# BOOK OF ABSTRACTS

10th of October 2024

# MATERIALS ENGINEERING SYMPOSIUM ON INNOVATIONS FOR INDUSTRY 2024

MESII

Sustainable Materials Innovations for Industrial Transformations

Organized by the Society of Materials Engineering Students

Department of Materials Science and Engineering

Faculty of Engineering

University of Moratuwa

**MATERIALS ENGINEERING SYMPOSIUM ON INNOVATIONS FOR INDUSTRY 2024**
Sustainable Materials Innovations for Industrial Transformations

Materials Engineering Symposium on Innovations for Industry (MESII-2024) is being organized for the 7th time by the Department of Materials Science and Engineering of University of Moratuwa. The main objective of this event is to facilitate the industry to recognize and gain awareness on the research activities carried out by the final year undergraduates of the Department as well as provide an opportunity to get a comprehensive understanding about the activities and facilities of the Department.

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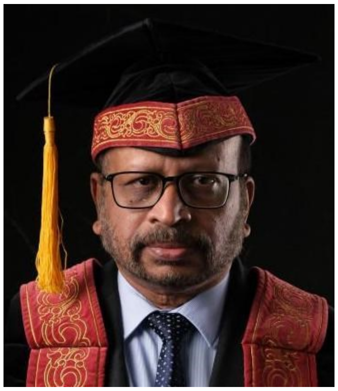
# Table of Contents

# Message from the Vice-Chancellor



It is with great pleasure that I extend my warmest congratulations to the Department of Materials Science and Engineering at the University of Moratuwa for organizing the 7th Materials Engineering Symposium on Innovations for Industry (MESII) -2024, themed "Sustainable Materials Innovations for Industrial Transformations." This significant event serves as an important platform for advancing research, encouraging collaboration, and showcasing the innovative advancements made by the department in the field of Materials Science and Engineering.

As the Vice Chancellor, I am proud of the department's ongoing efforts in pushing the boundaries of knowledge and its steadfast dedication to addressing global challenges through sustainable material solutions. The theme of this year’s symposium reflects the essential role that materials science plays in driving industrial transformations, particularly as industries worldwide shift towards more sustainable practices.

The contributions of our students and researchers are key to this transition. Their work, featured in this symposium, highlights the intersection of cutting-edge research and real-world applications, demonstrating how innovative materials can contribute to a sustainable future. I am continually impressed by the depth of their research and their commitment to making meaningful contributions to both academia and industry.

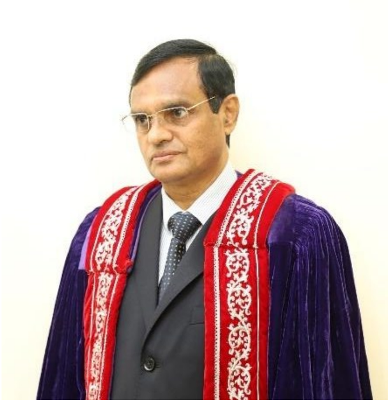
The University of Moratuwa strongly emphasizes building university-industry collaborations, recognizing that these partnerships are vital for equipping our students with practical insights into the real-world demands of industry. The insights shared at this symposium will undoubtedly inspire future collaborations that drive innovation and create lasting impacts.

I extend my best wishes for the success of the symposium and express my sincere appreciation to all who have worked tirelessly to bring this event to fruition. Let this gathering of bright minds and industry leaders continue advancing sustainable innovations that will transform industries for the betterment of society.

Prof. N. D. Gunawardena

Vice-Chancellor

## Message from the Acting Dean



I would like to extend my heartfelt congratulations to the Department of Materials Science and Engineering at the University of Moratuwa for successfully organizing the seventh annual symposium, themed "Sustainable Materials Innovations for Industrial Transformations." This symposium provides an excellent platform for our final-year undergraduates to present their research findings to a diverse audience that includes both academia and industry professionals. It is a proud moment for the Faculty of Engineering to witness the creativity and innovation demonstrated through the students' final-year project work.

The symposium plays a key role in fostering collaboration between academia and industry, especially in the context of research and development. The exposure and feedback received from industry partners will undoubtedly help the Department fine-tune its future research directions and better align with industrial needs. Moreover, it highlights the importance of preparing prospective engineering students with a clear understanding of the opportunities and scope within the field of Materials Engineering, enabling them to make informed career choices.

This symposium is a reflection of the Faculty’s commitment to nurturing independence, self-reliance, and innovative thinking in our undergraduates, ensuring they are well-equipped to face future challenges. The research and skills gained through these experiences will not only add value to the already distinguished engineering degree but also contribute to the broader development of the country through innovative solutions.

I extend my best wishes for the success of this event and sincerely hope that the knowledge, insights, and collaborations formed here will have a lasting impact on the next generation of materials engineers. May this symposium continue to serve as a beacon of excellence for both the department and the Faculty of Engineering.

Prof. Asoka Perera

Acting Dean, Faculty of Engineering

## Message from the Head of the Department

It is with great pleasure that I extend my congratulations to the Department of Materials Science and Engineering, in collaboration with the Society of Materials Engineering Students, for organizing the seventh Materials Engineering Symposium on "Sustainable Materials Innovations for Industrial Transformations". This symposium stands as an important milestone for showcasing the outstanding research efforts of our undergraduates, while also strengthening the department's engagement with industry and strengthening the connections between academia and industry.

The symposium, which was originally initiated by Prof. (Mrs.) Asha Galhenage, began with the twofold objective of highlighting the research capabilities of our students and enhancing department-industry interactions. Over the years, it has grown significantly, evolving into a prominent event that brings together students, academics, and industry professionals to explore innovative solutions for industrial transformation.

