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College of Engineering

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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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LETTER FROM OUR DEAN

We are pleased to introduce the 2nd volume of Digest: Research & Innovation, College of Engineering. This e-magazine was created for esteemed researchers to present their research activities, innovations, findings, and original work and for KPK researchers and academicians to enhance their visibility and present their work to a wider audience.

This series of articles explores the most recent advancements in material science, mainly focusing on developing materials suitable for energy conversion and extracting biopolymers from natural sources. The topics covered in the articles range from improvements in the manufacturing of graphene oxide to noninvasive techniques for assessing the ripeness of native fruits and the identification and extraction of various anthocyanins from local natural sources. In our pursuit of becoming a globally renowned university by 2025, we are placing a strong emphasis on conducting impactful and practical research.

The goal is for our research findings and conclusions to benefit different stakeholders and society as a whole. Furthermore, collaborative efforts in impactful and translational research are essential to ensure the sustainability and broad impact of our findings. The Office of Research and Innovation KPK needs your ongoing support to keep the research going and drive innovation. We appreciate all the writers and collaborators who have shared their diverse research topics. To make our magazine successful and sustainable, we invite all scholars and researchers to contribute their research highlight summaries.

Let's all work together to showcase our research activities and innovations to the world.

Thank you.

PROFESSOR TS. DR. AIDAH JUMAHAT
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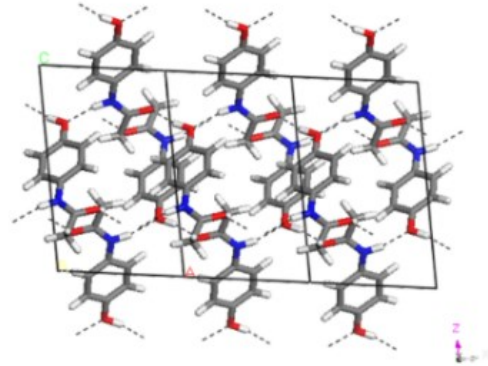


Tailoring Crystal Morphology of Paracetamol Using a Computational Approach

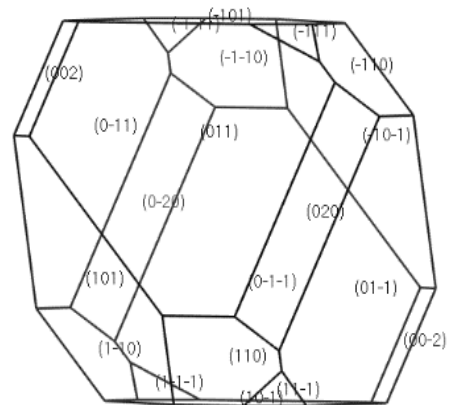
Crystal shape, or morphology, plays a critical role in pharmaceuticals. Unwanted crystal shapes can create challenges in manufacturing processes like filtration, flowability and compressibility. This ultimately affects the final product's quality, including its dissolution rate and stability. This research tackles the challenge of predicting and controlling crystal morphology during crystallisation processes by modifying solvents. The unique aspect lies in using computational approach to analyse interactions between solvents and specific crystal surfaces of paracetamol. The findings revealed that the solute-solvent interactions can be dominated by non-bonded interactions, such as van der Waals forces, electrostatic forces, and hydrogen bonds, depending on the solvents used. This is due to the nature of the solvent functional groups, whose strength of interaction with paracetamol surfaces determines the preferential growth of certain surfaces, ultimately influencing the overall crystal shape.

Notably, the findings aligned with observed crystal morphology, i.e., prism-shaped crystals, when using a specific solvent, highlighting the accuracy of the approach. Such findings aid in achieving precise control over morphology, which is crucial for pharmaceutical development. This also provides a powerful tool for researchers to engineer desired crystal shapes to avoid downstream manufacturing failure issues, potentially leading to drugs with optimised dissolution rates, bioavailability, and stability. This translates to improved drug efficacy and potentially fewer side effects, impacting patient health and treatment outcomes.

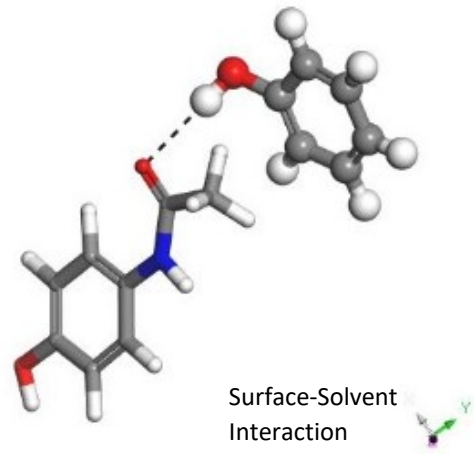
This research paves the way for a more rational design of crystallisation processes in pharmaceutical manufacturing. Beyond immediate drug development, the approach could be applied to other materials where crystal morphology is critical, such as pigments, catalysts, and functional materials. This opens doors for innovation in various scientific and technological fields.



