DIGEST

RESEARCH & INNOVATION

COLLEGE OF ENGINEERING

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RESEARCH & INNOVATION OFFICE

The "Digest: Research & Innovation, College of Engineering" e-magazine is a publication created by the Office of Research & Innovation in the College of Engineering, Universiti Teknologi MARA. Its primary objective is to showcase the research and innovation of our esteemed researchers specialising in various engineering fields within the college. The publication provides a platform for researchers to publish their findings and innovative solutions to various engineering and scientific challenges. The ultimate goal of this effort is to promote research visibility and enhance the reputation of Universiti Teknologi MARA to global standards. This initiative aims to inspire greater interest and participation in research to improve our institution and society.

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FROM THE DEAN

With great enthusiasm, we present the 3rd volume of Digest: Research & Innovation, published by the College of Engineering (KPK), Universiti Teknologi MARA (UiTM). This e-magazine allows esteemed researchers to share their groundbreaking activities, innovations, and findings. Our goal is to raise the profile and visibility of KPK scholars and researchers so that their work can contribute to the collective advancement of knowledge and can be reached by a wider audience.

This volume delves into various innovative approaches that address crucial global challenges while promoting sustainability and efficiency. It highlights the potential of innovative solutions, from the emergence of the BWB-X mini UAV designed for inter-city parcel delivery and military applications to incorporating eco-friendly natural fibres like kenaf and Arenga pinnata into composite materials.

Furthermore, the investigations on High-Density Polyethylene (HDPE) and Polyethylene Terephthalate (PET) underscore our commitment to waste repurposing through the enhancement of cement bricks. Integrating Sustainable Development Goals (SDGs) with information and communication technology (ICT) in engineering education seeks to foster critical thinking skills among students, equipping them for a rapidly changing world.

This Digest also presents vital topics such as hydrodynamic modelling for flood control, AI-driven rainfall prediction systems for agricultural optimization, and applying the Taguchi method to improve carbon nanotube field-effect transistors. Additionally, it explores ArtiRock's innovative approach for sustainable water treatment using coal ash. Developing a natural lotion incorporating Centella Asiatica alongside a novel liquid crystalline terpolymer further reflects the demand for sustainable solutions in cosmetics and energy.

We invite you to engage with the diverse research featured in this volume, as it exemplifies the spirit of innovation and collaboration that defines our academic community. Together, we strive to create a sustainable future through research and innovation.

Sincerely,

PROFESSOR TS. DR. AIDAH JUMAHAT
DEAN OF RESEARCH & INNOVATION,
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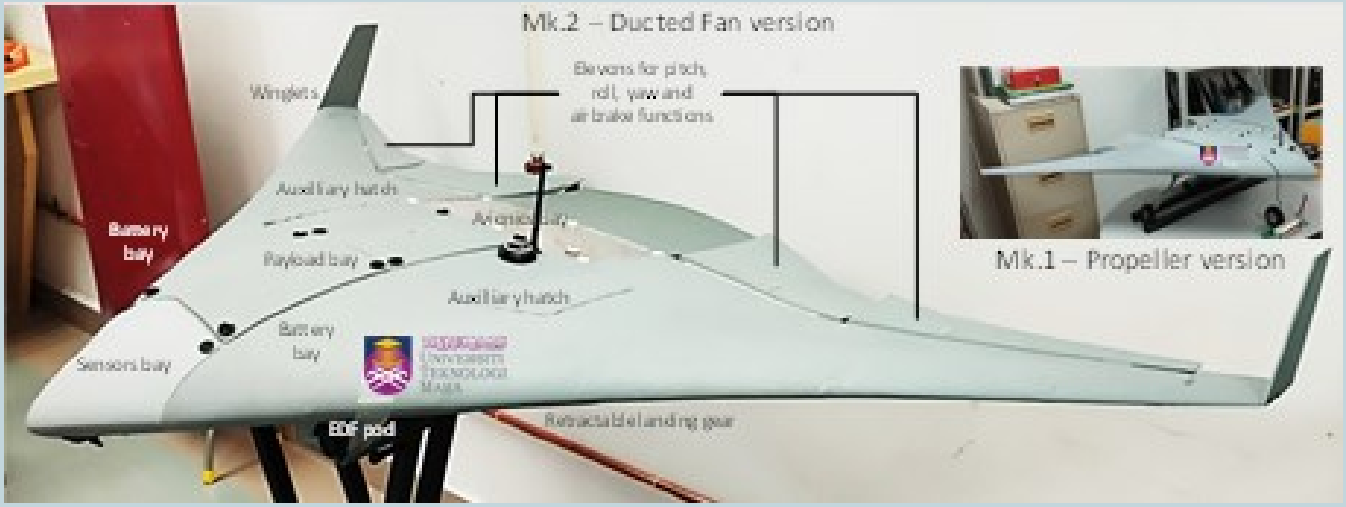
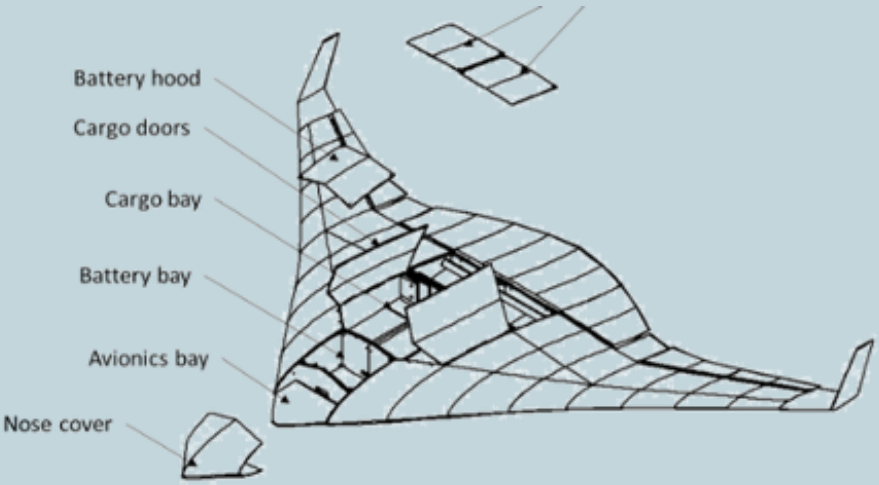
Editorial Team

Blended Wing-Body Unmanned Aerial Transport Aircraft

by Associate Professor Dr. Rizal Effendy M. Nasir





Most parcel delivery companies aspire to replace road-going riders and drivers with unmanned drones for last-mile delivery purposes. These multirotor drones are limited to a range of only 10 kilometres. 60 to 100-kilometre inter-city parcel transport still uses land transport such as postal vans or lorries and is susceptible to traffic conditions. There is a need for fast or urgent inter-city parcel transport service that is quicker than regular land transport without waiting for bulk postages. BWB-X is a mini unmanned aerial vehicle with a fixed-wing configuration designed to transport parcels/items up to 2 kilograms. The unmanned aircraft system (UAS) is designed based on the team's research in blended wing-body technology – an advanced aerodynamics that enhances performance and efficiency. The UAS, which measures only 2.0 m in wingspan, 1.5 m in length, and less than 0.5 m high, is a hybrid between conventional and flying-wing aircraft that allows all-lifting wing-body with huge volumes to carry payloads.