I would like to take this opportunity to express my sincere appreciation to Dr. (Mrs.) Hansinee Sitinamaluwa, this year's program chair, for her dedication, planning and commitment to ensuring the success of this event are truly commendable. I also extend my heartfelt thanks to all the academic and non-academic staff of the department for their continued support.

Additionally, I would like to commend the members of the Society of Materials Engineering Students, who have worked tirelessly to organize this event.

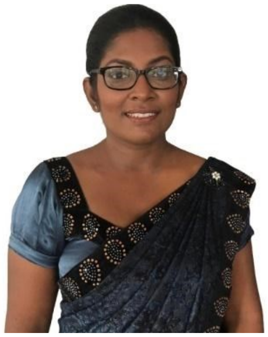
Finally, I wish to congratulate all the young researchers who will be presenting their papers and posters. Your work is a reflection of the creativity, innovation, and problem-solving skills that are developed within the Department of Materials Science and Engineering. I am confident that your research will have a meaningful impact on both industry and society.

Mr. V. Sivahar

Head/Department of Materials Science and Engineering

Faculty of Engineering, University of Moratuwa

## Message from Symposium Chair



It is my great pleasure to welcome you to the 7th Materials Engineering Symposium on Innovation for Industry (MESII) - 2024. This event provides a platform to celebrate the remarkable achievements of our undergraduate students, explore cutting-edge advancements in materials engineering, and foster stronger connections between academia and industry. Our students have demonstrated exceptional organization skills in planning and executing this symposium, and their commitment to excellence is evident in the quality of the research presented here today. Your active participation is what makes MESII a thriving space for collaboration and knowledge exchange.

This year, MESII 2024 places a primary emphasis on showcasing our research strengths to the industry. We aim to highlight the wide-ranging capabilities of our students and faculty and demonstrate the impact of our research on solving real-world challenges. Through oral and poster presentations, we hope to inspire industry stakeholders to explore potential avenues where our work can support their needs and innovations.

In addition to showcasing our research, we are excited to introduce new initiatives aimed at fostering collaborations between academia and industry. One key initiative is implementing a mechanism for industry collaborative projects. We believe that hands-on exposure to real-world industry challenges is key to enhancing the learning experience for our students. During MESII 2024, we will be exploring pathways to implement collaborative projects where industry partners can propose and guide final-year research projects. This will not only help address industry-specific needs but also prepare our students for a seamless transition into professional roles.

I am confident that MESII 2024 will open new avenues for collaboration, drive innovation, and help us collectively contribute to the growth of our industries. I encourage everyone to actively participate in the discussions and networking opportunities throughout the event. Thank you for being part of MESII 2024, and I look forward to an inspiring and productive symposium.

Dr. Hansinee Sitinamaluwa

Symposium Chair – MESII-2024

# List of Abstracts

# Biodegradable Chitosan-Nanohydroxyapatite Bone Scaffolds: Fabrication, Characterization, and Optimization

**N. B. N. Nuwarapaksha, D. L. L. Perera, and S. U. Adikary***

*Department of Materials Science and Engineering, University of Moratuwa*

**Email: suadi@uom.lk*

Bone defects with critical-size fractures require clinical intervention for fracture healing. Commonly used treatments have limitations like donor morbidity, limited donors, and mechanical mismatches. Bone scaffolds are developed to address these limitations and improve bone formation, vascularized ingrowth, and biodegradability as bone remodels. In this study, bone healing scaffolds have been fabricated using a coprecipitated chitosan-nanohydroxyapatite composite. Fourier-transformed infrared spectroscopy, scanning electron microscopy, energy dispersive x-ray analysis, x-ray diffraction spectroscopy and thermogravimetric analysis were used to analyze the extracted chitosan and composite. Cylinder-shaped bone scaffolds were obtained by freeze-drying the composite with gelatin. Scaffold fabrication experiments were conducted by varying the composite: gelatin ratio for better shape retention and mechanical properties. Bone scaffolds were analyzed for porosity, pore size distribution, compressive strength and in-vitro bioactivity. An optimum composition in terms of shape retention and other required properties was obtained by the scaffold fabricated using 70% composite (Chitosan: nanohydroxyapatite - 70:30) and 30% gelatin. This sample had 85% porosity, exhibiting a compressive strength of 0.2 MPa that mimics the compressive strength of cancellous bone. The bioactivity of the scaffolds was successfully analyzed by conducting an in vitro biomineralization test for the composite and an in vitro biodegradation test for the scaffold.

**Keywords**: *Chitosan, Nanohydroxyapatite, Bone scaffolds, Biomimetic scaffolds*

# CaO Synthesized By Eggshells to Control Salt Stress

**W. D. S. Y. Gunawardane, G. T. Karunaratne, and A. S. Galhenage***

*Department of Materials Science and Engineering, University of Moratuwa*

**Email:* galhenagea@uom.lk

Rising environmental concerns have fueled the search for sustainable solutions in agriculture. This research delves into the potential of eggshell-derived Calcium Oxide (CaO) as a promising biogenic material and an eco-friendly strategy to combat salt stress in plants, a major threat to crop productivity. This research reviews the synthesis and application of eggshell-derived CaO for salt stress management. The findings reveal that nano CaO derived from eggshells can effectively improve soil health, promote plant growth, and contribute to sustainable agricultural practices. The research highlights the role of calcium in alleviating the adverse effects of salinity by improving ion balance and physiological processes in plants. By utilizing readily available waste material, this study not only provides a practical solution to soil salinity challenges but also emphasizes the importance of waste utilization in fostering environmentally friendly agricultural practices.

