanical engineers to search for the exotic materials properties that can be created by these techniques. AM involves unique fabrication conditions and thus offers opportunities to produce materials with tailored strength and ductility. Nevertheless, the highly nonconventional microstructures created by AM techniques impose tremendous challenges to understand the strength scaling law and other materials properties. This overview talk will present our group effort in the recent decade to investigate the strength and ductility of several model materials systems including pure copper, 316L stainless steel, and medium entropy alloys. All these materials were fabricated by laser powder-bed-fusion, which is one of the popular AM techniques to manufacture structural metals. In all these cases, we observe a hierarchical microstructure and multiple length scales that render a myriad of strengthening mechanisms. These interesting microstructures include solidification enabled cellular structures, low-angle grain boundaries, and dense dislocations. High uniform tensile elongation is often observed in many cases due to the progressive work-hardening mechanisms triggered by these hierarchically heterogeneous microstructures. We will further elaborate the influence of residual stresses and other defects (such as pores) on mechanical behavior and conclude with some outstanding issues that call for future research.

# The Rise of Metamaterials Enabled by Additive Manufacturing

Rashid K. Abu Al-Rub\*

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## Abstract

In nature, metamaterials exhibit enhanced multi-functionalities driven mainly by their sophisticated topologies and length scales. These natural systems have inspired the development and expansion of synthetic architected materials or lattices for revolutionary applications. Due to advances in additive manufacturing (AM), design for additive manufacturing (DfAM) gained considerable attention in the last few years. Of particular interest is designing metamaterials with topologies based on triply periodic minimal surfaces (TPMS) which attracted a lot of attention recently due to their mathematically-controlled fascinating topologies and superior physical and mechanical properties. This talk focuses on the design, additive manufacturing, and use of TPMS-based metamaterials for enhancing the multi-functionality of additively manufactured components made of metals, polymers, ceramics, and composites. We summarize our various investigations on multifunctional properties of these novel types of metamaterials and their applications to light-weighting of AM components and enhancing the performance and efficiency of mechanical and thermo-fluid systems such as sandwich panels, heat exchangers, energy storage devices, catalytic converters, etc.

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# **MXenes-based Electronics and Sensors**

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MXenes are one of the most interesting families of 2D materials as they exhibit a variety of properties that make them unique among other 2D materials. These include fast electronic and ionic transport, significant redox activity, high surface charge density, the ability to intercalate many types of ions and molecules, and tunable properties by modifying their composition and surface functional groups. This has led to the exploration of MXenes for an unusually large number of potential applications. In this talk, I will discuss the fundamental properties of MXenes and demonstrate how our group has developed them for use in several applications in electronics, sensing, and energy devices. Specifically, I will discuss applications that capitalize on ionic transport in MXenes and strong redox activity, including salinity gradient energy harvesting and electrochemical devices. Further, I will discuss applications that capitalize on the strong electronic transport in MXenes including using them as contact materials for wide bandgap semiconductor devices, solar cells, and as additives in conductive hydrogels.

# INVITED ABSTRACTS

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<b>Chunlei Yang</b>	Superdense Lithium Deposition Via Surface/Bulk Modifications For Stable Lithium Metal Batteries
<b>Ahsanulhaq Qurashi</b>	Advanced Functional Nanomaterials for Clean Energy Applications
<b>Chinmay Phutela</b>	Exploring new horizons in Metal Additive Manufacturing: Innovations and Opportunities
<b>Panče Naumov</b>	Dynamic Organic Crystals: A New Class of Smart Engineering Materials
<b>Nouar Tabet</b>	Perovskite Solar Cells: Defects Passivation and Stability
<b>Hussein A. Kazem</b>	The Impact of Dust on Photovoltaic Performance: Historical, Current, And Future Outlooks
<b>Eyad Masad</b>	Advances In the Design of Sustainable and Resilient Infrastructure Materials
<b>Wenjie Li</b>	Tuning Band Alignment at Grain Boundaries for Efficiency Enhancement in CZTS Solar Cells
<b>Hussein A. Younus</b>	Catalyst Transformation During Electrochemical Water Oxidation Using Cobalt Oxyhydroxide under Neutral Conditions
<b>Rashid A. Ganeev</b>	Nonlinear Optical Characterization of Quantum Dots And Nanoparticles of Different Shapes Using High-Order Harmonics Generation And Z-Scans
<b>Nirpendra Singh</b>	Two-Dimensional (2D) Materials for Thermoelectric Applications

# SUPERDENSE LITHIUM DEPOSITION VIA SURFACE/BULK MODIFICATIONS FOR STABLE LITHIUM METAL BATTERIES

Wei Wu, Haidi Yao, Changjing Ma, Fang Niu, Xingzi You, Qiange Duan, Cheng Yang, Qilong Wu, Chunlei Yang<sup>\*1</sup>

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Lithium metal batteries (LMBs) specialize in energy density, while the immoderate dendrite growth and solid electrolyte interphase (SEI) proliferation have been impeding their practical application. The key is the regulation of  $\text{Li}^+$  diffusion/nucleation behaviors towards a dense deposition [1]. Herein, modifications undertaken from surface/bulk are proposed to not only participate the formation of an inorganic-enriched SEI in the surface but also induce an overwhelming bottom-up lithium growth pattern in the bulk (see Fig. 1). A superdense lithium deposition enables a highly reversible dendrite-proof plating/stripping behavior even under ultrahigh-rate conditions. It gives record-breaking cumulative plating/stripping capacity for symmetric cells and extreme fast charging performance for high-areal-capacity full cells, thus improving the state-of-the-art for long-term cycling of practical LMBs and further expanding the use of LMBs to high-loading and power-intensive scenarios [2]. The proposed approaches are also applicable to match the roll-to-roll production process, presenting the efficient strategies to realize the high performance lithium metal anode of industry-adaptable potential.



**Figure 1.** Schematic of the surface/bulk evolution behaviors.

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## Advanced Functional Nanomaterials for Clean Energy Applications

Ahsanulhaq Qurashi \*

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To advance the progress of miniaturized devices, numerous promising new advanced functional materials have been systematically investigated in past few years. In this talk, I will discuss various potential electrode materials for energy and sensing devices. This talk provides a broad spectrum of the state-of-the-art research activities that focus on the functional metal-oxide nanostructured (MOXN) systems and their characterizations by diverse and momentous techniques. It commences with the synthetic methods and possible mechanisms that have been employed to form these nanostructures. A wide range of remarkable characteristics will be presented, organized into sections covering a number of nanostructured metal-oxides. Efforts on chemical and biological sensors will be conversed. Additionally. Finally, an overview of challenges, frontiers and opportunities of materials for renewable energy conversion and storage systems will be deliberated.

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## **Exploring new horizons in Metal Additive Manufacturing: Innovations and Opportunities**

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The realm of additive manufacturing (AM), widely known as 3D printing, is undergoing a transformative phase, reshaping contemporary manufacturing landscapes across various sectors. This transformation is driven by the range of benefits these manufacturing methodologies provide. While the acceptance of polymeric materials-based AM techniques has already established a significant presence and is being widely adopted in diverse industries, metal additive manufacturing is still in its developmental stages, particularly in the MENA region. The focus of the Technology Innovation Institute's additive manufacturing team spans various facets of the AM process, including the process, materials, design, digitisation and applications. This talk will primarily concentrate on material innovations in the context of metal additive manufacturing and the importance of material development in the industrial context. Currently, the use of conventional materials in metal AM, especially in processes like Laser Beam Powder Bed Fusion (PBF-LB), is common. These materials are not specifically engineered for the unique physics complications that arise due to laser-matter interaction in these processes. This presentation aims to shed light on the latest advancements in printable metals suitable for PBF-LB, highlighting the ongoing research and development efforts at TII.



# Dynamic Organic Crystals: A New Class of Smart Engineering Materials

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**keywords:** *smart materials, crystals, adaptive properties, mechanical properties, solid-state chemistry*

## Abstract

The anticipated shift in focal point of interest of solid-state chemists, crystal engineers and crystallographers from structure to properties to function of organic solids parallels the need to apply our accumulated understanding of the intricacies of crystal structure to explaining the related properties, with the ultimate goal of harnessing that knowledge in applications that require soft, light-weight, and/or biocompatible organic solids.<sup>1</sup> In these developments, the adaptive molecular single crystals warrant a particular attention as an alternative choice of materials for light, flexible, and environmentally benign devices, primarily memories, capacitors, sensors, and actuators. Some of the outstanding requirements for application of these dynamic materials as high-efficiency energy storage devices are strongly induced polarization, high switching field, and narrow hysteresis in case of reversible dynamic processes. However, having been studied almost exclusively by chemists, molecular crystals still lack the appropriate investigations that reliably evaluate their reproducibility, scalability, and actuating performance, and some important drawbacks have diverted the interest of engineers from these materials in applications. United under the umbrella term crystal adaptronics, the recent research efforts aim to realistically assess the appositeness of dynamic crystals for applications that require fast, reversible and continuous operation over prolonged periods of time. With the aim to highlight the most recent developments in the research of adaptive molecular crystals, in this lecture I will discuss their assets and pitfalls. The lecture will also provide hints on the likely future developments that capitalize on the untapped, sequestered potential for applications of this distinct materials class.

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# Perovskite Solar Cells: Defects Passivation and Stability

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## **Abstract**

Since 2009, the power conversion efficiency of perovskite solar cells (PSCs) has increased from 3.8% to 26.1% which is very close to the record efficiency of silicon heterojunction cell of 26.8% achieved in 2023. This unprecedented increase of performance over more than a decade has fuelled the research activity in the field and let some experts believe that perovskites could be an alternative to the dominating silicon based PV technology. PSC/Si tandem cells broke the thermodynamic limit of Silicon this year by reaching 33.9% efficiency. Yet, major challenges remain and need to be addressed before PSCs find their way to the market. These are namely the poor device stability due to the organic components and the toxicity of lead present in the device. We will discuss some of key approaches that have been successfully tested to address these two major issues including the engineering of the composition of the absorbing layer, the use of inorganic hole transport materials and machine learning algorithms to identify effective agents for the passivation of defects in the bulk and at interfaces.

# The impact of dust on photovoltaic performance: historical, current, and future outlooks

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## Abstract:

The accumulation of dust on the surface of photovoltaic (PV) modules impedes light penetration into the cells, resulting in decreased power output and system instability. Dust particles obstruct light transmission, diminishing photon absorption and conversion efficiency. Additionally, chemical interactions between dust particles and module surfaces may lead to etching, scratching, and discoloration, further compromising module functionality. A thorough examination of the physics and chemistry of dust particles in relation to PV modules enhances our understanding of their behavior and potential detrimental effects. To counteract the adverse effects of dust, various cleaning and mitigation strategies have been developed. Manual cleaning, once widely practiced, is labor-intensive and may not be practical for large-scale installations. Consequently, automated cleaning systems have emerged as efficient solutions, employing mechanisms like brushes, wipers, or high-pressure water jets to remove dust and maintain optimal module performance.

Establishing standardized protocols for assessing dust impact, including sampling time, cleaning frequency, dust homogeneity, and measurement periods, is crucial for accurate evaluation and comparison of cleaning strategies. Modeling plays a pivotal role in comprehending the complex interaction between dust and PV modules. Dust models need to account for factors such as particle size, shape, distribution uniformity, and the influence of environmental parameters like temperature, humidity, and wind speed. A comprehensive dust model incorporating these parameters can aid in predicting and mitigating the impact of dust on PV system performance. Integrating such models into PV system design software would enable accurate performance assessment and inform optimal system sizing and planning.

Exploring new prospects in the field of dust impact on PV modules presents exciting opportunities for advancements. Research gaps exist in areas such as developing a generalized dust model considering particle properties, studying the effects of dust on emerging PV technologies, and understanding the long-term performance and durability of modules in dusty environments. Addressing these gaps will enhance our understanding of the challenges associated with dust accumulation and pave the way for improved PV system design, maintenance, and performance in diverse environmental conditions. In conclusion, this paper provides a comprehensive overview of the impact of dust on PV module performance, emphasizing the importance of automated cleaning systems, exploring effects on glass and transparent materials, discussing mitigation and cleaning strategies, highlighting the significance of modeling, and identifying new research prospects.

# Advances in the Design of Sustainable and Resilient Infrastructure Materials

Eyad Masad

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The resiliency and sustainability of infrastructure systems are crucial for economic development and vitality. Infrastructure resiliency refers to the capacity to withstand disruptions, whether caused by material degradation or natural hazards, with little loss in function as well as rapidly and efficiently restore functionality. Sustainability entails maintaining high performing infrastructure using technologies and designs that reduce the environmental impact and reduce exploitation of natural resources.

This presentation will give an overview of multiscale characterization and modelling for the design of sustainable and resilient infrastructure materials. It will focus on the development of geopolymers incorporating recycled construction materials for 3D printing of infrastructure components [1, 2]. The geopolymer mixture has calcium hydroxide ( $\text{Ca}(\text{OH})_2$ ) as the main alkaline activator and incorporates nanomaterials such as nano-silica and nano-clay. The experimental results demonstrate that this material exhibits rheological, mechanical, and thermal properties that are suitable for additive manufacturing. The presentation will also discuss the use of atomic force microscopy for the characterization and development of plastic-modified asphalts [3, 4], and recycled asphalt binders [5, 6]. These materials are shown to exhibit improved rheological properties and performance over virgin unmodified binders. The talk will also explore the relationships between chemical, structural, and mechanical properties that influence performance of asphalt binders. The presentation will conclude by outlining future research directions to enhance infrastructure resilience and sustainability.

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# Tuning band alignment at grain boundaries for efficiency enhancement in CZTS solar cells

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Conducting atomic force microscopy has been performed for the fundamental understanding of the mechanism responsible for the lower power conversion efficiency (PCE) of CuZnSnS<sub>4</sub> (CZTS) solar cells than that of CuIn<sub>1-x</sub>Ga<sub>x</sub>Se<sub>2</sub> (CIGS) solar cells. The difference in efficiency is partly attributed to the distinctly different band alignment between the grain boundaries (GBs) and grain interior (GI) for the two materials. While CIGS shows type-II band alignment, CZTS was discovered to demonstrate type-I band alignment with the conduction band shifting downward while the valence band shifting upward at the GBs. The type-I band alignment in CZTS leads to both electron and hole trapping enhancing their recombination and lowers the PEC. Band engineering was realized by moderate oxidative annealing of CZTS. The preferential GB oxidation changes the band alignment into inverse type-I (*i.e.* the conduction band upward bending and Valence Band downward bending at GBs). The blocking of carrier recombination at GBs leads to 30% enhancement in PCE. Our work reveals the critical role of band alignment between the grain boundary and interior plays in polycrystalline thin film solar cells, and suggests band alignment engineering as a practical approach to enhance PCE. Furthermore, conducting AFM has been shown to be a powerful tool for qualitative and semi-quantitative characterization of band alignment in polycrystalline films.

# Catalyst Transformation During Electrochemical Water Oxidation Using Cobalt Oxyhydroxide under Neutral Conditions

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Water electrolysis holds great promise as a clean and environmentally friendly method for hydrogen production, especially when powered by renewable energy sources. However, the widespread economic adoption of water-splitting technologies faces challenges due to their high costs. Additionally, the scarcity of active and stable catalysts under acidic conditions, commonly used in proton-exchange membrane (PEM) electrolyzers, adds complexity as many efficient electrocatalysts rely on precious metals. To overcome these obstacles, it becomes imperative to focus on the development of novel materials based on earth-abundant resources, exhibiting high activity and exceptional stability. To achieve this goal, a detailed understanding of the reaction mechanism, reactive intermediates, and catalyst transformation under catalytic conditions is essential. We are particularly interested in investigating the catalytic transformation of earth-abundant metal oxides, hydroxides, and oxyhydroxides. Cobalt oxyhydroxide stands out as one of the most promising catalysts for the oxygen evolution reaction (OER) under neutral conditions.

In this study, we successfully electrodeposited cobalt oxyhydroxide thin films on various electrode types (GCE, ITO, and CP) using a simple two-step process, highlighting the ease and accessibility of this synthesis method for catalysts. The resulting films demonstrated excellent activity for the oxygen evolution reaction (OER) under neutral conditions (pH 7.0), with an onset potential of 1.50 V at 1 mA/cm<sup>2</sup> and a current density of 30 mA/cm<sup>2</sup> at 1.8 V. These values are on the top of reported electrocatalysts under neutral conditions. The activity of the electrocatalysts was significantly influenced by the type and concentration of the electrolyte, with the best performance observed in phosphate buffer, followed by carbonate and acetate electrolytes, while nitrate and chloride electrolytes showed very low catalytic activity. However, the electrocatalysts exhibited a decline in activity when operating in phosphate electrolyte, both under open circuit and catalytic conditions. Further analysis through XPS, Raman, and ICP revealed that the activity decline was attributed to catalyst deactivation caused by phosphate ions, rather than catalyst dissolution. These results provide valuable insights into catalyst deactivation mechanisms, leading to optimized catalyst designs and the proposal of new, more efficient catalysts.

# NONLINEAR OPTICAL CHARACTERIZATION OF QUANTUM DOTS AND NANOPARTICLES OF DIFFERENT SHAPES USING HIGH-ORDER HARMONICS GENERATION AND Z-SCANS

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Presently, applications of small-sized aggregates (clusters, quantum dots, and large nanoparticles (NPs)) cover immense areas like biomedicine, wastewater treatment, photocatalysis, drug delivery, oil recovery, applied sciences, polymer reinforcement, clinical medicine, liquid properties tuning, to mention a few of them. To match their applicability, the small and large NPs have to be characterized for a complete description. The important component in the description of NPs is the optical and particularly, nonlinear optical characterization of their properties. In this presentation, the characterization of the quantum dots and NPs synthesized by chemical method and laser ablation of materials is described using the high-order harmonics generation (HHG) and Z-scan techniques.

The frequency conversion of laser radiation toward the extreme ultraviolet region using NPs in laser-induced plasmas has shown the enhancement of harmonic yield in comparison with the atomic/ionic species [1]. Meanwhile, the HHG efficiency in that case is affected by the spatial shape of NPs.

Nonspherical NPs (e.g., triangles, cubes, rods, etc.) exhibit shape-dependent and size-dependent properties. Nonspherical NPs are finding diverse applications due to their fascinating optical properties. The possibility of shifting the resonance wavelengths by tuning the particle geometry allows us to use them in the fields of molecular labeling, biomolecular assays, trace metal detection, or nanotechnical applications. We present the HHG in the plasmas containing NPs of similar elemental state and different morphology. The application of quantum dots for efficient HHG is also discussed. In all cases, the HHG conversion efficiency in spherical and non-spherical NPs, as well as quantum dots, showed advanced properties compared to the atomic and ionic single-particle plasmas of the same elemental consistency.

The low-order nonlinearities of aggregated species like the Kerr effect and nonlinear absorption also show the specific dependencies on the shape of NPs. The nonlinear absorption measurements show a distinction in the manifestation of the saturable absorption, reverse saturable absorption, and two-photon absorption in the case of different morphologies of NPs [2]. Meanwhile, the Kerr-induced nonlinear refractive indices of the suspensions containing spherical NPs were larger than those of the nonspherical NPs. The optical limiting of ultrafast laser pulses based on the nonlinear absorption and refractive properties of NP suspensions is analyzed. We discuss the difference in the nonlinear optical response of those NPs.

The developed methods allow for the nonlinear optical characterization of different shapes and size distributions of the nanostructures from various materials for potential applications of the newly developed nanostructured suspensions and films in optoelectronics, diode lasers, and solar cells.

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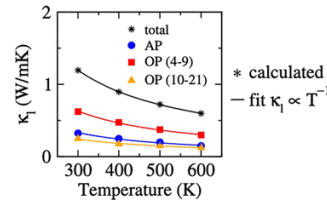
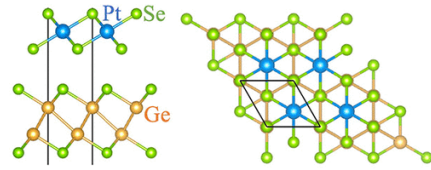
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# Two-Dimensional (2D) Materials for Thermoelectric Applications

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**Abstract**-The discovery of graphene, a one-atom-thick layer of carbon atoms, has opened up a window to the two-dimensional (2D) world of materials and triggered a surge of research activities on various 2D layered materials, including single layers of hexagonal boron nitride and transition metal dichalcogenides.



Thermoelectric materials can convert waste heat into electricity by turning temperature differences into currents. Generally, when materials conduct electricity well, they also conduct heat well. However, thermoelectrics requires the opposite, best conducts electricity well but conducts heat poorly. That is how they can maintain the temperature difference that drives the electrons. Manipulating the carrier concentration and band structures of materials has effectively optimized the electrical transport properties, whereas nanostructure engineering and defect engineering can significantly reduce thermal conductivity.

In the talk, I will discuss the thermoelectric properties of two-dimensional materials. I will also demonstrate various strategies to reduce the thermal conductivity and improve the electronic transport coefficient and discuss the design principles of two-dimensional materials for their applications in thermoelectric transport.



# Oral Presentations ABSTRACTS

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## Development and characterisation of a Fe/ZSM-5 zeolite membrane composite, application to the filtration of chromium hexavalent in aqueous media

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### Abstract

The present study explores the potential of a Clay support and a Fe/ZSM-5 zeolite membrane as effective adsorbents for heavy metal filtration. The raw Clay sourced from Wadi Haqil Ras Al-Khaimah-UAE, was utilized for fabrication of the clay supports sintered at 1000°C. Clay powders with a granulometry range of  $125 \mu\text{m} \leq \Phi \leq 250 \mu\text{m}$ , obtained through crushing and sieving with ASTM sieves. The Fe/ZSM-5 zeolite was synthesized via the hydrothermal method, using tetrapropylammonium bromide as an organic structure-directing template serving as a binder. The characterization of both the clay support sintered at 1000°C and Fe/ZSM-5 zeolite membrane was conducted through various techniques including XRD, FTIR, FE-SEM coupled with EDS. Notably the support with granulometry  $125 \mu\text{m} \leq \Phi \leq 250 \mu\text{m}$  exhibited relatively a high de-ionized water flux, stabilizing at  $140 \text{ L.m}^{-2}.\text{h}^{-1}$  after 120 min of operation, indicating excellent permeability. FE-SEM observations confirmed that Fe/ZSM-5 consisting primarily of granular particles with an orthorhombic crystal lattice, aligning with its crystallinity demonstrated by XRD analysis. The filtration tests for Cr(VI) solutions, conducted using a flow loop designed for dead-end filtration, demonstrated retention rates of 23% and 40% for the clay support and Fe/ZSM-5 zeolite membrane, respectively, after a working time of 120 minutes. These results suggest the potential of Fe/ZSM-5 zeolite as an effective alternative adsorbent for the removal of Cr(VI) from wastewater, showcasing outstanding performance in this application.

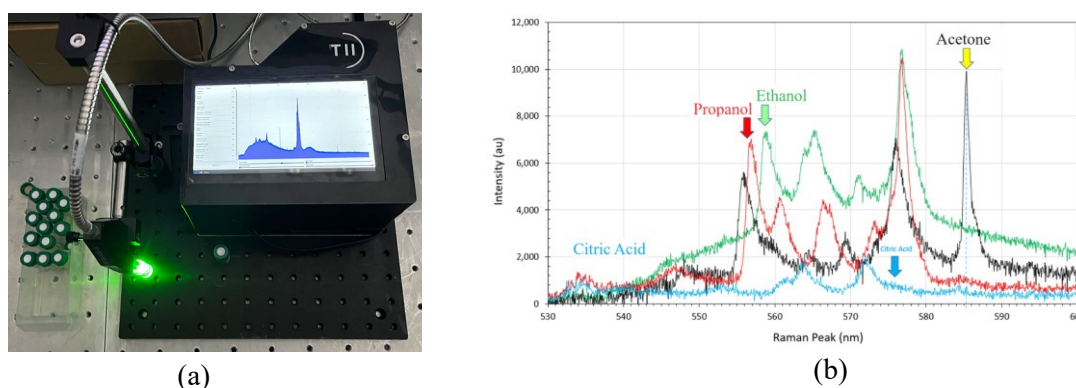
**Keywords:** Clay; Fe/ZSM-5 Zeolite membrane; Chromium hexavalent; Filtration.

# TOXIC MATERIALS IDENTIFICATION USING A CUSTOM-MADE MINIATURIZED RAMAN SPECTROMETER

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Materials characterization is generally based on the use of large and bulky tabletop Raman spectrometers operating in laboratory environment [1]. These instruments require much electrical power for CCD detector cooling and laser operation for achieving the required high resolution, high signal level, and low electronic noise for observing the very weak Raman signal. However, in many applications, the materials identification and characterization are needed instantly on the field without delays such as the case for identifying toxic materials, spills, pollutants, and forensics. In this paper, we present the results obtained from our recently developed portable and miniaturized Raman spectrometer for field operation [2]. The achieved results are excellent for the identification of different chemicals and toxic liquids (see Fig. 1). The measurements were conducted on small samples in less than 4 seconds.



**Figure 1.** (a) Our portable and Miniaturized Raman spectrometer developed in our laboratory with all the required components integrated (spectrometer, laser, touch screen, 6 hours battery, data acquisition and control, wireless communication). (b) The measured spectra of different chemicals being identified.

The results are shown instantly through our developed user interface (GUI) on the screen of the instrument with the raw data as well as the final result from the comparison to a local material library. The interface shows the name of the matching material from the local library with the % similarity to identify the unknown material. This is done instantly in a few seconds depending on the Raman signal intensity for a given unknown material.

In summary, we have successfully detected the concentration of several chemicals in water solutions down to 1.4% and only requiring a small drop with a volume down to 4  $\mu$ l. Further developments and customizations are ongoing to extend the detection limit for specific use-cases and clients' requirements.

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# ZINC-GRAPHITE BATTERY BASED ON BROMINE CHEMISTRY

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## Abstract :

Due to cost and safety concerns, lithium-ion batteries are not considered suitable for large-scale energy storage applications. Recently, zinc-graphite batteries with anion storage chemistry have been investigated as a safer and more cost-effective alternative. However, anions such as TFSI<sup>-</sup>, FSI<sup>-</sup>, OTf<sup>-</sup>, and ClO<sub>4</sub><sup>-</sup>, which were initially explored, failed to deliver impressive electrochemical performance. On the other hand, halogen anions, specifically Br, I, and Cl, have garnered attention due to their notable electrochemical performance compared to the previously mentioned anions. Among these, our interest lies in Br due to its high redox potential and the possibility of achieving high energy storage. Consequently, we have investigated the zinc-graphite battery using Br anions, along with a water-in-salt electrolyte, achieving high areal capacity, power density, high-rate performance, and stable cycle performance for over 1000 cycles. We employed in-situ and ex-situ studies to gain insights into the Br reaction process at the graphite electrode.

# **Microstructure and Scratch Resistance behaviour of TC4 (Ti-6Al-4V), Al 5053, and TC4/Al5053 dissimilar alloys produced by Wire Arc Additive Manufacturing**

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In the current study, wall structures of TC4 (Ti-6Al-4V), Al 5053, and TC4/Al5053 dissimilar alloys were manufactured using the wire-arc additive manufacturing (WAAM) process based on gas metal arc welding. Optimized parameters, including a current of 170A (for welding, arc, and arching), a voltage of 24 V (for welding, arc, and arching), a tip distance of 17.5 mm (minimum), and a welding speed of 4.5 mm/s, were employed for constructing the TC4 alloy structure. Meanwhile, a voltage of 14 V, along with the same parameters, was used for building the Al 5053 alloy structure. Furthermore, the best combination of voltages, 16V and 22V, were utilized for constructing the dissimilar alloy layers of Al 5053 and TC4 structures. A minimum length of 150 mm with a building height of 120 mm was achieved during WAAM. Before constructing the layers, the substrate surface was thoroughly cleaned to ensure proper bonding between the built layer and substrate surface, thereby avoiding distortion. The prepared samples underwent machining using a CNC machining center, and samples were cut using wire-cut electric discharge machining for microstructural and scratch resistance examinations. Microstructural examinations revealed the proper bonding of built layers in mono TC4, mono Al 5053, and dissimilar TC4/Al5053 alloys. Finally, the scratch resistance test was conducted in accordance with ASTM standards, and the performance of each sample was evaluated. The present research addresses the usage of lightweight materials with improved strength in TC4, Al5053, and TC4/Al5053 alloys for aircraft, space, automotive, and structural applications

**Keywords:** WAAM; Ti-6Al-4V; Al 5053; Microstructures; Scratch resistance

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# SPECTRAL COMPUTED TOMOGRAPHY: BRINGING COLOR TO MICRO-CT IMAGING

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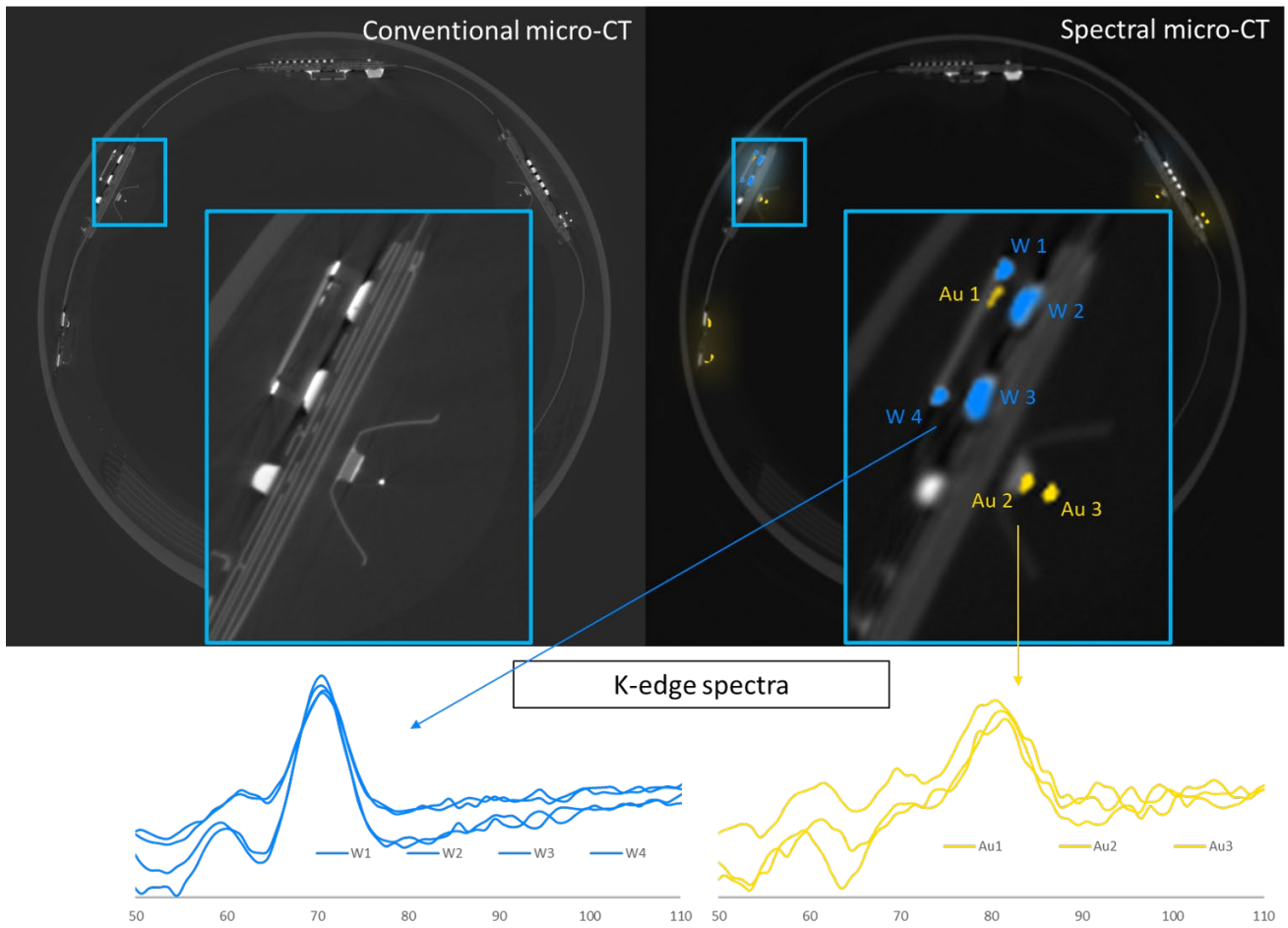
Micro-CT has the unique capability of studying internal structures of samples across scales, spanning from centimeters to micrometers. However, its effectiveness in material identification has some limitations, as the contrast obtained with a micro-CT scan is caused by a variety of factors. The attenuation coefficient of a material is influenced by factors like atomic number and density, alongside the X-ray energy, X-ray spectrum, and the used detector. In mitigating these limitations, we propose the incorporation of an energy-sensitive spectral detector into laboratory-based micro-CT scanner: The TESCAN UniTOM XL SPECTRAL.

This micro-CT scanner uses both traditional attenuation-based tomography and spectral measurements using the TESCAN PolyDET. Not only the attenuated intensity of the X-ray beam when traveling through a sample can be measured, but the entire energy spectrum (20-160 keV) of the X-ray beam can be acquired. In this work spectral results on a variety of samples in multiple fields of application are shown. The most obvious use of a spectral detector enhances micro-CT with EDS-like capabilities for elemental identification. Spectral imaging can non-destructively identify valuable elements inside a sample and provide the 3D distribution of those elements. This capability is especially useful for obtaining the distribution of elements like Au in ore samples, but also identifying elements in high end electronic devices[1].

All results show the large potential of spectral CT in enhancing attenuation-based micro-CT and providing new and unique insights in all types of materials.

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**Figure 1.** Conventional (1) and spectral (right) CT slice through the centre of a smart ring. Peaks at 69.5 and 80.7 keV indicate the presence of tungsten and gold. [1].

# Correlative Raman Imaging for 2D, Battery, and Composite Materials Analysis

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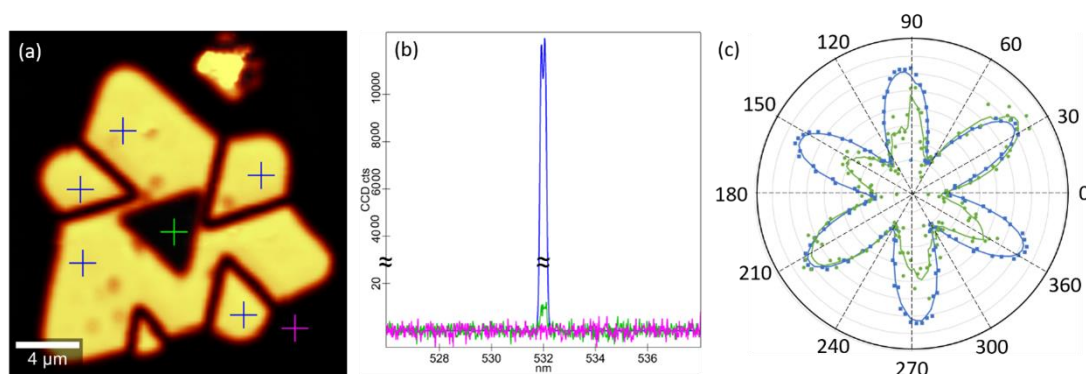
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Confocal Raman imaging, Atomic Force Microscopy (AFM), and correlative Raman electron microscopy have emerged as essential techniques for a variety of research fields, including Li-ion batteries, semiconductors, 2D materials, polymers, and biology. This presentation focuses on the comprehensive characterization of 2D materials such as graphene and transition metal dichalcogenides (TMDs), as well as the application of correlative microscopy techniques in understanding and improving Li-ion battery performance, and the analysis of composite materials.

The unique layered structure of 2D materials, shared by graphene and TMDs, significantly alters their properties compared to bulk materials, making them interesting for designers of electronics. Optimizing electronic device performance requires insights into the structure, crystallinity, and exciton dynamics of these materials. The first section of this contribution explores how various microscopy techniques, including confocal Raman microscopy, AFM, SEM/EDS, confocal Second Harmonic Generation (SHG) Fig (1), confocal photoluminescence imaging, and polarization-dependent measurements, can be combined to achieve a thorough characterization of 2D materials.



**Figure 1.** SHG analysis of the studied crystal. (a) Integrated intensity image of the SHG signal; (b) SHG signal from the Si-substrate (pink), monolayer (blue) and fourfold layer (green). (c) Polar plots of the SHG signal intensity as a function of the excitation polarization angle at the color-coded marked positions.

Li-ion batteries, widely used in applications ranging from portable electronics to electric vehicles, demand continuous improvement in performance, safety, charging speed, and cost reduction. To gain deeper insights into battery cell processes, correlative microscopy is employed to establish property-structure relationships. High-resolution microscopy methods including AFM and SEM, coupled with material-sensitive techniques such as Raman and EDS, enable a comprehensive understanding of microstructural fabric, chemical composition, crystallographic properties, and phase transitions within Li-ion batteries. The characterization of composite materials also benefits significantly from combining different analytical methods. The integration of data from various techniques enhances the overall understanding of the sample.

In summary, this presentation describes how the interdisciplinary use of correlative microscopy techniques can contribute valuable insights for the comprehensive characterization of both 2D materials and Li-ion batteries, offering a pathway for advancements in electronic device design and energy storage technologies.