It is powered by electric propulsion, either a propeller or a ducted fan, in which power comes from its twin lithium batteries. With a 100 km/h cruising speed, 100 km range and 100 minutes of flight endurance, the UAS consists of two central units – the aircraft and the ground control units. The former consists of a flight computer-IMU combo with auto stabilization and autopilot function with inertial and satellite navigation systems. Communication with the ground control unit is via radio for command, video transmission and telemetry, and 4g/5g internet protocol for beyond-line-of-sight command, control and telemetry. The ground control unit consists of a radio transmitter controller, laptop with mission management software, flight control joystick for BVLOS flight, transceiver, video screen, etc. The UAS can also be used by the military as a surveillance/intelligence and light aerial delivery (bombing) mission platform.

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The drive for sustainability in material science has spurred interest in alternatives to synthetic fibres traditionally used in polymer composites. Our research focuses on natural fibres, specifically kenaf and Arenga pinnata, as eco-friendly reinforcements in polymer matrices. While it is well known that natural fibres generally offer lower mechanical properties than synthetic options like glass or carbon fibres, the environmental benefits of natural fibres are compelling. This research aims to showcase the practical potential of kenaf and Arenga pinnata fibres in applications where environmental sustainability is prioritized over maximum mechanical strength.

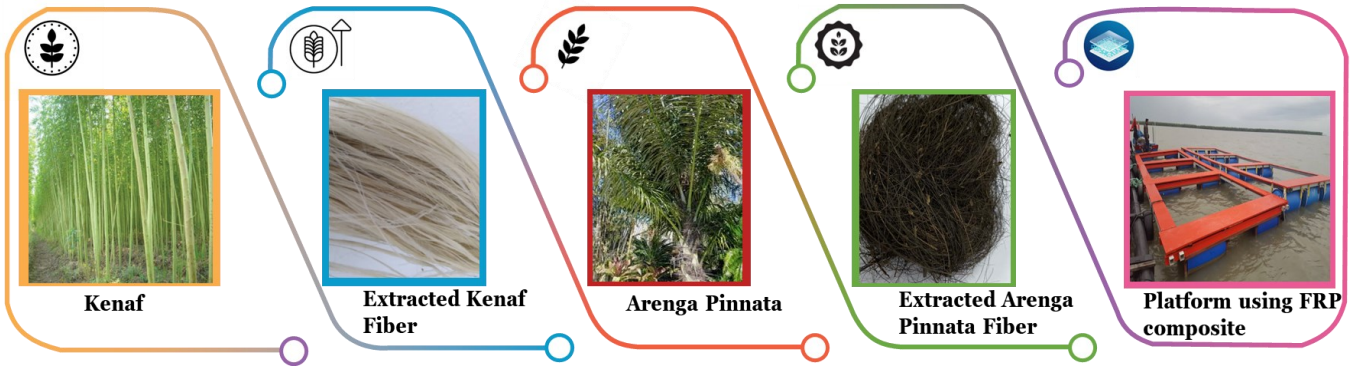
Our study demonstrates that kenaf and Arenga pinnata fibres can be effectively integrated into polymer composites, providing sufficient strength and durability for applications in industries such as packaging, furniture, and low-load-bearing structures. These natural fibres are renewable, biodegradable, and abundantly available, presenting an eco-friendly alternative to synthetic fibres, which depend on non-renewable resources and contribute substantially to environmental waste.

This research addresses the rising demand for sustainable materials by demonstrating the environmental advantages of natural fibres. Adopting natural fibre composites reduces carbon emissions, promotes renewable resource use, and minimises waste through their biodegradability. As industries focus more on eco-friendly practices, natural fibre-reinforced polymers present a compelling, sustainable alternative to traditional composites.

Promoting natural fibres over synthetic alternatives aligns with global sustainability goals and supports a circular economy by reducing reliance on finite resources and minimising environmental impact. This research highlights the critical balance between material performance and environmental responsibility, demonstrating how sustainable choices in material science can drive meaningful change.

Advancing Sustainable Materials through Natural Fibre-Reinforced Polymer Composites