Paracetamol

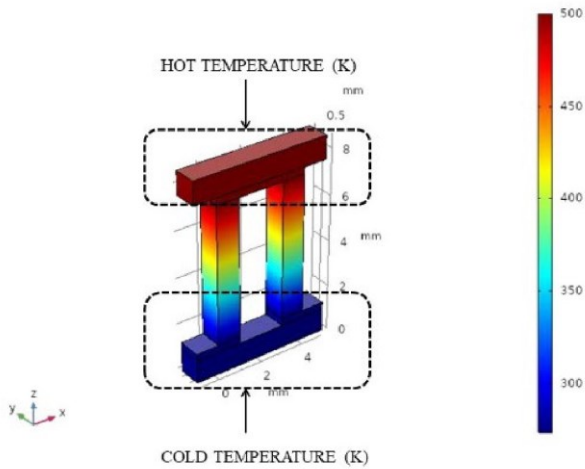


Crystal Morphology



Surface-Solvent Interaction

Exploring High-Temperature Materials for Enhanced Energy Conversion



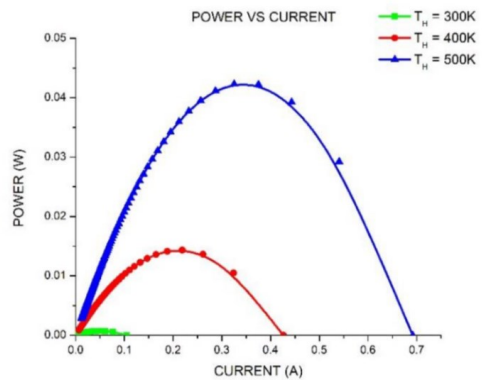
Temperature Distribution on Single Leg TEG

The research was driven by the pressing need to address the global energy crisis and explore sustainable energy sources. Thermoelectric generators (TEGs) offer a promising solution for converting waste heat into electrical energy. However, their efficiency is limited by the performance of the thermoelectric materials used. This research took a unique approach by investigating the potential of materials, specifically SrTiO_3 and $\text{Ca}_2\text{FeMoO}_6$, as alternatives to the commonly used Bi_2Te_3 in TEGs. Their excellent thermal and chemical stability at high temperatures makes them attractive candidates for high-temperature TEG applications.

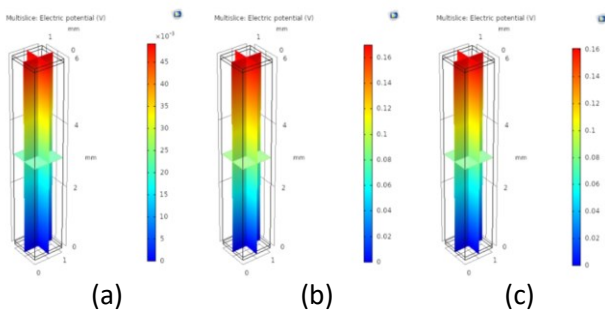
The research involved multiphysics simulations using COMSOL software to model and analyze the performance of single-leg TEGs using SrTiO_3 and $\text{Ca}_2\text{FeMoO}_6$ materials.

The simulations focused on studying these materials' temperature distribution, voltage potential, and electrical performance (output voltage and output power) under different hot-side temperatures and load resistances. The results demonstrated that SrTiO_3 outperformed $\text{Ca}_2\text{FeMoO}_6$ in terms of power output, which is consistent with its higher figure of merit (ZT).

The significance of this research lies in its potential contribution to developing more efficient and sustainable thermoelectric generators. By exploring alternative materials which can withstand higher temperatures, TEGs could be used in a broader range of applications, such as industrial waste heat recovery and automotive exhaust systems. Furthermore, the successful implementation of high-performance TEGs could lead to reduced energy consumption and greenhouse gas emissions, promoting a more sustainable future.



Power vs Current of different hot side (T_H) values for SrTiO_3 .



Electrical potential distribution to drive a current of 0.7A for (a) Bi_2Te_3 (b) $\text{Ca}_2\text{FeMoO}_6$ (c) SrTiO_3

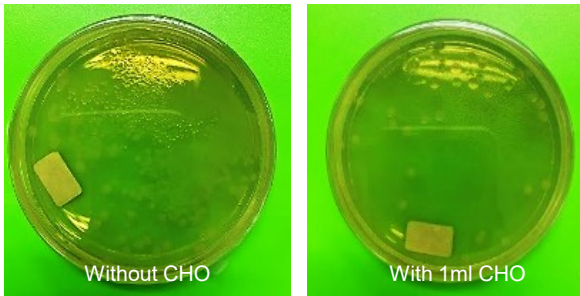
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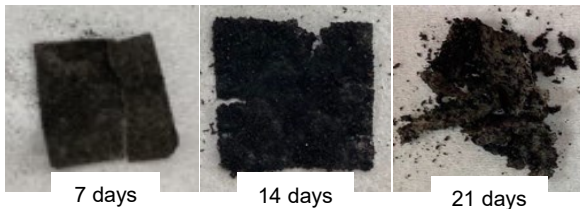
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Cassava Starch Biopolymer Film Incorporated with *Citrus Hystrix* Oil for Food Packaging



Bacteria colony of film



Biodegradability of film with 1 ml CHO

Food products easily deteriorate because of the growth of bacteria and the loss of moisture, gases, and nutrition. It becomes spoilage in a short period and reduces its quality. Artificial or chemical-based food preservatives are widely used in the food industry, but they are toxic and can cause adverse effects on human health. Antimicrobial or active packaging film serves as a new approach to food preservation and packaging that protects the foods from environmental conditions and can delay food spoilage. Thus, incorporating natural additives such as essential oil into film formulation is nontoxic and safe for humans. Essential oil contains active compounds to retard microbial activities. Therefore, the biopolymer film incorporated with essential oil could improve food quality, extend food's shelf life and make it biodegradable. This study explores the potential of *Citrus Hystrix* oil (CHO) as an active ingredient in the film formulation. The CHO was extracted using the hydrodistillation method, and then it was incorporated into the film formulation, which

consisted of cassava starch and glycerol. The film was produced using the casting technique, and its characterization was determined.