# Investigation of high-power continuous wave laser interaction process with aluminum

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Aluminum and its alloys have been paid increasing attention due to their high thermal and electrical conductivity, good workability, low density, high specific strength, good corrosion resistance, lightweight, attractive appearance, and intrinsic recyclability in various sectors such as automotive, aerospace, and defense industries [1]. High-power continuous wave (CW) lasers have been employed in different laser processing of metals and alloys such as cutting, drilling, and welding [2]. The interaction of high-power laser beams with metals exhibits either conduction or keyhole mode, which depends on the laser intensity. Conduction mode has a shallow and wide penetration depth profile, whereas key-hole mode exhibits narrow and deep penetration. The understanding of both conduction and key-hole modes at different laser parameters and metal thicknesses is crucial for both the laser welding and drilling processes. The laser interaction with metals results in heating and melting leading to the formation of the melt pool. The ejection of the melt from the laser interaction zone is the primary process involved in the laser drilling process. Furthermore, computational studies furnish valuable information about the transient laser heating and melting process, melt flow, solidification, and formation of defects [3].

In this study, we have extensively investigated the interaction of a high-power laser with aluminum at different conditions. The laser drilling times are determined at different laser parameters and different thicknesses of aluminum. Cross-sectional analysis has been performed by cutting, grinding, polishing, and etching of the laser-irradiated aluminum. An optical microscope has been used to capture the image of the surface and cross-section of the laser-irradiated area. The efficiency of laser energy coupling with aluminum has been evaluated by determining the penetration profile and depth through cross-sectional analysis at different laser powers and interaction times. COMSOL modeling has also been carried out to understand the interaction of high-power lasers with aluminum. The heat conduction model, computational fluid dynamics (CFD), and deformed geometry modules are used to simulate the laser-irradiated zone. The evolution of the penetration depth and width is analyzed to understand the influence of high-power CW laser on thick aluminum. This study will be beneficial to improve the process parameters in the laser machining process.

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# Experiments on Hydrogen Production Enhancement Through Ball-Milled Graphene Deposition on Copper Foam

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This study investigates a novel approach to enhance hydrogen production by employing ball milling for depositing graphene onto copper foam substrates. Copper foam, a three-dimensional porous structure, provides a conducive framework for catalytic reactions, while graphene, augments the catalytic performance of the composite material. The integration of graphene onto copper foam is expected to improve the catalytic properties of the material for enhanced hydrogen evolution reaction (HER) performance. The synthesis process involves the mechanical exfoliation of graphene using ball milling at an RPM of 350 for four minutes, followed by the deposition onto a copper foam substrate. The characterization of the synthesized material is conducted using various analytical techniques, including scanning electron microscopy (SEM), X-ray diffraction (XRD), and Raman spectroscopy. The results reveal the successful formation of a few layer graphene atop the copper foam with a well-defined morphology and intimate contact between graphene layers and copper surfaces. The electrocatalytic activity of the graphene-deposited copper foam is evaluated through electrochemical impedance measurements and chronoamperometry, to assess the electrode performance for hydrogen evolution. Differential Electrochemical Mass Spectroscopy (DESM) is employed to quantify the amount of evolved hydrogen and oxygen in the electrolysis reaction. The fabricated graphene-copper foam composite demonstrates promising potential as an efficient and durable catalyst for hydrogen production. The findings suggest that the synergistic interaction between graphene and copper foam enhances the HER performance, making the composite material a viable candidate for applications in renewable energy systems. This study contributes to the ongoing efforts to develop cost-effective and sustainable catalysts for hydrogen evolution, addressing challenges in the transition to a clean and renewable energy future.

**Keywords:** Hydrogen Production, Electrolysis, Ball Milling, Copper Foam, Graphene.

# DESIGN AND TOPOLOGICAL OPTIMIZATION OF A WHEEL UPRIGHT USING FINITE ELEMENT ANALYSIS

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Uprights are one of the most critical structural elements in vehicle suspension systems. A standard upright serves as a physical mounting for the wheel hub and brake components, as well as linking the axle to the control arms [1]. Uprights are bulky by design to withstand the significant loads they observe during vehicle braking, maneuvering, and driving on rough terrain [2]. In automotive design, specifically race car design, utilizing lightweight components and reducing fuel consumption are imperative. This weight reduction-based paradigm is being adopted by the car industry at large, particularly due to the shift towards automotive electrification. Consequently, this work investigates the potential for using topological optimization to reduce the bulkiness and weight of uprights without compromising their structural integrity and reliability. An upright designed for a racing car is selected in this study. The methodology used in this study involves a two-stage optimization process. In the first stage, a level-set based topological optimization process is used to reduce the upright's weight by 30% to 50%. The optimization objectives and constraints include minimizing compliance, maximizing stiffness, and maintaining connectivity constraints. In the second stage, a subjective geometrical modification is introduced by the designer to clean up the geometry obtained in the first stage and facilitate its manufacturability. The structural response of the final optimized parts is investigated to validate their structural integrity and reliability. Topological optimization is performed on the upright using the finite element software ANSYS. Results show that a considerably enhanced upright is obtained after 48 topological optimization iterations and while maintaining a factor of safety of 2.5 as seen in Fig. 1. The optimized upright exhibited less stress concentrations and 39% lesser weight than the original upright.

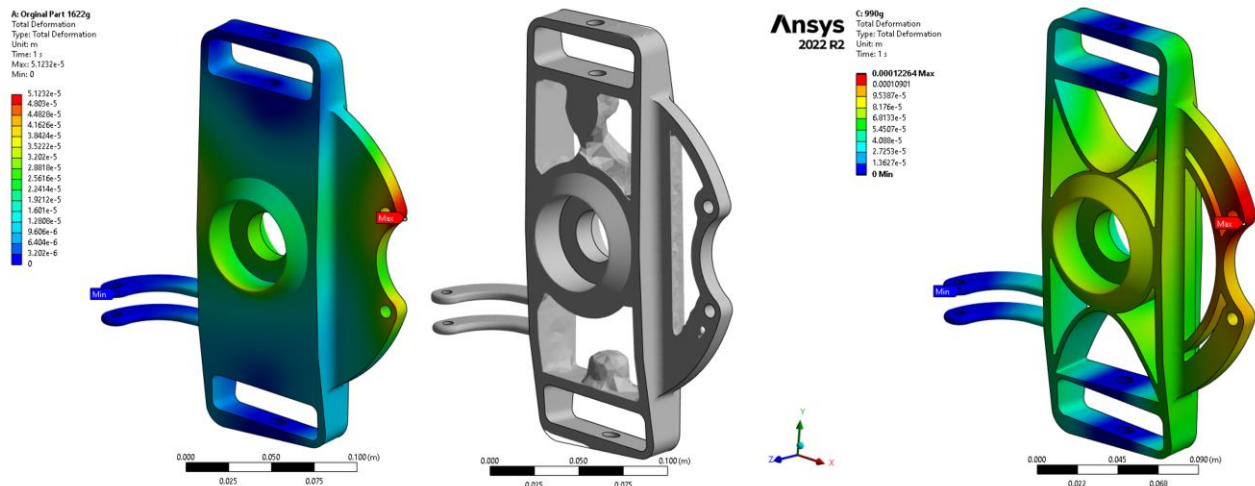


Fig. 1. The original upright (left), optimization output (middle) and the final design (right).

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# ROLE OF DIFFUSION KINETICS IN DEFINING THE TEMPERATURE RANGES FOR ACTIVATION OF DYNAMIC STRAIN AGING IN COMMERCIALLY PURE NIOBIUM AND VANADIUM METALS : A CONSTITUTIVE AND NUMERICAL MODELING APPROACH

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Metals soften with increase in temperature which results in the reduction of its strength. This softening however faces a resistance due to the segregation of solute atoms around dislocations under certain combinations of strain rates and temperature [1]. This solute environment prevents dislocations from moving and lengthens their waiting time at obstacles, thus causing an irregular increase in strength at higher temperatures known as dynamic strain aging (DSA) [2, 3]. Thorough experimental works have been reported but the literature particularly lacks a constitutive model that incorporates physical and microstructural parameters to capture DSA based on diffusion. The present study aims to present a constitutive model that utilizes the diffusion kinetics of the solute atoms to capture DSA in commercially pure bcc Niobium and Vanadium metals. The model is constructed by modifying the original constitutive VA model and employs the diffusion parameters to define the temperature ranges at which DSA is activated at a certain strain rate. Furthermore, computational simulations have been conducted for the modified VA model through the development of a VUMAT subroutine in ABAQUS. Both the constitutive and numerical models yield comparable results with respect to the experimental data and effectively capture the dynamic strain aging in commercially pure Nb and V metals.

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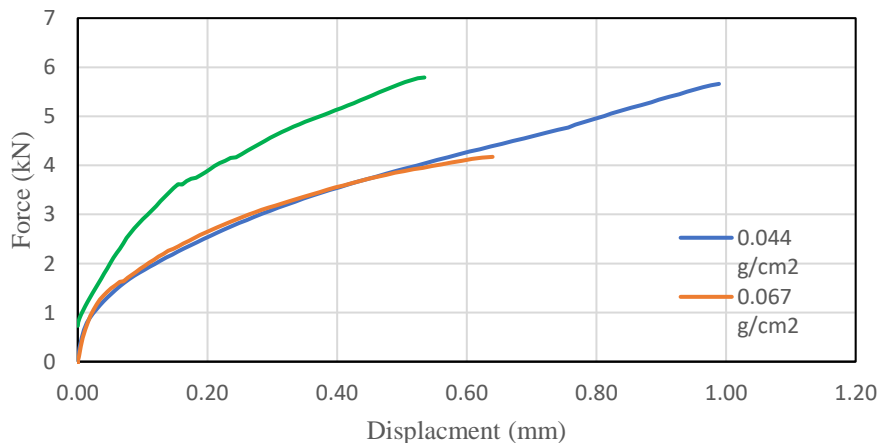
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# PARTICLE REINFORCEMENT OF FIBERGLASS POLYPROPYLENE USING SILICON CARBIDE PARTICLES

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Reinforcing fiber composites with particles is known to improve their uniaxial strength and toughness [1]. This work aims to provide insights into the effect of reinforcing particles on an additional important quantity that governs the failure of laminates, which is Inter Lamina Shear Strength (ILSS). In particular, this work investigates the Inter Lamina Shear Strength (ILSS) of thermoplastic composite laminates whose inter-ply interfaces are reinforced with silicon carbide (SiC) particles. The emphasis is on the impact of particle reinforcement with specific size variations and concentrations. The particles selected for this study consist of SiC, selected for its high density and strength [2]. Two particle variations were investigated of different sizes: 18 and 40  $\mu\text{m}$ . The experimental procedure involved placing SiC particles between two sheets of fiberglass-reinforced polypropylene plies, which were then pressed together using a hot press to ensure a cohesive bond. The resulting composite sample, which represented a single lap shear configuration, was tested using an Instron machine to evaluate its shear strength, failure point, and force-displacement curve. The introduction of SiC particles of different sizes aimed to assess the influence on the mechanical properties of the resultant composite material. Shear strength measurements gave an insight into the material's ability to withstand shear forces, while the examination of the failure point showcased the composite's structural limits. Furthermore, different particle concentrations (0.089  $\text{g}/\text{cm}^2$ , 0.067  $\text{g}/\text{cm}^2$ , 0.044  $\text{g}/\text{cm}^2$ ) were tested out under the same conditions. The experimental findings indicated that the addition of SiC particles significantly enhances the ILSS of Fiberglass polypropylene composites as shown in Figure 1. The different particle sizes resulted in different enhancement levels. However, the particle concentration was observed to be more influential than particle size. This research contributes to the broader understanding of particle-reinforced composites, offering valuable insights into the optimization of Fiberglass polypropylene for enhanced mechanical properties.



**Figure 1.** Force-Displacement Plot for Different Particle Concentrations

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# Microwave Synthesized Zeolitic Imidazolate Framework-8 (ZIF-8) As Detector Material of COVID-19 RNA

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The latest pandemic caused by the novel SARS-CoV-2 coronavirus has significantly affected the public health, the worldwide economy, and social life. Rapid and accurate diagnosis methods are essential in reducing the spread of viruses and preventing future outbreaks [1]. Metal Organic Frameworks (MOFs) has emerged as promising materials in biosensors development for detecting viruses thanks to their exceptional properties, including high porosity, tunable pore size, and large surface [2]. This research study aims to develop a Zeolitic Imidazolate Framework-8 (ZIF-8) based fluorescent biosensor for rapid COVID-19 RNA sequence detection. ZIF-8 was synthesized using the microwave method being a rapid, low energy consuming, and environmentally friendly synthesis technique. Comprehensive characterization study, including TGA, XRD, FT-IR, and N<sub>2</sub> adsorption/desorption isotherms, was conducted to examine the MOF's crystalline structure, thermal stability and discern the quenching mechanism. Experimental findings demonstrated that ZIF-8 exhibited excellent quenching properties, with a quenching efficiency of 72.1%. Furthermore, analyses of the adsorption mechanism of probe DNA into ZIF-8 revealed the electrostatic and  $\pi$ - $\pi$  stacking interactions, resulting in the formation of a P-DNA@ZIF-8 complex. The developed ZIF-8 biosensing platform exhibited high sensitivity towards COVID-19 RNA with an ultra-low limit of detection of 12 pM as shown in Figure 1, in a relatively short detection time of 30 minutes. Furthermore, ZIF-8 was tested against two mismatched RNAs to assess its selectivity. A much lower fluorescence recovery was obtained in comparison with that of the COVID-19 target RNA. The experimental study revealed promising capabilities of ZIF-8 as a biosensing material for COVID-19.

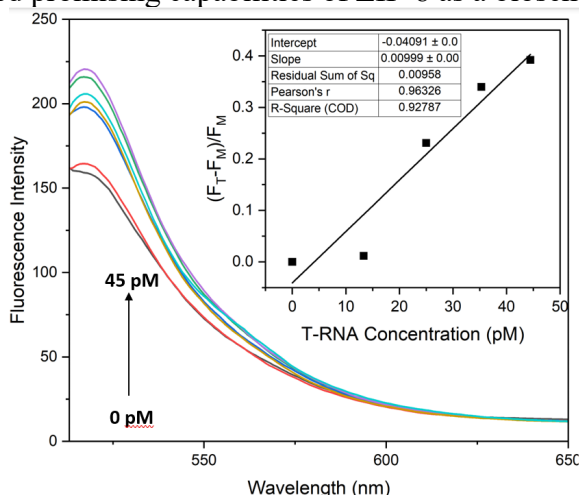


Figure 1: Fluorescence spectra of P-DNA with varying concentrations of T-RNA in TE buffer

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## **Scalable Designing of Flexible Electrodes using Laser-Induced Graphene (LIG) based nanocomposites through Room-Temperature Processing.**

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### **ABSTRACT:**

Clean energy is efficiently replacing fossil fuel energy for future photoelectrochemical applications. Research in developing and fabricating low-cost materials through room-temperature processing that provides high output and efficiency has been a main consideration. The room-temperature processing is a scalable, facile, and cost-effective approach to designing and fabricating electrodes. Polyimide's (PI) conversion to laser-induced graphene (LIG) using laser scribing has attracted much attention due to the exceptional properties of LIG like high porosity, high surface area, high thermal stability, and excellent conductivity, and LIG has replaced many materials in photoelectrochemical applications. In this research, we have designed electrodes through LIG-based nanocomposites by deposition of metals like Aluminum (Al) and metal oxides like Titanium dioxide (TiO<sub>2</sub>) on LIG using different processes like the Sputtering, Electrophoretic deposition (EPD) method, and Aerosol method respectively. These electrodes have been investigated to study various properties for photoelectrochemical applications. Various characterization techniques have also been used to study a significant difference in the properties of PI, LIG, TiO<sub>2</sub> powder, LIG/Al, and LIG/TiO<sub>2</sub> nanocomposite-based electrodes. A comparative analysis based on the optical and photochemical properties has been made which has suggested Synthesis of AC/ZnS was confirmed using Field Emission Scanning Electron Microscopy (FESEM) coupled with Energy Dispersive Spectroscopy (EDS). The formation of graphene was confirmed using Fourier Transform Infrared Spectroscopy (FTIR). Hence, on-site development and fabrication of LIG and LIG-based nanocomposites have been successfully achieved. Based on contrasting trends, a comparative study of chemical, electronic, and optical properties has been done in this research.

**KEYWORDS:** Polyimide (PI), Laser-Induced Graphene (LIG), LIG/TiO<sub>2</sub>, LIG/Al, Room-temperature processing, Photoelectrochemical applications.

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# Simulation, Economic and Environmental Analysis of a Mobilized Thermal Energy Storage System for Mediterranean Climate Buildings: Case Study

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Decades of research have been dedicated to the mobilized thermal energy storage system (M-TES), demonstrating its competitiveness alongside conventional heat generation methods such as oil/gas and biomass boilers. This study presents a notable case study set in a power plant, where waste heat is effectively harnessed using M-TES to provide both space heating and cooling in a university campus, as well as water heating. The study delves into the modelling of different heat exchangers within the M-TES system, with Erythritol serving as the chosen phase change material for latent heat storage. The simulation entailed replicating the charging phase, investigating the influence of Heat Transfer Fluid (HTF) flow, and assessing the potential of waste heat. The findings reveal that an increase in the heat transfer fluid causes a reduction in charging time and an enhancement in charging efficiency. Conversely, an escalation in waste heat potential leads to a decrease in charging efficiency, accompanied by a slight reduction in charging time. Furthermore, it provides insights into the discharging phase under varying loads, along with calculations related to the number of operational cycles and the effect of M-TES on power plant efficiency. Economic evaluation plays a crucial role in this research and is compared to previous studies. It demonstrates that the cost of heat (COH) decreases due to the increased scale and a greater number of containers. Moreover, using M-TES to cover both space heating and cooling loads proves to be more cost-effective compared to deploying it solely for heating purposes. This research opens avenues for sustainable and economically thermal energy storage solutions, with implications for a wide range of applications in the energy sector.

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# Magnetic Fe<sub>3</sub>O<sub>4</sub> nanomaterial supported heterogeneous catalysts for various green synthesis

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Many researchers are focusing in the development of sustainable materials by minimizing waste and pollution in the chemical synthesis. Generally, heterogeneous catalysts are given priority over homogenous catalysts in the industrial application regarding the easy separation of the catalyst from the reaction mixtures and obtaining pure targeted products with minimal involvement of purification steps. Most of the heterogeneous catalysts are prepared based on inorganic carriers such as silica and mesoporous silica. Magnetic nanomaterials based heterogeneous catalysts are superior to the other nanomaterials based heterogeneous catalysts because of using external magnet rather than using of centrifuge or suction filtration or gravitational filtration for the separation of catalyst from the reaction mixture. One of the most applicable magnetic nanomaterials is Fe<sub>3</sub>O<sub>4</sub> because of its fundamental properties and easy functionalization with appropriate linkers. We are interested in functionalization of Fe<sub>3</sub>O<sub>4</sub> with cheap, non-toxic and abundant biopolymer such as chitosan, abundant nano-silica and polyamide ligand following the modification of its surface with different ligands. Then, suitable metals (Ag, Cu, Co, Al and Pd) were deposited on the modified surface of magnetic Fe<sub>3</sub>O<sub>4</sub> and investigated for important organic transformations such as C-C, A<sup>3</sup>, C-N cross coupling reactions, oxidative amination of aldehyde and reduction of nitroarenes and most importantly conversion of greenhouse gas CO<sub>2</sub> to valuable cyclic carbonate.

# POTENTIAL APPLICATIONS OF DESALINATION BRINE REJECT IN CO<sub>2</sub> CAPTURE AND CATALYTIC CONVERSION

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Developing sustainable brine management methods is essential due to the brine's negative environmental impacts if disposed of on land and sea. Extracting resources and recycling the brine reject is a promising approach to minimize the negative environmental impact. Due to its chemical composition (rich in minerals and heavy metals), the desalination brine has good potential as a catalyst source and in CO<sub>2</sub> capturing and sequestration. This work investigates the physical and chemical characteristics of the brine powder from seawater and brackish water desalination, assesses its catalytic potentials, and quantifies its CO<sub>2</sub> capture and sequestration capacity. The results revealed that the global brine rejects from seawater desalination can sequester around 5,000 tons of CO<sub>2</sub> per every million cubic meters of brine reject daily. This simultaneously produces around 8,000 tons of Mg carbonate and 1,748 tons of Ca carbonate. The Ca and Mg carbonates may resemble dolomite's catalytic effect when primarily applied in biomass thermal conversion and may also generate revenue when applied in other industrial applications, such as additives in cement industries.

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# ELECTROCHEMICAL SYNTHESIZED POLYANILINE COATED GOLD-ARYL NANOPARTICLES AND THEIR EFFICIENCY IN DYES REMOVAL

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Methylene blue (MB) is a common synthetic dye in textile industry which implicates several health complications such as breathing difficulty, methemoglobinemia-like syndromes, chest pain, severe headache and mental confusion. Chemical, adsorption and many different catalytic routes have been used to eliminate MB from the environment and wastewater. The adverse effects of adding more chemicals to the environment has motivated many research laboratories to apply chemicals-free approaches such as sunlight, green synthesized catalysts and adsorption. We present our results on the fabrication of PANI coated gold-carbon nanocomposites by “green” and efficient electrochemical reduction of [HOOC-4-C<sub>6</sub>H<sub>4</sub>N≡N]AuCl<sub>4</sub> salt and their applications in MB adsorption.

Synthesis of gold-carbon-bond nanoparticles was achieved by the one-pot electrochemical reduction of aryldiazonium tetrachloroaurate(III) salt [HOOC-4-C<sub>6</sub>H<sub>4</sub>N≡N]AuCl<sub>4</sub> in the presence of polyaniline (PANI) emeraldine salt. Using two electrode cells and PANI, the electrochemical deposition of PANI-coated Au-COOH NPs was effective in KNO<sub>3</sub> supporting electrolyte at various potential values. Aryldiazonium gold(III) salt's cyclic voltammetry study yielded the deposition potential. The nanocomposites were evaluated with transmission electron microscopy (TEM), X-ray photoelectron spectroscopy (XPS) and thermal gravimetric analysis (TGA). The largest diffraction peak of the multibranching nanoparticles is seen in the direction of (111), suggesting that the deposition happened preferentially along this extremely energetic facet. The findings showed that, depending on the additional mass of PANI, the thermal stability of the gold nanocomposites and the gold percentage ranged from 5 to 23 weight percent. Analyzing the Selected Area Electron Diffraction Pattern (SAED) revealed the usual face-centered cubic structure rings of crystalline nanoparticles of gold (0). The complete reduction of the aryldiazonium cation and gold(III) was confirmed by Raman analysis, as evidenced by the presence of the gold-carbon peak and the lack of diazonium and [AuCl<sub>4</sub>]- vibrations. High methylene blue adsorption capacity was demonstrated by emeraldine-coated gold-carbon nanoparticles soaking in nanosand. It suggests that synthetic colors like methylene blue that are utilized in textile wastewater treatment could be eliminated using the created materials.

Nanosand was utilized as adsorption surface in the removal of methylene blue, the adsorption ability was boosted by Au-COOH/PANI nanocomposites, in which nanosand was soaked in two systems for comparison which are Au-COOH NPs and Au-COOH/PANI nanocomposites. These two systems were used to soak nanosand, and methylene blue adsorption research was subsequently carried out. For thirty minutes, the adsorption kinetics were observed with a UV-Vis equipment. The adsorption capacity and removal rate of nanosand in these two systems, as well as nanosand on its own without any substance on it, were compared. The maximum adsorption capacity and removal rate of Au-COOH/PANI nanocomposites were found to be 4.96 mg.g<sup>-1</sup> and 87.0%, respectively, whereas Au-COOH NPs on nanosand demonstrated 4.28 mg.g<sup>-1</sup> and 76.0%, respectively, and nanosand by itself demonstrated a 65.0% clearance rate. For the Au-COOH/PANI nanocomposites, the adsorption kinetics fit a pseudo-second order process with a correlation factor of 1.

After methylene blue was adsorbed, Au-COOH/PANI nanocomposites were detected by SEM-EDS and FT-IR. The amount of Au in the samples matched the percentage before to adsorption, indicating that there was no leaching of the nanocomposite to the adsorbent. Methylene blue adsorption on the nanosand resulted in a reduction in the Si-O peak observed by FT-IR.

By electrochemically reducing aryldiazonium tetrachloroaurate(III) salt [HOOC-4-C<sub>6</sub>H<sub>4</sub>N≡N]AuCl<sub>4</sub> in the presence of polyaniline (PANI) emeraldine salt, Au-COOH/PANI nanocomposites were produced. It improved methylene blue's adsorption on nanosand by using a pseudo-second order reaction process. Our Au-COOH/PANI nanocomposites, when adsorbed onto nanosand, circumvent the difficulties associated with the use of chemical reducing agents and homogeneous catalysts. It is intended to be utilized in the elimination of various different dyes found in wastewater and in the environment in general.

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# PROCESS DESIGN AND PRODUCT DESIGN OF PROPYLAMMONIUM FORMATE AS PHASE CHANGE MATERIAL FOR SOLAR WATER HEATING SYSTEMS

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## Abstract

Ionic liquids (ILs) were investigated to replace conventional Phase Change Materials (PCMs) for Solar Water Heating Systems (SWHS) applications. PCMs are capable of helping to overcome the intermittency problem of renewable energy sources via thermal energy storage (TES). TES is an energy storage technology that uses a suitable medium to retain the heat energy in sensible, latent, or thermochemical form and release it during off-peak hours [1]. In the case of PCMs, mainly the latent type of TES is employed. To select a suitable ionic liquid for the chosen application of SWHS, extensive databases for the most important IL properties concerning TES were compiled from a variety of literature sources and analyzed using Python. Melting point, the heat of fusion per unit volume, thermal conductivity, and heat capacity of ionic liquids (ILs) were primarily considered in the resulting database incorporating +300,000 data points and 86 unique ionic liquids. Propylammonium formate (PAF) was selected from the refined list based on the desired criteria for SWHS, including its melting point which lies within the effective range of 50 °C to 90 °C [2]. Furthermore, for the first time, a manufacturing process was designed to produce 10,000 tonnes/year of PAF. Aspen Plus was chosen to simulate the proposed process and verify its operability, while COSMO-RS was used in modeling the phase equilibria, and the Joback Method [3] was implemented to calculate the critical properties of the material. The initial process was also improved by incorporating heat integration and thus, reducing the need for heat and cooling utilities by 88%. The profitability analysis demonstrated that the net present value (NPV) and discounted rate of return (ROR) were higher in the heat-integrated design of the process compared to the original model, indicating a positive return from investment.

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# TRANSITION METAL SULFIDE BASED CORE-SHELL MATERIALS AS AN HIGH PERFORMANCE SODIUM-ION BATTERY ANODE

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The superior electrochemistry and cell design of lithium-ion batteries (LIBs) in the automotive and electronic industries have generated a lot of discussion over the last few decades [1]. Even though LIBs have a high energy density and good cycle life, their lack and rising cost have forced researchers to look at possible long-term alternatives. When taking into account its distribution, natural abundance, and reduced cost, sodium-ion batteries (SIBs) are without a doubt the most encouraging alternative from this perspective [2, 3]. The creation of anode materials with adequate capacity, high rate capability, and strong cycling stability is currently a difficulty for SIBs. The development of high-performance anode materials is seriously hampered by structural degradation caused by substantial volume expansion during continuous charge and discharge cycles, particularly for compounds based on alloying and conversion. Metal chalcogenides-based anodes outperformed other conversion/alloying anodes in terms of performance because of their greater capability, moderate reaction platform, wide range, and affordability. Large impedances and inferior rate performances are easily caused by the low inherent electrical conductivity. Significant internal mechanical stress will inevitably arise from the massive volume expansion that occurs during conversion and the subsequent alloying reaction phase. To solve this issue, we have designed various hierarchical metal sulfides with the different core-shell and yolk-shell strategies, which we have proved to be high-performance anode materials for SIBs. To identify the sodium storage mechanism, we also thoroughly investigated ex-situ measures (such as XRD, XPS, FE-SEM, and TEM). Furthermore, kinetic research analysis revealed that enhanced pseudocapacitive contribution and sodium-ion diffusion could be responsible for this increased electrochemical performance. In comparison to pristine metal sulfides, the optimized core-void-shell architecture shows outstanding capacity retention and high rate capability. Increased sodium reaction rate and reduced structural degradation are caused by the high electrode/electrolyte contact area and the short electron and sodium ion diffusion path made possible by the designed architecture.

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# Hierarchical Multiscale Modeling of Al-Cu/CNT Nanocomposite: From Atomistic to Macro-level Scales

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The mechanical properties of an armchair (6,6) carbon nanotube reinforced aluminum copper alloy nanocomposite are investigated using hierarchical multiscale modeling. In such methods, a bottom-up approach is followed where the data gathered from the fine scale are passed to the coarse scale by a bridging method like the homogenization techniques [1]. The proposed process followed in this research is illustrated in Fig.1, where the model was built at the nanoscale and scaled up to the macroscale. The mechanical properties of the nanocomposite at the atomistic scale were calculated using molecular dynamics simulation. The nanocomposite considered is transversely isotropic and hence five mechanical properties were required, namely the transverse and longitudinal moduli of elasticity ' $E_T, E_L$ ', the shear modulus ' $G$ ', and the Poisson's ratios in x-y ' $\nu_{xy}$ ' and x-z plane ' $\nu_{xz}$ ' [2]. Following this, the developed nanocomposite was homogenized into an equivalent fiber having the same structure and properties of the nanocomposite. Multiple equivalent fibers were then embedded in aluminum copper alloy composite following a hexagonal fiber arrangements. Finite element model was then developed to calculate the properties of the nanocomposite at the microscale under different volume fractions of the CNT [3]. The longitudinal modulus of elasticity, and the longitudinal and transverse Poisson's ratios were all observed to increase as the volume fraction of the CNT increases. On the contrary, the transvers modulus of elasticity together with the shear moduli were found to decrease as the volume fraction of the CNT increases. The main contribution of this work is analyzing aluminum copper alloys reinforced with nanofillers like carbon nanotubes starting from the atomistic level which is bridged to the macroscale level. This makes this new material ready for engineering applications.

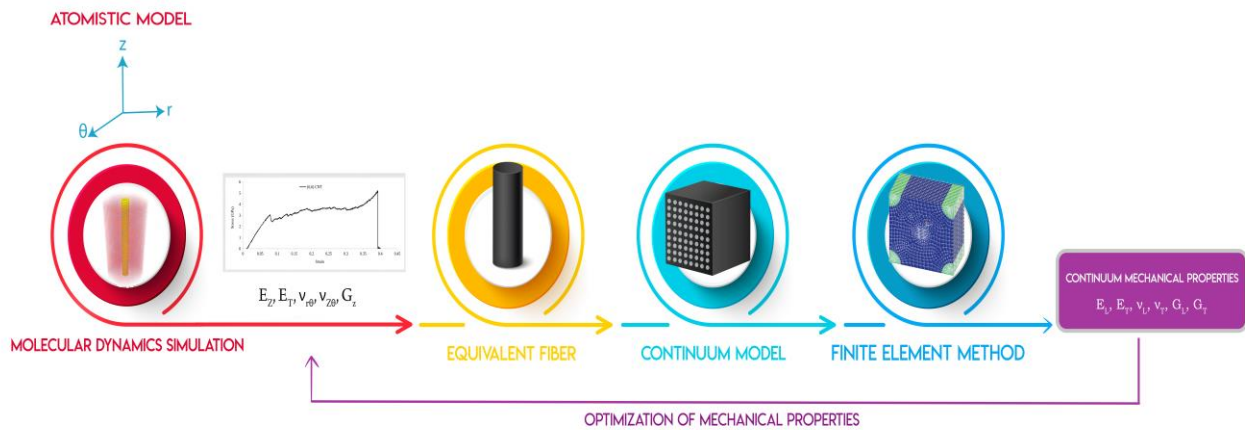


Figure 1. Multiscale simulation methodology.

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# Bifunctional Surface-Modified Gold-Aryl Nanoparticles on Graphene Oxide Platforms for Nitrophenol Reduction and its SERS Detection Proficiency

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## ABSTRACT

Gold diazonium salts, with a low reduction potential, excel as nanotextured surface modifiers, efficiently enabling spontaneous surface modifications.[1] Here we demonstrate the facile preparation of Graphene oxide decorated with gold-aryl (Au-C) nanoparticles through the reduction of aryldiazonium salt of tetrachloroaurate(III) in aqueous media called AuNPs-COOH/GO (AuNC).[2] The nanocomposite (NC) was efficiently utilized for catalytic reduction of 4-nitrophenol (4-NPh) and exceptional trace-level sensing of the same using Surface-Enhanced Raman Spectroscopy (SERS) technique. The apparent rate constants ( $K_{app}$ ) were measured and analysed across multiple catalytic cycles, varying  $\text{NaBH}_4$  concentrations, different amounts of NCs loading, and assessing the impact of incubating NCs in  $\text{NaBH}_4$ . Following an incubation period of 15 minutes, the catalyst exhibited an increase in the rate constant to  $1.0 \times 10^{-1} \text{ min}^{-1}$ , marking a pivotal phase in the reaction kinetics. The same AuNCs exhibit superior efficacy in detecting trace levels of 4-NPh. Maximum SERS activity is attained through optimal coating with AuNC (NC40) on a Si wafer due to its surface chemical composition, as confirmed by X-ray Photoelectron Spectroscopy surface analysis. Detailed assessment of the Au4f chemical environment and compact graphitic layers helped to optimize superior efficiency and reproducibility of the substrate. A broad linear detection range of  $10^{-3}$ – $10^{-7} \text{ M}$  was achieved for the detection of 4-NPh, with an impressive low relative standard deviation (RSD) value of 9.32% showcasing excellent repeatability of SERS substrate. Furthermore, examining the energy profiles, specifically the VBM and band gap values of both the substrate and analyte, helped to reveal the involvement of EM and charge transfer mechanisms in the SERS enhancement.

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# Integration of Finite Element Analysis and MBD Analysis for Different Component of a Racing Car Conversion

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Certification to race in a given group requires a safe and homologated vehicle. In this context, an Audi A3 is converted to a racing car. For providing passenger safety, a T45 carbon steel roll cage is designed and assessed via FEA under different loading scenarios. In addition, a redesign of the disc brake via a heat transfer simulation followed by a thermo-mechanical stress analysis showed that at a velocity of 150 Km/h, the maximum temperatures attained by the original and modified disc brakes are 300°C and 225°C respectively. Moreover, a suspension system is designed via multi-body dynamics analysis to give solace for the driver and absorb the shock. Through trial and error, a coil over with a stiffness of 80 N/mm and a damping coefficient of 0.3 N.s/mm is selected. Finally, the engine is homologated by modifying several parameters in order to increase power such as bore, stroke and valves. The total cost of the homologation is around 10,000 \$.

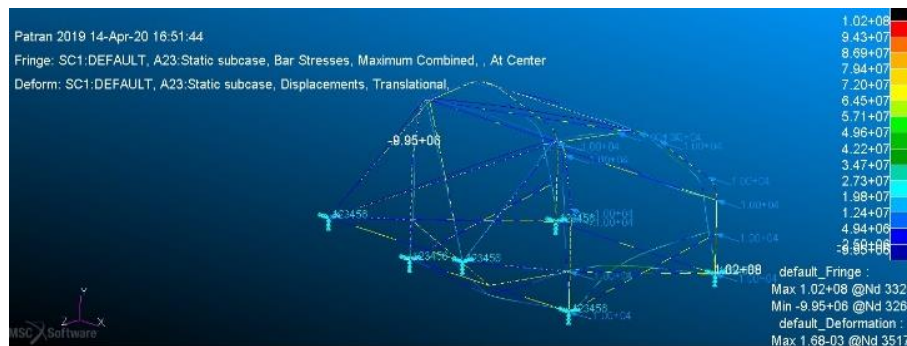


Figure 1. Results for the side impact case Combined stress (Pa)

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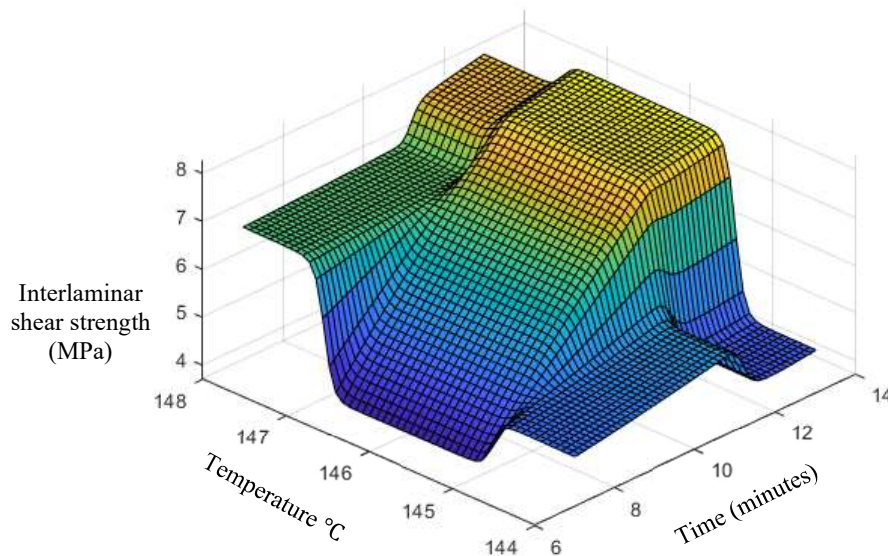
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# Artificial intelligence-assisted investigation of the effects of process parameters on the performance of thermoplastic laminates

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Thermoplastic fiber-reinforced polymer (FRP) composites are increasingly utilized in load-bearing structural applications due to their ease of repair and recyclability, making them a more sustainable option than thermoset-based composites [1,2]. Improving FRP's performance and sustainability is instrumentally dependent on optimizing their fabrication process parameters to minimize the energy consumed in their manufacturing without compromising their structural properties. Accordingly, this work investigates the interactive effect of processing temperature, pressure, and time on the interlaminar shear strength of thermoplastic composite laminates. Full factorial analysis ( $3^3$ ) with three levels per parameter is used to select the values of the investigated parameters. A hot press and a mold were used to fabricate the sample laminates, which were tested using a short-beam three-point bend configuration to measure their interlaminar shear strength. Artificial intelligence (AI) was used to establish a relationship between interlaminar shear strength and the process parameters. Results showed a complex nonlinear relationship between the process parameters and the interlaminar shear strength. However, AI was capable of effectively capturing this nonlinear relationship as seen in Figure 1, which shows the variation of interlaminar shear strength with time and temperature. Similar figures were obtained at the different pressure levels investigated. The optimal processing parameters were 146.2°C, 9.32 bar, and 13 minutes. Results demonstrated that increasing the processing time, pressure, and temperature beyond a certain threshold can result in deteriorating the performance of the fabricated laminates, confirming that an optimum set of process parameters exists.