**Keywords:** *Nano Calcium Oxide, Eggshells, Sustainable Agriculture, Soil Quality, Salinity, Eco-friendly Materials, Waste Utilization, Agricultural Applications*

# Determination of Strength of Weld Joints Using Ultrasonic Testing and Machine Learning

**N. C. Nanayakkara[1], K. W. G. P. A. Bandara[1], V. Sivahar[1]*, and A. T. P. Silva[2]**

[1]*Department of Materials Science and Engineering, University of Moratuwa*

[2] *Department of Computational Mathematics, Faculty of Information Technology, University of Moratuwa*

*Email: vsivahar@uom.lk*

Ultrasonic Testing (UT) is one of the well-known Non-Destructive Techniques (NDT) employed for weld inspection in industries. However, the relationship between the UT parameters and the strength of the welded joints subjected to various loading conditions is unknown.

The main purpose of this research is to present an integrated search system as a new approach for the assessment of tensile strength of the electric arc welded joints. To this end, electric arc. The novel approach of the present research is to provide a new methodology for static strength of electric arc welded joints based on the UT results by utilizing the XG Boost regressor machine learning model. Through this model, we will be able to predict welded joint strength without the conventional tensile testing. This approach helps to decrease the number of tests and the cost of performing destructive tests with appropriate reliability.

**Keywords:** *ultrasonics, machine learning, strength, weld joints*

# Development of a Microscopic Method to Determine the Alpha Phase Percentage in Homogenized Aluminium 6063 Alloy

**M. M. M. M. Bandara, S. P. Guluwita*, and G. I. P. De Silva**

*Department of Materials Science and Engineering, University of Moratuwa*

**Email: sguluwita@uom.lk*

This research introduces a microscopic method to quantify the alpha phase in homogenized Aluminium 6063 alloy, focusing on improving the understanding of phase transformation during homogenization. The study aims to convert β-AlFeSi intermetallic particles into more desirable rounded α-Al(FeMn)Si particles. Through the use of Scanning Electron Microscopy (SEM) and Energy Dispersive X-ray Spectroscopy (EDAX), the morphology and chemical composition of the alloy were examined. Advanced image processing and machine learning techniques were applied to enhance the accuracy of identifying and quantifying alpha and beta phases. This method not only improves the efficiency of detecting intermetallic particles but also provides a reliable mechanism to evaluate phase transformation during the heat treatment process. Results indicate successful quantification of the phase transformation, with a higher proportion of alpha particles post-homogenization, confirming the effectiveness of the proposed method.

**Keywords:** *Aluminum, 6063, transformation, alpha, beta, SEM, EDAX*

# Development of a New Composite for Spars in Unmanned Aerial Vehicle Wings, with Increased Strength-to-Weight Ratio

**D. M. P. S. Dissanayake, M. A. T. Devindi, A. M. P. B. Samarasekara*, and A. A. G. A. Abeygunawardane**

*Department of Materials Science and Engineering, University of Moratuwa*

**Email: bandu@uom.lk*

The primary structure of an unmanned aerial vehicle (UAV) wing typically consists of outer wing skins attached (either bonded or fastened) to a main wing spar, both made from advanced composite materials. The main wing spar is designed to bear the primary bending and transverse shear loads, while the wing skin handles torsional loads. Therefore, it is critical to develop a high-strength spar capable of withstanding these loads while maintaining a lightweight structure. This report presents an in-depth investigation into the development of a new composite material specifically designed for UAV wing spars to enhance the strength-to-weight ratio.

The study includes a detailed review of the fabrication techniques currently used for the existing materials, as well as the synthesis and composition of the new composite. Structural integrity and load-bearing capacity were evaluated through three-point bending and load tests, yielding valuable data for further optimization. Tensile tests were also conducted under various conditions to assess the material's mechanical properties.

In addition to experimental work, numerical analyses using SolidWorks 3D modeling and COMSOL Multiphysics simulations were employed to analyze the composite's behavior under different conditions, including structural loads and fatigue life cycles. The combination of experimental data with computational simulations provides a comprehensive understanding of the current composite's performance and offers critical insights for the development of high-strength, lightweight materials for UAV wing spar applications

**Keywords:** *Unmanned Aerial Vehicles (UAV), spar, composite, strength, durability, service life, numerical analysis, three-point bending, tensile test, SolidWorks, COMSOL, Finite Element Analysis (FEA), fatigue life analysis.*

# Development of Exhaled Breath Analyzer

**M. M. D. Samintha, D. R. C. Thalayarathna, and D. Attygalle***

*Department of Materials Science and Engineering, University of Moratuwa*

**Email: dattyga@uom.lk*

This study investigates the elevated levels of acetone found in the exhaled breath of diabetic patients compared to healthy individuals. A gas sensor, constructed from Zinc Oxide nanoparticles, will be employed to quantify the acetone concentration in exhaled breath. The research primarily aims to explore the relationship between the material and electrical attributes and the gas sensing performance of Zinc Oxide nanoparticles under UV excitation.

**Keywords:** *Gas sensor, Zinc Oxide, Acetone, Nanoparticles, UV excitation*

# Development of Low-Cost Wall Panels Using Waste Foundry Dust

**K. M. D. N. De Silva[1], M. U. S. Jayarathna[1], G. I. P. De Silva[1]*, and T. N. Fernando[2]**

[1]*Department of Materials Science and Engineering, University of Moratuwa*

[2]*National Engineering Research and Development Centre of Sri Lanka*

*Email: indikagip@uom.lk*

Waste foundry dust (WFD), a residual material generated by the metal casting industry, presents a significant environmental challenge due to its high volume and current disposal practices, which primarily involve landfilling. This research investigates the potential of WFD as an economically viable construction material for the development of wall panels. The study aims to address the depletion of high-cost and limited natural resources by proposing a substitute material that is both readily available and cost-effective. The research encompasses a comprehensive framework encompassing material selection, processing techniques, and rigorous testing protocols to evaluate the feasibility of incorporating WFD into wall panel production. Performance evaluation will focus on key parameters including flexural strength, thermal conductivity, and water absorptivity, benchmarking against existing wall panel products in the market. Sample 4, composed of a 1:1 ratio of cement and laterite soil, 0.75 foundry dust, and 0.25 biochar, exhibited the highest flexural strength at 4.56 MPa. This sample also demonstrated a thermal conductivity of 0.134 W/mK and a water absorptivity of 21.97%. Through the development of a cost-effective wall panel utilizing WFD, this research endeavors to contribute to the advancement of green building practices within the construction industry.