The major compounds in the extracted CHO were α -pinene (17.660%), citronellol (13.683%), linalool (11.022%), α -thujene (7.773%) and terpinene-4-ol (7.606%). The film's antimicrobial activity shows that CHO can inhibit the growth of *Escherichia coli*. Incorporating 1 ml CHO reduced the bacteria colony to 81% compared to film without CHO. The presence of the isopropyl group in α -pinene and the hydroxyl group in citronellol and linalool and cyclohexene ring of terpinene-4-ol are likely to contribute to the antimicrobial activity of CHO. The increase in CHO decreased the biodegradability of the films. The film without CHO and the film with 0.2 ml and 0.4 ml CHO were fully degraded in the soil after 21 days. The film containing 1 ml CHO had the lowest weight loss, 43.9%.

The water intake by the film in the soil promotes the entry of microorganisms; thus, due to the higher water availability within the material, the films were degraded in the natural environment.

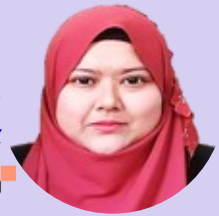
The film without CHO presented the highest tensile strength (3.35 MPa). The incorporation of CHO from 0.2 ml to 1 ml reduced the tensile strength by 26 % - 41 %. The addition of CHO up to 0.8 ml caused an increase in water vapour permeability, which is related to the decrease in tensile strength. The TGA shows that the presence of CHO reduced the degradation rate of the film, indicating better thermal stability than film without CHO. The incorporation of CHO suggested a promising natural antimicrobial additive for cassava starch film to be utilized as food packaging. The film resulted in good tensile strength and water vapour permeability, is thermally stable, is well degraded, and possesses antimicrobial activity. The developed film is possibly an eco-friendly packaging that is able to prevent food deterioration and prolong food's shelf life.

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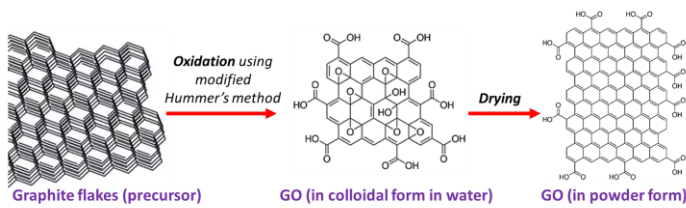
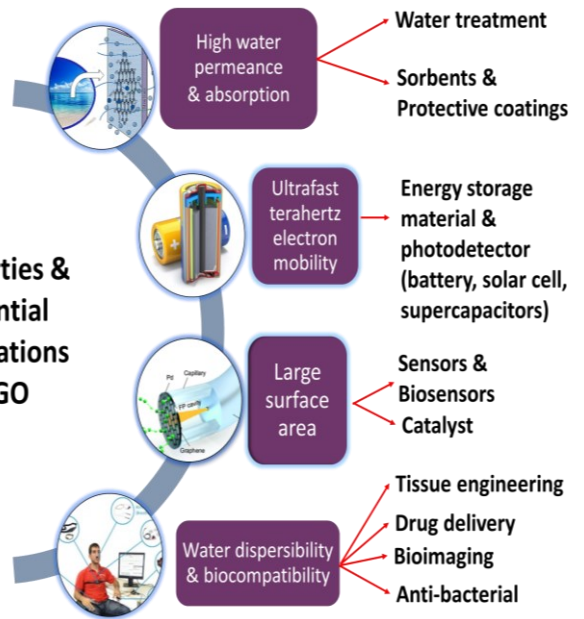


Simple and Low-Cost In-house Production of High Yield and Stable Graphene Oxide

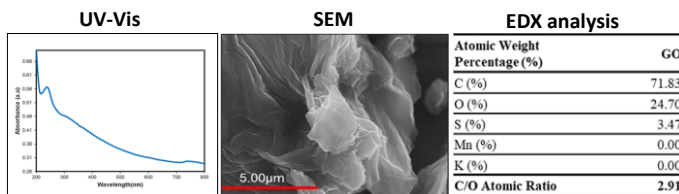
Graphene oxide (GO) possesses unique properties that are suitable for various applications. GO is the oxidized form of graphene and exhibits variable structures and properties depending on the synthesis process, incorporating groups such as hydroxyl, carbonyl, epoxy, and carboxyl. Due to its higher content of oxygen functional groups and increased number of defects, GO has a greater number of adsorption sites. These functional groups significantly influence the material properties, enabling potential applications in diverse fields of science and technology. The market demand for GO in advanced applications has driven its price from RM1,000 to RM8,000 per gram, depending on purity. This high price restricts research and further industrial-scale applications, especially given the lack of local supply.

Consequently, this study aims to develop a simple, low-cost, reliable, and stable synthesis method for GO using a straightforward setup based on a modified Hummer's method. An added benefit of excluding