**Figure 1** Interlaminar shear strength variation with time and temperature as predicted by artificial intelligence.

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# Nitrogen-Doped Activated Carbon: A Sustainable Solution for Efficient Lead Remediation from Water

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## Abstract

The present study delves into the adsorption capacity of nitrogen-doped granular activated carbon derived from coconut shells (N-GAC) for the efficient removal of  $Pb^{2+}$  from aqueous systems. The raw AC underwent a treatment process involving physical mixing followed by calcination at  $400^{\circ}C$  under a nitrogen atmosphere, utilizing urea and ethanol as the nitrogen source and mixing solvent, respectively. The N-GAC displayed enhanced surface and porous properties, presenting a specific surface area of  $474.6\text{ m}^2/\text{g}$ . Morphological characterizations conducted through SEM imaging and EDS mapping provided conclusive evidence of the successful impregnation and uniform dispersion of nitrogen atoms on both the surface and inner structure of the GAC. Adsorption experiments revealed that N-GAC exhibited superior adsorption capacity and removal efficiency compared to pristine GAC in  $Pb^{2+}$  removal. Notably, the adsorption capacity of N-GAC decreased as the initial solution pH exceeded 6.0, while changes in temperature showed an insignificant impact on  $Pb^{2+}$  removal. The maximum Langmuir adsorption capacity for  $Pb^{2+}$  by N-GAC was found to be  $11.9\text{ mg/g}$ . Kinetic data fit the pseudo-second order model, and isotherm results were well correlated with Sips and Langmuir models. Both isotherm and kinetic studies indicated that the removal process comprised a synergistic combination of physisorption and chemisorption processes, including electrostatic interactions and ion exchange. Overall, N-GAC emerges as a promising material for the adsorptive removal of heavy metals from water, showcasing its potential as an effective solution for environmental remediation.

**Keywords:** Activated carbon, Sustainable adsorbent, Nitrogen doping, Adsorption, Surface modification

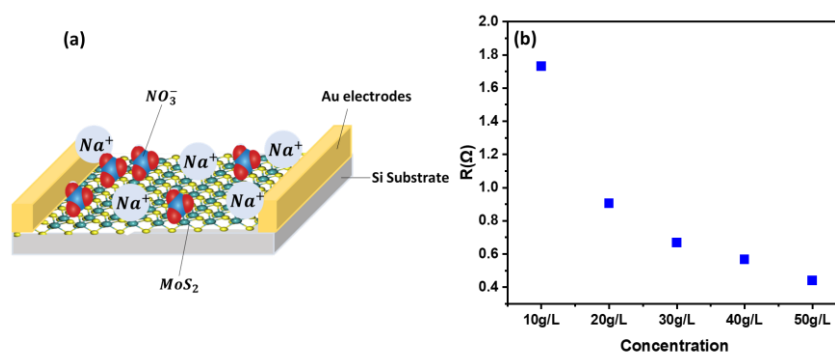
# MoS<sub>2</sub> BASED 2D MATERIAL SENSOR FOR WATER POLLUTANT

Maryam AlQaydi<sup>\*,†1</sup>, Abdellatif Bouchalkha<sup>†</sup>, Mimoun El Marssi<sup>\*</sup>, Chaouki Kasmi<sup>†</sup>, Steevy Cordette<sup>†</sup>, Mustapha Jouiad<sup>\*</sup>

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The fast growing population caused a surge of massive industrialization, which drastically increased the contamination of the environment. Among these pollutants, heavy metals pose a threat to our ecosystem including human health and living organisms. Unfortunately, these metals persist in the environment and accumulate in living tissues, hence disrupting the food chain[1]. Prior study, conducted using a variety of samples collected from different beaches in Abu Dhabi, showed that the most of the heavy metals were found to exhibit a high percentage of Nitrate ions [2]. In this context, we propose to develop a sensor based on 2D material, namely MoS<sub>2</sub> for early detection of these pollutant to allow fast countermeasures. The material constituting our device, was synthesized using chemical vapor desposition (CVD) [3] and monitored by means of two gold electrodes as shown in Fig. 1a. Our sensor showed a very fast response for detecting various Sodium nitrate ions concentrations in the range of 10 to 50 g/L at an applying bias of 5V.



**Figure 1:** (a) Schematic set up of developed MoS<sub>2</sub> Sensor (b) MoS<sub>2</sub> sensor resistance variation as a function of Sodium nitrate ions concentration

According to Fig. 1b, the sensor's exhibits a quasi-linear correlation with increasing sodium nitrate ions concentration, indicated by the change in the device resistance with respect to the nitrate ions concentrations in the solution. This finding indicates also that the increasing the high concentration of ions in the solution dramatically enhances the device conductivity, translated by lower electrical resistance. This work introduces a successful CVD-grown MoS<sub>2</sub> layers a reliable sensor for detecting heavy metal pollutants especially the ones containing the sodium nitrate ions with are the most encountered pollutant in Abu Dhabi beaches.

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# ANISOTROPIC GOLD NANOSTRUCTURES AS HIGHLY PLASMONIC SERS SENSOR FOR THE DETECTION OF FOOD ADULTERANTS

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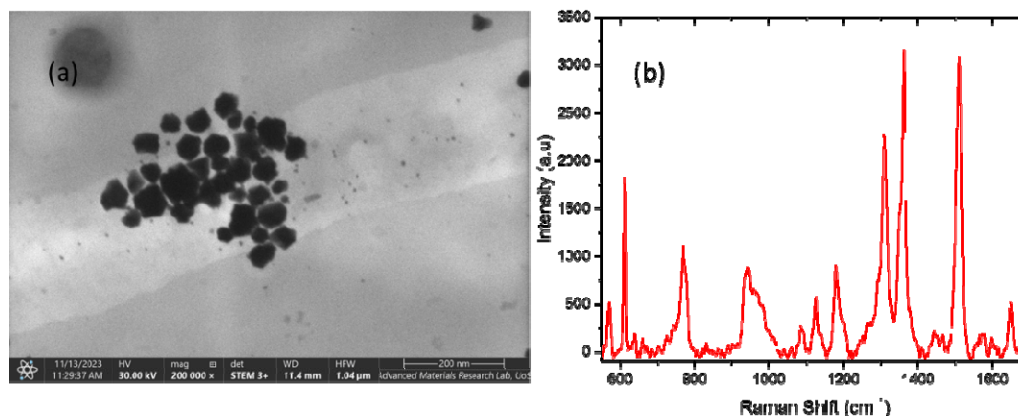
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## Abstract:

Surface Enhanced Raman Spectroscopy (SERS) can enhance the vibrational fingerprints of analytes, reaching orders of magnitude up to  $10^{12}$ . This profound enhancement has led to widespread applications in diverse fields such as environmental monitoring, food safety and medical diagnostics, enabling the detection of molecules at extremely low concentrations. However, this enhancement mainly depends on various factors including the nature of the substrates, morphology of the particles deposited on this substrate, etc. [1]. In this study, we have successfully synthesized anisotropic gold nanoparticles (A-Au NPs) via chemical method. The FE-SEM analysis using STEM imaging mode revealed diverse shapes and sizes of the AuNPs with anisotropic sharp edges which facilitate localized electromagnetic fields, concentrating energy at specific points and creating hot spots, thereby enhancing Raman scattering signals. X-ray photon electron spectroscopy (XPS) and elemental composition by energy dispersive X-ray spectrometer (EDS) studies were carried out to analyze the as-synthesized A-Au NPs. Moreover, A-Au NPs immobilized onto a cheap and easily available flexible substrate (plastic carry bag) and demonstrated their utility in the SERS detection of rhodamine 6G (R6G) at ultralow concentrations. The sensor is further exploited to sense toxic food additives with high sensitivity and reproducibility.

**Keywords:** SERS, food additives, flexible substrate, chemical method



**Figure 1.** (a) FESEM image of A-Au NPs & (b) Detection of Rhodamine 6G (R6G) on polythene carry bag

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# EVALUATING THE MECHANICAL PERFORMANCE OF BAILEY ASPHALT MIXTURES INCORPORATING NATURAL RIVER SAND THROUGH DYNAMIC MODULUS ANALYSIS

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This study aims to investigate the efficiency of Bailey method [1,2] of evaluating the elastic modulus of asphalt mixtures when natural sand is included in the mix at two coarseness levels of aggregate gradations: Fine-graded (FG) and coarse-graded (CG). Three mixes which varied with the percentage of the natural river sand were prepared at each coarseness level, namely: Coarse-graded with quarry sand only (CG-QS), coarse-graded with natural sands only (CG-NS), coarse-graded with quarry and natural sands (CG-QNS), fine-graded with quarry sand only (FG-QS), fine-graded with natural sands only (FG-NS), and fine-graded with quarry and natural sands (FG-QNS). The portions of the natural sand either in CG-QNS and FG-QNS mixes were minimized as possible without violating the Bailey ratios. The sensitivities of the volumetric measures with the elastic modulus ( $|E^*|$ ) were evaluated. The study's findings indicate that  $|E^*|$  was generally decreasing with the increase of the natural sand at various frequencies and temperatures. The dust proportion (DP) was the most significant volumetric. The Bailey gradation method successfully provided a similar gradation coarseness for CG-QNS compared to CG-QS, which resulted in comparable  $|E^*|$  and indicates a similar aggregate interlock. Moreover, a prediction model was developed to predict  $|E^*|$  at various frequencies and temperatures relying the DP as the main predictor for  $|E^*|$ .

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# 4D printing of magnetic shape memory polymer nanocomposite through the incorporation of LSMO nanoparticles.

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4D-printing has revolutionized traditional 3D-printing through the use of shape-shifting smart materials such as Shape memory polymers (SMP). This allowed for the construction of complex geometries that exhibit the ability to alter their shape through appropriate stimuli such as heat. As non-magnetic materials, SMPs require direct exposure to heat for the shape-memory effect to be triggered, which limits their applicability in many critical situations. This issue can be addressed through the incorporation of magnetic nanoparticles, allowing the nanocomposite to be remotely heated through induction heating. Induction heating does not require direct contact with the material, and hence, allows for the utilization of the SMP in rather more advanced applications such as soft robotics, biomedical, and aerospace applications. This work focuses on the  $\text{La}_{1-x}\text{Sr}_x\text{MnO}_3$  (LSMO) manganite with an optimized stoichiometry of  $x=0.3$  due to its prominent properties among other magnetic oxides. With its semi-metallic behavior, LSMO exhibits ferromagnetism, and a bulk magnetic ordering temperature ( $\approx 370$  °K) higher than the typical transition temperature of common thermoplastic SMPs ( $\approx 330$  °K). In this work, LSMO was made from pure metal powders and sintered into an ingot, which was put in an X-ray diffraction (XRD) test to confirm the formation of LSMO crystals. Solution mixing was used to incorporate LSMO nanoparticles into the SMP with nanofiller wt% of 15, 20, and 25. The nanocomposite was extruded into 1.75mm diameter filaments through melt extrusion. The physical properties of the nanocomposite filaments were evaluated through a physical properties measurement system. Dynamic Mechanical Analysis (DMA) test revealed a positive shift in the transition temperature of the nanocomposite (from  $\sim 36$  °C to  $\sim 40$  °C). Shape memory properties were evaluated via 3D-printing of a single-cell auxetic honeycomb structure and the strain measurements were obtained through Digital Image Correlation (DIC). Shape memory analysis showed a slight decrease in the shape recovery ratio, but with a more damped recovery behavior when compared to pure SMP. Furthermore, shape fixity of 100% was achieved regardless of the nanofiller wt%. The incorporation of LSMO nanoparticles in 4D printed SMP proved to have a negligible effect on the shape memory properties and transition temperature, while significantly enhancing the stability and duration of the recovery process. Accordingly, the present work creates a first step towards producing remotely activated magnetic 4D printed structures through recent and novel LSMO nanoparticles.

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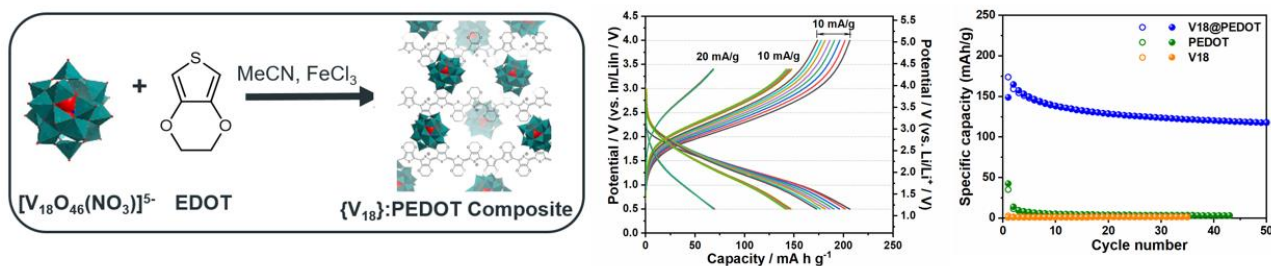
# HYBRID ORGANIC-INORGANIC COMPOSITE ELECTRODE FOR HIGH-PERFORMANCE POST-LITHIUM BATTERY

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The urgent need for economical and sustainable energy storage drives battery research nowadays. While, lithium-ion batteries (LIBs) are amongst the most successful electrochemical energy storage technologies as they offer high voltages, and thus, high energy densities, the currently used electrode materials appear not to be sustainable in the medium- and long-term due to the critical availability of several of the elements used (*e.g.* Li, Co), particularly as demand for batteries is increasing significantly.<sup>[1,2]</sup> Thus, we need new battery technologies based on earth-abundant elements, such as sodium, potassium and magnesium, which can compete with, or even surpass, the performance characteristics and economic scalability of the lithium-ion batteries we use today. However, suitable electrode materials and electrolytes still need to be developed to capitalize on the advantages of these alternative systems. Furthermore, current rechargeable ion batteries typically rely on so-called intercalation compounds (often metal-oxides) where the cycling stability is limited by the mechanical degradation of the structure during the lithium intercalation/ extraction.<sup>[3]</sup> Herein, we developed novel hybrids of organic-inorganic composites as electrode materials for (post-) Li-ion batteries. These electrode materials were synthesised using molecular metal oxides, so-called polyoxometalates (POMs)<sup>[3]</sup> and conductive organic polymers. The molecular nature of the redox active species offers a charge storage mechanism beyond intercalation. The stable anchoring of POMs to the conductive electrode reduced the solubility in the electrolyte and enhanced the overall performance ( see Fig. 1).



**Figure 1.** Schematic diagram of the synthesis approach of the hybrid POM/Conductive polymer composites and their electrochemical performance in solid-state Li batteries.

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# **Antiferromagnetic Spin Exciton Insulator States in Gadolinium Nickel Zinc Ferrite Nanoparticles**

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Unlike the many studies concentrating on exciton dynamics in binary and ternary oxide and nitride compounds [1,2], we present a primary account of the dynamics of spin excitons and their coupling with the antiferromagnetic background and critical temperature in the strongly correlated quaternary compounds of  $Gd^{3+}$ . The nanoparticles of gadolinium nickel zinc ferrite (GNZF), characterized by the  $GdFeO_3$  and  $GdO$ -rich material phases, exhibit a grain size of approximately 42 nm. This size effectively quantum confines the electron-hole pairs, giving rise to the generation of excitons within the nanoparticles. In samples with  $GdFeO_3$  as the majority phase, the optical energy gap is about 1.9 eV, while in the  $GdO$ -rich sample, it is 1.6 eV. Notably, the exciton transitions with a binding energy of  $\approx 100$  meV are clearly discernible in the absorption spectra. The molar magnetic susceptibility obtained from the field-cooled and zero-field-cooled data shows unequivocal signatures of antiferromagnetic behavior arising at temperatures below 18 K. The coupling of the spin exciton states with the antiferromagnetic background causes the fall and rise of the molar susceptibility, indicating the emergence of antiferromagnetic exciton insulator states. The magnetic susceptibility reaches its peak due to the exciton gap temperature aligning with the point at which the energy needed to dissociate exciton pairs becomes comparable to the thermal energy within the system. During this phase, a significant quantity of excitons is generated, resulting in a surge of magnetic susceptibility. As the temperature continues to decrease, the exciton population decreases, causing a subsequent decline in magnetic susceptibility.

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# DECORATION OF Cu<sub>2</sub>O NPs ONTO 2D LAYERED MATERIAL TO CONSTRUCT A TRICOMPONENT NANOCOMPOSITE MATERIAL FOR ELECTROCHEMICAL H<sub>2</sub> EVOLUTION

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## **Abstract:**

Electrocatalytic hydrogen evolution reactions (HER) present an enduring strategy towards hydrogen fuel production and are vital for sustainable energy conversion. To explore efficient and durable HER electrocatalysts, we synthesized Cu-oxide nanoparticles supported on a 2D heterostructure comprising MoS<sub>2</sub>/g-C<sub>3</sub>N<sub>4</sub> for their electrochemical application in hydrogen production. The formation of this nanocomposite material was established through different characterization techniques including XRD, XPS, RAMAN, HRTEM, and FESEM-EDS. The electrocatalytic activity of the prepared nanocomposite for HER performance was studied in acidic electrolytes using Cyclic Voltammetry, Linear Sweep Voltammetry, and Electrochemical Impedance Spectroscopy. The nanocomposite showed superior current density and reduced overpotential in comparison not only to its components but also to numerous recently reported electrocatalysts. The excellent HER performance of the prepared nanocomposite material was further confirmed through the lower tafel slope and high electrical double-layer capacitance. Furthermore, the reported nanocomposite retained a stable current density up to 8 h indicating its high stability as HER electrocatalyst with minimal degradation. The composite material's substantial electrochemically active surface area, coupled with the synergistic interactions among its components, played a pivotal role in achieving excellent performance in the hydrogen evolution reaction.

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# Bending and Shear Response of Perturbated Honeycombs

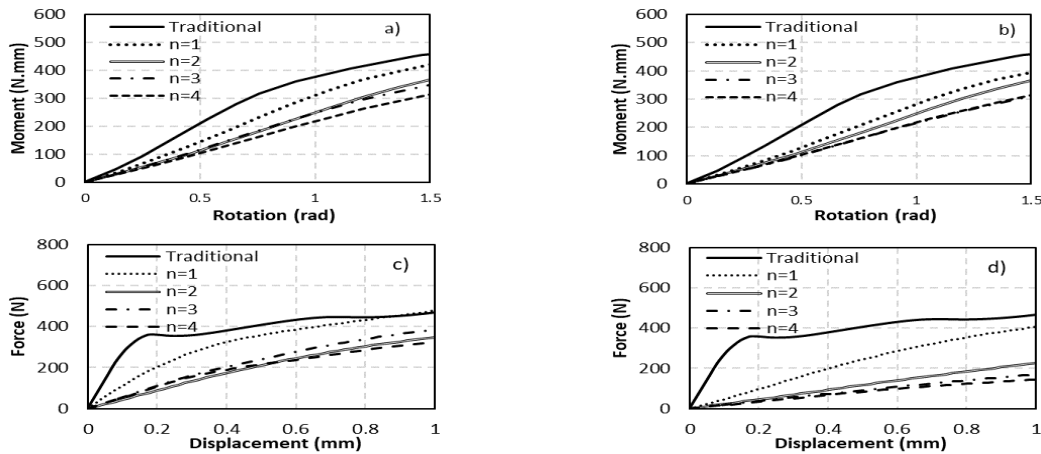
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Sandwich panel structures with cellular cores have been utilized in various industries due to their unique mechanical properties, such as their strength-to-weight ratio [1]. To increase their utility, various efforts tried to enhance the mechanical properties of cellular core sandwich panels without compromising the strength-to-weight ratio. One of the most recent approaches proposed to enhance honeycomb cores is the introduction of sinusoidal perturbations onto their cell walls, varying in amplitude and frequency. Most studies involving sinusoidal perturbations have focused on characterizing the enhancing effects of these perturbations on the energy absorption capacity of honeycombs [2-3]. Accordingly, this study computationally investigates the effects of sinusoidal perturbations on properties other than energy absorption, specifically, bending and shear stiffness.



**Figure 1.** Bending moment response for (a) 0.15mm amplitude and (b) 0.3mm amplitude. Transverse Shear Response for (c) 0.15mm amplitude and (d) 0.3mm amplitude.

Results, summarized in Fig.1, illustrate the bending and shear response for perturbation amplitudes of 0.15 and 0.3 mm at different frequencies (1,2,3, and 4). The lowest bending stiffness and peak moment occurred at a frequency and amplitude of 4 and 0.3 mm, respectively, with the peak moment in the most perturbed case being about 45% lower than the unperturbed case. The reduction in stiffness due to perturbations also lowers the core's resistance to permanent deformation and yielding, identified as the stress level where the transverse shear stress-strain curve shifts from linear to nonlinear. Results highlight an adverse effect of perturbation.

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# HOT AND FREE CARRIERS DYNAMICS IN HYBRID LEAD HALIDE PEROVSKITE

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Hybrid lead halide perovskites have recently emerged as a promising material in photovoltaics, and have achieved over 26% power conversion efficiency.[1] They have also exhibited excellent performance in other potential applications, such as photodetectors, light emitting diodes, lasers, and, X-ray imaging scintillators due to their remarkable optical and electronic properties and their excellent solution processability.[2-4] Despite tremendous successes in energy conversion efficiency, the solar-to-electrical conversion efficiency for perovskite materials can be further improved by capturing the hot carriers in the solar cells.[5]

In general, hot carrier cooling is one of the inevitable losses that can truly limit the Shockley-Queisser efficiency in photovoltaics. In other words, a very significant improvement in solar cell efficiency could be achieved if the energy of hot carriers could be captured. However, the harvesting of hot carriers is highly challenging because their thermalization process occurs on a timescale of 100s of fs, which is followed by charge recombination.[6] It is worth pointing out that the dissociation of excitons into the free carriers in perovskite structures is very efficient due to their low exciton binding energy. There has been extensive research undertaken to understand the hot carrier dynamics in metal halide perovskite, even under different excitation fluences, using a variety of experimental techniques.[7-8] However, no progress has been made in capturing the transition of the hot carriers into free carriers or in elucidating how these free carriers behave compared to the ones generated without excess energy via band-edge excitation.

Here, we employed femtosecond pump-probe measurements with different pump excitation energies to explore and decipher the interplay between hot and free carriers in cation-dependent lead iodide single-crystal perovskite materials prepared by inverse temperature crystallization methods. Our experimental results demonstrate the efficient transition of hot carriers into free carriers within hundreds of femtoseconds. Moreover, we find that the slow formation of free carriers from the hot carriers and a strong propagation of coherent longitudinal acoustic phonons (CLAP) in methyl ammonium lead iodide (MAPbI<sub>3</sub>) as compared to formamidinium lead iodide (FAPbI<sub>3</sub>) perovskite (MAPbI<sub>3</sub>) and mixed formamidinium methyl ammonium lead iodide (FA<sub>0.6</sub>MA<sub>0.4</sub>PbI<sub>3</sub>). Our investigation provides a crucial fundamental insight into the relaxation of hot carriers into free carriers that can be beneficial for the development of renewable energy applications like photovoltaics, photocatalysis etc.

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# **Femtosecond transient absorption study of silicon nanoparticles synthesized by laser ablation of bulk silicon in water**

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The outstanding properties of silicon nanoparticles (SiNPs), such as the tunability of their optical properties across a wide range of energies, efficient light absorption, and high emission quantum yields, make these structures great candidates for the photonics, photovoltaics or microelectronics materials. The key properties of SiNPs are shaped by the processes occurring on a time scale ranging from femtoseconds to nanoseconds. The ultrafast temporal evolution of nanometer-sized semiconductor structures might be successfully investigated using femtosecond time-resolved transient absorption pump-probe spectroscopy (FTAS).

Here, we present our studies on SiNPs using a home-built FTAS setup based on a femtosecond Yb:YAG laser system. We prepared the SiNPs samples using simple, green, versatile, low-cost laser ablation synthesis in water. To monitor the ultrafast photoinduced events in Si-based NPs, the laser pulses centred at 1030 nm with a frequency of 50 kHz and durations of 240 and 40 fs were utilized. The frequency of photons in a 240 fs pulse was tripled in BBO crystal to allow the interband excitation of SiNPs, while 40 fs one generated a white light pulse in Sapphire crystal for the spectrally-resolved characterization of photoexcited species. The results of the femtosecond transient absorption spectroscopy indicate a strong effect of the pulse energy on the ultrafast events in synthesized NPs suspensions due to different concentrations of surface trap states.

# **EFFECT OF CONCRETE COMPRESSIVE STRENGTH ON THE BOND PERFORMANCE OF FLEXURAL PRISMS EXTERNALLY STRENGTHENED WITH CFRP LAMINATES**

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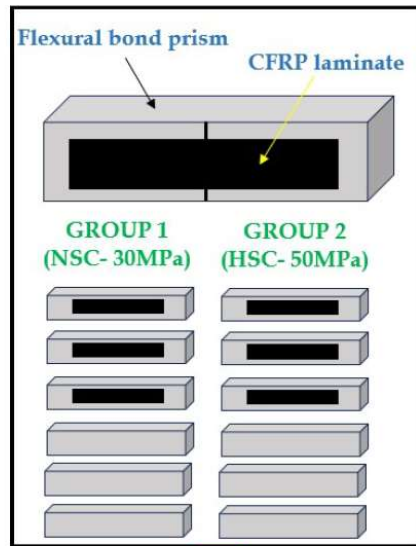
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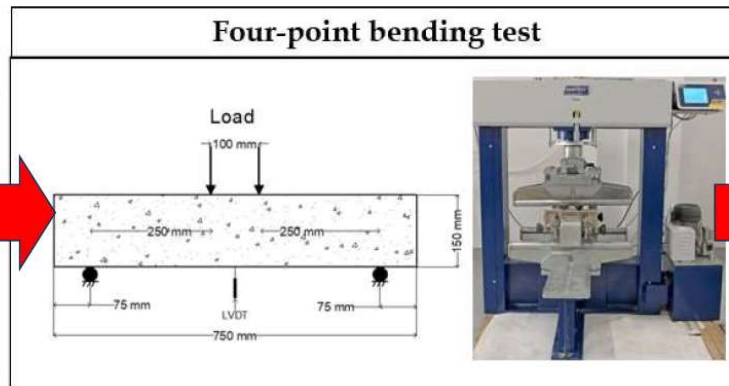
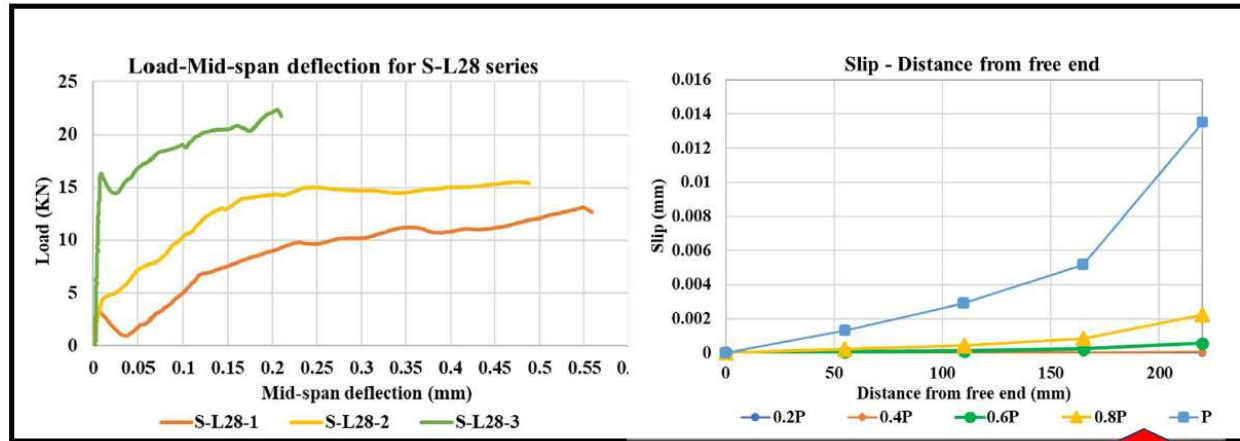
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This paper presents a study from an ongoing research project on the bond performance of carbon-fiber reinforced polymer (CFRP) strengthened prisms. The advent of fiber reinforced polymer (FRP) composites has led to a breakthrough in the field of strengthening and repair of reinforced concrete (RC) infrastructure. Extensive research has been conducted since then to evaluate the performance and behavior of RC structures externally strengthened using different types and configurations of FRP composites. Although there is an abundance in literature on the influence of several parameters on the performance of the FRP-concrete bond, the effect of compressive strength of concrete has not been dealt with much consideration to the best of the author's knowledge. The influence of concrete compressive strength on the distribution of strains and interfacial bond-stress along the length of CFRP laminate is still obscure. The aim of this paper is to evaluate the effect of normal strength concrete (NSC – 30MPa) and high-strength concrete (HSC - 50MPa) on the bond performance of plain concrete prisms notched at the mid-span and strengthened using CFRP laminates. Two groups of six prisms each were cast using the two design mixes. Three prisms from each group are strengthened using CFRP laminates, while the remaining prisms were un-strengthened to serve as control prisms. Two linear variable differential transducers (LVDT's) and a series of equidistantly placed strain gauges were installed on strengthened prisms to obtain prism midspan deflection and CFRP strain along the laminates. After achieving 28 days of curing in standard lab conditions (temperature maintained at  $23\pm 3^{\circ}\text{C}$  and a humidity of  $50\pm 10\%$  relative humidity), all prisms are tested under four-point loading at a displacement-controlled rate of 0.25mm/min. The ultimate mid-span deflection, maximum and ultimate strains at the mid-span, strain distribution at different positions along the length of the laminate and bond/shear stress versus slip was analyzed in an effort to evaluate the bond performance of flexural prisms. The average ultimate load carrying capacities and mid-span deflection of CFRP-strengthened NSC and CFRP-strengthened HSC prisms was 31.33 and 35.02 kN and, 0.41 and 1.54 mm respectively. The average CFRP strain values corresponding to ultimate load was 2930.119 and 3544.01 $\mu\epsilon$ . It can be concluded from the experimental results that the concrete compressive strength has minimal effect on the flexural bond performance of concrete prisms externally bonded with CFRP laminates.

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### EFFECT OF CONCRETE COMPRESSIVE STRENGTH ON THE BOND PERFORMANCE OF FLEXURAL PRISMS EXTERNALLY STRENGTHENED WITH CFRP LAMINATES



**Bond stress**

$$\tau(x_i) = 0.5 n_f t_f E_f \left[ \frac{(\varepsilon_i - \varepsilon_{i-1})}{(x_i - x_{i-1})} + \frac{(\varepsilon_{i+1} - \varepsilon_i)}{(x_{i+1} - x_i)} \right]$$

**Interfacial slip**

$$s(x) = s(0) + \sum_{i=n}^x 0.5 [ (\varepsilon_i - \varepsilon_{i-1}) (x_i - x_{i-1}) + (\varepsilon_{i+1} - \varepsilon_i) (x_{i+1} - x_i) ]$$

Figure 1. Graphical representation of abstract



# CONSTRUCTION INNOVATION- GRAPHENE OXIDE AS THE DIFFERENTIATING NANOADDITIVE FOR CONCRETE AND COATINGS

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## Abstract

When discussing graphene materials, their mechanical strength, impermeability, flexibility, thermal and electrical conductivity, and lightness are key reference points, earning them the moniker "all-in-one material." This versatility makes graphene suitable for various applications, including electronics, medicine, plastics, coatings, construction, and renewable energies. However, it's crucial to note that the behavior of these materials at the nanometric scale depends on factors such as the type of graphene, functionalization, concentration, and the specific processes involved in each industry.

Since the isolation of graphene in 2004, significant efforts have been made to comprehend its multifunctional properties. Nevertheless, the primary challenge lies in translating this knowledge from the laboratory to industrial applications, hampered by the high cost and low yield of graphene. Fortunately, the construction industry, particularly the concrete and coatings sector, appears to be one of the most promising fields for the integration of this nanotechnology.

In this context, we present a diverse array of representative trials conducted on various concrete designs and environmentally friendly, antimicrobial, and anticorrosive coatings enhanced with graphene materials. These trials showcase the multifunctional properties of graphene in different commercially available products tailored for industrial applications.

# SUSTAINABLE FATTY ACID BASED IONIC LIQUID (FA-IL) PHASE CHANGE MATERIALS FOR THERMAL ENERGY STORAGE

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## Abstract

The energy crisis is escalating due to the increase in population, urbanization, environmental concerns and technology advancement. Development of alternate energy resources and efficient energy storage techniques are needed to reduce the gap between demand and supply. Latent heat thermal energy storage systems [1] employing phase change materials are one such promising technology for the storage and conservation of thermal energy from renewable resources [2]. This work presents the synthesis and application of a new class of PCMs developed by conjugating various fatty acid (FA) and ionic liquids (IL). The performance of the fatty acid PCMs were improved by combining with ionic liquids exhibiting properties such as high density, wide liquid temperature range, high chemical stability, non-volatility, non-flammability, high heat capacity, and high storage density. In this study, four fatty acids such as octanoic acid, nonanoic acid, decanoic acid and dodecanoic acid were conjugated with 1-hexadecyl-3-methyl-imidazolium chloride [C<sub>16</sub>Mim]Cl by a metathesis reaction and the effect of alkyl chain length on the properties of the resulting ILs were studied (Fig.1). The chemical structure of the FA-ILs was confirmed by FT-IR and NMR spectroscopy and the water content in the ILs were analyzed by Karl Fischer titration. DSC was used to evaluate the ILs' thermal properties such as latent heat of fusion and specific heat capacity, and melting point. The TGA analysis showed the high thermal stability of the FA-ILs. The prepared ILs exhibited melting point in the range of 35-80°C, significantly lower than the unconjugated IL ([C<sub>16</sub>Mim]Cl), and suitable for use with solar technology. The thermal properties of the FA-ILs can be tuned by varying the chain length of the fatty acid as they exhibit increase in melting point and heat of fusion with respect to their chain length. The DSC and TGA analysis prove the suitability of the prepared FA-ILs for solar energy storage applications.