**Keywords:** *waste foundry dust, wall panel, laterite soil, biochar, flexural strength*

# Development of Optical Property Based Oil Quality Analyzer

**P. S. K. Perera, B. M. S. B. Bogahawaththa, and D. Attygalle***

*Department of Materials Science and Engineering, University of Moratuwa*

**Email:* dattyga@uom.lk

This article introduces a highly sensitive, rapid and low-cost sensing method for online analysis of engine oil quality and predicts the exact time of oil expiration. The multi-mode optical fiber (MOF) is tapered with great accuracy in measuring the oil refractive index values in engines. In this research, viscosity is considered as the most critical parameter of the engine oil, which contributes to the oil degradation. By comparing the viscosity values of the oil and refractive index values of the oil, the exact quality of the oil is predicted.

**Keywords:** *refractive index, viscosity, optical properties, oil quality, engine oil*

# Development of Shape Memory Polymer Nanocomposites for Aerospace Applications

**G. W. Y. De Zoysa, D. M. K. D. Dissanayake, and A. M. P. B. Samarasekara***

*Department of Materials Science and Engineering, University of Moratuwa*

**Email:* bandu@uom.lk

This study explores the integration and characterization of shape memory composites designed for aerospace engineering, with a focus on Cyanate Ester (CE) as the shape memory polymer (SMP). CE-based SMPs are recognized for their exceptional high-temperature properties, stemming from the Cyanurate network formed during curing, which enhances their resilience in harsh environments. The shape memory properties of CE are further improved by introducing flexible modifiers into its highly crosslinked structure. Cyanate Ester/Polyethylene Glycol (PEG) composites are highlighted as sustainable SMPs for space applications due to their high glass transition temperature, superior mechanical properties, and durability. This work examines how varying PEG content influences the glass transition and curing temperatures. Characterization techniques, including SEM, FTIR, DSC, TGA, and mechanical testing, are employed to evaluate the performance of these composites. The study aims to optimize mechanical strength, thermal stability, and shape memory behavior, advancing the development of aerospace materials for deployable structures, hinges, antennas, and morphing components, particularly in high-temperature environments.

**Keywords:** *Shape Memory Polymer Composites, Cyanate Ester, Glass Fiber Reinforced Composites, Aerospace Applications*

# Development of Sustainable Cement Based Material for Additive Manufacturing

**D. N. G. Jayananda, S. H. Liyenage, and G. I. P. De Silva***

*Department of Materials Science and Engineering, University of Moratuwa*

**Email:* indikagip@uom.lk

This paper presents experimental results on the optimization of sustainable cement-based mix for additive manufacturing techniques. An extrusion-based 3D Cement Printing (3DCP) machine was modified for the experiment according to the requirement. Cement-based mix was designed and tested for the printing process. A mix design was tested for the fresh properties of the mix: extrudability, flowability, workability, buildability and open time. The printing machine and parameters were enhanced to achieve the required properties of the printing process. The potential of enhancing sustainability of the mix was investigated by reducing the carbon footprint of the process. Supplementary cementitious materials (SCMs) such as fly ash and silica-fume were considered as environmentally friendly materials to add as a portion of binder to the mix. This experiment yielded in mixing fly ash and silica fume to replace conventional binder proportionally, successive in fresh properties. The effect of additives in the cement mic was observed.

**Keywords:** *3DCP, Additive manufacturing, Mix design, optimized concrete mix design, Sustainability, Printing parameter.*

# Enhancing Mechanical Properties of Nylon – 6 Using Eggshell Powder as a Reinforcement

**H. G. M. J. Thilakarathne, D. G. S. M. Shirantha, and S. V. Udayakumara***

*Department of Materials Science and Engineering, University of Moratuwa*

**Email:* udayakumara@uom.lk

This research investigates the formation and composition of eggshell powder (ESP) obtained through two distinct methods: one involving the inclusion of the inner shell membrane and the other without. Eggshells underwent washing, drying, and milling processes to produce ESP. The impact of milling time (6, 9, and 12 hours) and method (dry and wet) on particle size was explored for both types of eggshells. Thermogravimetric analysis determined the calcium carbonate composition of ESP, while scanning electron microscopy (SEM) and ImageJ software were employed for particle size analysis. Results indicate that ESP without the shell membrane exhibited thermal stability up to 600 °C, with subsequent decomposition releasing 44.39% mass due to calcium carbonate decomposition. The composition of calcium carbonate in ESP without the shell membrane was approximately 97.68%. Conversely, ESP with the shell membrane showed a weight loss of 5.2% around 350 °C, resulting in a calcium carbonate composition of 94.34%. SEM images revealed that increasing milling time led to a reduction in particle size within a certain range, while particles started to agglomerate after 12 hours. The presence of the inner shell membrane had minimal impact on particle size. Plastomilled nylon composites with different ESP percentages (10%, 15%, 20%) were tested for water absorption percentage and hardness. Additionally, plastomilled nylon composites were tested for tensile properties. Results indicate that optimal mechanical properties were exhibited in the 15% ESP composition, and the eggshell membrane had an impact on the bonding between polymer chains and powder particles inside the matrix voids. Having an inner shell membrane improved the overall mechanical properties at 15% composition.