Properties & Potential Applications of GO



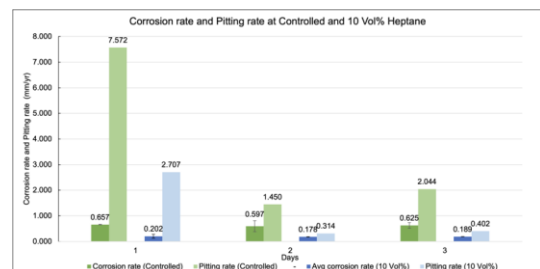
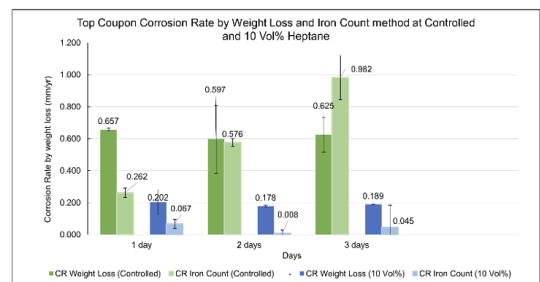
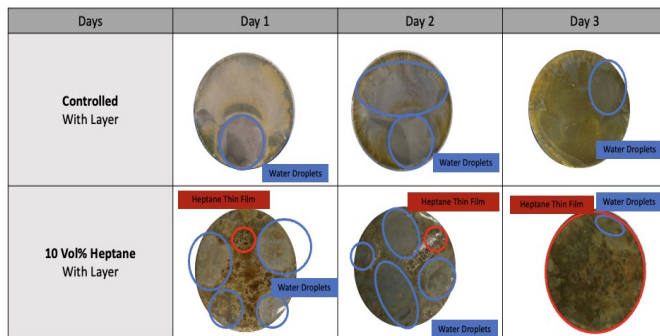
sodium nitrate (compared to conventional methods) is the elimination of harmful gas by-products such as nitrogen and dinitrogen tetroxide produced during the experiment. By systematically controlling the synthesis parameters, a high yield of up to 76% (1.76 g) of GO can be produced from 1.0 g of graphite powder. The synthesized GO exhibits excellent stability, which is confirmed through various characterizations; hence, there is evidence that high-quality GO can be produced locally. Our GO products are available either in suspension in water (colloidal form) or in powder form, depending on the intended application. In conclusion, the synthesized GO has a wide range of fascinating and distinctive features, making it ideal for various advanced applications.



Characterisations of GO using UV-Vis, SEM and EDX

Effect Heptane on Top-of-Line Corrosion Mechanism in Sweet Water Hydrocarbon Co-Condensation Environment

Global oil and gas production involves extracting and treating wellhead fluids such as crude oil, natural gas, and brine before production can begin—offshore structures like multiphase piping and deviation drilling extract oil and gas from reservoirs. Subsea production starts in the reservoir, followed by drilling to create a well for extraction. The oil and gas are transported to a processing plant via an underwater pipeline and riser system. Additional processing is required for natural gas to meet export standards.



Natural gas is categorized into three types: gas from gas wells, gas associated with other formations, and gas from condensate reservoirs. The processing of natural gas depends on the presence of liquefiable hydrocarbons. Gas from gas wells consists mainly of methane, while gas associated with other formations contains abundant liquefiable components. Gas-condensate reservoirs contain a high percentage of dissolved heavier hydrocarbons like heptane. Natural gases also contain acid gases such as hydrogen sulphide and carbon dioxide.

Pipelines are the primary mode of transportation for natural gas, oil, and condensate, although they can suffer from containment loss due to leaking, inadequate equipment design, defects, and corrosion. Factors like rain, humidity, salt water, and chemicals cause external corrosion of pipelines. Proper design, material selection, routine maintenance, and inspection are essential for preventing corrosion. Understanding how water and hydrocarbons co-condense and wet the pipe wall is critical for preventing corrosion.

Our study examined the impact of introducing a small amount of heptane on the top-of-line corrosion process in a water hydrocarbon co-condensation sweet environment. The results highlighted the significant influence of n-heptane on the Water Corrosion Rate (WCR), showing a substantial 90% difference in WCR with and without heptane. This directly impacted the Top of Line Corrosion (TLC) rate, exhibiting a notable 70% contrast in the TLC rate with and without heptane. Although the pitting rate was slightly higher without heptane, the WCR and TLC rates remained stable in both scenarios, potentially due to consistent gas and steel temperatures. It is worth noting that the experiments did not directly compare the duration of exposure.

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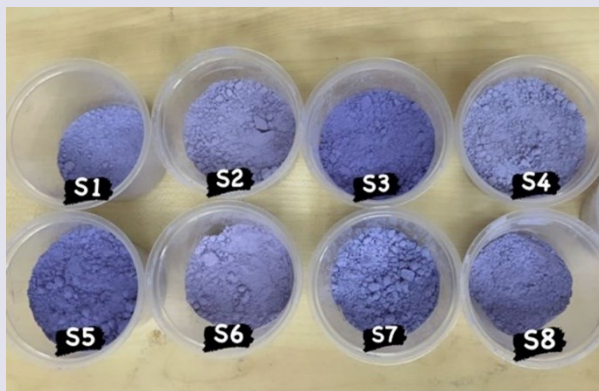
50 Shades of Blue: The Power of Anthocyanins in Blue Pea (*Clitoria ternatea*) Flower

From the garden to your plate, the mesmerizing blue hues of the blue pea flower captivate the eye and offer incredible health benefits. However, beyond their beauty, these vibrant blooms hold the secret to enhancing food preservation and fighting diseases.

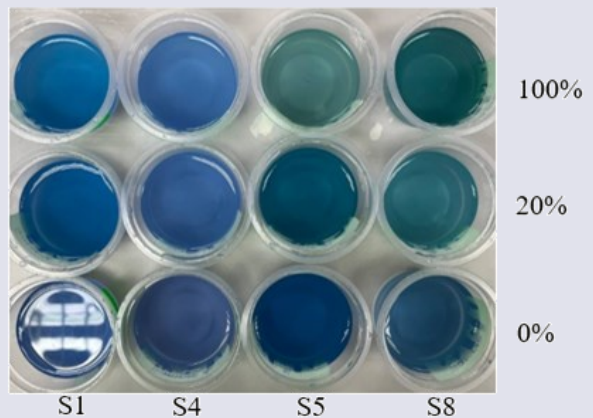
Lipid oxidation and free radical production are notorious for degrading food quality, leading to unpleasant flavours and shortened shelf life. Moreover, these processes contribute to serious health conditions like

atherosclerosis, diabetes, rheumatoid arthritis, Alzheimer's disease, and cancer. To combat these issues, antioxidants like anthocyanins — responsible for the striking blue colour of the blue pea flower — can be incorporated into functional foods to prolong the shelf life and boosting health.