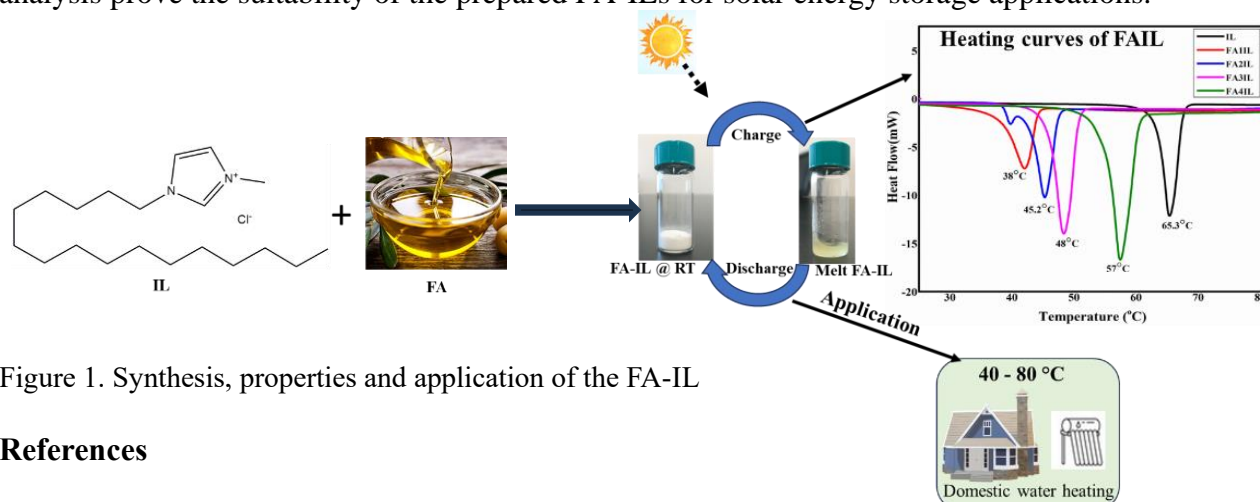


Figure 1. Synthesis, properties and application of the FA-IL

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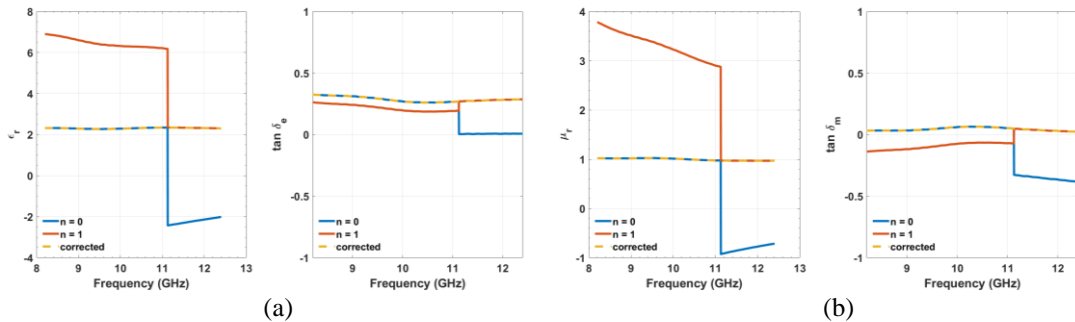
# ACCURATE EXTRACTION AND NUMERICAL VALIDATION OF THE PERMITTIVITY AND PERMEABILITY OF DIELECTRIC MATERIAL

Shaikha Aldhaheeri<sup>\*1</sup>, Papa Ousmane Leye, Islem Yahi, Chaouki Kasmi, and Felix Vega

Directed Energy Research Centre, Technology Innovation Institute, United Arab Emirates.

Determination of the complex permittivity and permeability of material is an important topic in many applications (stealth technology, electromagnetic interference, microwave circuit design...)[1]. The Nicolson Ross–Weir (NRW) method, based on transmission and reflection measurements [2], is one of the most commonly used methods for extraction of the EM properties of material.

In this study, we implement an NRW algorithm for material characterization in a broadband frequency range using an X-band rectangular waveguide. A known polystyrene-based sample material of thickness 9.6 mm is measured. This technique is known to suffer from resonance when the electrical length of the material reaches one-half guided wavelength. Figure 1 shows the extracted complex permittivity and complex permeability of the polystyrene-based sample. As shown in Figure 1, resonance at 11.1 GHz corresponding to the half-guided wavelength in the material is observed on the extracted permittivity and permeability.



**Figure 1.** Complex permittivity and complex permeability of the polystyrene-based sample material: (a) Real part of the permittivity ( $\epsilon_r$ ) and electric loss tangent ( $\tan \delta_e$ ), (b) Real part of the permeability ( $\mu_r$ ) and magnetic loss tangent ( $\tan \delta_m$ ).

This divergence problem of the algorithm is solved by implementing an iterative and stable technique correcting the phase shift of the propagation factor from consecutive frequency measurement steps. Figure 1 shows the extracted permittivity and permeability after correction. The extracted parameters meet the expected values. An accurate determination of the electromagnetic properties of the material is achieved using the proposed technique. As next step, this technique will be validated through measurement of various materials (magnetic materials and lossy materials) and compared with different algorithms.

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## **Find the needle in the haystack – Find, extract, and analyze your sample across length scales.**

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From integrated materials engineering of microelectronics components and deformation in advanced alloys and composites to pore transport and ionic mobility in lithium-ion batteries or other energy materials, many problems in materials science can only be fully understood in 3D. The main thrust of materials science is to connect macroscale material properties with specific micro- and nanoscale structures. In this light, it has long been the goal of materials researchers across a wide range of application areas to identify and analyze critical nanoscale features buried deep within bulk samples.

Locating and imaging these nanoscale “needles in haystacks” requires microscopy techniques that provide critical insights into how representative the chosen sample site is compared to the bulk, enabling intentional and reliable nanoscale 3D investigations across sample types. They should offer deeper levels of understanding to accelerate the development of new materials in areas like nanomaterials, electronics research, next generation energy materials and advanced metallurgy.

The sample in volume analysis workflow is a unique correlative LaserFIB and XRM way to identify, prepare and analyze your needle in a haystack.

If you need to digitize more than one needle of haystack, we talk about an automated way to image your samples with high throughput.

Furthermore, the combination of a scanning laser microscope and research light microscope enriches your materials characterization capabilities.

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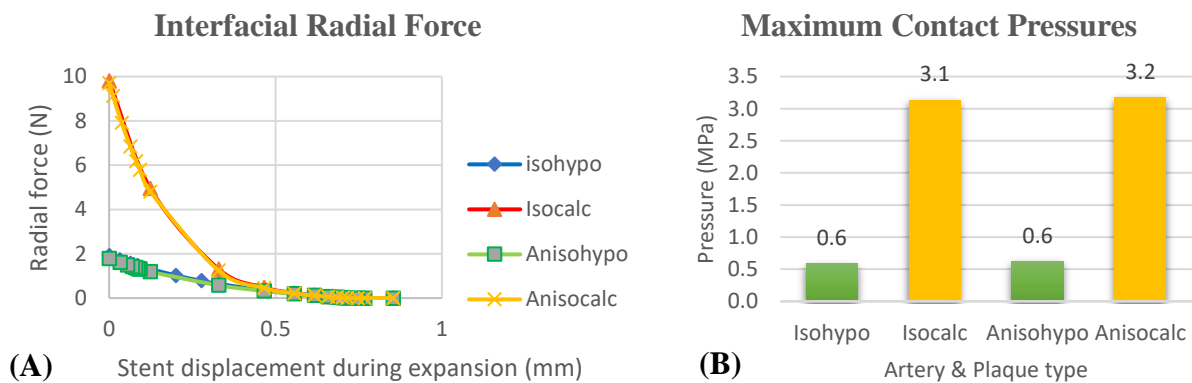
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# Self-Expanding Stents: A Finite Element Analysis of their Interaction with the Wall of Blood Vessels

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Self-expandable stents manufactured from nitinol alloys are commonly utilized alongside traditional balloon-expandable stents to provide scaffolding to stenosed arteries. However, a significant limitation hampering stent efficacy is restenosis, triggered by neointimal hyperplasia and resulting in the loss of gain in lumen size, post-intervention. In this study, a nonlinear finite element model was developed to simulate stent crimping and expansion and its interaction with the surrounding vessel. The superelasticity model incorporated in Abaqus, based on the work of Auricchio and Taylor [1], was utilized in defining nitinol. The isotropic and anisotropic behaviours of the hyperelastic artery and plaque were modelled using Ogden [2] and Holzapfel [3] strain energy potentials respectively. The main aim was to determine contact pressures and forces (see Fig. 1) induced at the interface between an artery wall with plaque and an expanded stent, for hypocellular and calcified plaques and varied plaque thicknesses.



**Figure 1.** (A) Contact normal forces on stent surface during expansion (B) Bar chart representing maximum interfacial contact pressures

The results demonstrate the drawbacks of plaque calcification, which triggered a sharp contact pressure and radial force surge at the interface, potentially leading to rupture and restenosis. A regression line was then established to relate hypocellular to calcified plaques. Regarding the directionality of wall properties, contact pressure and force observations were not significantly different between isotropic and anisotropic arteries. Furthermore, the model having a thinner plaque experienced a lower peak contact pressure and radial force at the contact interface.

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**POSTERS** | February 13–15, 2024

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# THE USE OF CETYLPYRIDINIUM CHLORIDE- MODIFIED ZEOLITE WITH ALGINATE COMPOSITE AS A NOVEL APPROACH TO DENTAL HYGIENE FORMULATION

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The modern era and its advanced technologies have led to a significant change in human behaviour. This has increased global expenditure in dental procedures and become the 4th most expensive disease to treat [1]. *Bacillus cereus* (*B. cereus*), *Serratia marcescens* (*S. marcescens*), *Escherichia coli* (*E. coli*), and *Streptococcus pneumoniae* (*S. pneumoniae*) have been strongly associated with the causes of oral diseases. Research even shows the adverse effects of the discussed strains outside the oral cavity [2-6]. Hence, it is urgent to find a solution that is both economically viable and medicinally valuable. In previous study, the complexation of cationic surfactants (Cetylpyridinium chloride (CPC)) and smectite clays (montmorillonite) has been explored for treating dental diseases [7]. This study focuses on formulating a novel composite of zeolite encapsulated in alginate (Zt-Alg) and zeolite encapsulated in alginate modified with CPC (CPC-Zt-Alg) by mixing CPC and zeolite with 5wt% sodium alginate solution which was poured drop by drop in a 2 wt% calcium chloride solution to allow spherification, resulting in beads. The surface morphology, chemical composition, stability, and anti-bacterial properties of the composite beads were studied along with viability with HBEC-5i cells. CPC-Zt-Alg beads were investigated (via bactericidal assay) against two gram-positive strains (*B. cereus* and *S. pneumoniae*) and two gram-negative strains (*E. coli* and *S. marcescens*) proving 100% bactericidal activity against all the strains tested; furthermore, it has shown 5.9% toxicity to HBEC-5i cells confirming that the composite is safe for human use.

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# MECHANICAL CHARACTERIZATION OF 3D-PRINTED POLYCARBONATE FILAMENT REINFORCED WITH CARBON-FIBER (PC-CF).

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Improving the strength, stiffness, and thermal stability of 3D printed parts by fused deposition modeling (FDM) has motivated the incorporation of fiber reinforcements in FDM filaments [1]. Along this path, recently, polycarbonate FDM filaments reinforced with short carbon fibers have been introduced. This work aims to enhance the structural reliability and integrity of components 3D printed using Polycarbonate filaments reinforced with carbon fibers (PC-CF) by optimizing their printing parameters. Accordingly, this work initially investigates the material properties of PC-CF and subsequently examines the impact of various printing parameters on the mechanical properties of samples printed using PC-CF. Process parameters investigated include the infill pattern and the print speed. Two infill patterns, concentric and grid infills, are studied. Additionally, each of these infills is printed at three different speeds: 20, 40, and 60 mm/s. The printed specimens were tested using a universal testing machine at quasi-static rates to characterize their stress-strain behavior. 2D digital image correlation was used to measure the full-field strain in the tested specimens. Stress-strain curves were used to obtain the stiffness, yield, ultimate stress, toughness, and maximum strain. Results showed that the concentric infill pattern generally exhibits superior properties compared to the grid pattern. Also, lowering the printing speed for both patterns improved the overall properties. The results demonstrated that optimizing the printing parameters can lead to enhancements of up to 40%, 94%, and 30% in ultimate strength, yield strength, and stiffness, respectively.

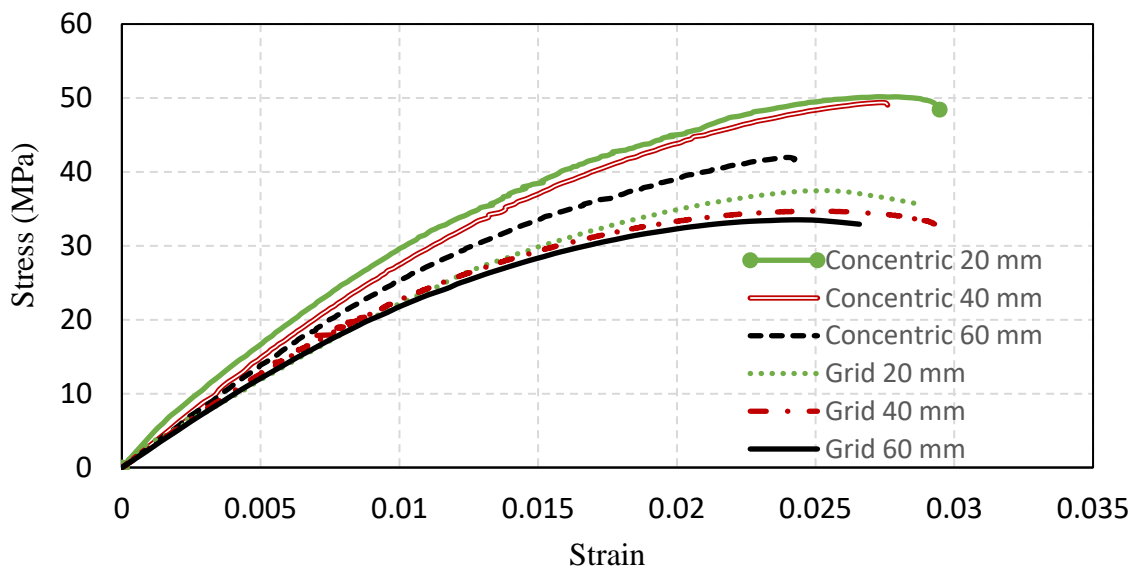


Figure 1. Stress-strain curves for the tested specimen for 6 different printing parameters.

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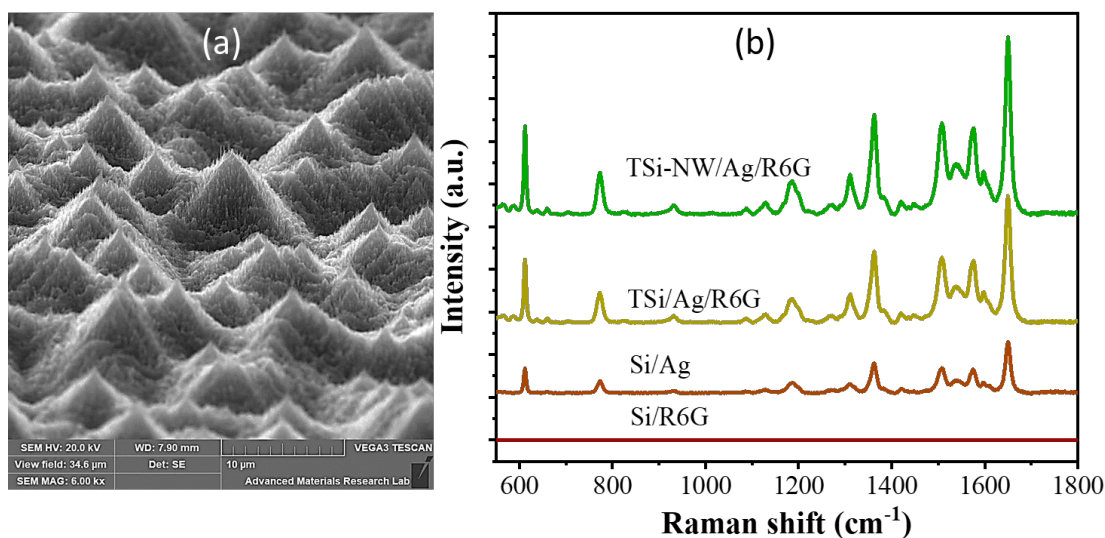
# TUNING SERS ACTIVITIES OF PYRAMIDAL-NANOWIRE/SILVER CHEMOSENSORS FOR EFFECTIVE DETECTION OF MULTI-HAZARDOUS POLLUTANTS

Abdel Rahman Allan<sup>\*1,2</sup>, Soumya Columbus<sup>1</sup>, Krithikadevi Ramachandran<sup>1</sup>, Kais Daoudi<sup>1,2</sup>, Mounir Kaidi<sup>1,2</sup>

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Three-dimensionally oriented nanostructures play a pivotal role in designing optical sensors [1]. In the present work, we tried to design high surface area silicon pyramid/nanowire hybrid arrays for surface enhanced Raman spectroscopy (SERS) sensing applications (Fig. 1a). Plasmonic silver was also conjugated on the hybrid substrates for facilitating surface plasmon resonance. The nanowire length was varied by altering the etching time up to 4 minutes. As-fabricated sensor was well characterized using XRD, UV-visible reflectivity, and XPS analysis. We observed that SERS performance of the hybrid sensors was altered by the nanowire length. The structural features were optimized for getting superior SERS activities using common probe molecules (Fig. 1b). Moreover, the hybrid substrates exhibited exceptional reproducibility and reusability, rendering them ideal for cost-effective, reusable sensors. Finally, we probed the chemo-sensing potential of hybrid arrays for detecting multi-hazardous pollutants that manifested high sensitivity down to picomolar concentrations. This underscores the exceptional potential of the constructed sensors as SERS sensing platforms for environmental remediation applications.



**Figure 1.** (a) SEM images of hybrid substrates & (b) SERS activities of hybrid substrates with references

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## **Boosting the charge storing ability of Ni foam current collector via femtosecond laser treatment**

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Nickel (Ni) foam got immense attention as current collectors to produce energy storage devices in recent years due to their remarkable electrochemical characteristics. However, some work still needs our attention to improve the charge transfer property, water transport and more electrochemical surface area of the Ni foam (current collector) to prepare highly efficient energy storage devices. In this work, we prepared femtosecond (fs) laser treated Ni foam in air (Femto-Air) to enhance their specific surface area, water transport and electrochemical properties and compared with untreated (neat) Ni foam current collector (electrode). X-ray diffraction (XRD), scanning electron microscope (SEM) and energy dispersive X-ray (EDX) techniques were used to analyze the change in crystal structure, morphology and elements present in the Femto-Air and neat Ni foam samples. SEM images illustrate micro/nano structures produced on the fs laser treated Ni foams while EDX analysis shows the presence of respective oxides on it. Brunauer-Emmett-Teller (BET) surface area analysis exhibits ~ 5 % increase in the specific surface area of Femto-Air as compared to neat Ni foam. Drop shape analyzer was used for measuring wetting angle values using D.I water 5 and 2  $\mu\text{L}$  droplets and noted that the neat Ni foam is initially behaving like hydrophobic while after almost 60 seconds the water start to penetrate through the Ni foam and becomes hydrophilic. Whereas the Femto-Air Ni foam behaves like super-hydrophilic from the start and this characteristic makes it perfect for the preparation of highly conductive supercapacitor current electrode member. This fast water transport helps in the fast redox reactions and ultimately improves the overall capacitance capability of the device. We observed ~ 10 $\times$  and ~ 15 $\times$  improvement in the areal capacitance of the Femto-Air samples through cyclic voltammetry and galvanic charge-discharge test, respectively, in 3 M KOH electrolyte solution utilizing three-electrode configuration as compared to neat Ni foam electrodes (current collectors). Whereas the electrochemical impedance spectroscopy explains that the Femto-Air Ni foam electrode has negligible charge transfer resistance. This methodology can help us to prepare better Ni foam current collectors and base electrodes materials for any active material coatings on it to produce high energy density devices.

**Keywords:** Femtosecond laser; Supercapacitor; Current collector; Specific surface area; Water contact angle; Electrochemical study.

# Magnetoimpedance spectroscopy of phase separated $\text{La}_{0.5}\text{Ca}_{0.5}\text{MnO}_3$ polycrystalline manganite.

Mourad Smari <sup>a,\*</sup> and Yousef Haik <sup>b,c</sup>

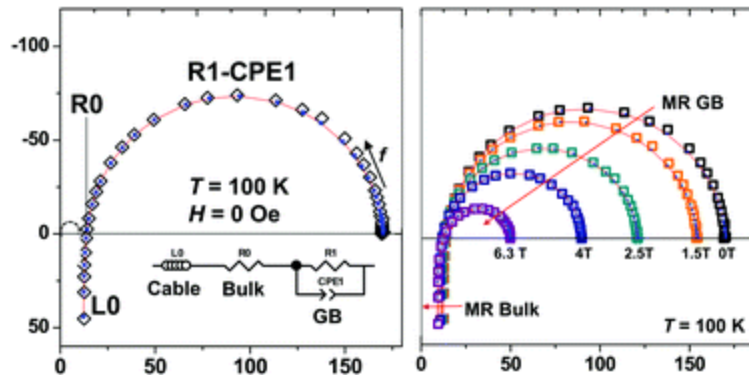
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Magnetoimpedance spectroscopy was carried out to  $\text{La}_{0.5}\text{Ca}_{0.5}\text{MnO}_3$  polycrystalline manganite that had undergone phase separation. An adapted sol-gel method was used to manufacture  $\text{La}_{0.5}\text{Ca}_{0.5}\text{MnO}_3$  powder. The presence of both the ferromagnetic Pnma and the charge ordered antiferromagnetic P21/m phases was indicated by structural and magnetic data. The observations of magnetization versus temperature revealed multiple magnetic transitions, including PM-FM at approximately 240 K, FM-AFM at about 170 K, and AFM-FM at about 100 K, from the high temperature paramagnetic (PM) phase to an FM phase upon cooling. In order to differentiate between the dielectric contributions from the grain boundary (GB) and the grain interior bulk portions, data on magnetic field (H)-dependent impedance spectroscopy was fitted with an analogous circuit model using sintered pellets. The bulk and GB magnetoresistances could be separated in this way, and it was shown that both reached a maximum of approximately 80% at  $H = 10$  T, close to the metal-insulator transition (MIT) at around 100 K. The fact that the GB resistance was approximately three times higher than the bulk resistance suggests that the GBs are the primary source of both the direct current (DC) resistance and the DC magnetic resonance (MR). All discovered magnetocapacitance effects, including those with a CO phase, were determined to be minor, falling below approximately 3%.

Complex plane plot of  $Z''$  vs  $Z'$  at 100 K at various applied H



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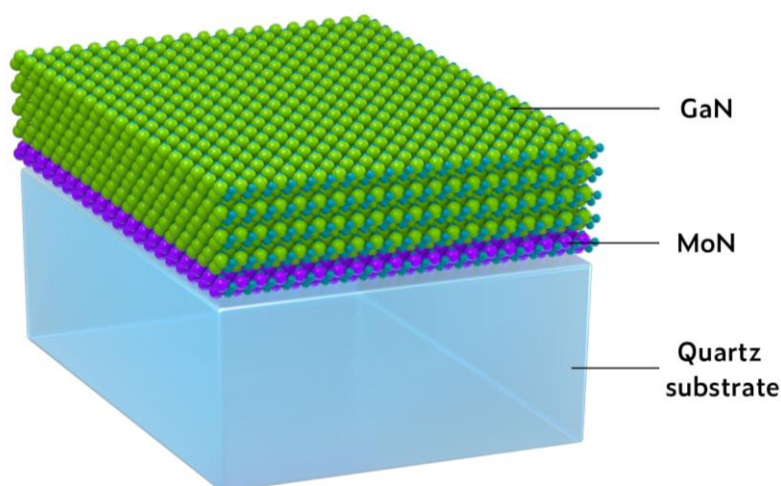
# GaN Epitaxy with the support of large-area 2D MoN

Xiangming Xu<sup>1</sup>, Husam Alshareef.

Physical Science, and Engineering Division (PSE), King Abdullah University of Science and Technology (KAUST), Thuwal 23955-6900, Saudi Arabia.

A great fundamental challenge exists for wide-bandgap single-crystal GaN films (or other epitaxial films) to grow on disordered or large-lattice-mismatched substrates such as quartz glass and Diamond substrate. However, there is a significant demand to do so since it can greatly expand the functionality of wide-bandgap devices. Here our discoveries found that the 2D MoN layer we synthesized over a 2-inch scale can be an excellent buffer layer for GaN grown on quartz substrate with highly controlled lattice mono-orientation, as shown in Scheme in Figure 1.[1]

Our 2D MoN layer is synthesized through the chemical transformation of the large-area precursor 2D MoS<sub>2</sub> film. The MoS<sub>2</sub> has been epitaxially grown on sapphire 0001 substrates with a mono-oriented feature in both in-plane and out-of-plane direction over a 2-inch wafer, thus our 2D MoN layer is also a mono-oriented single-crystal layer. The method to achieve the 2-inch wafer-scale MoS<sub>2</sub> film with a single-crystalline structure is through the unique method we developed, which is epitaxial phase conversion of MoO<sub>2</sub> films.[2-4] Our achievement poster here suggests a great promising potential to use a 2D MXene-like buffer to tackle the fundamental challenges faced in the growth of wide-bandgap films and relevant device fabrication.



**Figure 1.** Scheme of Single crystal GaN grown on a disordered substrate with the support of 2D MoN layer.

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# SHAPING THE FUTURE: UNVEILING THE COST-EFFICIENCY BATTLE BETWEEN WIRE BENDING DIES AND WIRE BENDING JIG

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Smart materials, particularly shape memory alloys (SMAs), have become a focal point in materials research due to their remarkable ability to react to external stresses and revert to their original shape, finding applications in vibration control, buckling, damping, and impact resistance. Composite structures, having external applications in engineering, benefit from incorporating SMAs into the structure allowing mitigation of instabilities and improvement in impact performance of the structures [4-5]. These versatile alloys can take the form of meta lattice structures, which can be used as core structure for the composite panels. The lattice structures can be characterized by a lower elastic modulus, high stiffness-to-weight ratio, low thermal expansion coefficient, and a substantial specific surface area, depending on the chosen fabrication technique. These structures can be manufactured using conventional techniques, which are investment casting, wire woven techniques, foaming, powder metallurgy and other methods. However, the problem associated with these techniques is randomly generated structures making them limited in applications [1-3]. This paper specifically delves into the economic and technical considerations of two wire bending approaches, both classified under conventional techniques, in the fabrication of octet structures using Nitinol wires. One method employs dies for wire forming, while the other utilizes a wire bending jig. A bending press is also used to bend the preformed wires. Mechanical tests, involving an impact drop tower, are conducted to compare absorption energies of the lattice structures produced by both processes. Additionally, feasibility studies are undertaken to assess the cost and time required for fabricating the structures, offering a comprehensive analysis of the economic and technical aspects involved.

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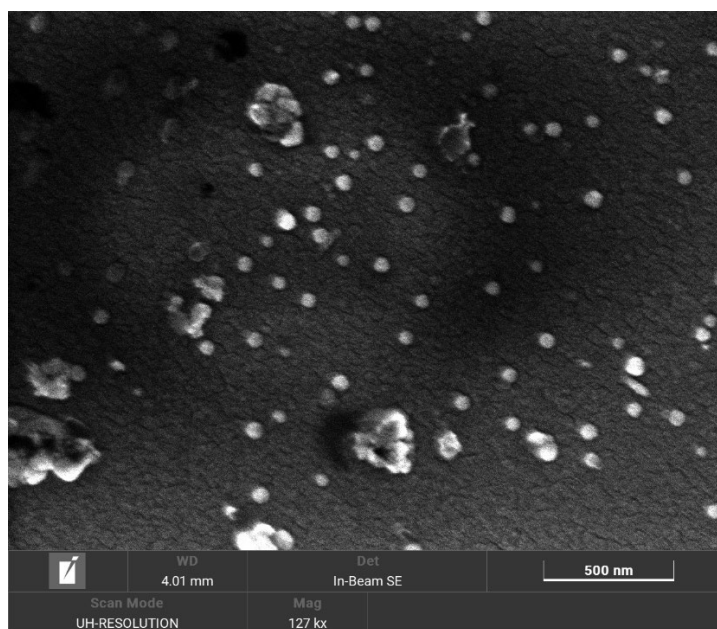
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# Production of nanoparticles from polymer using laser ablation in water

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Plastic is one of the most serious environmental hazards these days. Therefore, the use of plastic waste for the synthesis of various types of materials can not only save people and the environment from the dangers of plastic, but also serve as a source of useful substances for use in various fields. For example, various optically active nanomaterials can be synthesized from plastic waste, which can be used as bioimage devices or sunscreens. In this paper, we present a new approach to the production of nanoparticles by nanosecond laser irradiation of polystyrene in water. As a result of laser exposure, nanoparticles with an average size of 50 nm were formed in the solution. At the same time, the presence of optically active centers in these nanoparticles made it possible to detect them using optical spectroscopy. Transforming plastic waste into valuable nanoparticles through laser processing represents a promising approach. This method not only diminishes plastic pollution but also offers a route to obtain useful materials using a more environmentally friendly, straightforward, cost-effective, and adaptable technology.



**Fig. 1.** SEM image of the resulting plastic particles deposited from solution onto a Si substrate. Scale bar is 500 nm.

# DFT Study of As, B, and P Doped $\text{Li}_6\text{SiO}_4\text{Cl}_2$ : Mechanical, Electronic, and Optical Properties for Advanced Optoelectronic Applications

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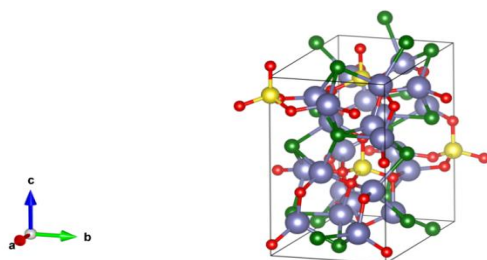
Najwa Al Bouzieh<sup>ai</sup>, Nouredine Amrane<sup>a,\*</sup>

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## Abstract

This study employs Density Functional Theory (DFT) to investigate the properties of  $\text{Li}_6\text{SiO}_4\text{Cl}_2$  doped with As, B, and P.  $\text{Li}_6\text{SiO}_4\text{Cl}_2$  is a promising lithium-containing oxide with potential applications as a solid electrolyte in rechargeable lithium-ion batteries due to its unique structural and electronic properties. The mechanical property calculations demonstrate the stability of all three dopant configurations, indicating their feasibility for practical applications. Electronic property analysis reveals that these configurations exhibit semiconductor behavior, enhancing the material's potential for electronic devices. Furthermore, the study shows an enhancement in the optical properties of the doped  $\text{Li}_6\text{SiO}_4\text{Cl}_2$ , which could be advantageous for optoelectronic applications. The results suggest the potential applicability of these doped configurations in various electronic and optoelectronic devices, highlighting the significance of  $\text{Li}_6\text{SiO}_4\text{Cl}_2$  as a versatile material for advanced energy storage and conversion technologies.



**Figure 1: Crystalline structures of  $\text{Li}_6\text{SiO}_4\text{Cl}_2$ . The grey balls indicate Li atoms, the green balls indicate Cl atoms, the red balls indicate O atoms, and the yellow balls indicate Si atoms.**

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# Dome-Shaped Structures and SERS Unveil High Sensitivity in Melamine Detection

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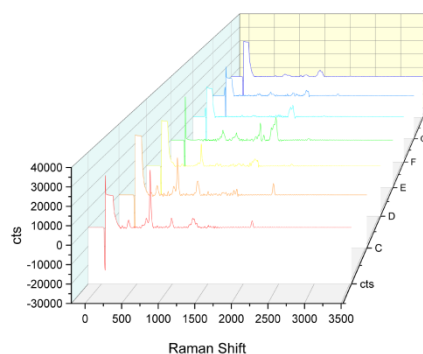
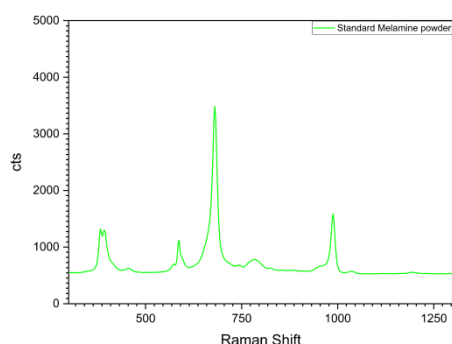
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Melamine adulteration in dairy products is used for showing false protein content. Renal failures and kidney stones are possible with over-intake of melamine. Infants, feeding on such adulterated milk, are at higher risk[1]. A fast and sensitive technique is urgently required for detecting very minute contents of melamine. Surface-enhanced Raman spectroscopy



(SERS) is a rapid method for detecting very minute concentrations of testing substances that

Figure 1. Raman Spectra of Standard Melamine Powder

Figure 2. 3D comparison plot of SERS Spectra of Melamine conc.  $10^{-3}$  to  $10^{-9}$

requires suitable substrates and surface conditions for sensitive detection. In this study, we employ femtosecond laser ablation method to produce SERS substrates decorated with plasmonic metal nanoparticles for efficient detection of melamine. It was shown, that SERS signal strongly correlated with the type of laser-induced structures and decorated with plasmonic gold nanoparticles on the surface of substrates. The surface structures, which we classify as nanosized domes and nanoripples, were decorated with gold nanoparticles deposited from femtosecond pulsed laser deposition were demonstrated significant SERS enhancement. The results are very conclusive and show that using this method we can detect melamine upto the concentration of  $10^{-6}$  mol/L in milk. The substrate covered with nanosized dome-shaped structures were found to be more proficient in detecting melamine. In the meantime, substrate covered with nanoripples structures couldn't detect beyond  $10^{-3}$  concentration limit. Surprisingly, both domes and ripples could be employed to detect



Rhodamine (R6G) to  $10^{-6}$  concentration [2]. The physical reasons correlating SERS detection with surface structures have been elucidated. Our findings can be employed for SERS detection of melamine in milk matrix in compliance with FDA legal restrictions. In general, these results lay the foundation for the development ultrafast laser-based structuring of substrates for detection of any biomolecules by their SERS fingerprints

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# Improving the Shear Capacity of Reinforced Concrete Beams with Various Web Openings Shapes using Pre-Stressed Fe-SMA Bars: Numerical Investigation

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The presence of web openings in the shear span might have a significant impact on the structural behaviour of reinforced concrete (RC) beams. Specifically, shear capacity and crack propagation are affected. This paper aims to explore the feasibility of reinforcing the web opening in the shear zone of RC beams through the utilization of iron-based shape memory alloy (Fe-SMA) bars. The current study employed numerical analysis using ABAQUS software. The investigation involved beams with different web opening shapes (diamond, circular, and square) that were strengthened with prestressed Fe-SMA bars. The results demonstrated that the presence of web openings can lead to a notable decrease in the cracking and ultimate loads of the beams, with reductions ranging from 11% to 50% and 36% to 48%, respectively. However, the addition of pre-stressed Fe-SMA bars around the web openings (circular, diamond, and square) restored the shear capacity of the beam, enabling it to exhibit behaviour similar to solid beams. The technique proposed for enhancing shear strength was most effective for beams with square web openings, as it could restore both the shear strength and stiffness of the beam. Nevertheless, for beams with circular and diamond openings, the use of prestressed Fe-SMA beams could recover nearly 80% of the shear capacity of the solid beam. This study highlighted the significance of reinforcing web openings in RC beams, particularly in shear zones, and provided substantial insights into how to strengthen beams with such web openings, thereby contributing to the development of safer structures. However, it was advised that additional laboratory experiments should be carried out to confirm, supplement, and expand the findings of this numerical investigation.



**Figure 1.** Various web openings shapes [1].

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# Vapor-Triggered Mechanical Actuation in Polymer Composite Films Based on Crystalline Organic Cages

*Lukman O. Alimi, Fang Fang, Basem Moosa, Yanjun Ding, Niveen M. Khashab\**

The fabrication of smart materials, which can efficiently mimic biological systems through the introduction of soft components, is of great importance in the emerging fields of sensors and actuators. Herein, a smart composite film that can mechanically respond to vapors trigger then readily restores its original shape upon the removal of the stimuli is reported. This actuating composite film was prepared by mixing the highly elastic poly (vinylidene fluoride) (**PVDF**) polymer with the flexible and crystalline organic cages (**Oba-cage**) at variable concentrations. The mechanism of the mechanical response could be accurately recorded due to the ordered cage crystals. This work highlights the importance of designing smart materials at the molecular level to precisely control the response or reaction upon the introduction of different triggers, which can ultimately lead to a monumental leap in the field of soft robotics.

# **Optimizing Atmospheric Water Harvesting through the Utilization of Alginate-Silica Hydrogel and Carbon Nanotubes Composite for Enhanced Solar-driven Water Capture**

**Amira S. Mohammed Ali <sup>a,b</sup>, Hanaa M. Hegab <sup>a,b</sup>, Faisal Almarzooqi <sup>a,b</sup>, Maguy Abi Jaoude <sup>c,d</sup>, Shadi W. Hasan <sup>a,b</sup>, and Fawzi Banat <sup>a,b,\*</sup>**

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## **Abstract:**

The increasing demand for freshwater resources has spurred the development of novel approaches for atmospheric water harvesting. Utilizing carbon-based materials as effective water vapor collectors from the atmosphere and solar thermal absorbers has been advocated as a viable solution to the current challenge of water scarcity. The use of carbon nanotubes, graphene, carbon black, and mesoporous carbon as adsorbents has been widely studied in the literature. The hygroscopic properties of these materials make them ideal candidates for the collection of water vapor from the atmosphere; their microstructure is the real reason to form a strong capillary force to adsorb water vapor after being used as a matrix for the salt. Moreover, their ability to absorb solar energy can further enhance their efficiency for this application. This research proposal aims to investigate the potential of polymeric hydrogels (alginate hydrogel) containing silica-gel, and hydroxylated carbon nanotubes (CNTs) harvesting water from the atmosphere. Silica-gel is inexpensive, stable, and has been used as a dissident, besides clays which are well known for their water adsorption characteristics. In addition, the CNTs-OH play a vital role in enhancing the desorption process kinetics. Some hydrogels are well known for their water retention and adsorption at high relative humidity but they suffer from low water adsorption in low relative humidity. The performance of the hydrogels in water vapor uptake and retention was investigated at different relative humidity 30, 70, and 90%, and showed the potential of such composite hydrogel for this application. The desorption experiments were carried out using solar simulated under 1 sun and will be presented.