**Keywords:** *Eggshell Powder (ESP), TGA, Ball mill, Scanning Electron Microscope (SEM), Plastomill, Durometer, Tensile Testing*

# Extraction of Limonene from Citrus Peels and Its Application as an Eco-Friendly Insect Repellent

**V. S. Manatunga, M. G. C. L. Jayawardhana, and S. V. Udayakumara***

*Department of Materials Science and Engineering, University of Moratuwa*

**Email: udayakumara@uom.lk*

Many plants are frequently referred to as natural pesticides because of their insecticidal qualities. The peel of the orange fruit contains large amounts of the compound d-limonene, which makes it a valuable fruit in addition to being edible. A common pesticide in commercial insect repellents is d-limonene. D-limonene, found in orange peel oil, ranges from 90 to 95 percent and acts as a repellent for ants, mosquitoes, and flies. Flies and mosquitoes are kept away from gardens by scattering pieces of orange peel around. An at-home method for avoiding mosquito bites is to rub orange peel on the skin. Important naturally occurring bioactive substances such as ascorbic acid, essential oils, and antioxidants are found in citrus species. Citrus fruit peels, which are frequently thrown away as waste, contain a complex mixture of volatile and non-volatile compounds that are extracted into essential oils. Conventional methods such as steam distillation and solvent extraction, while simple and robust, yield lower percentages. In contrast, novel methods, despite being more effective, tend to be less cost-efficient. This paper specifically focuses on refining the steam distillation process for improved extraction of orange oil, and the experimental setup involved a forced choice test, where ants were given the option to escape from a petri dish via two microscope slides: one treated with the limonene solution and one untreated as a control. The results indicated a significant repellent effect, with a much lower number of ants choosing the treated slide. This demonstrates the potential of limonene as a sustainable alternative to synthetic insect repellents.

**Keywords:** *limonene, steam distillation, orange peels, insect repellent, citrus oil*

# GO-PES Membrane for Industrial Dye Effluent Water Purification

**K. G. N. Gamage, A. M. S. S. Athapaththu, and H. S. Sitinamaluwa***

*Department of Materials Science and Engineering, University of Moratuwa*

**Email:* hansinees@uom.lk

Clean water scarcity is a major global issue, posing significant challenges for both the environment and human health. A major concern in industrial wastewater management is the presence of elevated concentrations of dyes in water systems. Graphene-based nanomaterial membranes offer a proactive solution, effectively removing industrial dye contaminants from water. The intrinsic two-dimensional structural attributes and remarkable properties exhibited by graphene and graphene oxide (GO) provide opportunities for their integration into nanoporous materials. When combined, these materials offer modifiable characteristics, enabling fine-tuning for enhanced efficacy in water filtration applications. Utilizing a pressure-assisted technique, synthesized GO-PES (GO-Polyether Sulfone) nanoporous membranes demonstrate heightened efficacy in the removal of Methylene Blue (MB) and Methyl Orange (MO), excelling particularly in key parameters such as membrane selectivity and permeation flux. In this study, industrial dye filtration membranes were synthesized using four different concentrations of graphene oxide (GO) to modulate the amount of GO incorporated. The results reveal notable trends: for MB, selectivity increased from 65.1% to 72.4% as GO concentration rose, while flux decreased from 0.03332 to 0.01806 m3/m2s. Similarly, for MO, selectivity increased from 47.9% to 72%, with flux decreasing from 0.02968 to 0.01851 m3/m2s.

**Keywords:** *Graphene-oxide, membrane, filtration, industrial dye effluent, Methylene Blue, Polyether Sulfone*

# Graphene Oxide-Based Nanofluid for Heat Transfer Applications

**M. D. P. Arachchi[1], D. M. C. Sandaru[1], S. M. Rajapaksha[2], A. A. G. A. Abeygunewardane[1], and H. S. Sitinamaluwa[1]***

[1]*Department of Materials Science and Engineering, University of Moratuwa*

[2] *Department of Materials and Mechanical Technology, University of Sri Jayawardenepura*

**Email:* hansinees@uom.lk

This research investigates the performance of Graphene Oxide-Deionized Water (GO-DI water) nanofluid, and partially reduced Graphene Oxide-Deionized water (prGODI water) nanofluid for enhanced heat transfer efficiency. GO and prGO were derived from Sri Lankan graphite via the modified hummers method followed by thermal reduction in a tube furnace. The effect of particle loading was analyzed on the viscosity, thermal conductivity (TC) and stability of nanofluid. The results show that the nanofluids beyond mass loading of 0.5 wt% of GO/prGO show poor stability. prGO was found to be more effective in enhancing the TC of the nanofluid, due to the enhanced TC of the prGO particles. TC enhancement of nanofluids up to 30% was achieved, with the highest increment shown by the nanofluid with 0.75 wt% prGO. Furthermore, the thermal transport characteristics of the nanofluids were computationally modelled using finite element analysis. The average convection heat transfer coefficient (CHC) of 0.5 wt% prGO-based nanofluid showed a 52% increment, highlighting the effectiveness of prGO-based nanofluids. Importantly, the nanofluids with particle concentrations below 0.5 wt% show performance enhancement ratio (PER) values suitable for practical applications. The outcome of this research shows the potential of GO-based nanofluids as state-of-the-art heat transfer fluids to be used in the coolant industry.