by Dr. Zaidahtulakmal Mohd Zahib & Professor Ts. Dr. Aidah Jumahat



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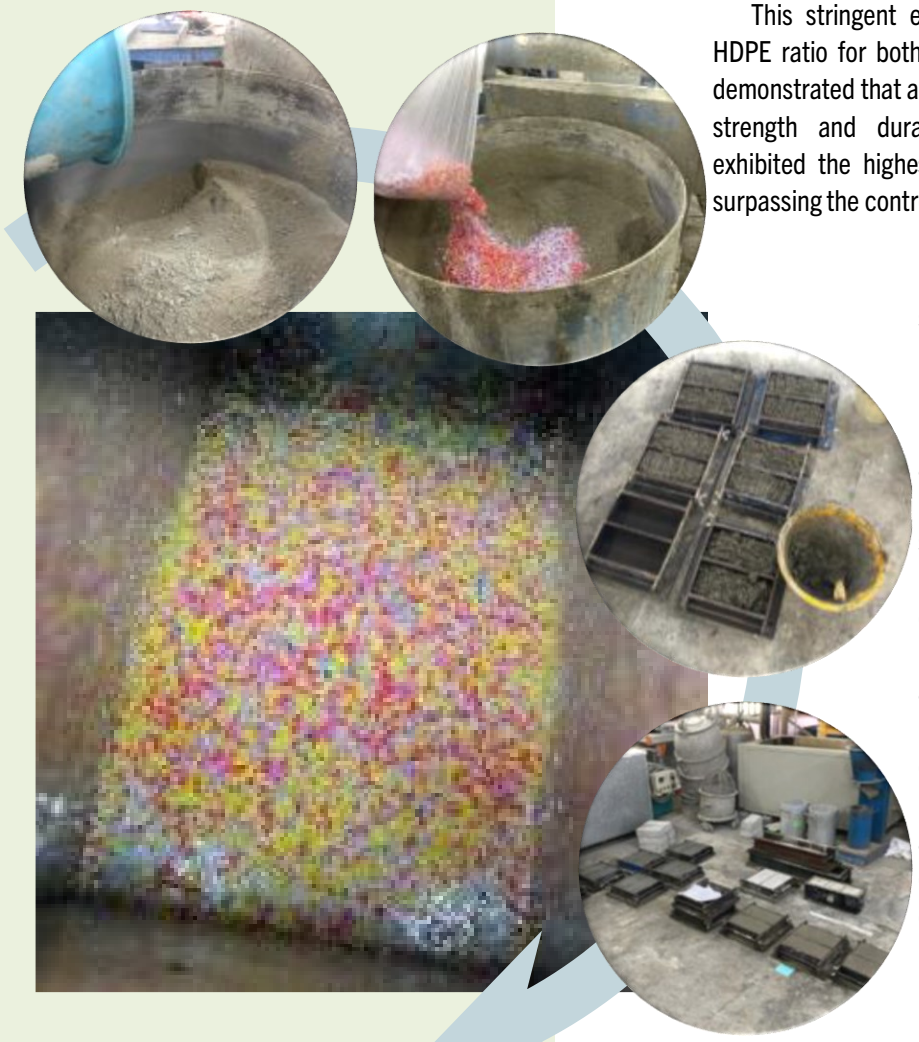
Eco-Friendly Bricks: A Sustainable Solution with High-Density Polyethylene HDPE

by Nurul Fatin Fathirah Abdul Aziz & Ir. Dr. Raden Maizatul Aimi

Concrete and bricks constitute the foundation in modern construction; however, their conventional manufacturing processes significantly contribute to carbon emissions. The rising demand for bricks compels the construction industry to seek sustainable alternatives urgently. An innovative solution may involve tackling another environmental concern—plastic waste. Polyethylene Terephthalate (PET), a plastic frequently utilised in water bottles, demonstrates significant potential as a sustainable additive in brick production, minimising waste while improving brick performance. This research investigated the incorporation of PET in concrete bricks to mitigate plastic waste and enhance brick durability. The incorporation of PET as a partial substitute for fine aggregate enhances the eco-friendliness of bricks while maintaining their structural integrity.

This study incorporated High-Density Polyethylene (HDPE) into cement bricks as a partial substitute for sand, thereby repurposing plastic waste and improving the structural properties of the bricks. Bricks were manufactured with differing HDPE concentrations—2.5%, 5%, 7.5%, and 10%—and subsequently evaluated for compressive strength and water absorption over a 28-day curing duration.



This stringent evaluation sought to ascertain the ideal HDPE ratio for both resilience and robustness. The findings demonstrated that a small quantity of HDPE can enhance both strength and durability. Bricks containing 2.5% HDPE exhibited the highest compressive strength at 31.94 MPa, surpassing the control sample.

However, as the HDPE content increased beyond 2.5%, compressive strength decreased, highlighting the importance of a balanced ratio. Furthermore, bricks with higher HDPE levels showed increased water absorption, even though all samples remained within permissible limits. This suggests that meticulous management of HDPE content is critical for performance optimisation.

This study suggests a promising avenue for sustainable construction. Bricks made from recycled HDPE reduce carbon emissions, reuse waste, and improve durability. HDPE-infused bricks, a low-carbon alternative, could help the construction industry become more environmentally friendly.

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Building Greener Bricks with Polyethylene Terephthalate (PET)

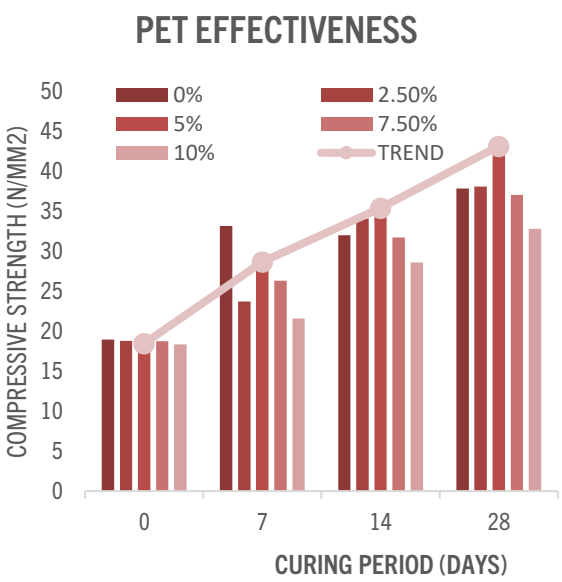
by Ahmad Farhan Mohd Faizal & Ir. Dr. Raden Maizatul Aimi

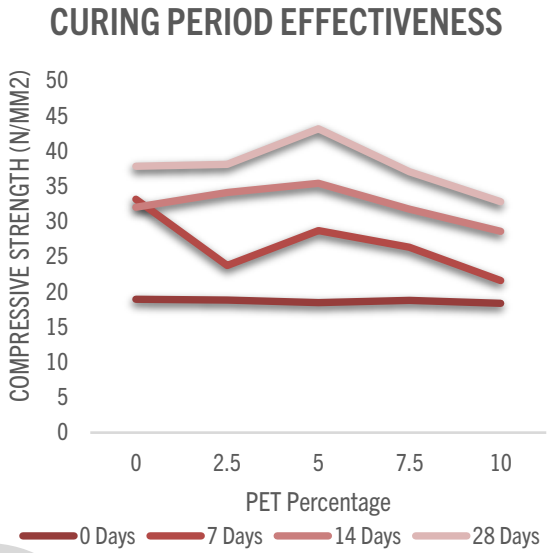
Concrete and bricks are fundamental to contemporary construction; however, their manufacturing processes generate significant carbon emissions. With the increasing demand for bricks, the construction sector requires sustainable alternatives. Mitigating plastic waste could represent a novel environmental remedy. Polyethylene Terephthalate (PET), a plastic utilised in water bottles, can potentially diminish waste and enhance brick performance as a sustainable additive.