The preparation method and the characterization of the composite hydrogel will be shown in terms of identification of their morphology by scanning electron microscope, thermal properties by the thermogravimetric analysis (TGA), and structure analysis by the (FTIR). Increasing the content of the hydroxylated carbon nanotubes increased the rate of desorption compared to the pristine hydrogel. Also increasing the nanomaterials concentration increased the thermal resistance of the hydrogel. Different concentrations of hydroxylated carbon nanotubes were used ranged from 1% to 7%; 5 % of hydroxylated carbon nanotubes was the optimum in terms of water adsorption and it was chosen for further investigation.

### **Conflicts of interest**

There are no conflicts to declare.

### **Acknowledgments:**

This work was supported by the Center for Membranes and Advanced Water Technology (CMAT) at Khalifa University of Science and Technology in Abu Dhabi (UAE) (Award No. RC2-2018-009).

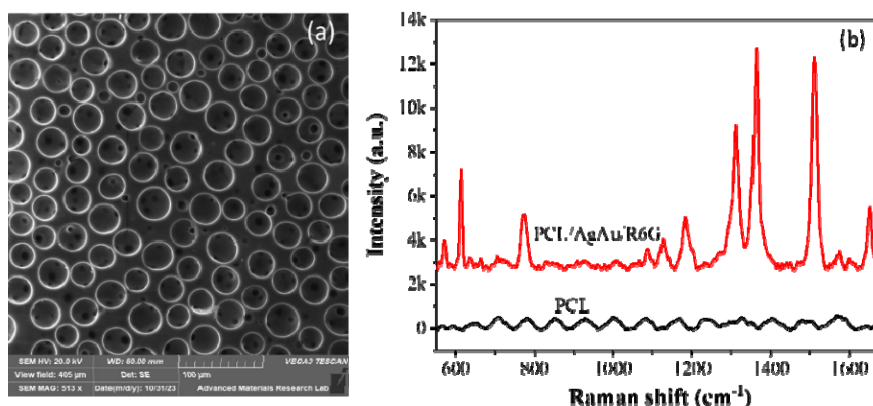
# WELL-LIKE POLYMER FILMS EMBEDDED WITH SILVER-GOLD CORE-SHELL NANOPARTICLES AS HIGHLY FLEXIBLE, BIODEGRADABLE AND LOW-COST BIOSENSORS

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Surface-enhanced Raman spectroscopy (SERS) evolving as a smart, rapid and next-generation sensing platform for a wide variety of applications [1, 2]. Highly efficient and environmentally friendly sensors have attracted great interest in recent years. Herein, we attempted to fabricate an environmentally friendly biosensing platform made up of well-like polycaprolactone films (Fig. 1a) with silver-gold hybrid nanoparticles as flexible SERS sensors for detecting trace-level biomolecules. Fabrication and functionalization strategies were optimized to get high SERS efficiencies. Morphological analysis has shown that the subsequent addition of poly(ethylene glycol) has created a tuneable well-like structure. The homogenous distribution of hybrid nanoparticles was further confirmed using elemental analysis. Further, the structural and chemical compositional analysis of the as-fabricated sensor has been well investigated. The high SERS activity of the hierarchical polymer film sensor could be attributed to the high surface area associated with the well-like morphologies that can accommodate much higher metal nanoparticles on the polymer surface (Fig. 1b). The reproducibility and efficiency of the sensor have also been investigated for evaluating biosensing characteristics. The optimized sensor showed superior efficiency for sensing biomolecules with very low concentrations.



**Figure 1.** (a) SEM images of PCL films & (b) SERS properties of Ag-Au bimetallic nanoparticle incorporated on PCL films.

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# *Sulfidation of Nickel Iron layered hydroxide for improved electrocatalysis*

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## **Abstract**

Oxygen electrocatalysis has been studied broadly due to its significance in several energy conversion devices including metal-air batteries and fuel cells. In electrocatalysis, electrical energy is electrochemically derived through chemical species at electrode/electrolyte interfaces. Transition metal layered double hydroxides (LDHs) especially NiFe-based LDH, have been extensively fabricated as advanced oxygen electrocatalysts with improved electrical conductance, greater redox active sites and suppressed aggregation. For this purpose, the present study discusses the impact of sulfur incorporation into nickel-iron layered double hydroxide NiFe-LDH-S scaffold for improved oxygen evolution activity. A series of NiFe-LDH-S catalysts with different degree of sulfidation was prepared by controlling the concentration of thiourea. The optimized version of NiFe-LDH-S exhibited eximious catalytic activity in terms of minimized over potential (350mV) and decreased charge transfer resistance ( $R_{ct}= 6.40\Omega$ ) with good current stability over 24h as compared to greater over potential (380mV) and increased charge resistance ( $R_{ct}= 7.47\Omega$ ) of pristine NiFe-LDH. Consequently, the presented work features the importance of electronic modulation in bimetallic hydroxides via anionic sulfur engineering for enhanced OER kinetics.

# BOND SLIP MODELS FOR CFRP-TO-CONCRETE JOINTS AT ROOM TEMPERATURE

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Fiber-reinforced polymer (FRP) composites have increasingly been used in the past 40 years. They are ideal option for external strengthening of reinforced concrete (RC) structures due to their superior properties, including the high strength-to-weight ratio and ease of installment. The structural behavior of strengthened RC beams and the efficiency of the external FRP applied are both highly dependent on the bond performance between FRP and concrete. This paper presents an experimental study on the bond slip behavior of carbon fiber reinforced polymer (CFRP) sheets, applied to concrete structures under room temperature conditions. The experimental investigation involved the strengthening of three concrete prism specimens with CFRP sheets. The prism specimens were tested under a three-point bending setup. The bond slip phenomenon was analyzed using strain gauge readings attached to the CFRP laminate before testing. The calculated model aimed to accurately capture the bond slip behavior and its associated parameters, including the maximum shear stress, and maximum slip. These parameters were compared with theoretically derived formulas available in the literature. The results were compared to three theoretical equations proposed by Harries et al. [1]. Two of the equations overestimated the FRP stresses when compared to experimental measurements. However, they have shown good agreement when compared to the force measurements determined from equilibrium of the concrete compression forces. Therefore, the comparative analysis assesses the accuracy and reliability of the proposed bond slip model by benchmarking it against established theoretical formulations, enhancing the overall efficiency and safety of such retrofitting applications.

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# THREE-POINT BENDING TESTS OF SANDWICH PANELS WITH VARYING CORE GEOMETRY

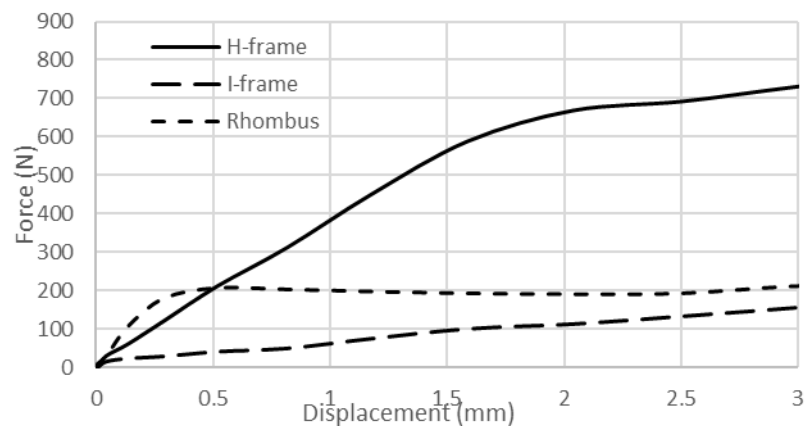
Assil Charkaoui<sup>1</sup>, Noha M Hassan<sup>2</sup>, Zied Bahroun<sup>2</sup>

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Sandwich panels, renowned for their lightweight yet robust construction, are widely utilized in the automotive and aerospace industries. These panels consist of two outer layers encasing a core, offering an exceptional strength-to-weight ratio [1]. Enhancing their mechanical properties can be achieved by modifying the core geometry [2]. It is essential to understand the flexural behaviour of the cellular core within a sandwich panel as it directly contributes to the energy absorption capabilities of the panel [3]. Finite element modelling is employed as the computational analysis method to investigate how different unit core configurations affect the panels' behaviour in three-point bending tests. This research aims to provide a deeper understanding of the flexural properties of sandwich panels, potentially guiding improvements in their design and application.



**Figure 1.** Flexural response illustrating force-displacement curve for H-frame, I-frame and Rhombus unit cells.

The results obtained from the three-point bending test conducted on ABAQUS/Explicit are shown in Fig 1. The flexural behaviour of different core structures in the sandwich panels significantly affects the mechanical performance of the sandwich panel. In a low-velocity impact application, the core structure exhibits bending, shear and out of plane compression forces. Three point bending test combines shear and bending behaviour, which directly contributes to the energy absorption capabilities of the sandwich panel. From the obtained results, the flexural modulus of all three cellular cores is similar to each other, where the rhombus unit cell exhibits the highest flexural modulus. However, the highest peak load observed is the H-frame unit-cell, absorbing the highest energy out of all the unit-cell shapes presented.

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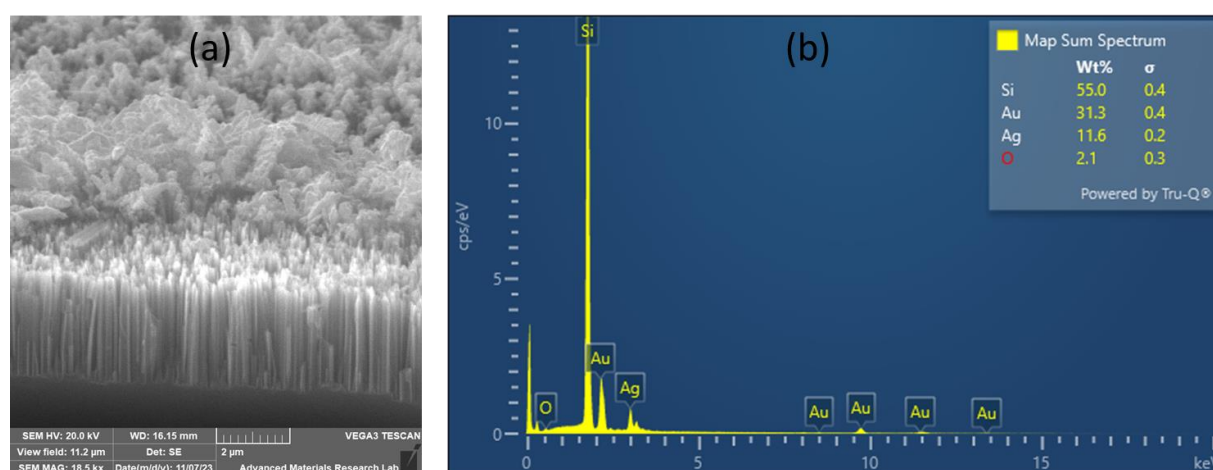
# FUNCTIONALIZATION OF SILICON NANOWIRES WITH MULTILAYER PLASMONIC METAL NANOPARTICLES FOR OPTICAL SENSING

Ayoub Al Awad<sup>\*1,2</sup>, Anakha Udayan<sup>1</sup>, Soumya Columbus<sup>1</sup>, Kais Daoudi<sup>1,2</sup>, Mounir Kaidi<sup>1,2</sup>

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Rapid and accurate detection of trace-level molecules is crucial for various applications, including biomolecule sensing and environmental monitoring [1,2]. However, conventional methods often lack sensitivity and require complex instrumentation. In this study, we attempted to fabricate multilayer silver-gold nanoparticle-decorated silicon nanowires for optical sensing using surface-enhanced Raman spectroscopy (SERS). Our approach involves etching of silicon surface into nanowire morphology, followed by electroless deposition of silver and gold as illustrated in Fig. 1a. The physical and chemical characteristics of the sensor have been well studied (Fig. 1b). The unique nanostructure exhibits excellent analyte molecule adsorption and generates strong SERS signals, enabling ultrasensitive detection of trace-level biomolecules. We demonstrate the effectiveness of the sensor for detecting amino acids and DNA with high sensitivity and selectivity. Our investigation revealed that as-prepared sensors have potential applications in biosensing applications.



**Figure 1.** (a) & (b) SEM image and EDS spectra of silicon nanowire with silver and gold nanoparticles.

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# RAMAN SPECTROSCOPY AND MOLECULAR PROPERTY INVESTIGATION OF L-ASPARAGINE

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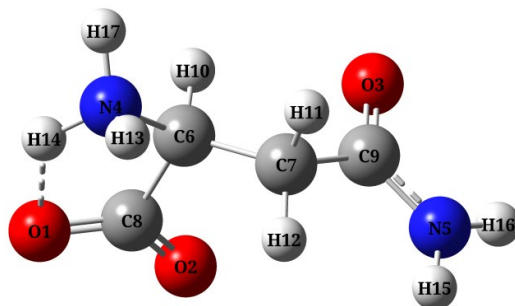
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Amino acids are molecules that have been widely studied in recent years because they are the main components of proteins. The presence of H-acceptor and H-donor centers such as carboxyl and amino groups in their structures is important in the secondary structure of proteins and in the process of aggregation in various solutions [1]. From a structural point of view, amino acids have two types of structures: neutral and zwitterionic. L-asparagine ( $C_4H_8N_2O_3$ ) is an important amino acid that can be found in both protein and free form [2]. It is also important in the metabolic modulation of cellular processes in nerve and brain tissues. Because it is involved in the conversion of amino acids in the liver, it is required for the synthesis of glycoproteins and a wide range of proteins.

In the current work, the physical-chemical properties of the zwitterionic structure of L-asparagine (ZWASN) were analyzed using DFT theory. We also tried to study spectral characteristics using Raman spectroscopy. Structural parameters (bond length and bond angle) and quantum chemical properties such as dipole moment, HOMO-LUMO gap, MEP surface, Mulliken charge analysis, electron affinity, ionization energy, and chemical potential were reported for the first time. Intramolecular H-bonding was analyzed using AIM, RDG, NCI and ELF.

The geometric structure of the zwitterionic L-asparagine (Fig. 1) was optimized based on the B3LYP/6-311++G(d,p) basis set at Gaussian 09W software. Figure 1 shows that there is an internal hydrogen bond (N4-H14 $\cdots$ O1) between ionized carboxyl ( $COO^-$ ) and amino ( $NH_3^+$ ) groups of zwitterionic asparagine. The intermolecular hydrogen bond length is 1.8 Å.



**Figure 1.** The optimal geometry of zwitterionic L-asparagine.

The potential energy surface of ZWASN was scanned around the N4-C6-C8-O1 dihedral angle to localize the structure corresponding to the energy minimum. The result of the scan showed that the ZWASN geometric structure with the

calculated N4-C6-C8-O1 dihedral angle equal to 12.43 degrees has the minimum potential energy.

All hydrogen (H) atoms in the molecule are positively charged. Among them, H atoms bonded to nitrogen atoms are charged more than H atoms bonded to carbon atoms. The oxygen atoms in the molecule are positively charged, and the oxygens in the ionized carboxyl group (O1 and O2) have a higher electron density than the remaining oxygen (O3). Also, the nitrogen atom of the ionized amino group (N4) has a smaller electron density than the nitrogen atom of the non-ionized amino group (N5). The carbon atoms C6, C7, and C9 in the molecule are negatively charged, and the carbon atom C8 is positively charged. The dipole moment of ZWASN is 13.2 Debye.

The molecular electrostatic potential (MEP) surface show that negative potentials are primarily on oxygen and nitrogen atoms. Positive potentials are on the hydrogen atoms of the amino group. The HOMO-LUMO energy gap of ZWASN is 0.24 eV, which indicates its reactivity.

Vibrational spectra are one of the main characteristic properties of a molecule. The L-asparagine molecule consists of 17 atoms and has 45 vibrational modes. The Raman bands corresponding to the N-H vibration of L-asparagine are located in the range of 3100–3600  $\text{cm}^{-1}$ . The spectral peak located at 3401  $\text{cm}^{-1}$  belongs to the  $\text{NH}_2$  asymmetric stretching mode. The spectral peak located at 3110  $\text{cm}^{-1}$  belongs to  $\text{NH}_2$  symmetric vibrations. Spectral bands of C-H stretching located in the range of 2900–3000  $\text{cm}^{-1}$ . Spectral bands of C=O stretching vibrations are located in the range of 1650–1700  $\text{cm}^{-1}$ . The spectral band located at the wave number of 1694  $\text{cm}^{-1}$  belongs to the non-ionized C=O stretching vibration. The spectral peak located at 1674  $\text{cm}^{-1}$  belongs to ionized COO asymmetric stretching vibration modes. Spectral bands belonging to  $\text{NH}_2$  bending vibrational modes are located in the range of 1400–1600  $\text{cm}^{-1}$ . The theoretically calculated and experimentally observed wave numbers were compared and found to be in good agreement. These experimental and computational results will help in studying the physical-chemical properties of L-asparagine.

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# EFFECT OF VANADIUM ON MAGNETIC ORDERING AND TRANSPORT PROPERTIES OF CoNiCr MEDIUM ENTROPY ALLOYS THIN FILMS

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High Entropy Alloys (HEAs) have nailed their spot in terms of high strength, ductility, corrosion, and oxidation resistance, along with tremendous cryogenic properties. Along the application lines, their electrical transport and magnetic properties have gained a huge research interest in the last decade. CoNiCr is a ternary medium entropy alloy system that shows a non-typical electromagnetic response due to high configurational entropy, lattice mismatch, and magnetically driven short-range chemical order, along with strange metallicity. Vanadium was introduced in this ternary system to fine-tune the lattice mismatch. This research extends the exploration into the realm of thin films and focuses on the transport and magnetic properties of films of CoNiCr, CoNiCr<sub>0.5</sub>V<sub>0.5</sub> and CoNiV developed via magnetron sputtering for the thicknesses ranging from 10 nm to 300 nm. These films were uniformly deposited over Si/SiO<sub>2</sub> substrates. The morphological, topographical, and structural analyses were performed by FESEM, AFM, and XRD, respectively. This FCC system shows an increase in lattice parameters with the introduction of V. The magnetic moment and coercivity are significantly increased as compared to bulk samples, especially in CoNiCr<sub>0.5</sub>V<sub>0.5</sub>, due to magnetic ordering. This work highlights the versatility and controllability inherent in medium entropy alloys, building on earlier studies of bulk materials and opening the door for customized functionality in a variety of applications.

# **SURFACE MAGNETOTRANSPORT SHOWS EXOTIC SPIN STRUCTURES IN THE CHALCOGENIDES NiS<sub>2</sub>**

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We present on the surface magneto-transport at low temperatures in single-crystal NiS<sub>2</sub>. On cooling from 40 K to 30 K, isotropic magnetoresistance is reported due to a field-induced shift of the first-order weak ferromagnetic ordering transition. Down to 15 K, larger anisotropic magnetoresistance effects are observed, which is due to spin-switching activities owing to the presence of surface weak ferromagnetism. At the lowest temperatures below 5 K, the spin reorientation continues to be active, generating multi-spin structures in low magnetic field regime. Anomalous Hall effects were detected in the low temperature region. These results explain controversial electronic and magnetic structures of NiS<sub>2</sub> antiferromagnetic Mott insulator at low temperatures.

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# EFFECTS OF DISPENSING PARAMETERS OF ANTISOLVENTS ON THE FORMATION OF CsFAPbI<sub>3</sub> PEROVSKITE FILMS

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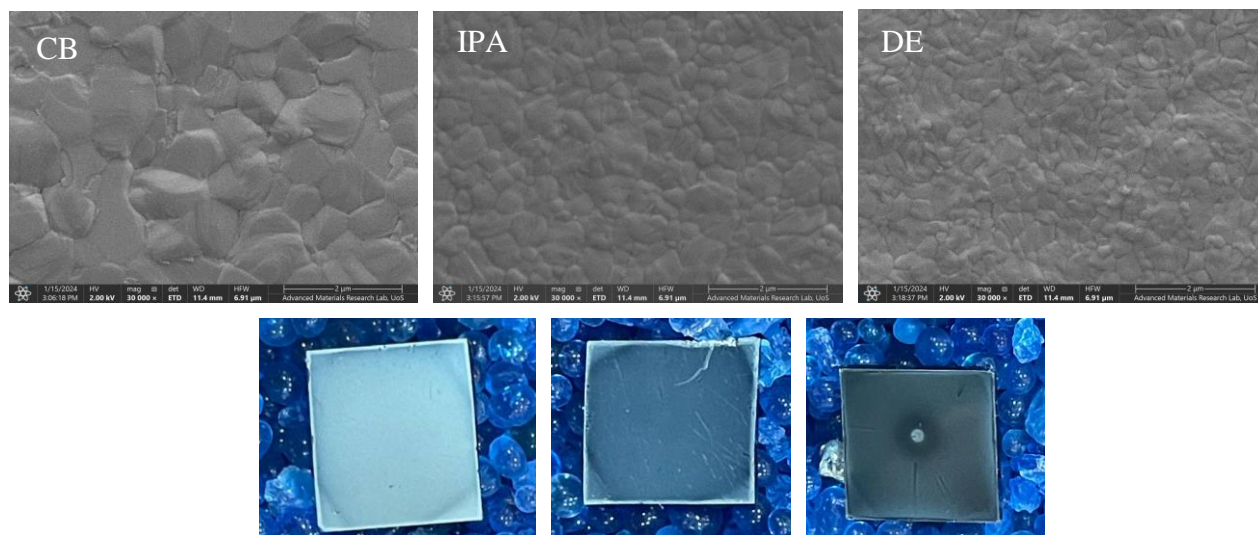
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The fabrication of high quality CsFAPbI<sub>3</sub> perovskite films is crucial for advancing the performance of perovskite-based solar cells. In this study, we systematically investigate the impact of different antisolvents, namely chlorobenzene (CB), isopropyl (IPA), and diethyl ether (DE), on the morphology and optoelectronic properties of the fabricated films.

Controlled volumes (200, 400, 600, and 800  $\mu$ L) of antisolvents were used with different dispensing parameters such as time and speed during the deposition process. The effects of these variables on film quality, crystallinity, and surface coverage were investigated.

To comprehensively evaluate the CsFAPbI<sub>3</sub> perovskite films, Time-Resolved Photoluminescence (TRPL) measurements was conducted to probe carrier dynamics and recombination kinetics and Field Emission Scanning Electron Microscopy (FESEM) and Atomic Force Microscopy (AFM) to analyze surface morphology roughness. Additionally, X-ray Diffraction (XRD) as used to assess the crystallographic properties of the perovskite films.

Preliminary FESEM results from the deposition of CsFAPbI<sub>3</sub> perovskite films using 200  $\mu$ L of each antisolvent during the 20s in second stage reveal significant variation in the grain sizes. Notably, the utilization of CB demonstrates larger grain formation compared to the other antisolvents. As grain boundaries play a key role in reducing the stability and efficiency of perovskite solar cells, these interesting findings shall contribute to the development of a fabrication process that enables the production of perovskite-based devices of higher performance.



**Figure 1.** FESEM images of CsFAPbI<sub>3</sub> perovskite films deposited with 200  $\mu$ L of CB, IPA and DE.

# High sensitivity low-temperature ethanol and acetone gas sensors based on silver/titanium oxide decorated laser-induced graphene

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The increasing environmental and safety concerns necessitate the creation of advanced gas sensors capable of effectively identifying volatile and hazardous organic substances. In this study, we report on the successful design of chemiresistive sensors based on porous LIG to effectively detect volatile organic compounds (VOCs), including acetone and ethanol. Flexible 3D porous laser-induced graphene (LIG) was produced using femtosecond laser texturing on polyimide tape. The 3D porous LIG primarily consists of multilayer graphene sheets comprising two or more monolayers. To enhance the sensors' capabilities, we created LIG-based heterojunction devices by decorating the LIG with Ag and TiO<sub>x</sub> ( $x \leq 2$ ) nanoparticles (NPs) using femtosecond pulsed laser deposition. Our experiments revealed that the LIG sensors decorated with Ag and TiO<sub>x</sub> NPs exhibit higher sensitivity, with the Ag NP-decorated LIG devices demonstrating superior sensitivity and response. The sensor is reversibly responsive at ambient temperature towards the target VOCs in concentrations below 3000 ppm. Moreover, we propose a mechanism to elucidate our findings, which is based on the difference in the work function and energy level alignment associated with adsorbate-adsorbent interactions. The improved sensitivity of the Ag NP-decorated porous LIG sensor is attributed to the favourable work function of Ag and the abundant availability of adsorption sites.



# **Ti<sub>2</sub>C<sub>3</sub>T<sub>x</sub> Composite Membranes for an Electrified Filtration System to Mitigate Microplastic Fouling**

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The escalating environmental challenge of microplastic (MP) contamination in water bodies and treatment facilities calls for innovative strategies to mitigate its impact on water scarcity and disturbance to water treatment processes. This study proposes a novel approach using electrified membranes, specifically sulfonated polyethersulfone (SPES)/Ti<sub>2</sub>C<sub>3</sub>T<sub>x</sub> composite membranes. The fabrication involved sulfonation of polyethersulfone and Ti<sub>2</sub>C<sub>3</sub>T<sub>x</sub> synthesis, followed by composite assembly. These membranes were precisely designed to optimize its physiochemical properties, enhancing conductivity while preserving water flux. The investigation involved testing the membranes under varying electric potentials to develop an efficient MP fouling mitigation strategy. Performance assessments revealed a significant increase in MP flux to up to 49 L.m<sup>-2</sup>.h<sup>-1</sup> at 2 V, attributed to multiple mechanisms. Additionally, intermittent voltage application in a "30 min ON, 60 min OFF" mode demonstrated enhanced stability in water flux, facilitated by in-situ coagulant generation and membrane surface cleaning. This study lays a foundational framework for the implementation of the SPES/Ti<sub>2</sub>C<sub>3</sub>T<sub>x</sub> composite membrane system as a robust MP fouling mitigation strategy, opening avenues for further exploration of membrane materials to advance and optimize the efficacy of the system in addressing microplastic pollution.

**Keywords:** Microplastics; ultrafiltration; 2D materials; MXenes; electrokinetics

# OPTIMIZATION OF PROCESS PARAMETERS FOR ADDITIVE MANUFACTURING OF POLYMERS

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Polyethylene (PE), known for its desirable mechanical properties, faces challenges in additive manufacturing (AM) due to issues like excessive shrinkage and poor adhesion. This research presents a framework to upcycle PE waste into valuable feedstock for fused deposition modelling (FDM), addressing sustainability in materials and manufacturing processes. Low-density PE (LDPE) and high-density PE (HDPE) pellets, categorized as industrial waste, were sourced from Qatar Petrochemical Company (QAPCO). To improve PE's printability, we blended Pre-puff Polystyrene (PS) beads with varying ratios of LDPE and HDPE. A 5 wt% addition of styrenic block copolymer (SEBS) was used to ensure blend compatibility and homogeneity. After blending the constituents in a twin-screw extruder, the blends were granulated, dried, and extruded into standard 1.75 mm filaments using a 3DEVO Composer 350. Filament quality was evaluated using tensile strength tests, filament roundness, and printing trials, which involved printing a single perimeter cube with a 0.6 mm nozzle at various temperatures. This helped identify the optimal blend for FDM before examining the effect of FDM process parameters. We varied two FDM process parameters, specifically nozzle diameter (0.4 to 0.6 mm) and nozzle temperature (240 °C to 260 °C), on the printed object's dimensional accuracy, shrinkage, warpage, and mechanical properties. Our findings illuminate the significant role of AM in promoting sustainable manufacturing practices and enhancing material properties, marking a step forward in the utilization of recycled materials in advanced manufacturing processes.

Keywords: Sustainability, additive manufacturing, feedstock filament, fused deposition modelling, polyethylene

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# Investigation of the Influence of Bromide Concentrations on the Optical, Morphological, and Stability Properties of Methylammonium based Perovskite Solar Cells

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## Abstract

Perovskite solar cells, particularly those based on Methylammonium lead iodide ( $\text{CH}_3\text{NH}_3\text{PbI}_3$ ), have demonstrated remarkable photovoltaic performance. In this study, we systematically incorporated varying concentrations of bromide into Methylammonium lead iodide films ( $\text{CH}_3\text{NH}_3\text{PbI}_{3-x}\text{Br}_x$ ). The investigation aimed to elucidate the potential improvements in device's performance and stability, as well as to gain insights into the fundamental properties such as the optical and morphological features of the resulting hybrid perovskite systems. The optical properties of the modified films were analyzed through UV-Vis spectroscopy, revealing shifts in absorption spectra corresponding to the introduction of bromide. By carefully controlling the bromide concentration, we observed tunable changes in the bandgap, achieving a bandgap of 1.67 eV for a bromide concentration of  $x = 0.45$ , which offers optimal light absorption in the solar spectrum. Morphological analyses, including scanning electron microscopy (SEM) atomic force microscopy (AFM), and X-ray diffraction (XRD) were conducted to evaluate the impact of bromide incorporation on crystallinity and surface morphology. The results showed an increase of the average grain size with the incorporation of bromide. Preliminary results show considerable enhancement of the power conversion efficiency (PCE) through bromide substitution. A PCE of 13.0% was achieved for a bromide concentration of  $x = 0.45$  as compared to 8.4% without any bromide. Furthermore, the stability and carrier lifetime of the perovskite films will be further investigated using Time-Resolved Photoluminescence (TRPL).

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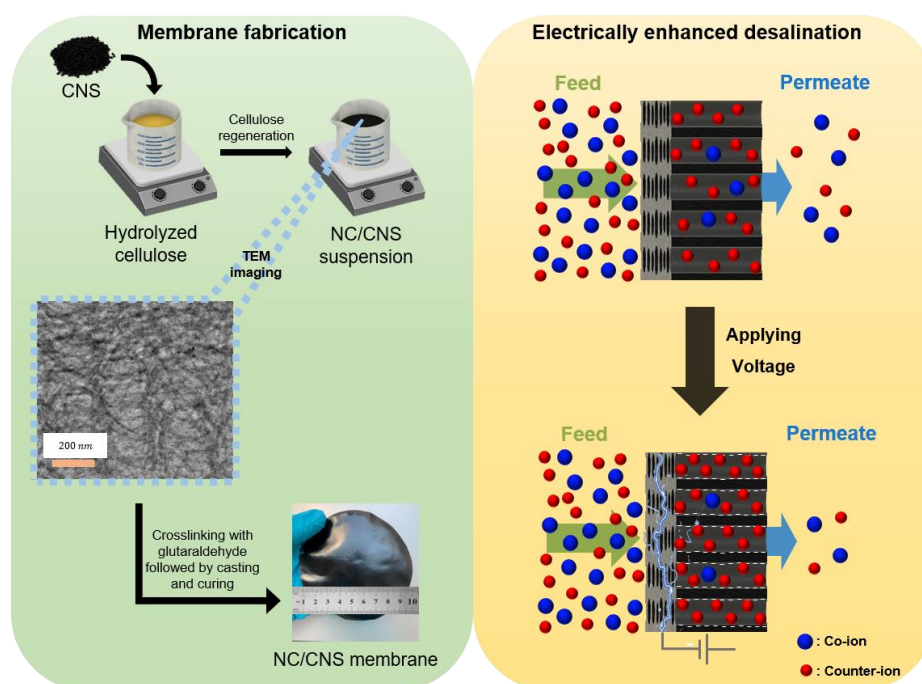
# UNVEILING THE POTENTIAL: ELECTRICALLY CONDUCTIVE NANOFILTRATION MEMBRANES FOR ENHANCED DESALINATION

Haya Nassrullah<sup>\*,†1</sup>, Jamaliah Aburabie<sup>†</sup>, Nidal Hilal<sup>†</sup>, Raed Hashaikeh<sup>†</sup>

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Electrically conductive nanofiltration (NF) membranes have emerged as promising candidates for desalination, offering unique electroactive functionalities that extend beyond conventional separation capabilities. However, limited understanding of rejection mechanisms, attributed to challenges in fabrication techniques and material selectivity control, hinders their widespread adoption. To address these limitations, we present an innovative approach to fabricate an electrically conductive NF membrane, entrapping carbon nanostructures (CNS) within a regenerated cellulose network crosslinked with glutaraldehyde. Utilizing a straightforward method, we entrap CNS within regenerated networked cellulose by blending CNS in hydrolyzed cellulose, followed by regeneration (Figure 1). Transmission electron microscopy (TEM) confirms effective CNS intercalation without chemical modification. The resulting membrane exhibits remarkable electrical conductivity ( $6044 \pm 6.404$  S/m), providing a foundation for exploiting electroactivity in desalination applications. Under a -1 V external voltage, our membrane demonstrates enhanced rejection rates for NaCl (43.8% to 54.6%) and Na<sub>2</sub>SO<sub>4</sub> (75.6% to 81.7%) without significantly impacting permeate flux. This improvement stems from increased Donnan potential difference induced by polarization charges during negative bias application (Figure 1). Moreover, the membrane showcases reversible ion transport control, exceptional recyclability, and self-cleaning capabilities. The suggested fabrication method and the application of electricity to enhance membrane performance could have significant implications for various applications in membrane-based desalination technologies.



**Figure 1.** Schematic illustration of membrane fabrication and separation mechanism.

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# PHOTODEGRADATION OF METHYLENE BLUE DYE BY PERSULFATE ACTIVATION USING PVDF-CuFe LDH CATALYTIC MEMBRANES

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Layered double hydroxides (LDHs) are widely accepted as heterogenous catalysts due to outstanding catalytic performance, including reactivity, stability, and selectivity.[1] In this work, polyvinylidene fluoride (PVDF) intercalated CuFe layered double hydroxides (LDH) catalytic membranes were fabricated and applied for photodegradation-assisted persulfate activation of methylene blue dye from water. The characterization results demonstrated the successful immobilization of CuFe LDH nanoflakes within the PVDF matrix forming a heterogenous porous structure and increased hydrophilicity. The photodegradation of MB dye using PVDF-CuFe membrane-assisted potassium persulfate (PP) system was modeled by the BoxBehnken design (BBD) [2] and well described by the quadratic model with 96.4 % accuracy. The complete MB degradation was observed at an initial dye concentration (104.03 mg/L), PP concentration (116.53 mg), PVDF-CuFe membrane catalyst dosage (76.64 mg), and reaction time (178.54 min). The redox cycle of Fe<sup>3+</sup>/Fe<sup>2+</sup> or Cu<sup>2+</sup>/Cu<sup>+</sup> in PVDF-CuFe membrane promoted the efficient generation of HO•/SO<sub>4</sub>•<sup>-</sup> in PP for accelerated MB degradation mechanism [3]. The results showed that PVDF-CuFe catalytic membranes exhibited great potential for use as a recyclable catalyst for the efficient degradation of MB dye in PP assisted advanced oxidation process.

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# DESIGNING OF HIGHLY STABLE ALLOY ANODE BY SURFACE AND INTERFACE ENGINEERING FOR SODIUM-ION BATTERIES

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In a world heavily reliant on fossil fuels, the pursuit of sustainable alternatives for energy storage has become paramount. One promising avenue is the transition to batteries, recognized for their potential to address environmental concerns and reduce dependence on non renewable resources. Among the various types of batteries, lithium-ion batteries (LIBs) have emerged as a popular choice, showcasing properties that make them suitable for widespread use. Notably, LIBs share certain characteristics with sodium-ion batteries (SIBs), indicating a broader potential for sustainable energy storage solutions [1]. While LIBs have paved the way, SIBs are now gaining prominence as a cost effective and environmentally friendly option for energy storage systems. This surge in interest is attributed to the abundance of sodium resources on Earth [2]. Through thorough exploration of the mechanisms and the use of high performance electrode materials, significant improvements have been made in the electrochemical properties of SIBs. To enhance the competitiveness of SIBs, there is a concerted effort focused on alloy type anode materials boasting high theoretical capacities and appropriate redox potential [3]. In the context of large scale energy storage, materials featuring safe sodiation potentials, abundant earth deposits, and environmental friendliness are particularly advantageous. Our research aims to identify innovative approaches to investigate the root causes of significant volume expansion in alloy-based materials during continuous charging and discharging processes. The Metal Organic Framework (MOF) derived post transition metal carbide (pTM-C) has successfully synthesized using hydrothermal and followed by annealing treatment. The structural characterizations (such as XRD, FE-SEM, EDX measurements) revealed that the prepared material confirmed its successful formation with the porous crumbled sheet like morphology. The electrochemical characterization provided its improved storage performance compared to the pristine. This systematic progression is geared towards not only contributing valuable insights to the SIB field but also setting the stage for the development of cutting edge, high performance anode materials. This comprehensive approach ensures a well rounded exploration of sustainable energy storage solutions, pushing the boundaries of innovation in the pursuit of a more environmentally friendly and cost effective future.