Anthocyanins are natural pigments found in many plants, and the blue pea flower is a rich source of these powerful compounds. However, their high thermal sensitivity and instability require encapsulation within protective wall materials to preserve their benefits. These materials must exhibit excellent rheological behaviour, dispersibility, and stability, ensuring a stable coating, controlled release, and protection against environmental factors. Spray drying emerges as a popular technique for encapsulating these pigments, converting liquid dispersions into dry, stable products.



Spray-dried encapsulated blue pea
flower powder



Various blue shades at different light
intensity

Our research focused on the morphological and colour stability of blue pea powder extracts after spray drying at different temperatures. We discovered that powders encapsulated with 100% maltodextrin at higher temperatures resulted in larger particles due to rapid drying and increased feed viscosity. Conversely, particles encapsulated with Arabic gum were smaller, and temperature had a minimal impact on their size. Interestingly, a combination of maltodextrin and Arabic gum produced even smaller particles, likely due to reduced droplet stickiness at lower drying temperatures.

Significantly, the vibrant blue anthocyanins from the blue pea flower were successfully encapsulated using maltodextrin and Arabic gum. This breakthrough encapsulation method not only preserves the stunning

colour and health benefits of anthocyanins but also offers a promising solution for improving food handling and extending shelf life.

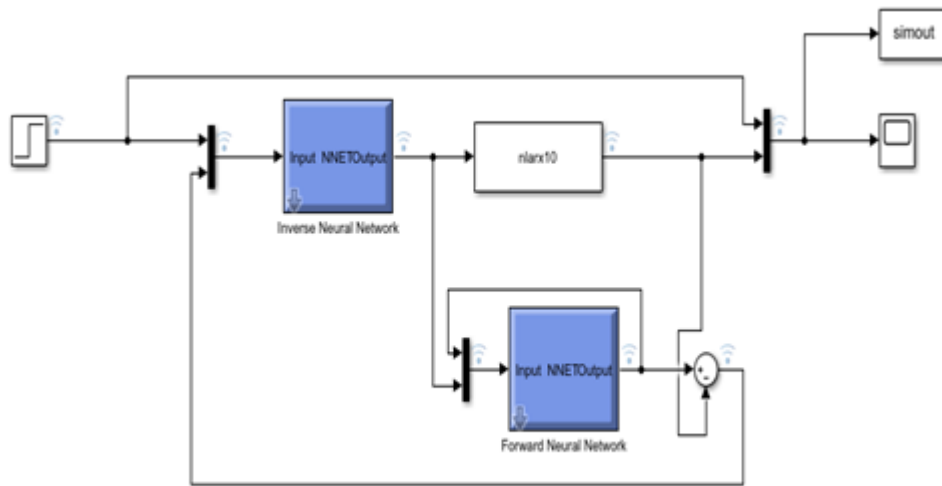


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Simulation Diagram of IIMC

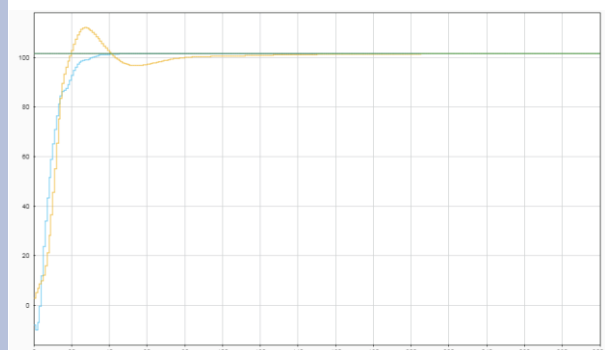
Dissolved oxygen (DO) is one of the key elements that influence bioreactor performance and is essential for aerobic bacteria in bioreactors. Hence, any uncontrolled fluctuation in DO concentration may lead to problems in aerobic growth or a decrease in the efficiency of microorganism metabolism, eventually leading to detrimental production and undesirable by-products. The biological process is highly dynamic, making it challenging to design using a conventional PID controller, as any changes cause instability to the controller parameters. The study presented the development of a control strategy for dissolved oxygen (DO) in a bioreactor. In this study, the system identification toolbox in MATLAB was used to simulate a mathematical model of the process based on simulation data running from MINIFORS (MINIFORS, Infors). An artificial neural network (NN) with a Levenberg-Marquardt training algorithm and feed-forward back propagation network was used as a training method.

The model consists of a single input (aeration rate) and a single output (dissolved oxygen), and the simulation was carried out in a Simulink environment in MATLAB. Based on the result, IIMC shows good performance with no overshoots and undershoots compared to the PID controller with an overshoot of 11.8% and an undershoot of 3.2%. Besides that, IIMC also has a faster settling time, which is 43s, compared to the PID controller, with a settling time of 163s. IIMC is also able to reach multiple set points without overshooting. For the disturbance test, the IIMC performance in dealing with disturbance was satisfactory. The disturbance slightly affected the process; however, the controller reached a targeted set point as designed. Overall performance, IIMC shows good performance in a

Integrated Internal Model Control (IIMC) of Dissolved Oxygen (DO) in Bioreactor

bioreactor. The findings of this study will be incredibly useful for many industries such as bio-process, wastewater and others.