This study investigated the incorporation of PET in concrete bricks to mitigate plastic waste and enhance durability. PET can partially substitute fine aggregate in bricks, enhancing their strength and environmental sustainability. Bricks were manufactured using an experimental method with different PET content levels (2.5%, 5%, 7.5%, and 10%) and subsequently cured for up to 28 days. Each variation underwent testing for compressive strength and water absorption to determine the optimal PET ratio for resilient, durable bricks.

The outcomes were encouraging. Bricks with 5% PET exhibited the highest compressive strength, exceeding that of the control samples, indicating that a moderate PET concentration enhances the material's strength. Furthermore, elevating the PET content to 10% markedly diminished water absorption, achieving values as low as 0.37% after 28 days. The water-resistant characteristics of PET diminish porosity, rendering bricks less susceptible to moisture damage. Integrating PET into concrete bricks reduces plastic waste and conforms to global sustainable development goals. Replacing a fraction of traditional materials with recycled PET allows the construction industry to reduce its carbon footprint and enhance environmental sustainability. This method represents a tangible progression in sustainable construction by generating resilient building materials that reduce environmental impact—one brick at a time.

Brick Sample





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SDG-based with ICT-driven in Engineering Education

by Associate Professor Dr. Marfiah Ab. Wahid

Integrating the Sustainable Development Goals (SDGs) with Information and Communication Technology (ICT) into engineering education is an essential necessity within the current academic framework. An innovative educational approach is needed to equip future engineers with the skills they require to support global sustainability initiatives, given the increasing environmental issues, including water security and climate change.

By integrating an ICT-driven approach into the SDG-based engineering curriculum, my research aims to address this issue in a novel way. To enhance students' critical thinking and problem-solving abilities, this approach strongly emphasises real-time data analysis, smart decision-making tools, and simulation-based learning.

Based on the research findings, students participating in the integrated ICT SDG module significantly improved their understanding of sustainable practices and their ability to apply engineering principles to real-world problems. When it comes to providing solutions for global issues such as resource management and renewable energy, this student is more skilled at combining technical knowledge with sustainability objectives.

Because it can potentially transform engineering education completely, this research is very important. Students are better prepared to tackle the complexities of contemporary engineering challenges when integrating SDG concepts. A broader impact can result from the global enhancement of this teaching approach, influencing engineering curricula everywhere. After graduation, individuals will possess the necessary skills to address important societal concerns such as resource conservation, climate resilience, and sustainable infrastructure development, thereby supporting long-term sustainability initiatives worldwide through ICT technology. Using this method, they can become more technically skilled while developing a sense of social responsibility.

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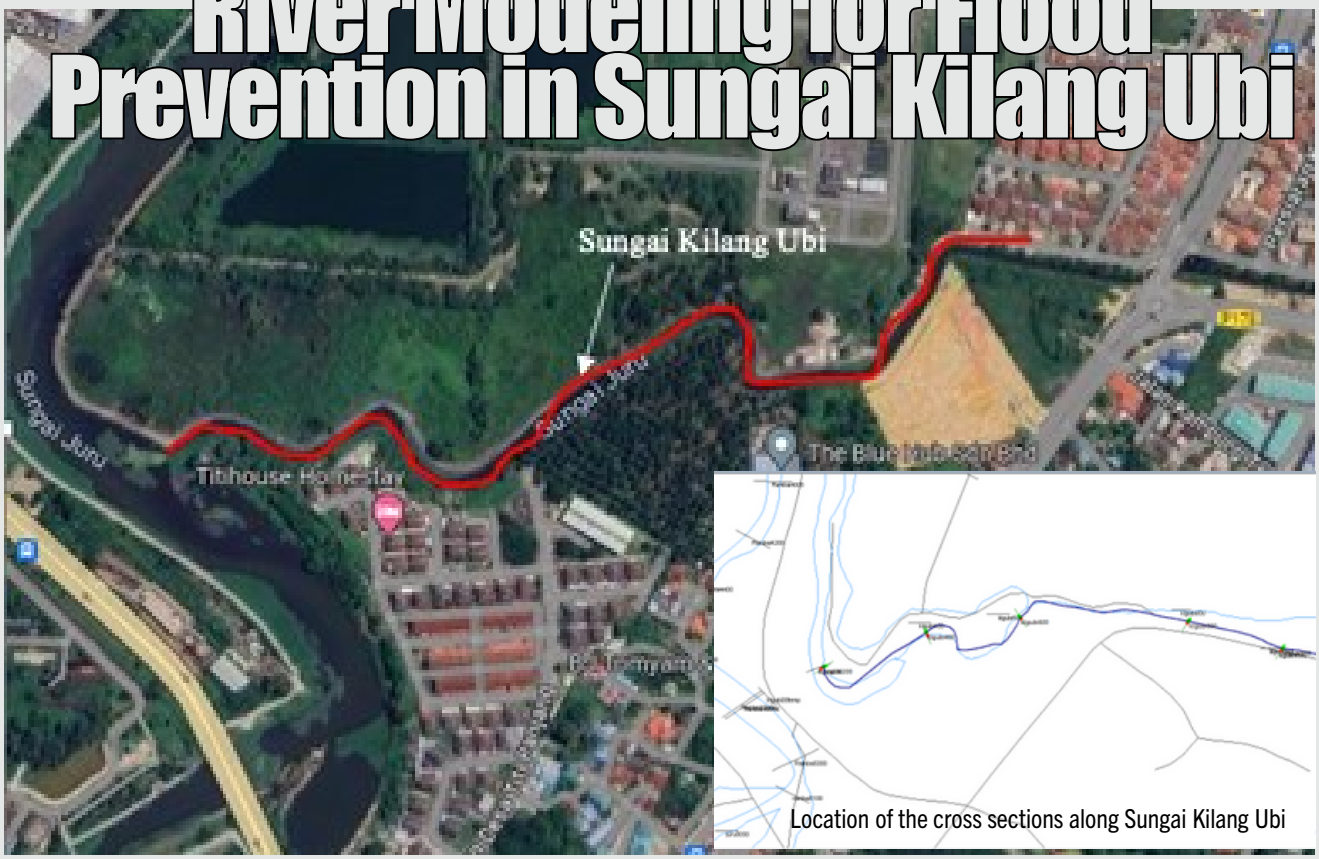
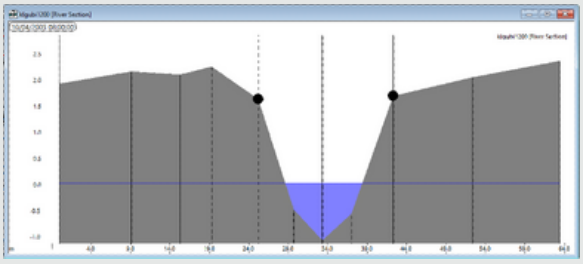
River Modeling for Flood Prevention in Sungai Kilang Ubi