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# A BENCHTOP X-RAY DIFFRACTOMETER AS A TOOL FOR THIN FILM CHARACTERIZATION

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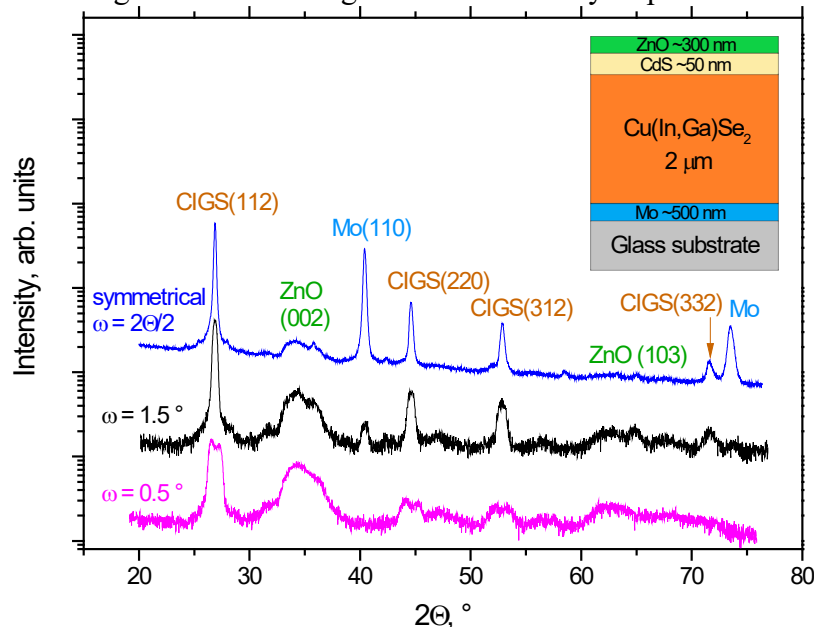
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While expensive and heavyweight high-resolution X-ray diffractometers (XRD) are mainly exploited in semiconductor industry, compact and low-cost XRD tools can be helpful for some similar tasks.

In this work, we used a benchtop diffractometer TELLUS (LINEV SYSTEMS) equipped with a wafer holder to measure grazing-incidence X-ray diffractograms (GIXRD) of Cu(In,Ga)Se<sub>2</sub>-based solar cell structure and AlN epitaxial layers as well as X-ray reflectometry (XRR) of AlN layers.

A series of GIXRD measurements of the solar cell multi-layered structure performed at varied angle between the incident X-ray beam and the sample surface allowed to separate impacts of different layers and, therefore, perform depth-dependent phase analysis. As can be clearly seen from the Fig. 1, a higher incident angle results in a larger relative intensity of peaks caused by deeper layers.



**Figure 1.** Grazing-incidence X-ray diffractograms of multi-layered thin film structure demonstrating possibility of depth-dependent analysis (the  $\omega$  denotes the incident angle). The inset shows the structure design.

GIXRD of a series of 320 nm thick AlN epitaxial layers grown at different conditions revealed a presence of a larger fraction of a polycrystalline phase in the layers grown at lower temperature. The fact was confirmed by scanning electron microscopy.

In addition, thickness values of thin nucleation AlN layers grown on Al<sub>2</sub>O<sub>3</sub> substrates were determined by XRR. The data can be used for fine calibration of gas flows during epitaxial growth.

The measurements demonstrate the potential of the compact and low-cost X-ray diffractometer which can be adapted for thin film characterization. The obtained results will be used to develop a new model of a bench-top multipurpose XRD tool suited not only for GIXRD and XRR but also for other types of measurements (texture, residual stress, etc).

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# EFFECT OF SLENDERNESS RATIO ON THE BEHAVIOR OF RC BEARING WALLS UNDER FIRE EXPOSURE

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Reinforced concrete (RC) bearing walls are commonly used in building structures to resist axial and lateral loads. Therefore, their ability to withstand loads when exposed to fire is important. The behavior of RC walls under fire exposure is affected by various factors, such as slenderness ratio, concrete strength and composition, and axial load. This paper aims to investigate the effect of slenderness ratio on the structural performance of RC walls subjected to fire. A series of numerical simulations were conducted on RC walls with different slenderness ratios. The simulations are performed on a three-dimensional (3D) finite element (FE) model, after validating its thermal and structural behavior using previously published experimental data [1]. The walls were exposed to standard fire curve (ISO834) [2] and hydrocarbon fire curve [3] on one side. The thermal and structural response of the walls were assessed in terms of temperature distribution, out-of-plane deformations, and cracking patterns. The results showed that slenderness ratio had a significant influence on the fire behavior of RC walls. The walls with higher slenderness ratios exhibited higher temperature gradients and larger deflections compared to the walls with lower slenderness ratios. The paper also discusses the possible mechanisms and implications of the observed phenomena and provides some recommendations for the design and assessment of slender RC walls under fire conditions.

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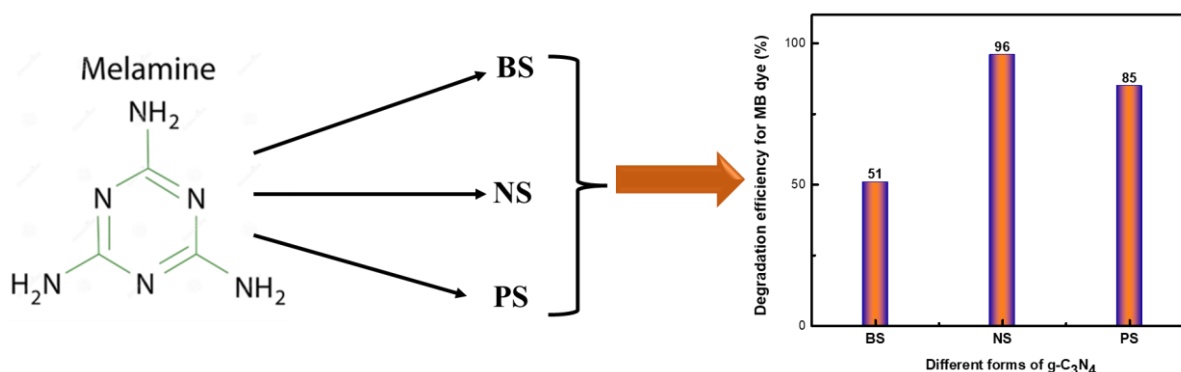
# Rapid Photocatalytic degradation of textile dye contaminants in water with 2D graphitic carbon nitride (g- C<sub>3</sub>N<sub>4</sub>)

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Remarkably, g-C<sub>3</sub>N<sub>4</sub> exhibits similarities to graphene, attracting significant attention from researchers for various applications [1, 2]. The synthesis of g-C<sub>3</sub>N<sub>4</sub> involves the thermal pyrolysis of melamine. Direct thermal pyrolysis at 500°C yields 2D bulk g-C<sub>3</sub>N<sub>4</sub> (BS). The BS undergoes further thermal treatment to achieve nanometer-sized thin sheets of g-C<sub>3</sub>N<sub>4</sub> (NS). Simultaneously, the BS undergoes wet chemical steps to introduce porosity in g-C<sub>3</sub>N<sub>4</sub> (PS). The different types (BS, NS, PS) were systematically characterized for their structure, morphology, and optical properties. X-ray diffraction (XRD) and Fourier-transform infrared spectroscopy (FTIR) confirm the presence of tri-azine units through their corresponding crystalline planes and bonds, including C-N and C=N. Optical properties indicate strong absorbance in the UV region, evident from their surface plasmon resonance (SPR) bands. Photocatalytic dye degradation studies reveal their capability to convert dyes into their non-toxic forms under UV light. The efficiency of degradation is assessed as 51% (BS), 96% (NS), and 85% (PS), respectively (Fig. 1).



**Figure 1.** g-C<sub>3</sub>N<sub>4</sub> structures and its effect in Photocatalytic removal of Methylene Blue Dye

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# Innovative Electrolyte Strategy for Enhancing Performance and Stability in Aqueous Zinc-Iodine Batteries

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## Abstract:

Aqueous Zinc-iodine (Zn-I<sub>2</sub>) batteries show promise as energy-storage systems due to their high energy/power density, safety, and cost-effectiveness. However, polyiodide shuttling can limit their cycling life, leading to significant active mass loss. While previous studies addressed this issue using separators and electrode surface modifications, this work introduces a simple yet effective approach to suppress polyiodide shuttling during the deposition of I<sub>2</sub> on the cathode electrode in Zn-I<sub>2</sub> batteries. To achieve this, an electrolyte composed of a water-in-salt (WiSE) combination with a selected non-aqueous solvent was optimized. The addition of the non-aqueous solvent enhanced the WiSE's ability to facilitate the movement of I<sup>-</sup> ions, promoting their uniform reaction at the electrode surface. As a result, the developed Zn-I<sub>2</sub> battery exhibited high coulombic efficiency (~100% at 10 mA cm<sup>-1</sup>) and exceptional cycling stability, exceeding 3000 cycles. This innovative electrolyte strategy provides new insights and a practical solution for achieving high-performance aqueous Zn-I<sub>2</sub> batteries.

# Nanogenerators

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With the focus on environmental sustainability along with the growth in technology, many research fields are emerging. One such field is exploiting the natural environment by harvesting all types of energy readily available for sustainable power. Nanogenerators use displacement current as a driving force to convert mechanical energy into electricity without the need of an external power supply. In particular, triboelectric nanogenerators, TENGs, based on the triboelectric effect and electrostatic induction, have become a promising technology especially for self-powered sensing system and energy harvesting.

Triboelectric nanogenerators are made of two different materials that rub against one another. Due to the difference in electron affinities, one material will become positively charged, and the other negatively charged. At the same time, induced charges will be generated on the back electrode of the two materials. Then, when the two materials are separated, an air gap will be created, resulting in a dipole moment. The electric field generated by the dipole is proportional to the dipole moment. If the materials are continuously in contact then separated, then for a closed-circuit system, a small amount of AC current will be generated. To generate a potential difference, four different modes of operations could be used: vertical mode, sliding mode, single-electrode mode, and free-standing mode.<sup>1</sup> The vertical mode where tribo-materials are vertically moved apart has been shown to have numerous applications as power source and active sensor. It also has a straightforward structure and will be studied in this work.

Most materials used for TENGs are dielectric synthetic polymers due to their low weight, resilience, biocompatibility, low cost, and flexibility. However, they are non-biodegradable, thus causing air, water, and soil pollution as well as greenhouse gas emissions. Based on the concept of reduce, reuse, and recycle, developing TENGs based on waste material and/or naturally biodegradable food waste that match the properties of the conventional ones are potential alternatives that will contribute to the circular economy. The output current, voltage, and power of TENGs made of different materials will be studied theoretically and will serve as a guidance to find the optimal material to be used in TENGs for specific applications.

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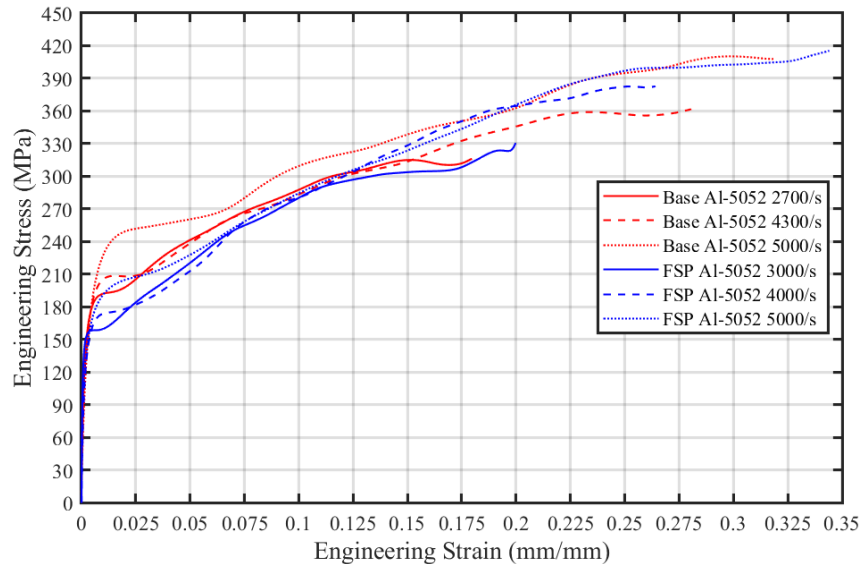
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# DYNAMIC TESTING OF FRICTION STIR PROCESSED ALUMINUM-5052

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Friction stir processing (FSP) is a new process that has been proposed to alter the grain structure of metals and alloys. FSP was inspired by Friction Stir Welding (FSW), which is an advanced solid-state material joining process patented by The Welding Institute (TWI) [1]. The refined and equiaxed grain structure produced by FSP affects the yielding, plastic behavior, and high-strain-rate properties of the material. This work aims to investigate the effect of friction stir processing on the high-strain-rate behavior of aluminum-5052 using a Split Hopkinson Pressure Bar (SHPB) system [2]. The FSP parameters used in processing the aluminum-5052 samples are a rotational speed of 1000 rpm and feed of 150 mm/min. Samples with dimensions of 3.06×3.09×6.06 mm (Width × Height × Length) were prepared using an EDM (Electrical Discharge Machining) machine. The SHPB bars were made of Aluminum-7075-T6 with a density of 2810 kg/m<sup>3</sup>, Young's modulus of 71.7 GPa, and a bar diameter of 9 mm. The dynamic response of the FSP samples was measured at three different strain rates, and the response was compared to that of the unprocessed (Base) samples (Figure 1).



**Figure 1.** Engineering Stress-Strain graph at high strain rates for the FSP and Base Aluminum-5052 samples.

As shown in Figure 1, strain rates ranging from 2700/s to 5000/s were achieved. The yield stress for unprocessed Al-5052 increased from 183 MPa to 240 MPa (31.1%) for strain rates of 2700/s to 5000/s, respectively. However, The yield stress for the FSP Al-5052 increased from 155 MPa to 190 MPa (22.6%) for strain rates of 3000/s to 5000/s, respectively. The yield of FSP Al-5052 was lower than that of its corresponding unprocessed Al-5052. Yet, the hardening rates of FSP samples were higher than those of their corresponding unprocessed Al-5052 samples. Results confirmed that FSP can affect the high-strain-rate behaviour of Al-5052.

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# THE INFLUENCE OF FEMTOSECOND LASER SHOCK PEENING ON FUNCTIONAL FATIGUE PROPERTIES OF TiNbZrSn BIOCOMPATIBLE SHAPE MEMORY ALLOY

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Shape memory alloys are of vital significance for biomedical applications because of their unique properties, including superelasticity and shape memory effect. NiTi is a highly valued alloy for these applications because of its excellent superelastic properties. However, the toxicity of NiTi because of Ni ions released in the human body may lead to cancer if used as a biomedical implant. Therefore, Ti-Nb alloys are potential candidate materials to replace NiTi for biomedical applications owing to their biocompatibility. Zr and Sn are added to these alloys as alloying elements to enhance biocompatibility and superelasticity. The limitation of TiNbZrSn alloy is its functional fatigue response which limits the use of alloy in biomedical applications. The functional degradation in superelastic properties with cycling is amplified in the vicinity of geometric stress concentrations such as drilled holes. This study aims to improve the functional fatigue response of the TiNbZrSn alloy using laser shock peening (LSP), and specifically, the use of femtosecond laser will be explored for this purpose. Two types of tensile dog-bone samples were prepared for LSP experiments: one without any drilled hole and the second one with a hole drilled in the center of the sample. The results from the LSP experiments show great potential with up to 8% improvement in the superelastic recovery strains and their stability under cyclic loading up to 100 cycles.

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# FERRIC SULFATE-INDUCED HYDROPHOBIZATION OF LIGNOCELLULOSE WASTE FOR OIL SPILL CLEANUP

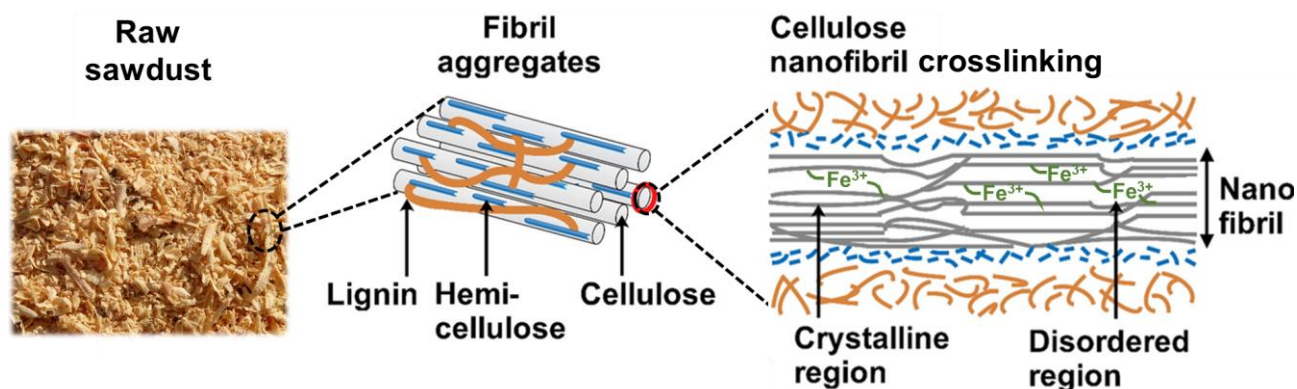
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Accidental release of crude oil and refined petroleum products into the marine environment is an inevitable risk during oil exploration, production, transportation, and storage. It is estimated that more than one hundred million gallons of crude oil is accidentally spilled into the oceans every year [1]. The adverse effects of oil spills on marine and terrestrial ecosystems and human health are well-documented [2,3]. As a result, effective technologies for the remediation of oil spills are of extreme significance in order to reduce the ecological and health impacts. Notable methods for oil spill cleanup include the use of dispersants, sorbents, solidifiers, and skimmers [4]. Among these, oil-selective sorbent materials have gained significant attention due to their ease of application and an ability to completely absorb the spilled oil. Typical oil sorbents are based on synthetic polymers such as polypropylene and polyurethane. Despite being effective for oil spill cleanup, synthetic polymeric sorbents tend to be costly and cause secondary pollution. As a result, there is a growing interest in developing low cost and biodegradable sorbents such as those based on waste materials. In this study, sawdust waste was rendered hydrophobic via nano-surface engineering and utilized as a sorbent for oil spill cleanup. To impart hydrophobicity, nanofibrils within sawdust were crosslinked by treatment with 2 wt% ferric sulfate solution followed by drying (Fig. 1). The treated sawdust exhibited a water contact of more than 120° and was effective in oil spill cleanup.



**Figure 1.** Hydrophobization of waste sawdust by crosslinking of nanofibrils (modified after [5]).

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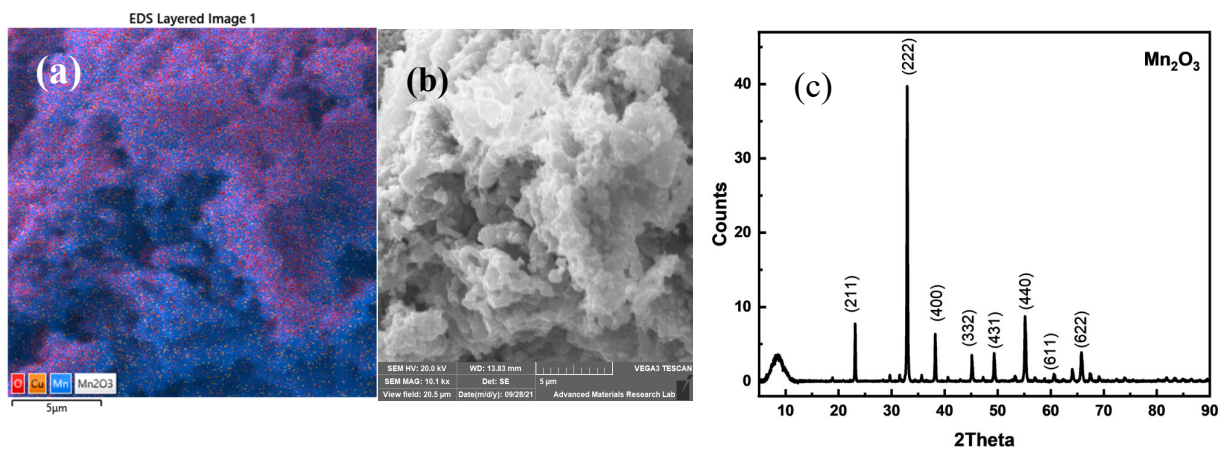
# Mn<sub>2</sub>O<sub>3</sub> DECORATED WITH BIMETALLIC NANOPARTICLES AS HIGHLY EFFECTIVE SERS AND PHOTOCATALYTIC SYSTEMS

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Semiconductor metal oxide-metal nanoparticle hybrids have enormous interests as they have promising properties for sensing and catalytic applications. In the present work, MnO<sub>2</sub> has been successfully prepared by an annealing process using Mn(II) Acetate. MnO<sub>2</sub> nanoparticles were further functionalized with silver-gold core-shell nanoparticles. Hybrid particles have been then characterized by the techniques of XRD, FTIR, SEM, and XPS. It has been observed that annealing of Mn (II) acetate gives two different oxide forms MnO<sub>2</sub> and Mn<sub>2</sub>O<sub>3</sub>. Using XRD analysis, the crystalline phases of the different forms were distinguished, and the morphological and binding energy properties were well examined using SEM and XPS respectively. Metal nanoparticle functionalized Mn<sub>2</sub>O<sub>3</sub> particles were exploited for SERS sensing and photocatalytic degradation of organic pollutants with high efficiency for environmental remediation applications.



**Figure 1.** a) EDS mapping; b) SEM image and c) XRD pattern of Mn<sub>2</sub>O<sub>3</sub>

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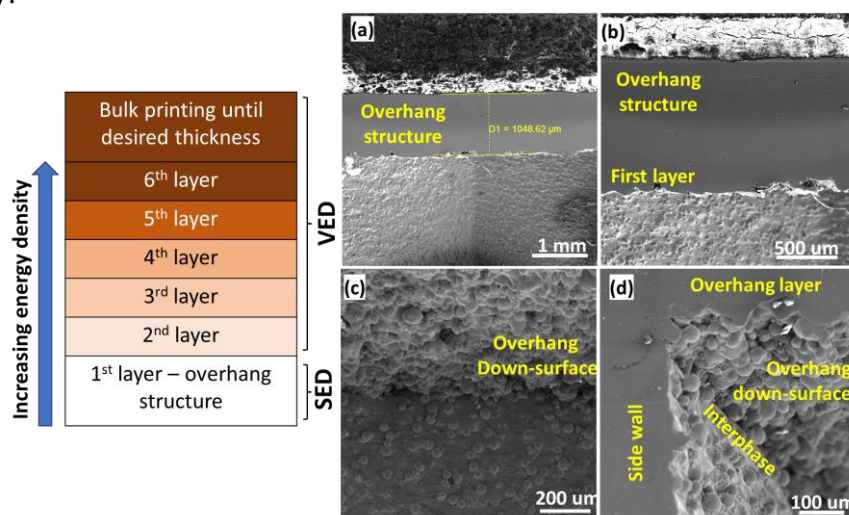
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# Optimizing Process Parameters for Support-Free Metal 3D Printing of 0° Overhangs in SS-316L

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The Powder bed fusion (L-PBF) additive manufacturing enable complex metal parts to be printed, but printing overhanging structures without supports remains challenging due to limitations in maximum overhang angle. This study focused on optimizing L-PBF process parameters to enable support-free printing of stainless steel 316L overhangs oriented at 0° angles to the build plate. The goal was to understand the parameters needed to print the critical initial overhang layer with high coverage and minimal defects, and then gradually transition to bulk parameters to complete the overhang structure. The surface energy density (SED), calculated from laser power, scan speed, and hatch spacing, was optimized first for printing the single 0° overhang layer. SED quantifies the applied energy per unit area. An SED of 1.33-2 J/mm<sup>2</sup> produced a first layer with minimal balling and spatter defects, with maximum coverage exceeding 95%. For subsequent layers, the volumetric energy density (VED) was gradually increased layer by layer from 33.33 J/mm<sup>3</sup> to 87.96 J/mm<sup>3</sup> until reaching bulk parameters, in 5 increments. This avoided damage to the first layer from excessive energy.



**Figure 1.** (left) Schematic illustration for gradually increasing energy density over the first single overhang layer until the bulk printing parameters are used. (right) SEM micrographs of the support free 0° overhang structures produced using the

This optimized parameter approach enabled a 10mm long, 1mm thick 0° overhang to be successfully printed without supports. Optical microscopy and SEM of the overhang cross-section revealed a uniform structure free of defects like porosity, cracking, or uneven edges. No dross buildup was observed on the overhang down-surface. The results demonstrate that systematically optimizing SED and VED can overcome inherent limitations in overhang angle, allowing more complex geometries to be printed support-free. Overall, this study provides an approach to expand the capabilities of laser powder bed fusion AM through process parameter optimization. The ability to print freestanding overhangs and lattices can enable lighter, more complex metal parts suited to aerospace and biomedical industries. This work lays a foundation for additional exploration into advanced support-free metal architectures.

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# FACILE DESIGN OF HIGHLY EFFICIENT SERS SENSORS USING MASK DECORATED WITH SILVER NANOPRISMS FOR ENVIRONMENTAL APPLICATIONS

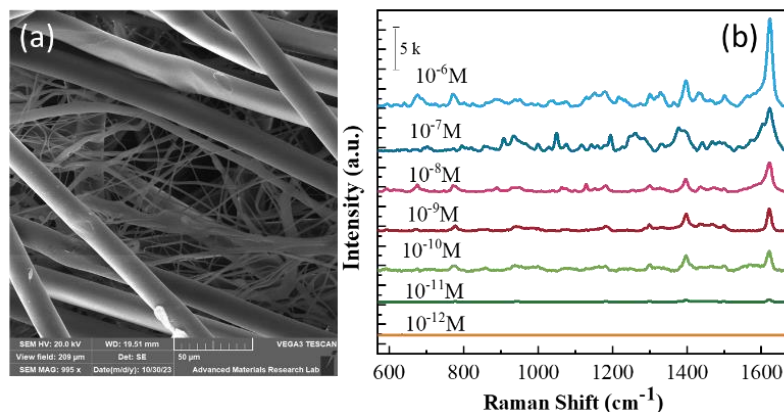
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Surface Enhanced Raman Scattering (SERS) sensors have attained enhanced attraction as an ultrasensitive analytical technique for detecting low concentrations of pollutants in a rapid mode. Recently, considerable research interests have been put into designing flexible and cost-effective SERS sensors with superior sensitivity and reproducibility [1]. In the present work, we investigated the efficacy of polymer-based mask layers (Fig. 1a) as flexible SERS sensors after modifying it with silver nanoprisms. Silver nanoprisms (SNP) have been synthesized using the chemical synthesis method and are well characterized. Moreover, the silver nanoprism immobilized mask substrates were well examined for studying their structural, morphological and optical characteristics. Morphological analysis using FESEM analysis has shown that silver nanoprisms have been homogeneously distributed over the fibrous mask layer. It has been found that the density of silver nanoprisms on fibers influenced SERS activities significantly. The variation of SERS activity with nanoparticle density has been well investigated by correlating to the corresponding morphological characteristics as well. The optimum sensor substrate demonstrated excellent efficiency, sensitivity, and reproducibility (Fig. 1b). The mask/SNP substrate is further exploited to sense multiple hazardous organic pollutants, which showed detection limits below picomolar levels. It is worthwhile to point out that mask/SNP sensors are promising candidates for rapid, ultrafast detection of environmentally hazardous substances cost-effectively.



**Figure 1.** (a) Morphology of mask & (b) LOD estimation of methylene blue using mask/Ag sensor

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# THE EFFECT OF LIPID COMPOSITION ON LOW-FREQUENCY ULTRASOUND RELEASE OF TRASTUZUMAB LIPOSOMES FOR BREAST CANCER TREATMENT

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Trastuzumab (TRA)-functionalized liposomes, designed to target cancer cells overexpressing the HER2 receptors, promise enhanced drug delivery to tumors with minimized exposure to healthy tissues, potentially increasing therapeutic efficacy and reducing side effects. In addition, the lipid composition of the liposomes is a critical factor in determining their stability and efficacy. These liposomes were prepared using the thin-film hydration method, involving dissolving DPPC, DPPG, DPPE, and DPPA cholesterol, and DSPE-PEG(2000)-NH<sub>2</sub> in a mixture of chloroform and methanol, forming a lipid film hydrated with a 30 mM calcein disodium salt solution, followed by sonication, extrusion, and purification. TRA was conjugated to DSPE-PEG(2000)-NH<sub>2</sub>, using cyanuric chloride (CC) as a linking agent, after liposome formation, ensuring active- or ligand-targeted delivery. The synthesized liposomes were characterized for size, lipid content, and TRA attachment, using dynamic light scattering, the Stewart method, and bicinchoninic acid (BCA) assay. Low-frequency ultrasound (LFUS) induced drug release was assessed at various power densities (6.2, 9, and 10 mW/cm<sup>2</sup>), with the release efficiency evaluated using fluorescence intensity measurements and expressed in terms of cumulative fraction released (CFR). Cellular uptake was tested using flow cytometry on HCC1954 breast cancer cells, with and without LFUS exposure [1]. The normalized release profiles showed that the conjugation of TRA enhanced the sensitivity of liposomes to LFUS and that calcein release increased with increasing power density. In addition, TRA-conjugated DPPA liposomes with LFUS (10 mW/cm<sup>2</sup>) was the most promising formula to achieve the highest drug uptake by the cancer cells.

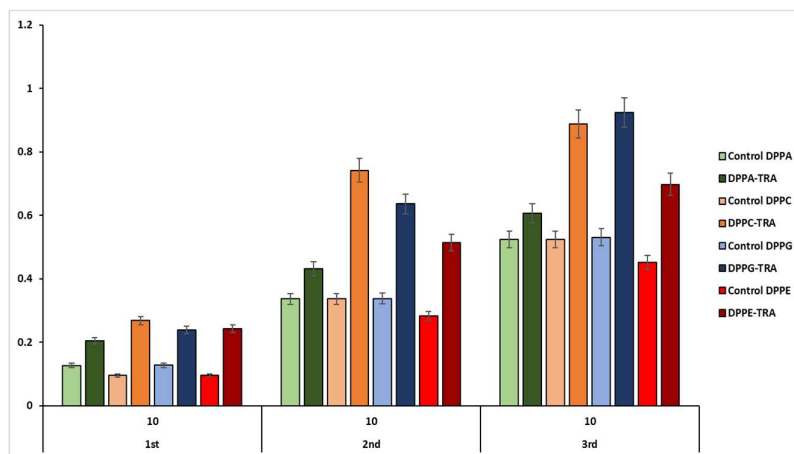


Figure 1. Release from the first 3 pulses of all tested liposomes at 10 mW/cm<sup>2</sup>.

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# Bending and Shear Response of Perturbated Honeycombs

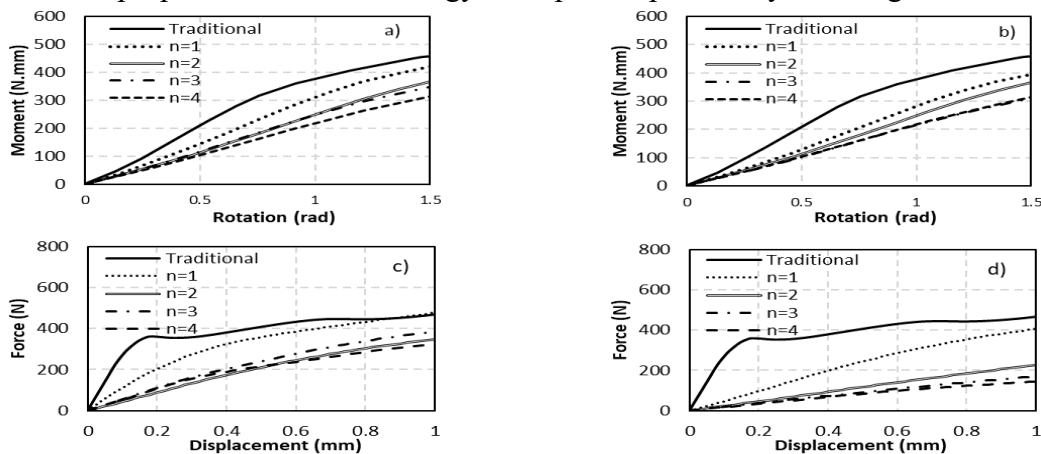
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Sandwich panel structures with cellular cores have been utilized in various industries due to their unique mechanical properties, such as their strength-to-weight ratio [1]. To increase their utility, various efforts tried to enhance the mechanical properties of cellular core sandwich panels without compromising the strength-to-weight ratio. One of the most recent approaches proposed to enhance honeycomb cores is the introduction of sinusoidal perturbations onto their cell walls, varying in amplitude and frequency. Most studies involving sinusoidal perturbations have focused on characterizing the enhancing effects of these perturbations on the energy absorption capacity of honeycombs [2-3]. Accordingly, this study computationally investigates the effects of sinusoidal perturbations on properties other than energy absorption, specifically, bending and shear stiffness.



**Figure 1.** Bending moment response for (a) 0.15mm amplitude and (b) 0.3mm amplitude. Transverse Shear Response for (c) 0.15mm amplitude and (d) 0.3mm amplitude.

Results, summarized in Fig.1, illustrate the bending and shear response for perturbation amplitudes of 0.15 and 0.3 mm at different frequencies (1,2,3, and 4). The lowest bending stiffness and peak moment occurred at a frequency and amplitude of 4 and 0.3 mm, respectively, with the peak moment in the most perturbed case being about 45% lower than the unperturbed case. The reduction in stiffness due to perturbations also lowers the core's resistance to permanent deformation and yielding, identified as the stress level where the transverse shear stress-strain curve shifts from linear to nonlinear. Results highlight an adverse effect of perturbation.

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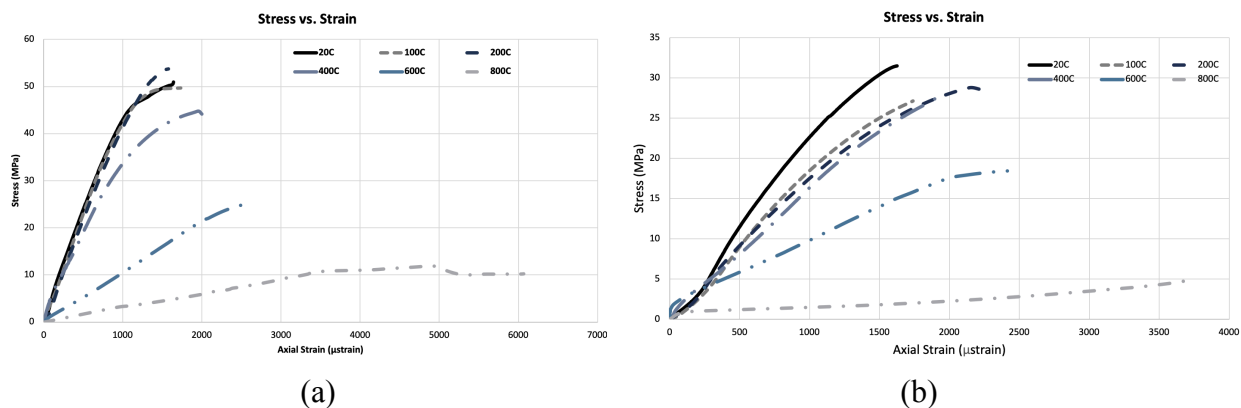
# INVESTIGATION OF NWC AND STRUCTURAL LWC USING LOCAL MATERIAL IN THE UAE EXPOSED TO ELEVATED TEMPERATURES

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Fires in buildings cause major damage to lives and property. Specifically, concrete's mechanical and thermal properties deteriorate after being exposed to high temperatures, potentially leading to structural system failure [1], [2]. Acknowledging the criticality of structural fire safety, this paper investigates mechanical properties and microstructure of normal weight concrete (NWC) and structural lightweight concrete (LWC) utilizing local materials in the UAE exposed to different steady-state temperatures (20°C, 100°C, 200°C, 400°C, 600°C, and 800°C) and ISO-834 standard fire curve [3]. Results show that mass loss increases at higher temperatures, with a significant increase starting at 400°C for both specimens. Samples exposed to the ISO-834 curve experienced severe mass loss and spalling, especially for NWC. Scanning Electron Microscopy (SEM) results support these findings where cracks in the specimen and internal aggregates are more prominent starting at 600°C exposure. Further, recessed zones were observed in the samples indicating the decay of perlite aggregates decreasing the mechanical property of LWC.



**Figure 1.** Stress-strain diagrams of (a) NWC and (b) structural LWC at elevated temperatures

The stress-strain diagrams of the specimens exposed to 20°C, 100°C, 200°C, 400°C, 600°C, and 800°C are plotted in **Figure 1**. The diagram shows the decrease in compressive strength and stiffness of concrete as exposure temperature increases for both types of specimens. NWC concrete reported a larger decrease in compressive strength than LWC at high temperatures. The diagrams also show the increase in ultimate axial strain with the increase in temperature for both types of concrete. The ultimate axial strain, resembling ductility of concrete, increases with temperature by a factor of 3.7 and 2.3 for NWC and LWC, respectively, at 800°C. The hoop strain of the specimens reported to increase significantly starting at 400°C indicating the existence of exterior cracks at this temperature. Overall, the results are in line with the behavior of concrete reported in literature. Such results provide a vital reference for future research, especially in the area of strengthening concrete.