**Keywords:** *Graphene Oxide, Nano Fluid, Thermal Conductivity, Convection Heat Transfer, Stability, Viscosity.*

# Integration of Cure Kinetics and Mathematical Modeling for Rubber Curing Process Optimization

**W. A. G. L. Kavindi, G. P. M. Geeganage, and V. S. C. Weragoda***

*Department of Materials Science and Engineering, University of Moratuwa*

**Email:* sampathw@uom.lk

The rubber industry produces a variety of products, including tires, gloves, footwear, and industrial components. Rubber curing is a complex process that involves heat, pressure, and time, transforming raw rubber into durable products. Optimizing this process requires accurate prediction of curing parameters, making mathematical simulations a valuable tool. This study aims to predict curing behavior qualitatively, estimating the rate and degree of cure over time at specific temperatures. A user-friendly software developed in this project generates curing parameters based on rheometer test data under isothermal conditions. This method eliminates the need for extensive laboratory work, providing an efficient way to determine optimal curing conditions. The software can also generate temperature profiles for specific points in rubber articles. Rheometer graphs from an RPA Flex machine provide the quantitative data for these simulations.

**Keywords:** *rubber curing, mathematical modeling*

# Machine Learning-Based Pb Replacements for Perovskite Solar

**H. A. H. M. Wijerathne[1], M. G. M. M. Karunarathna[1], G. A. Sewvandi[1]*, and P. Abeygunawardhana[2]**

[1]*Department of Materials Science and Engineering, University of Moratuwa*

[2]*Faculty of Computing, Sri Lanka Institute of Information Technology*

**Email: galhenagea@uom.lk*

The quest for efficient and environmentally friendly alternatives in the field of solar energy has led to an expanding interest in perovskite solar cells. This research explores the synthesis and optimization of perovskite materials as lead (Pb) replacements, addressing the environmental concerns associated with traditional formulations. The study comprehensively explores the intricacies of perovskite solar cells, covering fundamental concepts such as perovskite structure, influencing factors, and the essential principles of machine learning. In pursuit of sustainable alternatives, the project defines three pivotal target factors: the formability of perovskite materials, their band gap properties, and their efficiency when integrated into solar cells. Utilizing machine learning methodologies, the research employs diverse algorithms to predict and optimize these critical factors. The application of machine learning facilitates a systematic exploration of the vast parameter space, enabling the identification of novel perovskite formulations with enhanced properties.

By harnessing the power of machine learning, this research contributes to the advancement of eco-friendly energy solutions, offering valuable insights for the sustainable evolution of perovskite solar cell technology. The findings hold significant implications for the renewable energy sector, guiding future strategies towards more environmentally conscious and efficient solar power solutions.

**Keywords:** *Perovskite, Machine learning, Band gap, PCE*

# Mathematical Modeling of Rubber Elasticity and Stress – Strain Behavior Under Dynamic Loading

**H. A. A. Gamage, W. M. P. M. Gunasinghe, and V. S. C. Weragoda***

*Department of Materials Science and Engineering, University of Moratuwa*

**Email: sampathw@uom.lk*

Rubber, a versatile material used across fields such as materials science, physics, and civil engineering, has been widely studied for its elastic and dynamic properties. Researchers aim to understand how rubber-like materials, such as tires, respond to varying loads. This study focuses on developing a refined mathematical model for rubber elasticity and stress-strain behavior under dynamic conditions, combining mathematical modeling with experimental analysis. Current models like the Generalized Maxwell Model, Fractional Derivative Model, Mooney-Rivlin Model, and Prony Series have limitations in fully capturing the comprehensive behavior of rubber under dynamic stress. Using a Rubber Process Analyzer (RPA), this research involves careful sample preparation, iterative testing, and data analysis. Establishing a reliable mathematical model for rubber elasticity under dynamic conditions is critical for advancing the knowledge and exploring innovative industrial applications.

**Keywords:** *viscoelasticity, rubber, fractional derivative model, Prony series, Generalized Maxwell Model, rubber viscoelastic behavior*

# Mathematical Modeling of Rubber Friction and Wear Behavior in Engineering Applications

**M. W. T. Chamod , P. K. Miranga, and V. S. C. Weragoda***

*Department of Materials Science and Engineering, University of Moratuwa*

**Email:* sampathw@uom.lk

This study examines how rubber hardness and tensile strength influence friction and wear behavior in engineering applications. Using a robust mathematical modeling approach, the research explores the complex mechanisms governing rubber friction and wear across various surfaces. The study integrates theoretical formulations with experimental data to create a predictive model that accurately describes the tribological properties of rubber under different operational conditions. This research has wide-ranging implications, from improving road safety through better tire design to optimizing mechanical systems with rubber-based components, such as bearings and seals. The insights from this study can guide the development of more resilient and efficient rubber materials for engineering applications.

**Keywords:** *rubber friction, mathematical model, Amontons-Coulomb law*

# Modelling and Simulation of a Vertically Intergrated Nano Generator in Vibration Mode

**K. A. D. P. S. Paul and S.U. Adikary***

*Department of Materials Science and Engineering, University of Moratuwa*

**Email:* suadi@uom.lk

In the field of energy harvesting, recent advancements have paved the way for innovative technologies capable of converting ambient energies into usable power. This study investigates the viability of using piezoelectric nanogenerators to harness the underexplored potential of harvesting vibrational energy from voluntary and involuntary hand movements. Driven by a notable gap in existing technology, the research aims to model and simulate a vertically integrated ZnO-based nanogenerator, utilizing COMSOL Multiphysics, and specifically optimized for the frequency spectrum of essential tremor vibrations. This approach is supported by an in-depth vibrational analysis and the implementation of novel simulation techniques. The key findings reveal the nanogenerator's ability to efficiently convert low-frequency vibrational energy into substantial electrical power, demonstrating its potential for powering self-powered smart wearables and medical devices. These results contribute significantly to advancing piezoelectric energy harvesting technologies and pave the way for innovative healthcare solutions, thus marking a significant advancement in integrating energy harvesting with medical applications and smart wearables.