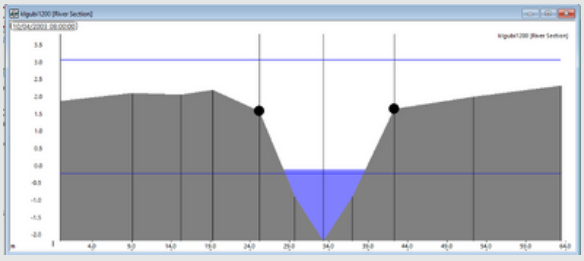
Location of the cross sections along Sungai Kilang Ubi

by Nur Shafikah Amirrudin, Mohamad Afizi Jamadin & Ir. Ts. Dr. Nuryazmeen Farhan Haron

Flooding remains a yearly challenge in Malaysia, affecting the environment and infrastructure, with Pulau Pinang particularly vulnerable. Sungai Kilang Ubi, a flood-prone river in this region, was recently studied to develop effective flood control measures using InfoWorks RS, a hydrodynamic modelling software. This study focuses on the 2003 flood event to simulate the river's behaviour, aiming to support flood prevention efforts. The modelling process involved building a 1-dimensional Sungai Kilang Ubi representation, incorporating critical water depth, flow, and velocity data. Researchers used survey data to model the river's cross-section and flow conditions accurately. This model, verified through calibration, allowed for the simulation of various flood scenarios, providing essential insights into how the river responds to heavy rainfall. The study found that river deepening is a practical solution for reducing flood risk in the area. By lowering the riverbed in specific sections, the model showed that water could flow more freely, reducing peak water levels and the chance of overflow. The data highlighted that this adjustment could make Sungai Kilang Ubi less susceptible to flooding during heavy rains.



Initial river cross section before improvement work



Final river cross-section after improvement work

Overall, this research demonstrates how river modelling can guide flood prevention planning. By giving local authorities detailed information on flood-prone areas and possible improvements, such as targeted river deepening, communities can be better protected against future floods. This approach is crucial as climate change and urban growth continue to raise flood risks in Malaysia.

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Localised Rain Prediction Model in Feedforward-Feedback Control Structure for Smart Irrigation Management

by Dr. Mazidah Tajjudin

Integrating artificial intelligence with agricultural practices promises transformative advancements in sustainable farming. One such innovation is an AI-driven system for highly localised rain prediction, designed to work within a feedforward-feedback control structure to enable precise, responsive irrigation management. This research presents a model that uses Convolutional Neural Networks (CNNs) to interpret real-time cloud images and predict rainfall for specific areas, allowing for a smarter, more adaptable irrigation system that activates based on short-term rain forecasts. Traditional irrigation systems typically depend on broad weather forecasts or soil moisture sensors, often falling short when dealing with localised and unpredictable rain patterns. This can lead to over- or under-irrigation, impacting crop health and wasting resources. By contrast, the proposed CNN model, trained on cloud formation data correlated with actual rainfall events, provides localised rain predictions that can be directly integrated into a feedforward-feedback control system. In the feedforward path, rain predictions from the CNN model proactively adjust irrigation schedules by anticipating rainfall, reducing water output if rain is expected. This approach minimizes water waste by addressing the likelihood of natural rainfall in advance. Simultaneously, in the feedback loop, real-time soil moisture data and environmental conditions are continuously monitored to refine water delivery further, ensuring that the crop's actual water needs are met. If rainfall is not expected, feedback controls adjust the irrigation output accordingly, maintaining optimal soil moisture levels for crop growth. This AI-based, dual-path control approach significantly enhances water-use efficiency, reducing waste and operational costs. It primarily benefits water-scarce regions and aligns with broader sustainability goals, enabling proactive and adaptive resource management. Extensive field tests will evaluate the model's accuracy and the control system's efficacy, paving the way for widespread adoption of a smarter, data-driven irrigation solution.

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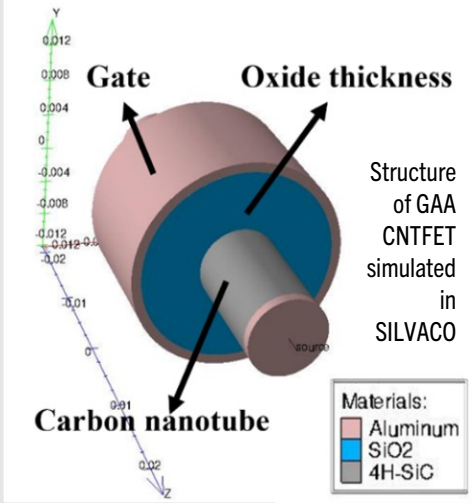
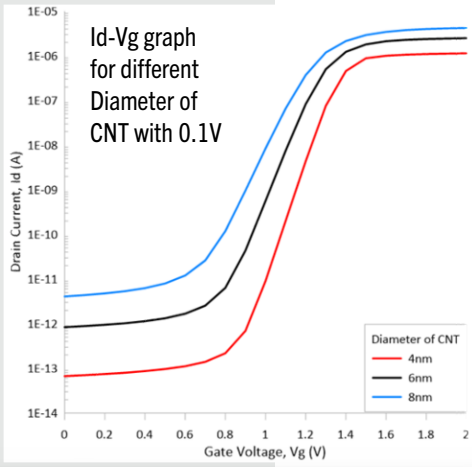
CARBON NANOTUBE FIELD EFFECT TRANSISTOR: Taguchi approach for device and circuit level optimization