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# **Femtosecond transient absorption study of silicon nanoparticles synthesized by laser ablation of bulk silicon in water**

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The outstanding properties of silicon nanoparticles (SiNPs), such as the tunability of their optical properties across a wide range of energies, efficient light absorption, and high emission quantum yields, make these structures great candidates for the photonics, photovoltaics or microelectronics materials. The key properties of SiNPs are shaped by the processes occurring on a time scale ranging from femtoseconds to nanoseconds. The ultrafast temporal evolution of nanometer-sized semiconductor structures might be successfully investigated using femtosecond time-resolved transient absorption pump-probe spectroscopy (FTAS).

Here, we present our studies on SiNPs using a home-built FTAS setup based on a femtosecond Yb:YAG laser system. We prepared the SiNPs samples using simple, green, versatile, low-cost laser ablation synthesis in water. To monitor the ultrafast photoinduced events in Si-based NPs, the laser pulses centred at 1030 nm with a frequency of 50 kHz and durations of 240 and 40 fs were utilized. The frequency of photons in a 240 fs pulse was tripled in BBO crystal to allow the interband excitation of SiNPs, while 40 fs one generated a white light pulse in Sapphire crystal for the spectrally-resolved characterization of photoexcited species. The results of the femtosecond transient absorption spectroscopy indicate a strong effect of the pulse energy on the ultrafast events in synthesized NPs suspensions due to different concentrations of surface trap states.

# **EFFECT OF CONCRETE COMPRESSIVE STRENGTH ON THE BOND PERFORMANCE OF FLEXURAL PRISMS EXTERNALLY STRENGTHENED WITH CFRP LAMINATES**

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This paper presents a study from an ongoing research project on the bond performance of carbon-fiber reinforced polymer (CFRP) strengthened prisms. The advent of fiber reinforced polymer (FRP) composites has led to a breakthrough in the field of strengthening and repair of reinforced concrete (RC) infrastructure. Extensive research has been conducted since then to evaluate the performance and behavior of RC structures externally strengthened using different types and configurations of FRP composites. Although there is an abundance in literature on the influence of several parameters on the performance of the FRP-concrete bond, the effect of compressive strength of concrete has not been dealt with much consideration to the best of the author's knowledge. The influence of concrete compressive strength on the distribution of strains and interfacial bond-stress along the length of CFRP laminate is still obscure. The aim of this paper is to evaluate the effect of normal strength concrete (NSC – 30MPa) and high-strength concrete (HSC - 50MPa) on the bond performance of plain concrete prisms notched at the mid-span and strengthened using CFRP laminates. Two groups of six prisms each were cast using the two design mixes. Three prisms from each group are strengthened using CFRP laminates, while the remaining prisms were un-strengthened to serve as control prisms. Two linear variable differential transducers (LVDT's) and a series of equidistantly placed strain gauges were installed on strengthened prisms to obtain prism midspan deflection and CFRP strain along the laminates. After achieving 28 days of curing in standard lab conditions (temperature maintained at  $23\pm 3^{\circ}\text{C}$  and a humidity of  $50\pm 10\%$  relative humidity), all prisms are tested under four-point loading at a displacement-controlled rate of 0.25mm/min. The ultimate mid-span deflection, maximum and ultimate strains at the mid-span, strain distribution at different positions along the length of the laminate and bond/shear stress versus slip was analyzed in an effort to evaluate the bond performance of flexural prisms. The average ultimate load carrying capacities and mid-span deflection of CFRP-strengthened NSC and CFRP-strengthened HSC prisms was 31.33 and 35.02 kN and, 0.41 and 1.54 mm respectively. The average CFRP strain values corresponding to ultimate load was 2930.119 and 3544.01 $\mu\epsilon$ . It can be concluded from the experimental results that the concrete compressive strength has minimal effect on the flexural bond performance of concrete prisms externally bonded with CFRP laminates.

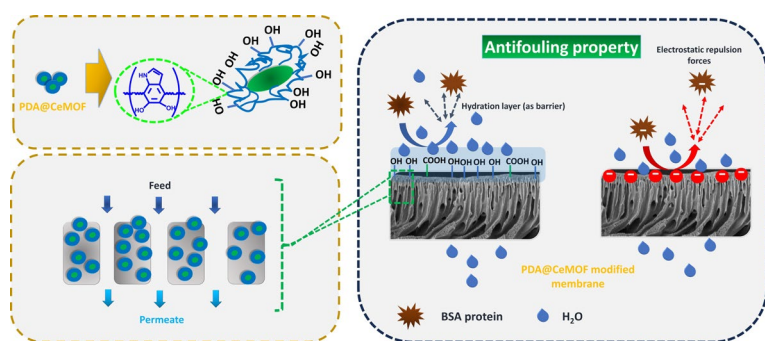
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# POLYDOPAMINE-MODIFIED Ce-MOF FOR ENHANCED ANTIFOULING CAPABILITY AND SELECTIVE SEPARATION IN PES ULTRAFILTRATION MEMBRANES

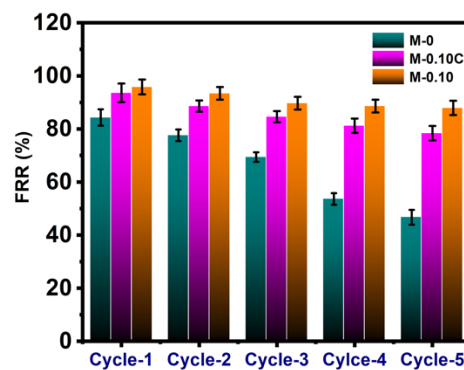
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<sup>1</sup>Authors share first authorship

The demand for antifouling membranes is significant due to the adverse impact of fouling on the efficacy and longevity of ultrafiltration membranes [1]. Metal-Organic Frameworks (MOFs) have recently emerged as effective additives for the fabrication of ultrafiltration (UF) membranes [2]. However, a thoughtful approach is crucial to harness their benefits and address their drawbacks. In this study, polyethersulfone (PES) UF membranes were tailored with polydopamine (PDA)-modified cerium (Ce)-MOF (PDA@Ce-MOF) to achieve enhanced antifouling properties and improved removal of biological macromolecules such as bovine serum albumin (BSA) and humic acid (HA) from wastewater bodies. The non-solvent induced phase separation (NIPS) method was employed to simultaneously fabricate and modify the membrane with various PDA@Ce-MOF concentrations, ranging from 0.05 to 0.50 wt.%. Results demonstrated substantial improvements in the membrane's morphology, hydrophilicity, porosity, and pore size at a 0.10 wt.% loading of PDA@Ce-MOF. The synergistic effect of PDA and Ce-MOF on the membrane significantly enhanced the pure water flux (337 LMH) and filtration performance when dealing with Bovine serum albumin (BSA) and humic acid (HA), achieving 145 LMH with 98% rejection and 164 LMH with 88% rejection, respectively. Moreover, the water-attracting functional moieties of PDA@Ce-MOF played a key role in impeding the deposition of BSA protein on the membrane surface, resulting in an outstanding flux recovery ratio (FRR) of approximately 87%, along with mitigated irreversible fouling.



**Figure 2.** Schematic depiction of the antifouling mechanisms of the PES/PDA@Ce-MOF UF membrane.

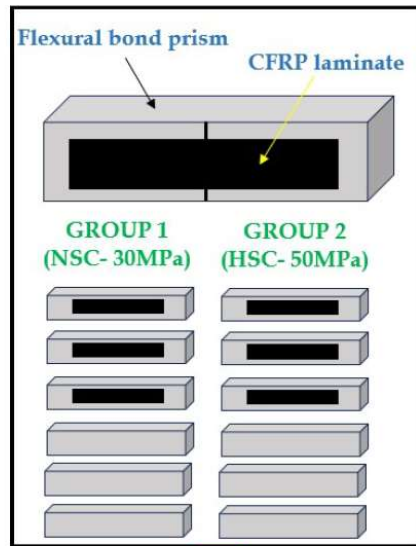


**Figure 1.** FRR values of pristine (M-0), Ce-MOF modified (M-0.1C), and PDA@Ce-MOF modified PES membranes over 5 filtration cycles.

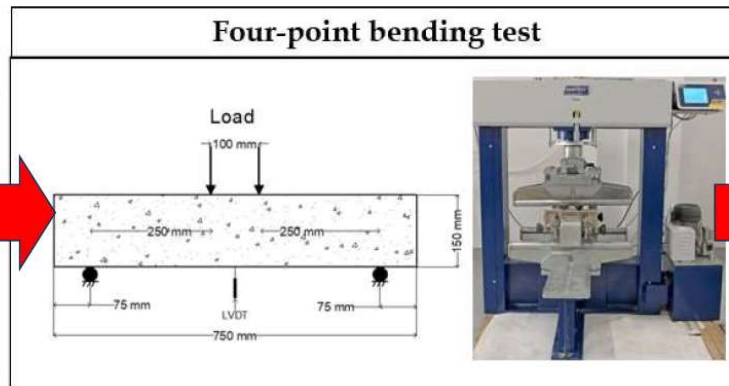
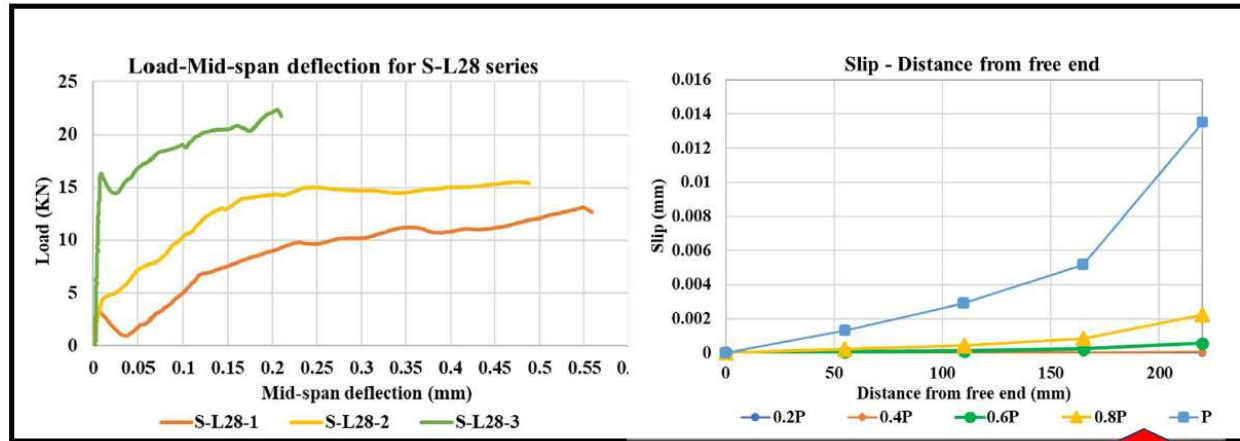
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### EFFECT OF CONCRETE COMPRESSIVE STRENGTH ON THE BOND PERFORMANCE OF FLEXURAL PRISMS EXTERNALLY STRENGTHENED WITH CFRP LAMINATES



**Bond stress**

$$\tau(x_i) = 0.5 n_f t_f E_f \left[ \frac{(\varepsilon_i - \varepsilon_{i-1})}{(x_i - x_{i-1})} + \frac{(\varepsilon_{i+1} - \varepsilon_i)}{(x_{i+1} - x_i)} \right]$$

**Interfacial slip**

$$s(x) = s(0) + \sum_{i=n}^x 0.5 [ (\varepsilon_i - \varepsilon_{i-1}) (x_i - x_{i-1}) + (\varepsilon_{i+1} - \varepsilon_i) (x_{i+1} - x_i) ]$$

Figure 1. Graphical representation of abstract



# **Ni-Ce<sub>2</sub>O<sub>3</sub> doped mixed matrix flexible membrane for chemiresistive acetone sensing applications**

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## **Abstract:**

Acetone in human breath is considered as an important biomarker with the ability to distinguish between diabetic and non-diabetic patients as the exhaled breath comprises of a mixture of gases such as CO<sub>2</sub>, N<sub>2</sub>, H<sub>2</sub>O, O<sub>2</sub> and trace levels of other volatile organic compounds (VOC) such as ethane, acetone to name a few. Acetone is formed due to the biological process between the human and the invading micro-organisms which then infuses into the blood stream and gets transported to the lungs becoming a vital component of the breath. This can be used as a non-invasive method to detect diabetes depending on the concentration. Acetone is also used as a solvent and cleaning agents in research laboratories posing as a threat to the users as prolonged exposures can cause damage to central nervous system, skin and eyes irritation, narcosis, nausea, headaches and dizziness. Cerium Oxide (Ce<sub>2</sub>O<sub>3</sub>) doped with Nickel (Ni) is proposed to be incorporated into a flexible polymer matrix of Chitosan (CS) integrated with ionic liquid glycerol (IL). The resultant membrane demonstrated sensitivity of 20.75% towards 100 ppm (parts per million) of acetone at an operating temperature of 60 °C. It also exhibited an excellent response and recovery times of 11 s and 14 s respectively. The stability and repeatability of the sensor showed a response between 18-20% with negligible errors bars. The selectivity parameter shows highest response for acetone gas among the other gases tested such as H<sub>2</sub>S, H<sub>2</sub>, C<sub>2</sub>H<sub>4</sub>, CO, CO<sub>2</sub>. Other noted advantages are that the membrane is highly flexible and easy to fabricate which can be proposed to be used as sensors in real time medical applications.

# Tetraphenyl and Triazine-based Porous Polymers for Selective Capture of Carbon Dioxide and Ultrahigh Iodine Uptake

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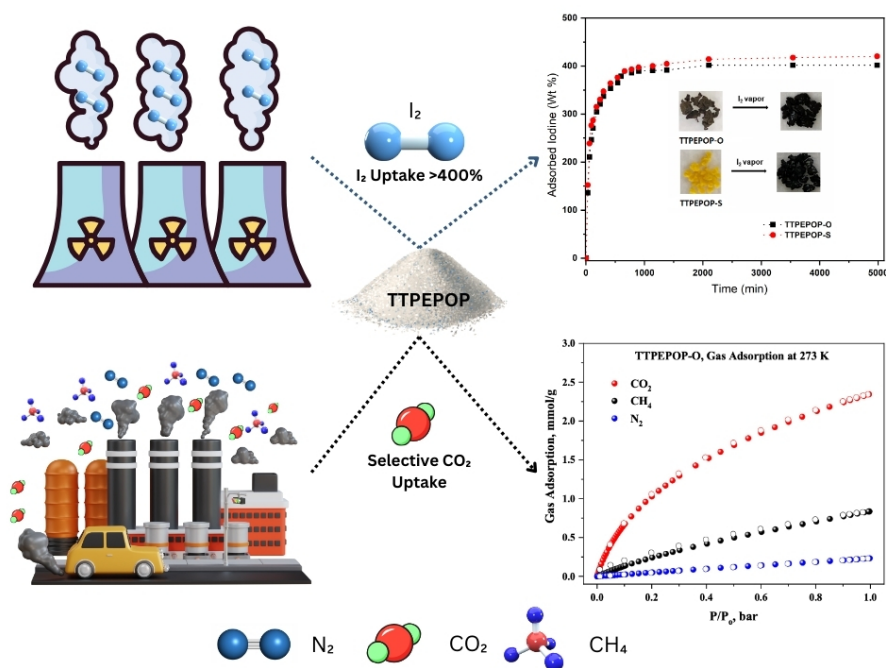
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## Abstract

The imperative for collective efforts to amplify global action against global warming and adhere to the critical target of limiting global temperature increase to 1.5°C was emphatically reiterated at the COP-28 conference in the UAE. The urgency to phase out from fossil-fuel to more sustainable energy sources is of paramount importance to reduce the worldwide carbon footprint given the significant detrimental contribution of CO<sub>2</sub> to climate change. While transitioning to nuclear energy is a potent alternative for generating green electricity, the associated release of radionuclides, such as iodine, jeopardizes the life of living organisms and ecosystems. Therefore, developing effective adsorbent materials capable of capturing both iodine and carbon dioxide (CO<sub>2</sub>) is essential. Herein, we report the synthesis of two nitrogen-rich tetraphenylethylene functionalized porous organic polymers by reacting 4,4',4'',4'''-tetra(2,4-diamino-1,3,5-triazin-6-yl)tetraphenylethylene (TTPE) with 2-carboxaldehydefuran or 2-carboxaldehydethiophene through Schiff base condensation reaction. This synthetic process resulted in the formation of two aminated linked-triazazine based porous organic polymers, namely TTPEPOP-O and TTPEPOP-S, which demonstrated notable Brunauer–Emmett–Teller surface areas of 741 and 999 m<sup>2</sup> g<sup>-1</sup>, respectively. The two polymers show an ultrahigh capacity for iodine uptake, exceeding 400 wt.% from vapor iodine, and can effectively extract up to 99% of the dissolved iodine from the iodine-cyclohexane solution. Additionally, TTPEPOP-O and TTPEPOP-S exhibit a mild CO<sub>2</sub> uptake of 2.34 and 2.94 mmol g<sup>-1</sup>, respectively, at 273 K and 1.0 bar, with a high selectivity to CO<sub>2</sub> over N<sub>2</sub> and CH<sub>4</sub>. The potential of these polymers as adsorbents for efficient sequestration of both CO<sub>2</sub> and iodine stems from their microporosity, the presence of  $\pi$ -conjugated moieties and the abundance of electron-rich nitrogen species within their framework. Beyond their morphological and structural attributes responsible of their significant adsorption capacity, their chemical and thermal stability, along with their environmentally friendly nature, further underscore their suitability as prospective materials to address environmental challenges.



**Keywords:** porous organic polymers, aminated-linked, climate change, CO<sub>2</sub> capture, iodine uptake, sustainable resources, environmental challenges.

# ACCELERATING SODIUM-ION ELECTRODE MATERIAL DEVELOPMENT THROUGH ARTIFICIAL INTELLIGENCE

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Rechargeable batteries have proven to be the most efficient energy storage solution for the intermittent renewable energy sources. Currently, the lithium-ion battery (LIB) is regarded as the leading energy storage system because of its power and energy density. Nevertheless, LIBs are facing issues such as the limited availability of lithium precursor materials and the cost attributed to this issue. Thus, sodium ion batteries (SIBs) are regarded as a highly promising alternative to LIBs, but they are still under research. Battery research and especially battery material design is challenging because of the complex structure-property relationships, where different materials interact unpredictably and uncontrollably. Conventional methods in material design involve experimental data and physics-based models which rely on a forward trial-and-error methodology thus requiring a long period of time. Hence, artificial intelligence can be used to accelerate the process of battery electrode material discovery. There are many parameters that determine whether the battery electrode material is suitable or not, such as the voltage and the specific capacity which both contribute to the overall energy density. Additionally, the volume change throughout the cycles contribute to the safety, efficiency and cyclability of the battery. Thus, several AI techniques such as decision trees, support vector machine, random forest, and deep neural network (DNN) models have been used to predict the average voltage, maximum specific capacity, and volume change of the battery. Table 1 shows the results obtained using the mentioned AI techniques for predicting the average volume. Based on the results obtained, machine could be a promising tool to accelerate the R&D of battery materials by overcoming its major challenges which are: dealing with a vast number of variables and large data quantity.

**Table 1. Summary of model performance in terms of MAE and R-squared values for predicting the average voltage**

	Model	MAE	R-squared value
Standard Machine Learning Models	Decision Tree	0.136	0.830
	Random Forest	0.105	0.915
	SVR	0.248	0.621
Deep Learning Model		0.124	0.970

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# Optimizing Geopolymer Concrete for 3D Printing Using Fiber Reinforcements

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This research investigates the effect of incorporating two different types of fibers within the geopolymer concrete (GPC) mixture composed of construction waste material. Steel and polypropylene (PP) fibers content will be the variable factors in this study which is aimed at optimizing the application of GPC in the 3D printing field. The mechanical, structural, and rheological properties of the GPC having these varying fiber contents have been reported in previous studies by the authors [1-3].

For the first part of this study, steel fibers, recycled from car tires, are added into the GPC mix with varying percentages of 0%, 0.8%, 1.0%, and 1.2% by volume. Mechanical properties such as compressive, flexural, and tensile strengths were evaluated. The results showed an optimum steel fiber content of 1.2%, where the tensile strength was doubled and a 16% increase in flexural strength was noted, while not affecting the compressive strength. In addition, the steel fibers contributed to the enhancement of the overall structural integrity by achieving a 20% increase in the interlayer bond strength and accumulating enhancements in the dynamic and static elastic modulus. Microstructure analysis was conducted by utilizing CT-Scans, SEM, and ASTM C642 tests to analyse the microstructure changes contributed by the steel fiber reinforcement. Moreover, additional testing was conducted on the 1.2% fiber content to study its effect on the early-age cracking and long-term durability. The Dual Ring Test, Autogenous Shrinkage, and compressive basic creep, demonstrated improvements in the durability criteria of the composite material[4].

The second part of this research aimed to study the incorporation of PP fibers in the GPC matrix with the same percentages as the steel fibers. Both cast and printed GPC samples were tested for their rheological and mechanical properties. Enhancements up to 8.16% in flexural strength and 71.7% in tensile strength were recorded with the addition of 0.8% PP fibers, but a reduction of 26.2% in compressive strength when compared with the non-reinforced mix. However, higher percentages of PP fibers showed diminishing returns in these properties and more voids evidence was captured by the ASTM C642 and then confirmed by the Scanning Electron Microscope (SEM). Furthermore, The SEM analysis showed signs of incomplete hydration, anisotropic distribution and clustering of the PP fibers. The increase of PP fiber percentage allows an increase in the flexural toughness, which is the amount of energy that could be absorbed prior to failure. This study concluded the importance of optimizing the geopolymer mix design when adding PP fibers to allow complete hydration within the GPC matrix, and the utilization of longer PP fibers for extending the bridging effects between the internal capillary voids. [5]

The findings from the two parts of this study conveyed that the addition of steel and PP fibers into the GPC matrix meaningfully enhanced its properties, corresponding to each of the fibers' unique attributes. Steel fibers resulted in higher strength and developed the overall structural integrity, providing enhancements to the material for load-bearing applications. On the other hand, PP fibers allowed the material to acquire increased flexural toughness, which is of high importance for improving the resilience of the composite material. This research highlights the benefits of

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utilizing fiber reinforcing GPC in the 3D printing industry, by providing an environmentally friendly and structurally reinforced material for additive manufacturing.

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# The magnetism of ultrafast laser-structured Holmium

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## Abstract

The unusual electronic configurations of the rare earth elements in the periodic table bring rich and sophisticated magnetic and electronic properties. The 4d electrons are fully filled, and 5d and 6s electrons serve as conduction electrons. The full 5s and 5p shells support and screen the 4f shell electrons which are responsible for the intriguing magnetic and electronic properties. Holmium has 10 electrons in the 4f shell with the orbital angular momentum of  $L=6$ , the spin angular momentum of  $S=2$ , and the total angular momentum of  $J=8$ . Such electronic configuration in Holmium makes it a special material with the highest magnetic moment ( $10.6 \mu_B$ ) among any naturally occurring element in the periodic table.

Rare earth magnetism is significantly different than the 3d metal magnetism where the Stoner model can explain the origin of magnetism. The magnetic ground state of rare earth metals such as holmium can be understood by the Ruderman–Kasuya–Kittle–Yosida (RKKY) interaction between 4f-electrons localized moments consolidated by the conduction electrons. A competition between ferromagnetism and antiferromagnetism arises due to the spatially damped oscillation of the spin polarization of the conduction electrons. Such a competition results in incommensurate helimagnetic magnetic structure in Holmium which makes it an extremely interesting material as a spin mixing layer for superconducting spintronics. The helimagnetic ground state of the holmium is very sensitive to the surface condition of the specimen either in bulk or thin film form. In this work we have contrasted the magnetic properties of the bulk holmium with femtosecond laser structured holmium. Our preliminary findings indicate femtosecond laser structuring can alter surface magnetism of holmium significantly.

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# Impact of Femtosecond Laser Surface Structuring on NiCoCr and NiCoV Medium Entropy Alloy Systems for an Overall Electrochemical Water Splitting

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## Abstract

Multi-principal element, medium, and high entropy alloys are recently known to exhibit a wide spectrum of intriguing mechanical, physical, electrocatalytic, and anticorrosive properties that are superior to traditional alloys. In this regard, the NiCoCr and NiCoV systems, which are among the most promising medium entropy alloys for a wide range of applications, show strong corrosion resistance in alkaline or acidic environments, in addition to their attractive potential for electrochemical water splitting. The electrochemical characteristics of these alloys are primarily linked to their versatility in adjusting compositions and constituent elements. This adaptability gives rise to distinctive properties, including a metal-hydrogen bond strength on par with platinum, resulting in significant catalytic activity. In this work, we demonstrate that the NiCoCr(V) system exhibits electrochemical performance in water splitting comparable to expensive Pt/C electrodes, thanks to its richness in oxidation states. Femtosecond laser surface structuring has been used to further enhance the oxidation states through tailored laser-matter interactions and increase the electrochemically active surface area by creating laser-induced periodic structures on the surface. A combination of X-ray photoelectron spectroscopy, Raman spectroscopy, X-ray diffraction, and high-resolution electron microscopy have been used to evaluate the impact of the laser processing on the surface. The electrochemical performances of the studied alloys were characterized for both Hydrogen evolution and Oxygen evolution reactions. In both cases, critical electrochemical parameters such as overpotentials and Tafel slopes monotonically improved by around 10-15 % compared to the unprocessed electrodes.

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# Mechanical, Electrochemical, and Physical Properties of CoNiCrFe alloy

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## Abstract

CoNi-based alloy systems are a typical example of multi-principle element alloys that exhibit exceptional mechanical strength at both cryogenic and high temperatures, as well as remarkable resistance to corrosion and oxidation. Here we discuss briefly the Physical, Mechanical, and Electrochemical properties of equiatomic CoNiCrFe multi-principal alloy. The alloy was synthesized in vacuum arc melting oven. The button was homogenized for 24 hrs in argon environment and quenched in cold water. Afterwards, the mechanically rolled samples were heat treatment at 1100 °C for 2 hrs and water quenching to room temperature was performed. The grain size and orientation of the single-phase FCC samples were studied through metallurgical microscope and Tescan field emission electron microscope equipped with EBSD respectively. We measured the transport and magnetic properties of the samples using a Cryogenics Ltd. high field measurement system with a vibrating sample magnetometer (VSM) option in the temperature range of 2–330 K. Here we also report the change in the magnetic entropy obtained from the M-H measurements of the samples. The mechanical properties of dogbone sample were performed using universal testing machine (Instron, Norwood, MA, USA). The samples were also tested as a bifunctional catalyst for hydrogen evolution (HER) and oxygen evolution reactions (OER) in electrolyzing water in acidic media.

**Keywords:** *Water Splitting; High Entropy Alloy, Magnetic Properties, Magnetic Properties*

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# A CYTOTOXICITY STUDY OF CURCUMIN ENCAPSULATED ULTRASOUND SENSITIVE LIPOSOME ON BREAST CANCER CELL LINE

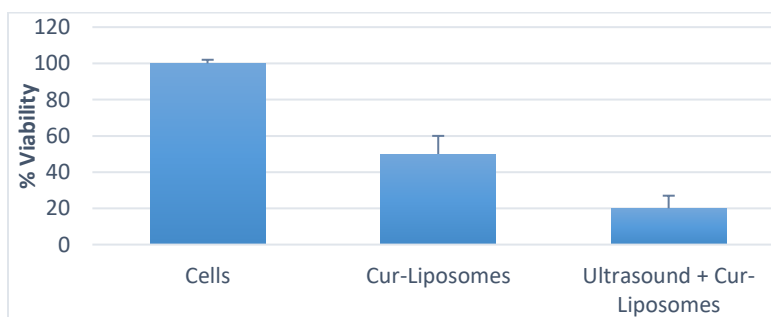
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Our study aims to unveil the anti-tumor potential inherent in herbal curcumin when encapsulated within liposomes. Liposomes, characterized by their unique structural features, provide a promising avenue for advancing drug delivery [1]. They have the capability to encapsulate curcumin, a well-known herbal compound recognized for its potent anti-cancer properties, thereby protecting it from degradation within the complex environment of the human body. This encapsulation not only enhances the stability of curcumin but also increases its bioavailability, ensuring a more substantial quantity effectively reaches the targeted cancer cells[2]. Once the liposomes reach the target site, the curcumin content encapsulated inside the liposomes can be released using ultrasound as an external triggering mechanism.

The liposomes were prepared by the conventional thin-film hydration method, and the curcumin along with the lipids, were dissolved in chloroform in a round bottom flask, which was evaporated using a rotary evaporator. The thin film formed around the sides of the round bottom flask was hydrated with PBS and extruded through 200 nm polycarbonate membranes.



**Figure 1.** *In vitro* cytotoxicity studies of curcumin liposomes on HCT1954 cells

The synthesized liposomes were less than 200 nm in radius. *In vitro* cytotoxicity studies carried out on the breast cancer cell line HCT 1954 showed a significant increase in cell death in the ultrasound-treated well plates compared to well plates that were not treated with ultrasound. This is due to the enhanced release of curcumin under the influence of ultrasound. Our studies showed that curcumin was encapsulated within the liposomes. The liposomes were sensitive to ultrasound triggering and were able to release the encapsulated curcumin under ultrasound.

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# **IN VITRO PERFORMANCE OF HUMAN SERUM ALBUMIN TARGETED LIPOSOMES WITH ULTRASOUND TRIGGERING**

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This study explores the application of Smart Drug Delivery Systems (SDDSs) for targeted chemotherapeutic delivery using Human Serum Albumin (HSA)-targeted liposomes loaded with Doxorubicin (DOX) and triggered by ultrasound. In the preparation of liposomes for drug delivery, a modified thin-film hydration method was employed using a specific lipid composition of 1,2-dipalmitoyl-sn-glycero-3-phosphocholine (DPPC), 1,2-distearoyl-sn-glycero-3-phosphoethanolamine-N [amino(polyethylene glycol)-2000] (DSPE-PEG(2000)-NH<sub>2</sub>), and cholesterol in a molar ratio of 13:1:16. The lipids were dissolved in chloroform, evaporated under vacuum to form a thin lipid film, and then hydrated with ammonium sulfate solution. The resulting liposomal solution underwent sonication, extrusion, and filtration for uniformity. A modified pH gradient method was employed to load the liposomes with the DOX. Subsequently, the liposomes were functionalized with HSA using cyanuric chloride as a linking agent. Purification was achieved through high-speed centrifugation to remove unconjugated moieties and any free unencapsulated DOX. Characterization included determining liposome size using dynamic light scattering (DLS), phospholipid content using the Stewart assay, and confirmation of moiety conjugation using the bicinchoninic acid (BCA) assay. The study further investigated the biological efficacy and cellular uptake of the liposomal formulation, along with the effects of ultrasound exposure on MCF-7 (HSA+ breast cancer) and HeLa (HSA- cervical cancer) cells, employing a 20-second continuous sonication in a 40-kHz bath at 1 W/cm<sup>2</sup>. The characterization of liposomes revealed that HSA-targeted liposomes were larger than control liposomes, with radii of  $101 \pm 1.56$  nm compared to  $83.5 \pm 0.734$  nm, respectively. Additionally, the lipid content of HSA-DOX liposomes was significantly lower than that of control liposomes (7.47 mg/ml vs. 16.9 mg/ml), indicating successful loading of DOX into the liposomes. The functionalization of liposomes with HSA was confirmed by increased protein content in the targeted liposomes compared to the control. The MTT assay results demonstrated the biological efficacy of the liposomal formulation. The study found that combining HSA-targeted liposomes and ultrasound exposure significantly enhanced cellular uptake by MCF-7 breast cancer cells compared to HeLa cervical cancer cells. The cell viabilities in MCF-7 cells were remarkably lower ( $15.7 \pm 0.613\%$ ) compared to HeLa cells ( $47.3 \pm 0.621\%$ ), indicating a more significant inhibitory effect on the breast cancer cells (p-value= $8.05 \times 10^{-7}$ ). Furthermore, the study observed that the application of ultrasound, in conjunction with both control and targeted liposomes, resulted in significantly lower cell viability in both MCF-7 and HeLa cells than in non-sonicated cells. This finding highlights the additional impact of ultrasound exposure in enhancing the therapeutic effects of liposomal treatments on cancer cells [1]. Overall, the study concludes that the combination of targeted liposomal delivery with ultrasound holds promise as an effective strategy for cancer treatment, demonstrating synergistic effects on inhibiting cell proliferation and growth.

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# ENVIRONMENTAL RISK ASSESSMENT OF HEAVY METALS FROM CO-PYROLYSIS OF SALICORNIA AND DATE PALM (PHOENIX DACTYLIFERA) BIOCHAR GENERATED THROUGH PYROLYSIS

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This research introduces an innovative method aimed at managing Salicornia and Date Palm through the generation of biochar via co-pyrolysis conducted within the temperature range of 400 to 600 °C. Despite the manifold advantages associated with producing biochar from the combined feedstock of Salicornia and Date Palm, comprehending the potential environmental ramifications linked to the process is crucial, particularly concerning the presence of heavy metals. The quantification of heavy metals in both biomass and biochar involved a meticulous procedure encompassing microwave digestion followed by ICP-AES analysis. Various pollution indices, notably the geo-accumulation index (GAI), ecological risk index (ERI), and the potential ecological risk index resulting from overall pollution (PERI), were employed to evaluate the environmental risk. The assessment of biomass and resultant biochar unveiled concentrations of metals Cd, Pb, Cu, Ni, Cr, Mn, and Zn ranging from 0 ppm to 36.5 ppm and 0 ppm to 52.9 ppm in biomass and biochar, respectively. The calculations for risk assessment indicated the absence of pollution risk in the biomass, while a minimal environmental risk was identified for the biochar produced within the temperature range of 400 to 600 °C. These findings signify the potential of biochar for environmentally favorable applications, such as carbon sequestration and soil enhancement, without compromising its ecological integrity. This study presents a promising methodology for managing Salicornia and Date Palm waste, ensuring minimal environmental impact stemming from biochar production, and suggests a viable pathway for eco-friendly applications of biochar.

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# QUANTUM POTTS CHAIN IN ALTERNATING FIELD

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The  $q$ -state Potts chain with ferromagnetic couplings,  $J = 1$ , in the presence of a transverse field,  $\Gamma$ , has a quantum phase transition at  $\Gamma/q = 1$ , which is continuous for  $q \leq 4$  and of first order for  $q > 4$ . Here we introduce a  $q$ -periodic alternating longitudinal field of strength,  $h$ , and study the phase diagram and the critical properties of the model. For  $h < q/(q - 1)$  there is a ferromagnetic ordered phase, for  $\Gamma < \Gamma_c(h)$  and at  $h = q/(q - 1)$  there is a classical endpoint at  $\Gamma = 0$ , with finite entropy at  $T = 0$ . We considered the  $q = 3$  model and using DMRG techniques we calculated the low-lying spectrum of the Hamiltonian, the transverse magnetisation and the spin-spin correlation function, all of which signalled a diverging correlation length at the transition point with the exponent of the three-state Potts model. In the vicinity of the classical endpoint the model is mapped to a quantum hard rod model, which belongs also to the universality class of the three-state Potts model. Also, the spectrum of the critical Hamiltonian is found in agreement with conformal invariance. At the same time the correlation function shows a jump at the transition point, thus the transition is of mixed order for  $h < q/(q - 1)$ .

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# Passive Radiative Cooling Solution

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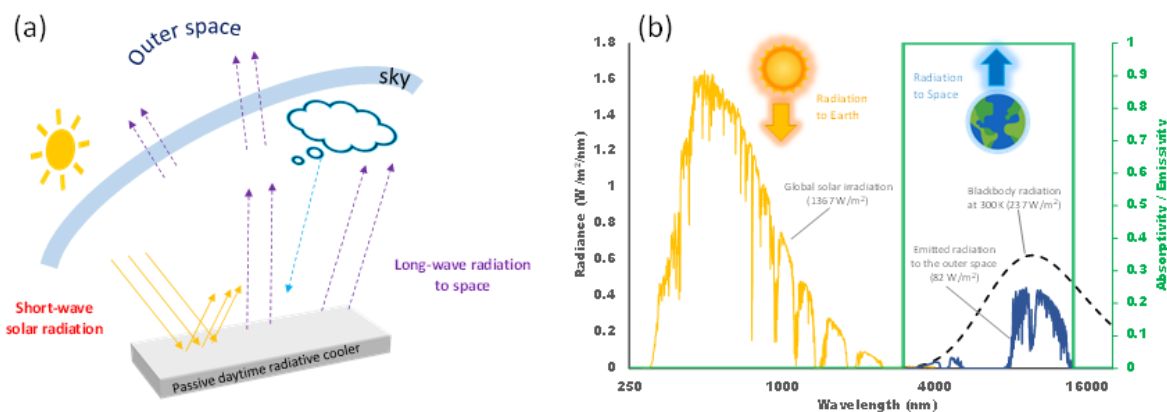
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NASA reported the hottest month ever recorded on Earth in July 2023, with daily highs reaching 54°C in the Gulf Cooperation Council (GCC) area [1], [2]. The UAE, experiencing temperatures surpassing 50°C in July 2023, faces an additional environmental challenge with one of the highest per capita carbon footprints, emitting over 25 tons of CO<sub>2</sub> as of 2022 [3], [4]. Fossil fuel combustion for energy and industrial activities are the major contributors to the country's CO<sub>2</sub> emissions [4].