**Keywords:** *Energy Harvesting, Piezoelectric Nanogenerators, Essential Tremor, Zno Nano wire, Vibrational Energy, COMSOL Multiphysics*

# Non-Destructive Approaches for Evaluating Young's Modulus in Human Bones Using Impulse Excitation

**J. P. T. C. K. Jayalath[1], H. W. M. M. Muthumali[1], A. A. G. A. Abeygunawardane[1]*, E. A. S. T. Edirisinghe[2], and P. H. Dissanayake[2]**

*[1]Department of Materials Science and Engineering, University of Moratuwa*

*[2]Department of Anatomy, University of Sri Jayewardenepura*

**Email: aravindag@uom.lk*

The aging global population has triggered a concerning surge in age-related health issues, notably osteoporosis and hip fractures, posing significant challenges to healthcare systems. This research endeavors a novel approach and to validate methodologies for assessing the mechanical properties of human bones using non-destructive techniques, with a particular focus on determining dynamic Young's modulus through various approaches guided by the Impulse Excitation method (ASTM E 1876 - 01). Considering the challenges encountered, the quest for non-destructive methods to accurately evaluate bone properties assumes paramount importance. Initial experimentation with methodologies like Arduino and Python spectrum techniques encountered difficulties, prompting a methodological shift towards the Audacity method. Despite initial challenges, the Audacity method yielded consistent results, offering valuable insights into bone mechanical properties. Anticipated outcomes encompass comprehensive characterization of fracture propagation mechanisms and the development of predictive numerical models. This study asserts that a validated methodology, exemplified by the Audacity method, establishes a robust groundwork for ongoing investigations into fracture mechanics, with far-reaching implications for healthcare strategies and fracture prevention.

**Keywords:** *Human Bones, Dynamic Young's Modulus; Fundamental Resonance Frequency; Impulse Excitation Method; Audacity Method*

# Optimization of Fluoride Varnish for Dental Applications

**K. A. P. T. Chandrapriya, W. M. A. S. Wijerathna, and G. A. Sewvandi***

*Department of Materials Science and Engineering, University of Moratuwa*

**Email: galhenagea@uom.lk*

This paper explores optimizing a fluoride varnish to enhance fluoride absorption, improve adhesion, and optimize texture for better patient comfort. Aiming to reduce reliance on imported products, the locally produced varnish uses pharmaceutical-grade shellac, sodium fluoride, and calcium phosphate. Experimental results show superior initial fluoride uptake and sustained release compared to commercial alternatives. The study also finds that smaller shellac particle sizes improve adhesion and texture, enhancing the application process, especially for pediatric patients. This examines the synthesis of the varnish and its basic physical properties and analyzes tooth surfaces before and after application using EDX and SEM. The optimized varnish formulation offers longer-lasting protection on tooth surfaces.

**Keywords:** *Fluoride Varnish, Demineralization, Enamel Remineralization, Shellac, Fluoride Absorption*

# Plastic Properties Estimation of Steel Alloys Using Machine Learning of Ultrasonic Data

**M. C. S. De Costa[1], V. Sivahar[1]*, and A. T. P. Silva[2]**

*[1]Department of Materials Science and Engineering, University of Moratuwa*

*[2] Department of Computational Mathematics, Faculty of Information Technology, University of Moratuwa*

**Email:* vsivahar@uom.lk

Steel alloys are crucial in various industries due to their enhanced properties compared to plain-carbon steel. Alloying elements are added to steels to improve specific properties such as strength, wear, and corrosion resistance. These elements include chromium, cobalt, columbium, molybdenum, manganese, nickel, titanium, tungsten, silicon, and vanadium.

This research on "Plastic Properties Estimation of Steel Alloys using Machine Learning of Ultrasonic Data" discusses a data-driven approach to estimate the plastic properties of steel alloys. This involves using machine learning algorithms to analyze ultrasonic data, thereby providing an alternative method for predicting the plastic properties namely yield strength, ultimate tensile strength and elongation. Such advancements could significantly enhance our ability to tailor the properties of steel alloys for specific applications, further increasing their importance in various industries.

**Keywords:** *ultrasonics, machine learning, plastic properties*

# Study on Diffusion Profile of Impurities in Crystaline Silicon

**W. A. Isuru, H. M. S. Hansana, and D. Attygalle***

*Department of Materials Science and Engineering, University of Moratuwa*

**Email:* dattyga@uom.lk

This study investigates the fabrication of p-n junctions on silicon wafers through furnace doping and the simulation of laser doping processes. The primary focus is on understanding the fundamental principles of semiconductor doping, particularly the use of Phosphoric Acid as a dopant precursor. The furnace doping process involved applying a precursor layer to silicon wafers, followed by heating to 1000°C, resulting in successful phosphorus doping, as confirmed by Energy-dispersive X-ray spectroscopy (EDX) analysis. However, an unexpected thin white layer formed on the samples, necessitating further investigation into its composition and potential impact on the doping process.

Due to constraints in equipment availability, the study also employed COMSOL Multiphysics software to simulate laser doping. These simulations provided valuable insights into optimizing doping parameters, predicting dopant profiles, and understanding the effects of different laser types (continuous wave and pulsed) on the doping process. The results highlight the importance of precise control over doping conditions, such as dopant concentration, temperature, and cooling rate, to achieve desired electronic properties in semiconductor devices.

This research contributes to the field of semiconductor fabrication by providing a comprehensive comparison of furnace and laser doping techniques, along with practical recommendations for optimizing the doping process. The findings lay the groundwork for future experimental work and offer a pathway to more controlled and efficient methods for p-n junction fabrication.