by Ir. Ts. Dr. Hanim Hussin

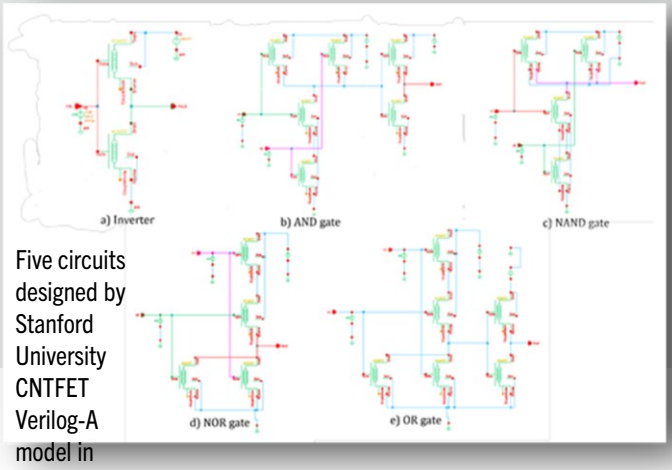
The research problem that motivated the study titled "CARBON NANOTUBE FIELD EFFECT TRANSISTOR: Taguchi Approach for Device and Circuit Level Optimization" is the increasing demand for energy-efficient, high-performance transistors, particularly as traditional silicon-based transistors encounter physical and performance constraints at nanoscale dimensions. The study utilizes the Taguchi method, a statistical optimization technique, to enhance the design and performance of carbon nanotube field-effect transistors (CNTFETs). This approach enables the systematic optimization of multiple parameters at both the device and circuit levels, resulting in improved energy efficiency and performance hence effectively addressing the limitations of conventional silicon-based technologies. The optimal combination for achieving the highest current ratio in CNTFETs consists of the CNT diameter, oxide thickness and dielectric material. The implementation of the Taguchi method results in a significant reduction in the power delay product (PDP) for the optimized CNTFET. These findings demonstrate that the Taguchi method provides substantial improvements in power efficiency and circuit speed, underscoring its potential for energy-efficient and high-speed circuit design. The research results are significant because they demonstrate a method for optimizing carbon nanotube field-effect transistors (CNTFETs), leading to more energy-efficient and faster electronic devices, which can contribute to reducing power consumption and improving performance in advanced technologies, benefiting society through more sustainable and powerful computing solutions.



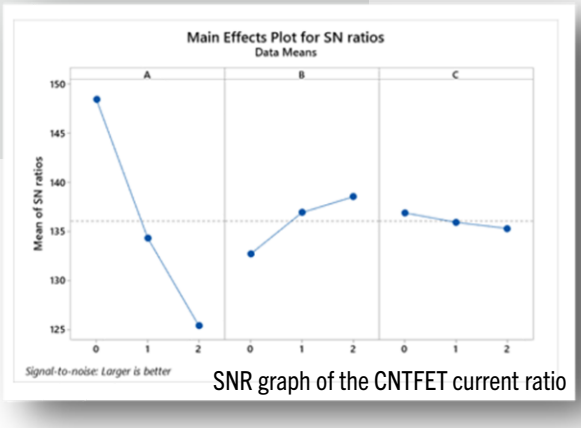
Structure of GAA CNTFET simulated in SILVACO



Id-Vg graph for different Diameter of CNT with 0.1V



Five circuits designed by Stanford University CNTFET Verilog-A model in Cadence Virtuoso



SNR graph of the CNTFET current ratio

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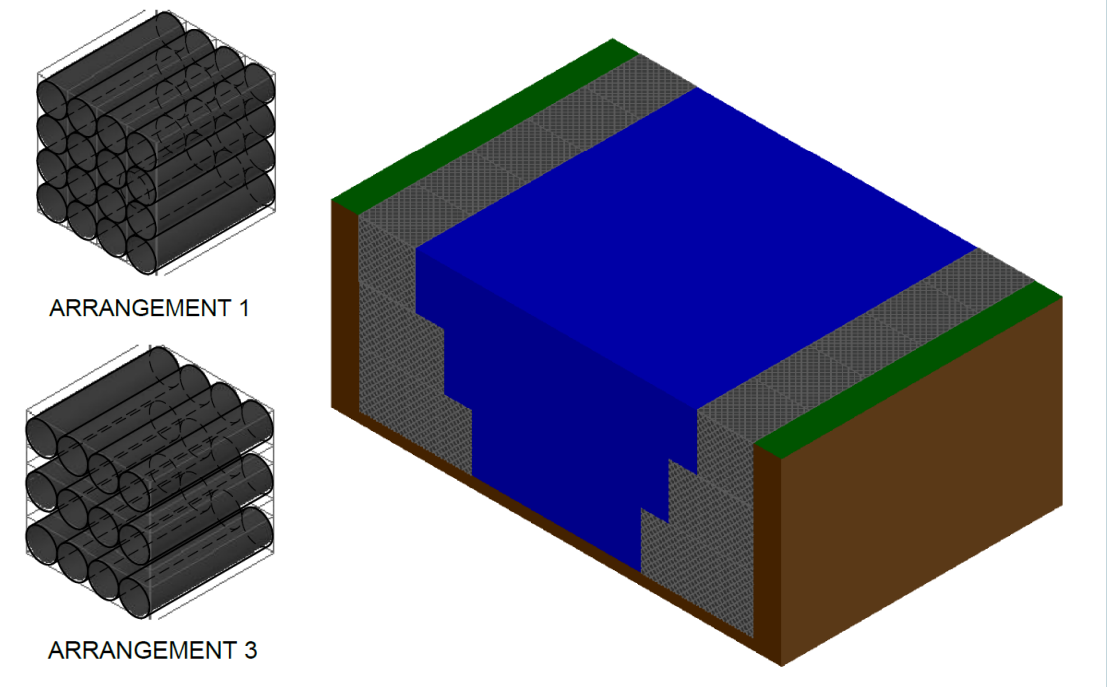
Revolutionizing Urban Water Treatment: GaBiF with ArtiRock for Sustainable Solutions

by Ahmad Amirul Adlyi Mohamed & Dr Miradatul Najwa Muhd Rodhi



As urbanization and industrial activities continue to expand, water pollution in urban areas poses an increasing threat to environmental and human health, particularly in developing countries. Current water treatment methods often need more sustainability and are too costly for widespread implementation. Inspired by the urgent need for an accessible solution, our research focuses on developing ArtiRock, an artificial rock filter media, as part of the Gabion Filter (GaBiF) system. The innovation lies in repurposing industrial waste—specifically coal ash from Kapar Energy Ventures—as a primary component of ArtiRock. This approach not only provides an efficient filtration system but also reduces coal ash waste, contributing to circular economy goals. In our study, ArtiRock showed promising results in laboratory trials, effectively removing contaminants from open water sources such as lakes and rivers. Our tests demonstrated ArtiRock's ability to meet Malaysia's Water Quality Index (WQI) standards, with high contaminant removal rates under various environmental conditions. These findings contribute to environmental engineering by introducing a low-cost, sustainable filter media that addresses water treatment and waste management.