The significant need for air conditioning units, which accounts for 70% of the GCC's peak power consumption, increases carbon emissions owing to the use of fossil fuels [5]. The cooling demand in the GCC is expected to more than triple by 2030 [5]. The continuous cycle of adding more air-conditioning units amplifies pressure on power grids, intensifying CO<sub>2</sub> emissions and global warming [6]. Addressing these challenges, a zero-energy, sustainable cooling solution harnessing the sky as a renewable resource is in development. This innovative approach aims to reduce electricity consumption, combat the urban heat island effect, and move towards carbon neutrality by enhancing heat flow to outer space. The passive radiative cooling solution, with high reflectivity and emissivity (see Fig.1), can supplement or even replace air conditioning units when integrated with a thermal energy storage system. As temperatures rise, implementing such solutions is crucial to break the detrimental cycle of escalating energy consumption and carbon emissions.



**Figure 1.** Schematic diagram of (a) the working principle of passive daytime radiative cooling, (b) Spectrum of AM 1.5 global solar radiation on Earth and surface thermal emission at 300K to the outer space. Green line represents the spectral properties of an ideal passive daytime radiative cooler showing zero absorptivity in the solar spectrum (250–3000 nm wavelength) while maintaining 100% emissivity in the earth's atmospheric transmission window (3000–14000 nm)

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# INNOVATIVE 3D PRINTING FOR ENHANCED WATER FILTRATION: TAILORING SURFACE PATTERNS OF MEMBRANES TO MINIMIZE ORGANIC FOULING AND MAXIMIZE PERMEABILITY

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The global issue of water scarcity affects millions of individuals worldwide, prompting a search for effective solutions. Membrane processes have emerged as promising water purification solutions; however, the persistent challenge of membrane fouling remains a significant hurdle. Feed spacers, an integral component of membrane modules, can exacerbate fouling by creating conditions conducive to foulant deposition. Additionally, the contact area of feed spacers with the membrane surface and its immediate vicinity often experiences higher concentration polarization (CP), leading to the formation of regions with near-zero mass transfer. To address these challenges, this study explores a novel approach to water filtration by investigating especially surface-patterned membranes as an alternative to conventional spacer-assisted membrane filtration. These membranes, featuring unique surface patterns like diamond (D) or honeycomb (HC) shapes created through 3D-printed replica molds with debossed geometries, were prepared using the phase inversion fabrication technique with polyethersulfone (PES) polymer solutions.

Comprehensive characterizations, including average porosity, pore size distribution, surface and cross-sectional morphologies, and hydrophilicity, were conducted. The diamond surface-patterned (D-Patterned) and honeycomb surface-patterned (HC-Patterned) membranes exhibited the highest water flux at  $76.6 \pm 16.9$  and  $88.3 \pm 17.4$  L/m<sup>2</sup>h, respectively (Fig. 1 (A)). Additionally, in 60-minute crossflow filtration experiments, these membranes exhibited reduced fouling from natural organic matter (NOM) compared to flat PES membranes, irrespective of the presence or absence of plastic feed spacers with analogous geometries (i.e., D spacer or HC spacer) as shown in Fig. 1 (B). The flux recovery ratio (FRR) after the second cycle of NOM filtration was  $83.2 \pm 2.2\%$  for D-Patterned,  $82.5 \pm 5.1\%$  for HC-Patterned, and  $77.7 \pm 4.5\%$  for the flat PES membranes. NOM rejection rates for the same membranes were  $73.8 \pm 0.9\%$ ,  $75.3 \pm 0.8\%$ , and  $81.8 \pm 0.5\%$ , respectively. The outstanding filtration performance of surface-patterned membranes underscores their superior anti-fouling and overall performance, making them a viable candidate for large-scale manufacturing and potential replacement of the current configuration used in spacer-assisted membrane filtration.

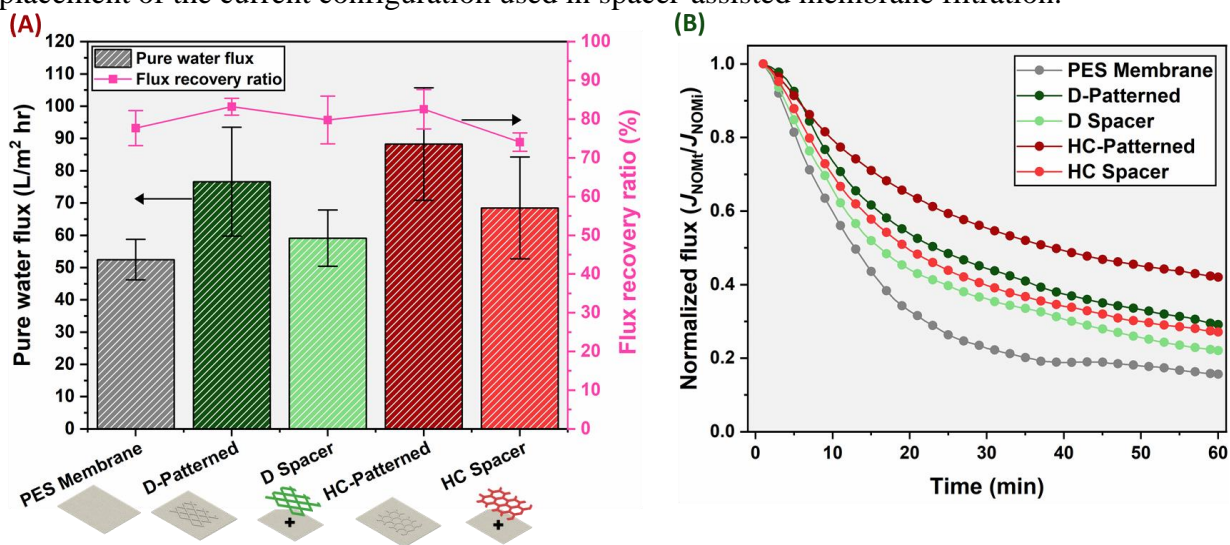


Figure 1. (A) Water flux and FRR (2<sup>nd</sup> cycle), and (B) Normalized flux over 60 mins of NOM filtration.

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# ELECTROCHEMICAL CONVERSION OF CARBON DIOXIDE INTO LONG CHAIN HYDROCARBONS ON FEMTOSECOND LASER-INDUCED COPPER OXIDES

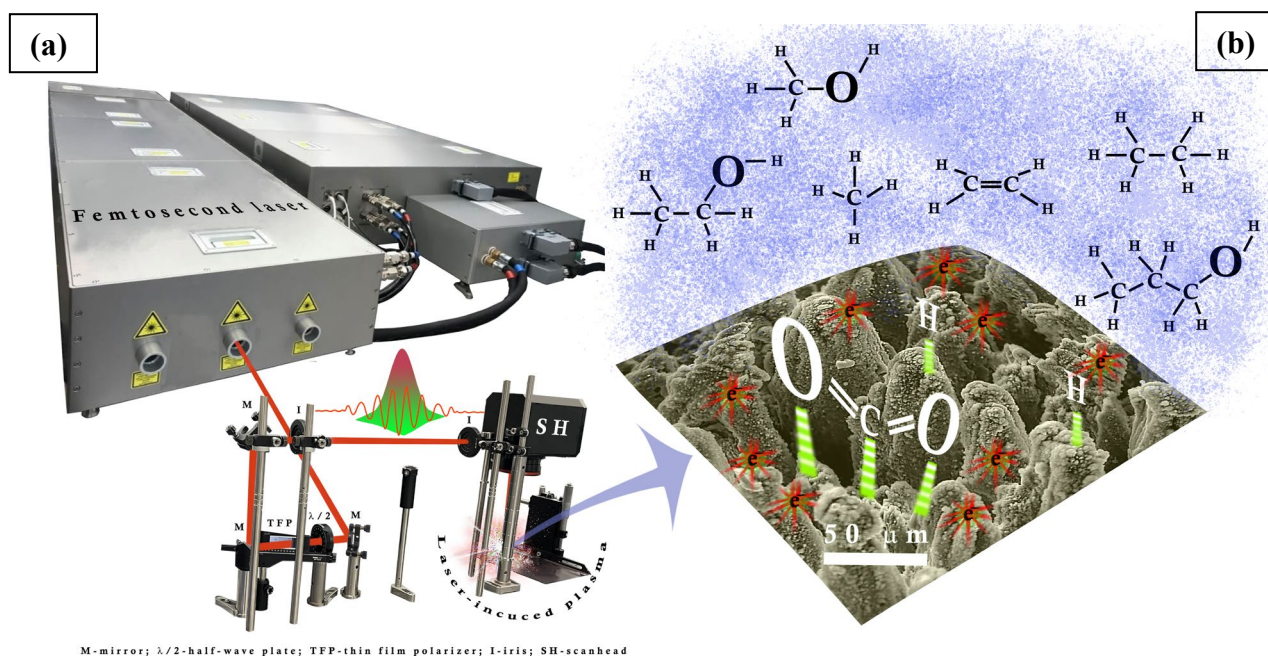
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Electrochemical reduction of CO<sub>2</sub> (ECR) into fuels and other value-added chemicals is a compelling strategy for energy security and CO<sub>2</sub> mitigation. Selective production of high density longer chain (C<sub>2+</sub>) hydrocarbons such as ethylene/ethane in the gas phase and ethanol/propanol in the liquid phase is very challenging. Herein, femtosecond laser is employed to synthesize copper oxide electrocatalysts and tune their selectivity towards C<sub>2+</sub> products. The laser induces favourable structural, morphological, and chemical changes for improved C-C coupling. A thorough investigation on the activity and selectivity is provided. The role of oxidation state and hierarchical structuring in steering the selectivity is highlighted.

To explore the effects on the imposed pressure on product selectivity, ECR experiments were conducted up to 4.5 bar in a custom designed Teflon lined stainless steel H-cell. Increasing the pressure improved CO<sub>2</sub> saturation, which in-turn increased the Faradaic efficiency (FE) of ethylene/ethane relative to H<sub>2</sub>. Further, a relative increase in the FE of liquid products was also witnessed with pressure. The activity of the catalysts was elucidated in terms of the onset and overpotentials ( $\eta$ ) witnessed for H<sub>2</sub>, CO, ethylene, and ethane. Electrochemical indicators such as charge transfer coefficient, electrochemical surface area (ECSA), turn over frequency (TOF), and TOF vs  $\eta$  analyses were also measured. This study is important because it not only unveils a facile route for tuning Cu selectivity but also provides important insights into the ECR on copper oxides.



**Figure 1.** Schematic of (a) femtosecond laser-based synthesis of hierarchically structured copper oxide electrocatalyst, and (b) electroreduction of CO<sub>2</sub> on the surface of this catalyst

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# Ecofriendly synthesis of ternary nanocomposite ( $\text{Fe}_3\text{O}_4/\text{SiO}_2/\text{Ag}$ ) from *Nerium oleander* leaves for catalytic degradation of environmental pollutants

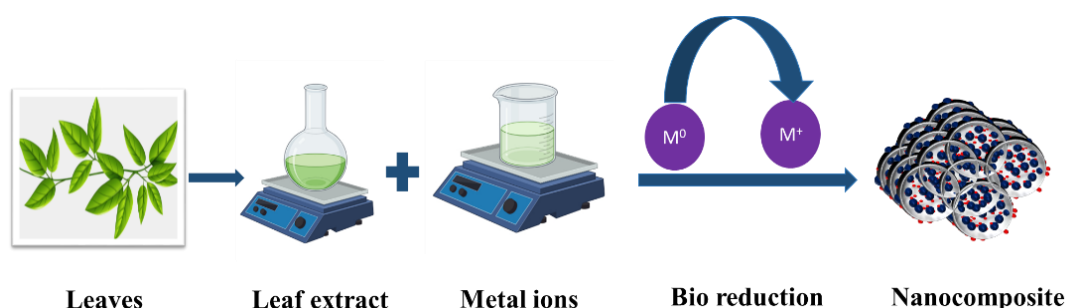
Zakia Kadid<sup>1,2\*\*</sup>, Krithikadevi Ramachandran<sup>1\*</sup>, Somia Hamil<sup>2</sup>, Soumya Columbus<sup>1</sup>  
Hussein M Elmehdi<sup>3</sup>, Kais Daoudi<sup>1,3</sup>, Mounir Gaidi<sup>1,3</sup>

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Synthesis of ternary nanocomposites using green and environmentally friendly methods, poses some challenges [1,2]. In this study, we successfully employed green techniques to produce the ternary nanocomposite  $\text{Fe}_3\text{O}_4/\text{SiO}_2/\text{Ag}$  (FSA). The analytical characterization of this nanocomposite included examinations of crystallinity, structure, morphology, and optical properties. X-ray diffraction (XRD) studies confirmed the presence of individual nanomaterials in the FSA nanocomposite through well-defined diffraction peaks. Transmission electron microscopy (TEM) revealed the specific characteristics of  $\text{SiO}_2$  in its microspheres shape as well AgNPs in spherical shape. Fourier transform infrared spectroscopy demonstrated the chemical bonds of Si-O-Si and Fe-O in the FSA nanocomposite. Optical analysis of nanocomposite revealed a broad absorption peak ranging from UV to visible region. The FSA nanocomposite exhibited catalytic activity in the degradation of both individual dyes and dye mixtures for water treatment applications. Notably, the FSA nanocomposite demonstrated efficient degradation in a short time span by their synergistic effect.



**Figure 1.** Green synthetic steps for the fabrication of  $\text{Fe}_3\text{O}_4/\text{SiO}_2/\text{Ag}$  nanocomposite

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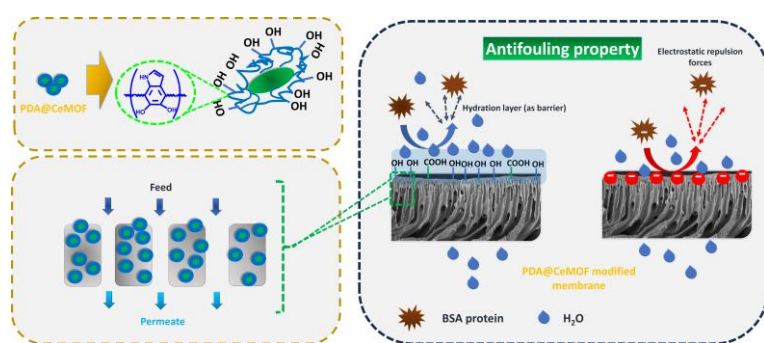
# SYNERGISTIC ADVANCEMENTS OF PDA-MODIFIED Ce-MOF FOR ENHANCED ANTIFOULING PERFORMANCE AND SELECTIVE SEPARATION IN PES ULTRAFILTRATION MEMBRANES

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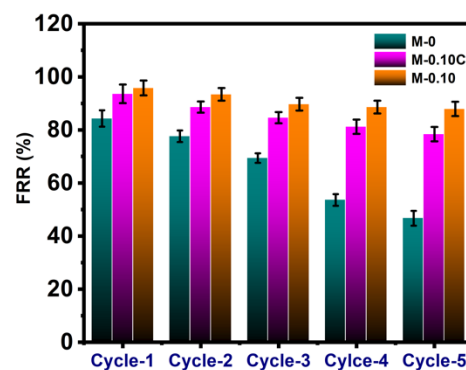
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The necessity for antifouling membranes is paramount, given the detrimental consequences of fouling on the effectiveness and lifespan of ultrafiltration membranes [1]. Metal-Organic Frameworks (MOFs) have recently surfaced as compelling additives in the construction of ultrafiltration (UF) membranes, demonstrating enhanced efficacy [2]. Nevertheless, a deliberate strategy is essential to leverage their advantages and mitigate potential drawbacks. In this study, polyethersulfone (PES) UF membranes were tailored with polydopamine (PDA)-modified cerium (Ce)-MOF (PDA@Ce-MOF) to achieve enhanced antifouling properties and improved removal of biological macromolecules such as bovine serum albumin (BSA) and humic acid (HA) from wastewater bodies. The non-solvent induced phase separation (NIPS) method was employed to simultaneously fabricate and modify the membrane with various PDA@Ce-MOF concentrations, ranging from 0.05 to 0.50 wt.%. Results demonstrated substantial improvements in the membrane's morphology, hydrophilicity, porosity, and pore size at a 0.10 wt.% loading of PDA@Ce-MOF. The synergistic effect of PDA and Ce-MOF on the membrane significantly enhanced the pure water flux (337 LMH) and filtration performance when dealing with Bovine serum albumin (BSA) and humic acid (HA), achieving 145 LMH with 98% rejection and 164 LMH with 88% rejection, respectively. Moreover, the water-attracting functional moieties of PDA@Ce-MOF played a key role in impeding the deposition of BSA protein on the membrane surface, resulting in an outstanding flux recovery ratio (FRR) of approximately 87%, along with mitigated irreversible fouling.



**Figure 1.** Schematic depiction of the antifouling mechanisms of the PES/PDA@Ce-MOF UF membrane.



**Figure 2.** FRR values of pristine (M-0), Ce-MOF modified (M-0.10C), and PDA@Ce-MOF modified PES membrane (M-0.10) over 5 filtration cycles.

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## Covalent organic frameworks (COFs) for the adsorption of radioactive iodine

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Nuclear energy continues to be an important supplier of electricity, but it has problems with waste management and the possibility to leak radioactive material. Iodine, a potentially harmful byproduct of uranium fission, is hazardous to both the environment and human health. Therefore, developing safe, effective, and affordable storage facilities for iodine waste is crucial. Owing to their well-controlled pore structure and substantial certain surface area, covalent organic frameworks (COFs) show promise for the adsorption of radioactive iodine. The newly developed COFs (SJ-COF, YA-COF, and AA-COF) shown amazing properties, including strong thermal and chemical stability, which made them ideal for efficient iodine capture. Notably, the ultrahigh iodine capture capacities of these COFs—8.52 g. g<sup>-1</sup>, 8.12 g. g<sup>-1</sup> and 7.01 g. g<sup>-1</sup>—were significantly greater than most previously reported materials. And The % removal efficiency for SJ-COF, YA-COF and AA-COF from I<sub>2</sub>/cyclohexane solutions were 87.0 %, 88.6% and 82.6 % respectively. It is noteworthy that the three COFs have high selectivity, reusability, and iodine retention abilities, maintaining iodine even after five recyclings. Based on the outcomes of the experiments, the adsorption processes of the three COFs were examined, and it was discovered that iodine was bound through physical-chemical adsorption. The findings of our work provide a ground-breaking standard for the removal of nuclear waste and demonstrate the enormous potential of COFs as adaptable porous structures that may be specifically designed to address major environmental concerns.

# Simulation, Economic and Environmental Analysis of a Mobilized Thermal Energy Storage System for Mediterranean Climate Buildings: Case Study

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Decades of research have been dedicated to the mobilized thermal energy storage system (M-TES), demonstrating its competitiveness alongside conventional heat generation methods such as oil/gas and biomass boilers. This study presents a notable case study set in a power plant, where waste heat is effectively harnessed using M-TES to provide both space heating and cooling in a university campus, as well as water heating. The study delves into the modelling of different heat exchangers within the M-TES system, with Erythritol serving as the chosen phase change material for latent heat storage. The simulation entailed replicating the charging phase, investigating the influence of Heat Transfer Fluid (HTF) flow, and assessing the potential of waste heat. The findings reveal that an increase in the heat transfer fluid causes a reduction in charging time and an enhancement in charging efficiency. Conversely, an escalation in waste heat potential leads to a decrease in charging efficiency, accompanied by a slight reduction in charging time. Furthermore, it provides insights into the discharging phase under varying loads, along with calculations related to the number of operational cycles and the effect of M-TES on power plant efficiency. Economic evaluation plays a crucial role in this research and is compared to previous studies. It demonstrates that the cost of heat (COH) decreases due to the increased scale and a greater number of containers. Moreover, using M-TES to cover both space heating and cooling loads proves to be more cost-effective compared to deploying it solely for heating purposes. This research opens avenues for sustainable and economically thermal energy storage solutions, with implications for a wide range of applications in the energy sector.

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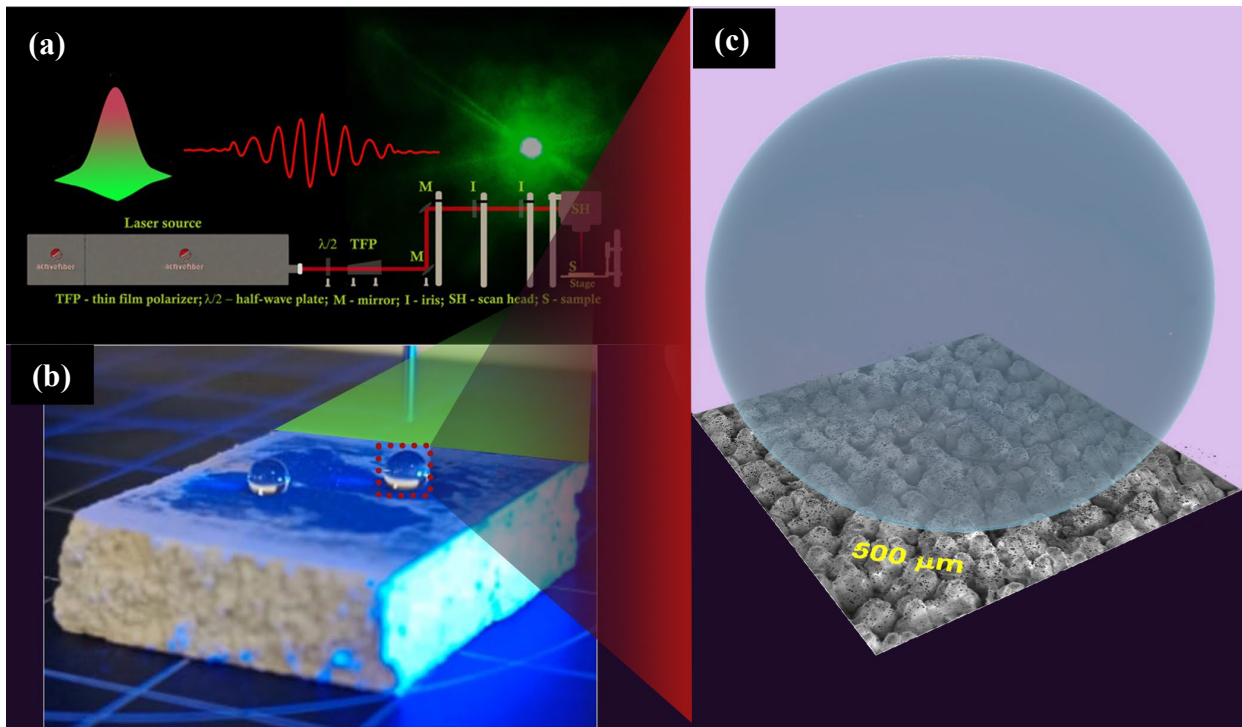
# FEMTOSECOND LASER-BASED FABRICATION OF SUPERHYDROPHOBIC CARBIDES FROM WASTE PLASTICS

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We report a method for developing superhydrophobic carbides from waste plastics by femtosecond laser-assisted carburization of metals, semiconductors, and oxides. A concentrated plastic dispersion is produced by femtosecond laser-ablation of polyethylene plastic submerged in toluene. Hydrogenated carbides are produced by dropwise application of the plastic dispersion onto the target material surface while being scanned with femtosecond laser at low power. Carbides of tungsten, silicon, and zirconium were synthesized with this method. These carbides exhibited remarkable hydrophobic characteristics. The hydrophobicity of these hydrogenated carbides was further enhanced with femtosecond laser-induced hierarchical structuring. A maximum water contact angle of around  $168^\circ$  and a minimum roll-off angle of approximately  $6^\circ$  were witnessed. The samples remained hydrophobic after 30 days of exposure to ambient air and remained so even after thermal treatments at  $100^\circ\text{C}$ . Using discarded plastics and avoiding fluorinated compounds to achieve superhydrophobicity while simultaneously producing carbides of immense technological importance makes this work significant from both an environmental and a technological standpoint. [1].



**Figure 1.** (a) Schematic of the femtosecond laser-assisted carburization process (b) An image of water droplets contacting superhydrophobic ZrC:H patterned over ZrO<sub>2</sub> substrate [1] (c) Schematic representation of a hierarchically structured hydrogenated carbide surface depicting superhydrophobicity

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# CONFINEMENT OF COMPRESSION ELEMENTS WITH FRCM SYSTEMS: A PROMISING ALTERNATIVE TO FRP CONFINEMENT

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Reinforced concrete (RC) structures face diverse damage throughout their lifespan, primarily from external factors. A key threat is the corrosion of steel reinforcement within the concrete, accelerated by cracks that facilitate the penetration of water and oxygen. The resulting internal pressure from steel corrosion leads to concrete cracking and delamination, significantly impacting structural integrity and reducing service life. In efforts to tackle such challenges, retrofitting, which involves strengthening or upgrading an older structure to improve its performance, load-carrying capacity, and durability is performed. One traditional and effective method involves the use of Fiber-Reinforced Polymers (FRP), where high-strength composite materials, such as carbon or glass fibers, are bonded to the existing structure to enhance its structural characteristics and mitigate the loss in the structural integrity of the RC system. While FRP boasts numerous advantages including durability, longevity, excellent fatigue resistance, non-conductivity, and ease of installation, it does have some disadvantages associated with it. Some of the disadvantages include weak resistance against fire, low reversibility [1], their vulnerability to ultraviolet (UV) radiations [2], and inability to be applied to wet surfaces. As an alternative solution to address these challenges, a novel material has emerged in recent years, with the objective of substituting the organic epoxy resin (commonly used in FRP) due to its association with the mentioned limitations. This innovative approach adopts a cement-based inorganic matrix to overcome the drawbacks associated with FRP. The resulting composite, where high-strength fibers are infused with an inorganic matrix, is known as fiber-reinforced cementitious matrix (FRCM), which is also known as Textile Reinforced Mortar/Concrete (TRM/TRC). The use of inorganic matrix makes FRCM more fire-resistant than FRP, as numerous research has shown FRCM to have better bond response at high temperatures [3-4]. Through utilizing FRCM systems, compatibility is achieved between the original building material and FRCM restoration system. Hence why FRCM systems are utilized in restoration works associated with historical buildings in Greece and Italy.

This research paper aims to review the repair potential of FRCM-jacketing techniques by comparing the results obtained from the literature for members subjected to compressive loading. The main variables included in this research study include slenderness, loading style (where some tests were conducted on eccentrically-loaded columns and others on columns subjected to seismic loading), damage level (fire, extreme loading, fatigue), type of FRCM, and cross-section of columns.

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# **Adsorption of lithium from brine using keratin derived from chicken feathers**

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With the rapidly growing global population, there is a continuous increase in the demand for resources, including Lithium. This trend is coupled with the raising of environmental issues due to mining for resources. As a result of that, it is imperative to explore alternative ways of mining for resources. Lithium is among the economically valuable elements to be extracted from different resources such as salt lakes and brines. Several techniques have been applied to extract lithium, such as solvent extraction, adsorption, precipitation, and membrane-based technology. However, it was concluded that adsorption shows high effectiveness and affordability in separating lithium ions from brines.

In this work, the adsorption of lithium from a synthesized sample of brine has been successfully achieved using keratin functionalized with a phosphoric group. Keratin was extracted from chicken feathers in an alkali medium to break down the structure of chicken feathers, followed by acidizing the medium to precipitate the keratin. Then, keratin was functionalized with 1 M phosphoric acid, acetic acid, or sulfuric acid to add a functional group to keratin. The adsorption of lithium was conducted with an initial concentration of lithium of 100 ppm at room temperature and for 24 hours with a continuous shaking at 500 rpm. By using inductively coupled plasma mass spectrometry, it was found that 31 mg/g adsorption capacity of lithium was achieved by functionalized keratin compared to 14.79 mg/g achieved by keratin only without functionalization. In addition to that, functionalizing keratin with phosphoric acid showed a superior adsorption capacity compared to other functionalizing agents. The work results prove the possibility of using keratin to achieve clean sustainable adsorption of lithium and suggest the possibility of achieving high adsorption capacities of lithium by appropriate functionalization of keratin.

# Integration of Finite Element Analysis and MBD Analysis for Different Component of a Racing Car Conversion

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Certification to race in a given group requires a safe and homologated vehicle. In this context, an Audi A3 is converted to a racing car. For providing passenger safety, a T45 carbon steel roll cage is designed and assessed via FEA under different loading scenarios. In addition, a redesign of the disc brake via a heat transfer simulation followed by a thermo-mechanical stress analysis showed that at a velocity of 150 Km/h, the maximum temperatures attained by the original and modified disc brakes are 300°C and 225°C respectively. Moreover, a suspension system is designed via multi-body dynamics analysis to give solace for the driver and absorb the shock. Through trial and error, a coil over with a stiffness of 80 N/mm and a damping coefficient of 0.3 N.s/mm is selected. Finally, the engine is homologated by modifying several parameters in order to increase power such as bore, stroke and valves. The total cost of the homologation is around 10,000 \$.

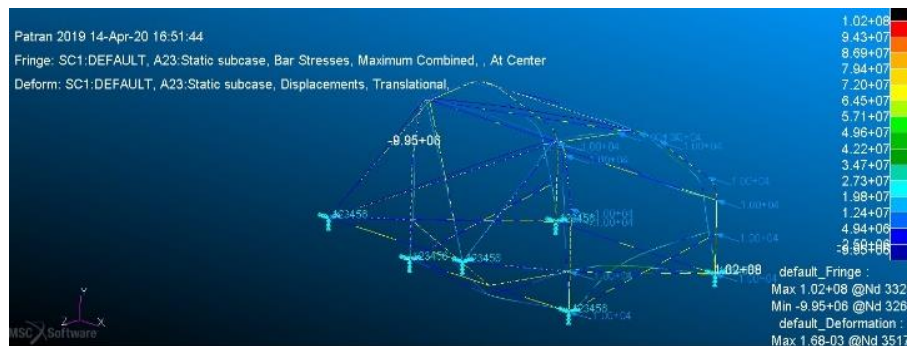


Figure 1. Results for the side impact case Combined stress (Pa)

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# Effect of Zycotherm Nano-based Warm Mix Additive on the Properties of Asphalt Binders in the UAE

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Warm-Mix Asphalt (WMA) additives are used to improve the performance and workability of the asphalt binders. This study used a nano-based saline, Zycotherm, to reduce the viscosity and improve the high-temperature performance of the asphalt binders. To investigate the impact of Zycotherm, penetration, softening point, viscosity and Dynamic Shear Rheometer (DSR) rutting parameter tests were carried out. Based on the results, the Zycotherm-modified asphalt binder with a percentage of 3% lowered the penetration by around 40% and the softening point by 4%, while increased the viscosity by 10% when compared to the control asphalt binder. Rheological testing showed a decrease in the complex shear modulus value and a decrease in the phase angle by around 24% for the Zycotherm modified asphalt binder, which means that the rutting resistance decreases by 13%. Zycotherm modified asphalt binder with a percentage of 1.5% showed nearly similar results as the 3% in terms of lowering the penetration by 20% and softening point by 2% while increased the viscosity even more than the 3% Zycotherm by an overall percentage increase of 11% when compared to the control asphalt binder. For the Rheological testing, the Zycotherm modified asphalt binder with a percentage of 1.5% also showed a 12% decrease in phase angle and complex shear modulus values.

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# Performance of Cement Mortar Mixtures containing Fine Aggregate and Admixtures

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The purpose of this study is to investigate the influence of the cement/sand (c/s) ratio on the behavior of cement mortar. The used c/s ratios in this study were 1:0, 1:0.45, and 1:0.83. The findings of this study showed that increasing the sand content reduces the compressive strength of the mortar mixture by 41.5 and 28.2% for the c/s ratios of 1:0.45, and 1:0.83, compared to the plain cement mortar (c/s: 1:0). The increase in sand content requires more water content to increase the workability and strength of the mixtures. However, the flexural strength slightly increased compared to the control mortar. In addition, to enhance sustainability, the cement was replaced with two waste industrial materials namely micro silica (MS) and fume treatment plant (FTP) dust by 20% of cement weight. The modified mixtures (c/s: 1:0) also showed reduced strength at the testing age. The compressive strength of the modified mixtures was reduced by 50% and 19% for the FTP and MS-modified mixtures, respectively. On the other hand, the flexural strength was reduced by 19.1 and 30.2% for the FTP and MS-modified mixtures. This reduction can help achieve certain strength requirements by lowering the cement content in cement concrete mixtures.

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# MXENE-BASED NANOCOMPOSITE ADSORBENT FOR SELECTIVE LITHIUM-ION SEPARATION

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**Keywords:** Lithium Recovery; MXene Nanocomposites; Adsorption; 2D materials.

The rapid expansion of sectors such as electric vehicles and sustainable energy solutions has driven a mounting concern regarding the depletion of global lithium reserves as well as the environmental ramifications of lithium mining practices. This research addresses these issues by developing a novel adsorbent for extracting lithium from brine, wastewater, and seawater, aiming to enhance the circular economy of lithium-ion batteries.

Focusing on two-dimensional (2D) nanocomposite materials, the study introduces a significant advancement with the development of MXene-based 2D nanocomposites, carefully engineered within a hydrogel matrix. These nanocomposites, including sulfonated graphene oxide and MXene, efficiently remove over 98% of lithium ions from brine and demonstrate excellent selectivity in the presence of various co-existing ions. The adsorbent, combining these components, shows high selectivity and efficiency in lithium-ion adsorption, indicating its potential as a scalable and effective lithium recovery solution.

This 2D nanocomposite presents a viable, effective solution for lithium-ion recovery, potentially mitigating the environmental footprint of conventional extraction methods. This advancement heralds more cost-effective, efficient lithium recovery methods from brine, crucial for the sustainable future of the lithium-ion battery industry.

# EXPERIMENTAL INVESTIGATION OF THE FLEXURAL BEHAVIOR OF CONCRETE CONFINED WITH WELDED WIRE REINFORCEMENT

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Rectilinear steel stirrups are commonly used for shear enhancement in reinforced concrete beams, yet they are associated with shortcomings, such as labor intensity, high costs, and manufacturing inconsistencies. Until recently, there have been limited use of welded wire reinforcement (WWR) as an alternative transverse reinforcement to stirrups. This type of reinforcement is manufactured through a cold-drawing process which affects the mechanical properties of steel by increasing its tensile strength but at the expense of reducing its ductility. In a companion study by the authors on the subject, Alhoubi et al. [1] found that WWR-reinforced beams perform well in shear, possessing 2-17% higher shear strength than stirrup-reinforced beams without much negative effect on the ductility. However, the impact of presence of WWR on flexural behavior was not considered in that research, which is crucial for structural applications. This study investigates the flexural behavior of concrete beams transversely reinforced with WWR, in which the steel mesh sheets are bent into a closed steel cage. While this method of reinforcement has the ability to control and manage diagonal tension cracks, it can also contribute to the flexural capacity of the member by confining the concrete within the core. The study involves testing six 2m-long beams with varying wire diameters (4, 6, 8 mm) and grid openings (25, 50, 100 mm). All beams had a longitudinal reinforcement ratio of 1.92%, with WWR yield strength equal to 509-590 MPa and concrete compressive strength equal to 35 MPa. A comparison was made between WWR-reinforced beams and equivalent stirrup-reinforced beams in which the stirrups had yield strength ranging 556-577 MPa. Results of the laboratory tests showed that WWR-reinforced beams had on average 15% higher flexural capacity, a modest 3% decrease in stiffness at service load, and a slight 1% increase in the flexural ductility compared to stirrup-reinforced beams. Moment-deflection relationships for the tested beam are shown in Figure 1. The theoretical component of the study confirmed that the flexural provisions of ACI 318 can reliably predict the bending moment capacity for WWR-reinforced concrete beams. However, it is recommended that longitudinal steel rebars should be added to the WWR closed steel cage, rather than solely depending on the WWR's longitudinal wires for flexural resistance.

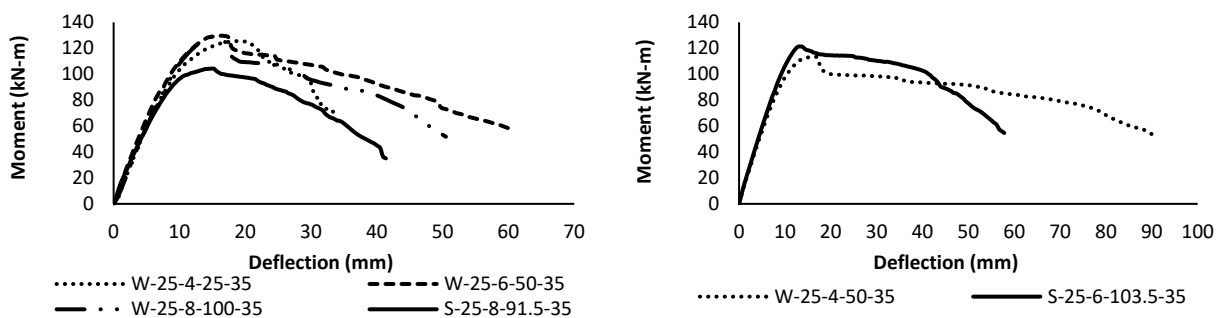


Figure 1. Moment-deflection curves for the tested beams.

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