**Keywords:** *doping, impurity, semiconductor, profiling, wafer*

# Synthesis and Characterization of *Aegle marmelos* Gum Based Antimicrobial Coating/Film for Food

**S. L. I. Madhushani, W. S. Manohari, A. M. P. B. Samarasekara*, and D. A. S. Amarasinghe**

*Department of Materials Science and Engineering, University of Moratuwa*

**Email: bandu@uom.lk*

This research focuses on the synthesis and characterization of Aegle marmelos gum (Bael fruit gum) for the development of antimicrobial coatings and films for food products. The precipitation method was identified as the most efficient technique for extracting bael gum (BG). A range of analytical techniques, including scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy (EDX), X-ray diffractometry (XRD), Fourier transform infrared spectroscopy (FTIR), and thermogravimetric analysis (TGA), were employed to assess the morphology, composition, and thermal behavior of the extracted pure BG. FTIR and XRD results confirm the polysaccharide nature of BG.

A specific formulation for both coating and film was developed, consisting of purified BG, citric acid, starch, and glycerol. This formulation was evaluated using an aging test on ripe lady finger bananas and veralu (Ceylon olive-*Elaeocarpus serratus*) fruits, with results demonstrating its effectiveness. The antimicrobial properties of bael gum and the finalized formula at three different concentrations were tested using the disk diffusion method.

Bael gum offers several advantages for food packaging, including strong adhesiveness, biodegradability, biocompatibility, antimicrobial activity, and non-toxicity. The primary aim of this research is to develop a non-toxic antimicrobial coating/film for food packaging. This innovative approach not only enhances food safety by extending shelf life but also promotes sustainability by reducing reliance on synthetic packaging materials. The promising results from this study open new possibilities for utilizing natural resins in various industrial applications.

**Keywords:** *Aegle marmelos, bael gum, antimicrobial, packaging*

# $TiO_2$ Nanotube Arrays for Sensing Applications

**W. A. S. N. Wijendra and H. S. Sitinamaluwa***

*Department of Materials Science and Engineering, University of Moratuwa*

**Email:* hansinees@uom.lk

Titanium dioxide ($TiO_2$) nanotubes have emerged as promising materials for gas sensing applications due to their high surface area and unique electronic properties. However, optimizing their synthesis for enhanced sensitivity remains a challenge. In this study, $TiO_2$ nanotubes were synthesized for use as an efficient gas sensing material for detecting ethanol by anodizing pure titanium (Ti) thin (~0.5 mm) foil pieces at varying voltages (60V, 70V, 80V). The structural characteristics of the synthesized $TiO_2$ nanotube arrays were analyzed using Scanning Electron Microscopy (SEM), revealing a variation in tube diameters from approximately 60 nm to 90 nm depending on anodization time (1 hour and 2 hours). The sample anodized for 2 hours at 60V and subsequently annealed at 450°C for 1.5 hours demonstrated a tube length of approximately 6 µm. Furthermore, this study details the design of the gas sensor circuit, the ethanol sensing chamber, and an Arduino-based temperature control system. The gas sensing performance of the $TiO_2$ nanotube-based sensor was evaluated under exposure to 1000 ppm ethanol, demonstrating the potential of this material for efficient alcohol detection.

**Keywords:** *$TiO_2$ nanotubes, semiconductor metal oxide, anodization, tube diameter, gas sensor*

# Unlocking the Differential Scanning Calorimetry Heat Signature

**E. M. T. C. Dharmasena, G. N. D. M. Perera, and D. A. S. Amarasinghe***

*Department of Materials Science and Engineering, University of Moratuwa*

**Email:* amarasinghes@uom.lk

This research delves into the realm of simulating reaction kinetics of materials using Differential Scanning Calorimetry (DSC). A mathematical model and a computational model have been developed to predict and analyze thermal characteristics on DSC curves, aiming to optimize machine-learning algorithms for kinetic parameter prediction. The study focuses on deriving theoretical models to generate simulated data due to the challenges of acquiring extensive real DSC data. By exploring various mathematical approaches, the research aims to characterize different reaction models through intricate analysis of the heat flow rate, reaction rate, and heat capacity variations in the sample. Emphasis is placed on formulating kinetic parameters, such as rate constants and activation energies, to model the degree of conversion during thermal events. Furthermore, the project introduces methodologies to preprocess DSC signals, including denoising techniques for signal accuracy. The investigation also includes fitting heat capacity variations of individual thermal events with the Shomate equation, enhancing the analytical capabilities of the software. Overall, this work lays the foundation for future advancements in predictive modeling and data analysis of DSC curves, paving the way for enhanced insights into material thermal behaviors and reaction dynamics.

**Keywords:** *Differential Scanning Calorimetry (DSC), simulation, analytical modeling, Shomate equation, signal denoising, reaction kinetics, heat capacity*

# Utilization of Water Purification Sludge in Compressive Stabilized Earth Blocks (CSEB)

**L. W. K. U. Dharmadasa, W. K. D. Madhumekhala, and S. P. Guluwita***

*Department of Materials Science and Engineering, University of Moratuwa*

**Email:* sguluwita@uom.lk

Annually, water treatment plants in Sri Lanka generate a substantial volume of sludge, primarily managed through landfill disposal. The utilization of sludge in the construction sector emerges as a financially viable and environmentally prudent alternative to traditional masonry units. This study investigates the potential of reusing water treatment sludge in the production of compressive stabilized earth blocks (CSEB), motivated by the analogous mineralogical composition shared between clay and water treatment plant sludge. Simultaneously, quarry dust is employed as a substitute for sand in the CSEB production process. Anticipated research outcomes encompass a comprehensive understanding of the applicability of water purification sludge in CSEB production, a comparative analysis of diverse sludges, and the formulation of an optimized mix design. The prepared blocks exhibit augmented strength over a 28-day period; however, a concomitant reduction in strength occurs with increasing the sludge proportions. This investigation contributes valuable insights to the sustainable reuse of water treatment sludge in construction practices.

**Keywords:** *Compressive stabilized earth blocks, Quarry dust, Water treatment plant sludge*

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