The significance of our research lies in its potential to make sustainable water treatment solutions accessible for urban communities, reducing reliance on expensive water treatment infrastructure. By enhancing the quality of urban waterways, this innovation can contribute to healthier ecosystems and communities, supporting broader goals in public health and environmental protection. The GaBiF system with ArtiRock has broader implications for addressing global water challenges, offering a scalable model for communities facing similar issues worldwide. As urban areas continue to grow, this project underscores the importance of sustainable, community-driven solutions to meet pressing environmental needs.

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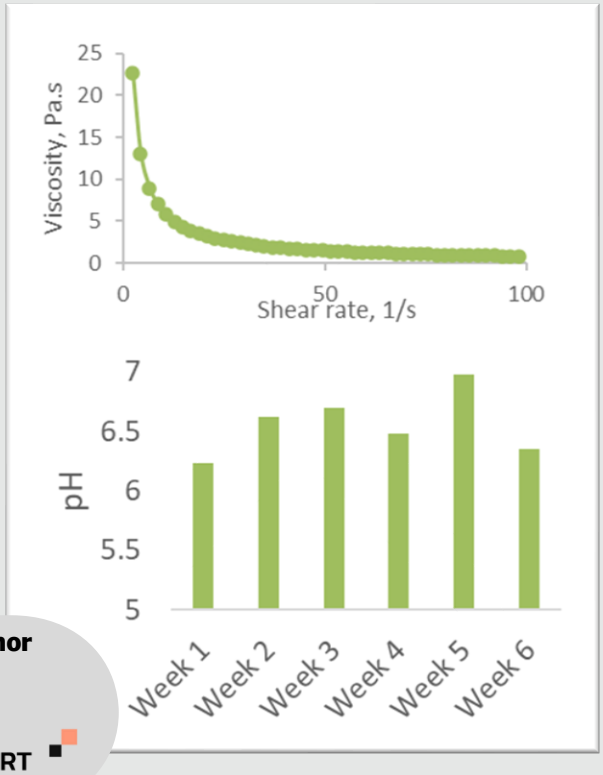
Centella Asiatica Natural Based Lotion

by Dr. Norasmah Mohammed Manshor

The rapid growth experienced by the cosmetic industry in past decades is driven by the increasing demand to enhance beauty, improve skin health and promote well-being. However, cosmetic formulations contain synthetic ingredients that act as preservatives, fragrances and additives to increase product stability, scent and overall performance. The wide use of synthetic chemicals in cosmetic products has raised concern as it could trigger the potential risk associated with long-term exposure. Consumers are actively seeking products that are sustainable, healthy and environmentally friendly. Thus, to address this issue, a natural-based lotion was formulated from *Centella Asiatic* extract, free from harsh chemicals, less harmful, and delicate to the skin.

Centella Asiatica, also known as pegaga, has been recognized as one of the top 10 herbs in Malaysia. The presence of bioactive compounds in *Centella Asiatica*, such as triterpenes and triterpenoids, has an injury recovery effect and anticancer and antimicrobial properties. Due to these benefits, *Centella asiatica* extract is a promising natural additive that can be incorporated into cosmetic formulations. In this study, the formulated lotion from the blend of *Centella Asiatica* extract with glycerine, xanthan gum, coconut oil, shea butter, emulsifying wax, beeswax and vitamin E was quickly absorbed, with a smooth texture and good scent. The pH of the lotion was in the range of 6 to 7, which indicates that it is gentle to apply on the skin.

After 6 weeks of storage at room temperature, the white colour of the lotion did not change, proving that the lotion is in good condition with no contamination. The odour and appearance of the lotion remain unchanged, with no oil-water separation after 6 weeks of storage, showing good stability. The viscosity of the lotion shows a decreasing trend with an increasing shear rate, indicating a non-Newtonian fluid, which is a suitable flow behaviour for lotion. The antimicrobial activity against *Escherichia coli* shows no growth of bacteria, proving that the lotion was not easily contaminated and has a long shelf life. The lotion is likely free from bacteria that could cause infections and irritations. This study provides valuable insight into formulating a new natural-based cosmetic, establishing scientific evidence supporting the benefits of plant-based extract, increasing confidence in natural cosmetics and driving the growth of the natural beauty industry.



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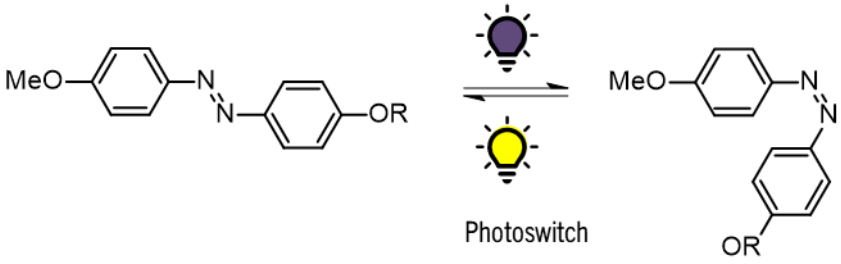
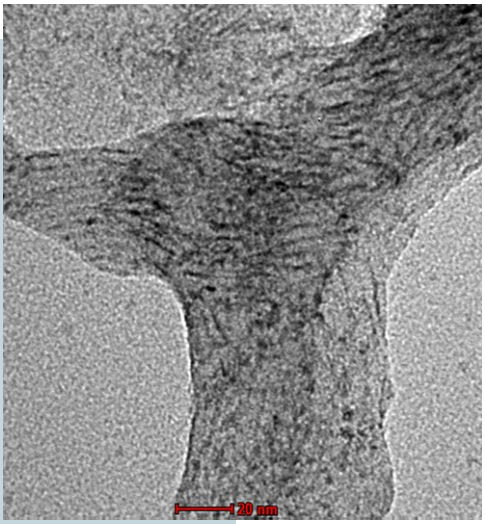
Light-Responsive Liquid Crystalline Terpolymers: Pioneering Advanced Materials for Sustainable Energy

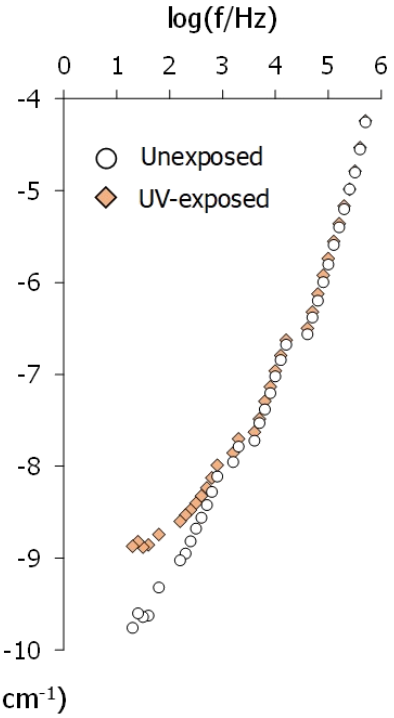
by Dr. Sakinah Mohd Alauddin

The increasing demand for sustainable energy highlights the need for advanced materials to improve traditional energy storage systems. These systems face challenges such as low ionic conductivity in dry conditions, limited adaptability, and insufficient capacity for dynamic energy storage. Effective ion and charge transport are crucial for optimizing energy storage devices like batteries, fuel cells, and supercapacitors. However, conventional polymer electrolytes often complicate ion transport through their solvent-induced phase-separated morphologies.