Step response of IIMC and PID controller.



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Malaysia has great advantages in agriculture in terms of having a good climate throughout the year. With these advantages, Malaysia stands for good opportunities to increase quality to market the produce locally and internationally.

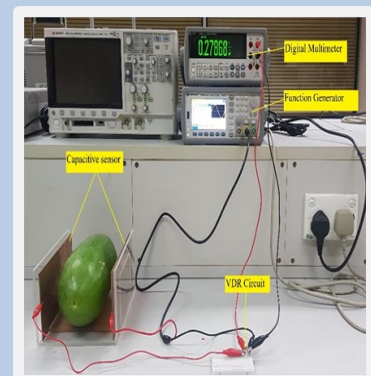
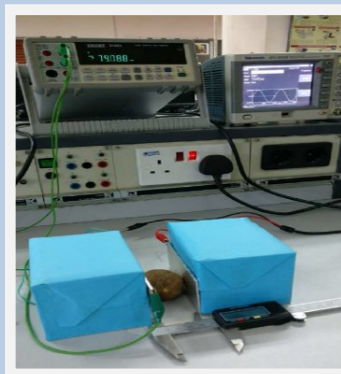
My research and innovation, named FRUITSENSE, addresses the challenge of accurately predicting fruit ripeness and sweetness using non-destructive measurement techniques in Malaysian agriculture. Traditional methods often

involve destructive sampling and subjective assessment, leading to inefficiencies in harvesting and marketing. In contrast, my approach utilises advanced methods such as spectroscopic methods like near-infrared (NIR) spectroscopy, hyperspectral imaging, and capacitive sensing techniques.

Non-destructive Techniques in Determining Malaysian Local Fruit Ripeness Level

Destructive methods in determining the Brix, pH level, firmness and water content were also carried out to correlate between destructive and non-destructive data. The results demonstrate the effectiveness of these techniques in reliably predicting fruit quality parameters without harming the fruit itself. This novel approach contributes significantly to scientific knowledge by offering a precise and efficient alternative to conventional methods. It enables farmers and distributors to make informed decisions on optimal harvest times, ensuring fruits reach consumers at peak quality, enhancing market competitiveness, and improving consumer satisfaction.

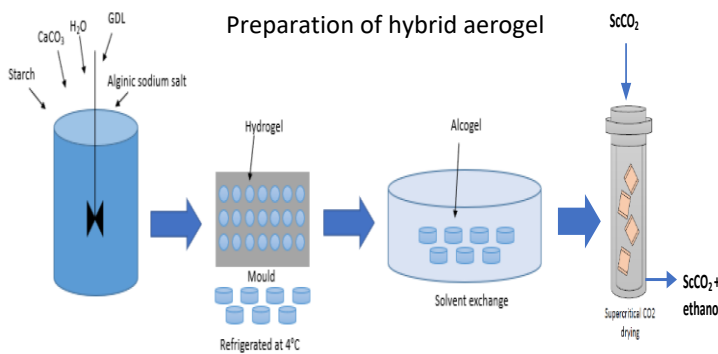
Beyond agricultural productivity, my research's societal impact includes reducing food waste and promoting sustainable agricultural practices. By minimising post-harvest losses and optimizing resource allocation, these techniques support environmental sustainability and contribute to global food security efforts. Finally, the research highlights the potential of non-destructive measurement techniques to revolutionize fruit quality assessment in agriculture, offering practical solutions with far-reaching implications for industry efficiency and sustainability.



Enhancing Drug Delivery: Advancements in Hybrid Aerogels and Supercritical CO₂ Drying

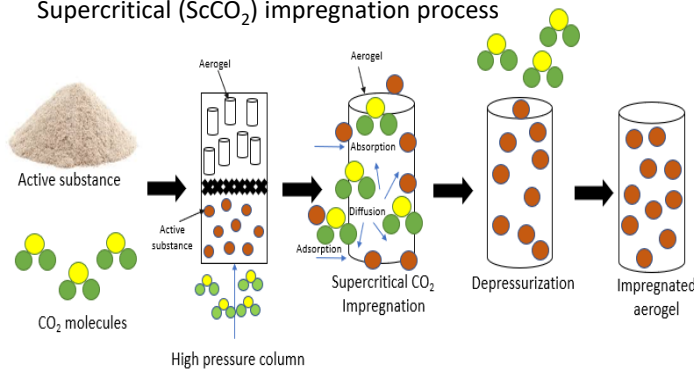
Supercritical fluid technology is a new approach in the pharmaceutical industry that uses supercritical fluids, mainly carbon dioxide (CO₂), to enhance drug delivery systems. These fluids exhibit unique properties of liquids and gases, making them ideal for aerogel production in drug delivery applications.

Aerogels are open porous materials with large specific surface areas and high pore volume, making them attractive for drug carriers. They have been studied for their biodegradability and biocompatibility, making them promising carriers for drug delivery systems. Polysaccharides like cellulose, starch, and alginates are used to prepare organic aerogels, which are relatively inexpensive, highly biocompatible, and non-toxic.



Oral administration is the most common route for drug delivery, and recent studies have focused on the pharmacokinetic and pharmacodynamic properties of drugs. Researchers are now using polysaccharides to prepare oral film-coated drugs, potentially for disease prevention and treatment. Hybrid aerogels made from variations of polysaccharides have shown

Supercritical (ScCO₂) impregnation process



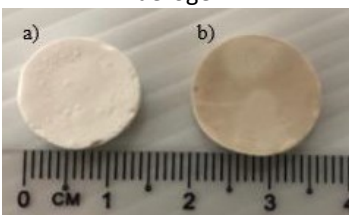
potential for improving mechanical strength and tailoring drug delivery to a fast or controlled released system.