Our research introduces a new liquid crystalline terpolymer that maintains high conductivity in dry conditions and features light-responsive properties. This material incorporates azobenzene derivatives, sulfonic acid groups, and methacrylate groups, allowing it to self-assemble into ion-rich structures, enhancing charge flow without additional additives. The azobenzene components can change shape with light exposure, enabling external control over the material's properties. This makes it ideal for advanced energy devices and solar thermal fuels. By combining strong ionic conductivity with light responsiveness, we enhance energy materials and demonstrate their practical applications in renewable energy storage and conversion technologies.







The broader impacts of this research include more efficient use of renewable energy resources, reduced environmental footprints, and the development of resilient energy infrastructure. Ultimately, our work shows how advanced materials can provide effective solutions to critical environmental and societal challenges, contributing to a sustainable energy future.

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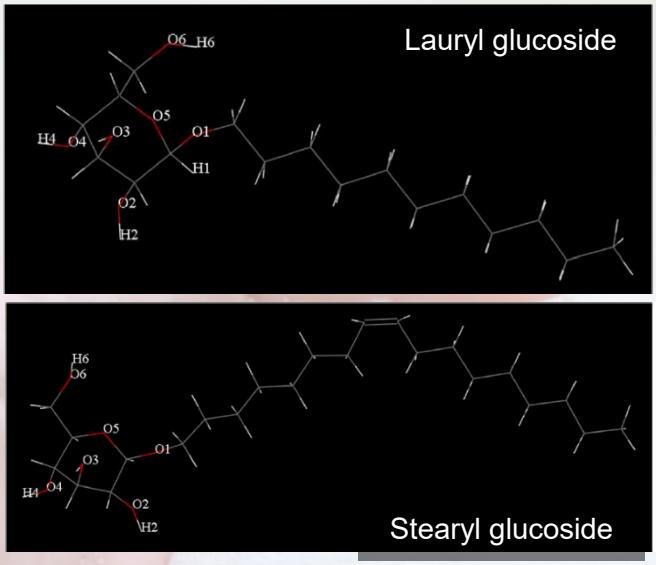
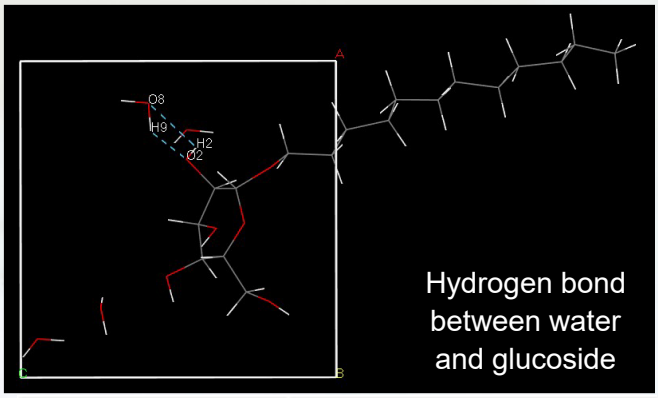
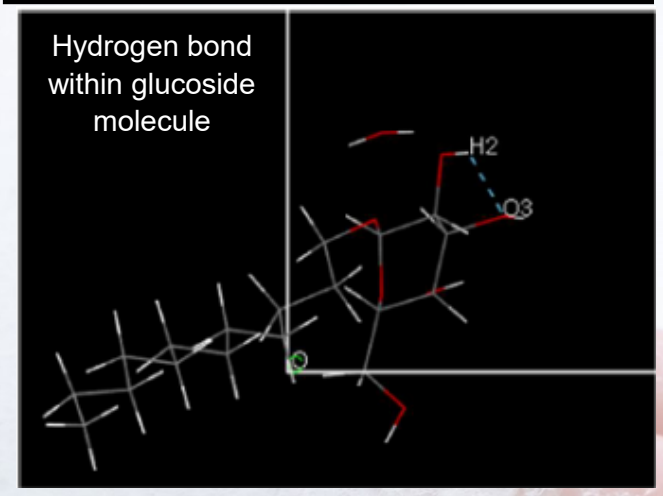
Unveiling the Nature of Interactions between Sugar-based Surfactants and Water through Computer Modelling

by Nur Farina Mohamad Silan, Assoc. Prof. Dr. Nornizar Anuar & Dr. Nurul Fadhilah Kamalul Aripin







Alkyl poly glucosides, sugar-based surfactants widely used in the cosmetics and detergent industries, owe their functionality to their amphiphilic properties. The interaction between water and glucoside plays a crucial role in the stability of these surfactants. While previous experimental works have explored this interaction, they have not delved into the molecular-level details. This is where our study, utilizing the molecular dynamics (MD) simulation technique, makes a unique contribution. By providing detailed information on the relationship between the structures of the molecules, our study enhances the understanding of the molecular dynamics of glucosides.

In our recent study, we used molecular dynamics simulation to examine the interactions between water and two types of glucosides - lauryl glucoside (with a 12-carbon alkyl chain) and stearyl glucoside stearyl glucoside (with an 18-carbon alkyl chain). Our findings revealed that a single water molecule establishes specific hydrogen bonds with both glucosides at the same atom position, H2-O3. However, the hydrogen bonding interaction was more pronounced in lauryl glucoside, suggesting a more robust interaction. By analysing the radial distribution function (RDF), we observed that the elongation of the alkyl chain leads to a decline in hydrogen bonding. Furthermore, we found that water itself exhibits more vital intermolecular forces of polar bonds. The system with one molecule of lauryl glucoside and four water molecules exhibited the most favourable hydrogen-bonding interaction among the various systems we investigated.

This study provides valuable insights into the effect of water solubility on different types of glucosides. It could also help design better surfactants for various applications.

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