Hybrid alginate/starch aerogels were synthesised and dried using supercritical CO₂ (ScCO₂). The results showed that increasing the starch content by 15wt% reduced volume shrinkage and increased thermal stability, making them more promising for drug delivery systems and biomedical applications.

Supercritical drying of blank hybrid alginate/starch aerogel



Impregnation of *Labisia pumila* into hybrid alginate/starch aerogel



In-situ impregnation was the best method for producing amorphous *Labisia pumila* encapsulated in the aerogels, as the drug loading is higher, and the aerogels offer accurate dose delivery. Further investigation is needed to find the most suitable organic solvent with high solubility with *Labisia pumila* and immiscible with CO₂ to increase compound loading. This research lays the groundwork for future studies on drug delivery methods by combining hybrid aerogels and herbal materials. With additional research and improvements, hybrid aerogels have the potential to be an effective tool for precise and efficient drug delivery. This has the potential to benefit patients and advance the fields of pharmaceuticals and biomedicine.

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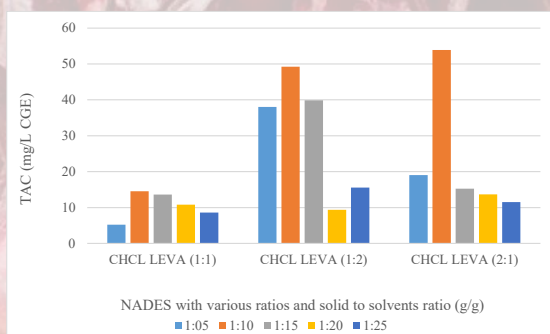
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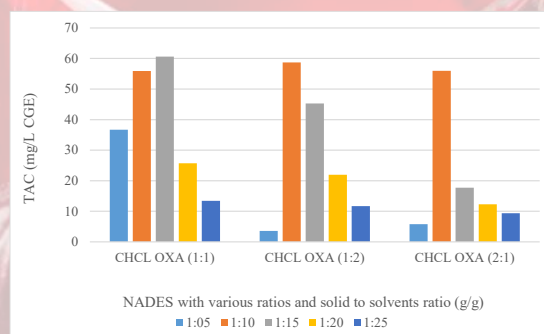
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Natural Deep Eutectics Solvents: A Green Approach to Extracting Anthocyanins from *Hibiscus Sabdariffa*



TAC (mg/L cyanidin-3-glucoside equivalent) against ratio of HBA and HBD and solid-to-solvent ratio (g/g) for ChCl: Levulinic acids NADES



TAC (mg/L cyanidin-3-glucoside equivalent) against ratio of HBA and HBD and solid-to-solvent ratio (g/g) for ChCl: Oxalic acid NADES

The increasing demand for natural food colourants has driven research toward replacing synthetic dyes with safer, plant-based alternatives. One notable example is the vibrant red pigment from *Hibiscus sabdariffa*, commonly known as roselle. This pigment, rich in anthocyanins, offers significant nutritional benefits. Traditional extraction methods, such as maceration and Soxhlet extraction, are inefficient, requiring large amounts of volatile organic solvents and considerable energy.

Our study addresses these limitations by exploring the use of natural deep eutectic solvents (NADES) in combination with microwave-assisted extraction (MAE). NADES are formed from a mixture of hydrogen bond acceptors (HBAs) and hydrogen bond donors (HBDs), offering high versatility, low vapour pressure, and excellent thermal stability. By experimenting with different HBA and HBD

ratios, we aimed to optimize the extraction of anthocyanins.

We discovered that NADES comprising choline chloride (ChCl) and oxalic acid in a 1:1 ratio significantly improved the extraction efficiency, yielding 60.60 mg/L of total anthocyanins content (TAC). This method demonstrated superior performance compared to ChCl paired with levulinic acid at a 1:15 solid-to-solvent ratio due to its higher polarity and selectivity.

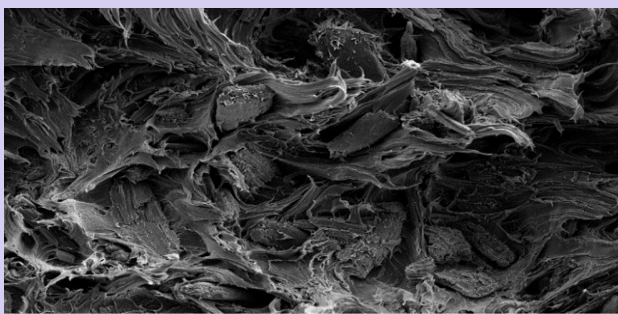
These findings are pivotal for the food industry, offering a greener, more efficient extraction method for natural colourants. By reducing reliance on synthetic dyes, this approach can enhance food safety and sustainability. Furthermore, the use of NADES in MAE could revolutionize the extraction of bioactive compounds, promoting the development of healthier, eco-friendly food products.

Assessing the Mechanical Properties of Kenaf Fiber and LDPE Composites

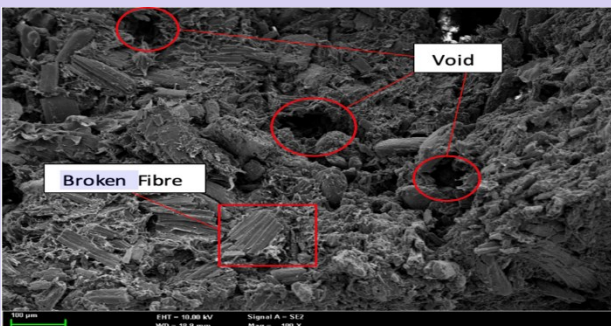
The escalating accumulation of plastic waste is engendering severe environmental ramifications, thereby catalysing the investigation of natural fiber composites to mitigate production expenses and enhance the mechanical properties of industrial products. Natural fiber, sourced from animals, minerals, and plants, are favoured due to their brief growth cycles, renewability, and abundant availability. This study specifically investigates bast fibers, such as kenaf fiber, which can attain lengths exceeding 3 meters within a three-month period and are suitable for reinforcing high-performance biodegradable polymer composites. However, the hydrophilic nature of kenaf fibers poses



Kenaf fibre after washing



SEM image taken from fracture surface of 10 wt% of Kenaf/LDPE composites at 100 μ m



challenges when integrating with nonpolar hydrophobic polymer matrices. The objective of this study is to evaluate the mechanical properties of composite materials by effectively integrating kenaf fiber with a polymer matrix and a coupling agent to augment reinforcement. Low-Density Polyethylene (LDPE), known for its flexibility, toughness, and corrosion resistance, is employed as the polymer matrix. Biocomposites reinforced with LDPE and natural fibers present a viable solution. The study utilizes the reactive extrusion method to amalgamate Kenaf with other polymeric materials and coupling agents.

The primary focus of this research is the application of Kenaf fiber and Low-Density Polyethylene (LDPE) as a polymer matrix in composite materials. Through the reactive extrusion process, Kenaf was combined with polymeric materials and coupling agents, including Itaconic Anhydride (IA) and peroxide. Kenaf composites were synthesized by incorporating varying percentages of Kenaf fibers into the matrix. Thermal Gravimetric Analysis (TGA) revealed that a high weight percentage of Kenaf within the LDPE matrix might diminish the composite's thermal stability. Fourier Transform Infrared Spectroscopy (FTIR) analysis indicated the presence of chemical bonds between the fibers and the matrix, such as C-O, C=O, and O-H. Morphological examination of the composites suggested that the coupling agent could enhance the interphase layer at the Kenaf and LDPE interface. Scanning Electron Microscopy (SEM) imagery of composites with 10% Kenaf displayed a smooth surface with minimal void spaces, whereas composites with 60% Kenaf exhibited a rough surface with minor fiber damage. An increased percentage of Kenaf in the composite was observed to reduce the chain mobility of the polymeric matrix.

SEM image taken from fracture surface of 60 wt% of Kenaf/LDPE composites at 100 μ m



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Infrared Drying Preserving Antioxidant from Bitter Melon

Chronic illnesses, including cardiovascular diseases, diabetes, and certain types of cancer, are significantly impacting the health and mortality rates of Malaysians. Our research focuses on the preservation of natural antioxidants through infrared drying techniques and explores the medicinal benefits of phenolic compounds in bitter melon. The utilisation of infrared drying is becoming a crucial method for preserving *Momordica charantia*, often known as bitter melon, especially for preserving its antioxidant capacity at a level similar to its fresh condition. This novel drying technique utilises infrared radiation to produce heat, effectively removing moisture from the food product. In contrast to conventional drying techniques that often require extended periods at elevated temperatures, infrared drying provides a faster and more energy-efficient option, essential for maintaining the delicate nutritional components.

Antioxidants are vital for health as they fight free radicals in the body, potentially reducing the risk of chronic diseases. The rapid drying process minimises the degradation of these antioxidants, ensuring that the dried product is almost as beneficial as the fresh fruit. Phenolic compounds, renowned for their antioxidant properties, are associated with various health benefits, including anti-inflammatory and anti-cancer effects. It is essential to comprehend the solid-to-solvent ratio to create extracts with the highest bioactivity. This can maximise the health benefits of antioxidant-rich products.

Additionally, understanding the correlation between solvent-to-solid ratio, phenolic content, and antioxidant capacity can help optimize extraction processes,

ensuring the highest possible yield and potency from natural sources. This knowledge can guide researchers, manufacturers, and product developers in making informed decisions about extraction protocols and formulations, thereby driving scientific research and fostering the development of innovative and effective products.

Our study reveals that the solid-to-solvent ratio significantly impacts the yield of total phenolic compounds (TPC) in bitter melon extracts. A high solid-to-solvent ratio yields higher TPC extracts, indicating that increasing the ratio improves the extraction efficiency of phenolic compounds. The antioxidant activity of fresh and dried extracts also follows a similar trend, with extracts obtained using a higher ratio exhibiting stronger free radical scavenging abilities. The antioxidant activity was around 90% for fresh and infrared dried extracts. This suggests a positive correlation between phenolic concentration and antioxidant capacity from fresh & infrared-dried bitter melon. The findings have implications for developing extraction methodologies to obtain effective yields of total phenolic compounds and better antioxidant capacity from bitter melon. Optimising infrared drying and extraction technologies to enhance bitter melon extracts' phenolic content and antioxidant capacity can lead to functional foods, dietary supplements, and pharmaceuticals with improved health-promoting properties.



Sample
Collection and
Preparation

Dried samples
preparation
using IR Dryer

Isolation
of phenolic
compound
using Soxhlet
extraction

Preparation
of TPC and DPPH
analysis

Analysis of TPC and
DPPH assays using
UV Vis
Spectrophotometer

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