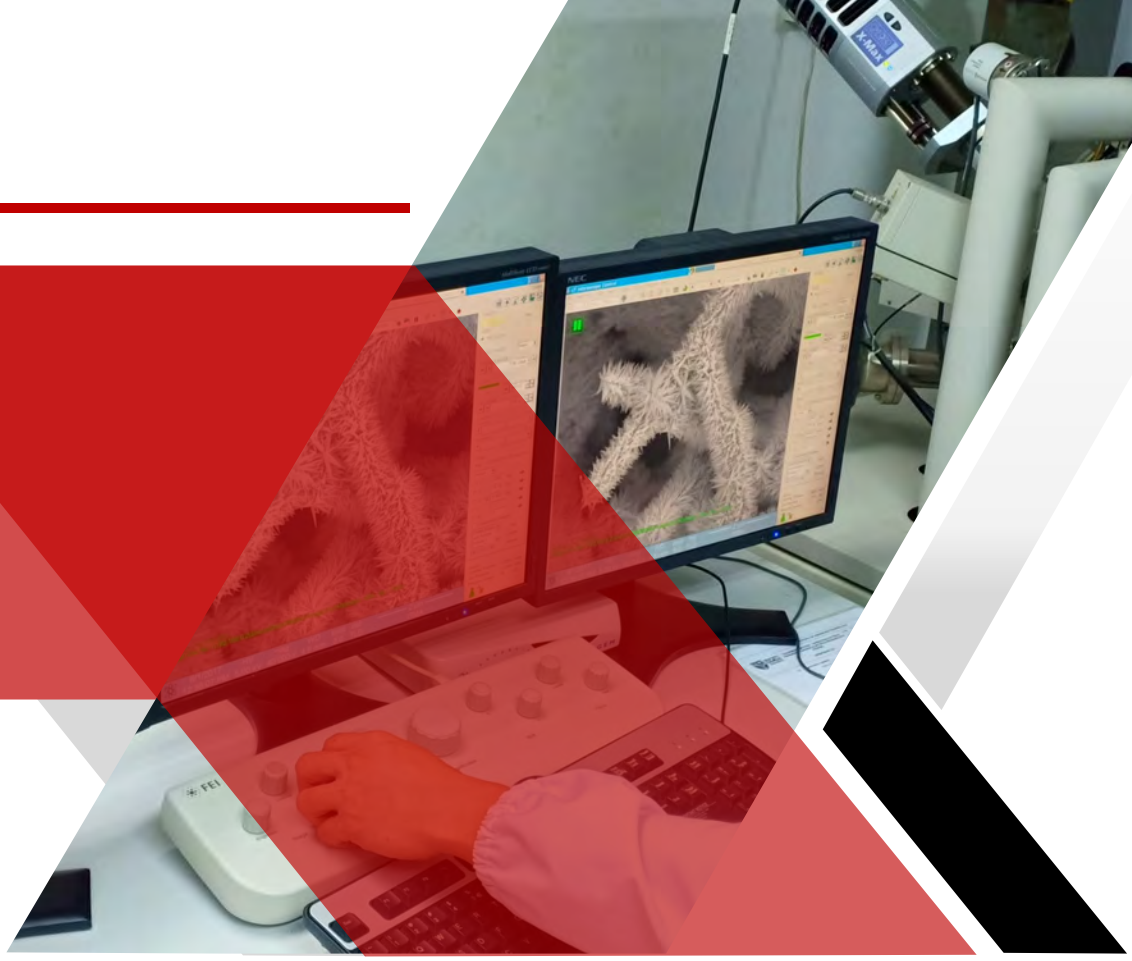

UNIVERSITI PUTRA MALAYSIA
BERILMU BERKHIDMAT

INSTITUT NANOSAINS DAN NANOTEKNOLOGI
INSTITUTE OF NANOSCIENCE AND NANOTECHNOLOGY

We train future research leaders as well as share research findings, expertise, and facilities with research and industry communities around the world.

ION2 RESEARCH PROFILE

OVERVIEW

The Institute of Nanoscience and Nanotechnology (ION2), formerly known as the Institute of Advanced Technology (ITMA) develops research laboratories in the field of nanotechnology and advanced materials focusing on the niche areas of nano-scale green synthesis and applications.




RESEARCH & DEVELOPMENT

ION2 comprises of three main research laboratories; attracting renowned researchers and trains future research leaders in niche areas related to nanoscale green synthesis and applications.

- Functional Nanotechnology Devices Laboratory (FNDL)
- Nanomaterials Synthesis and Characterisation Laboratory (NSCL)
- Nanomaterials Processing and Technology Laboratory (NPTL)

RESEARCH PROGRAM

- Nanomaterials and Carbon Nanomaterials
- Functional and Structural Nanomaterials
- Foundry of Reticular Materials for Sustainability (FORMS)
- Nanomaterials Processing
- Nanomaterials Technology
- Sensor Technology
- Electron Devices

ION2 has a list of experienced researchers from various areas of expertise.

FUNCTIONAL NANOTECHNOLOGY DEVICES

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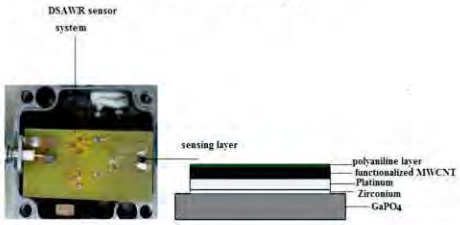
RESEARCH HIGHLIGHTS

1. Sensor Technology



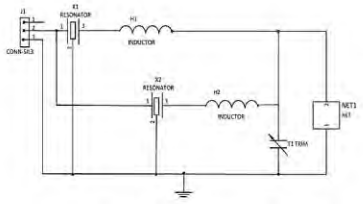


Figure 3. Schematic of DSAWR system with a resistor connected in parallel.

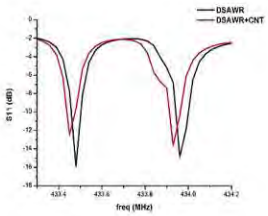


Figure 6. Plot of S11 *versus* frequency.

Yunusa, Z., Hamidon, M. N., Ismail, A., Isa, M. M., Yaacob, M. H., Rahmanian, S., . . . Shabaneh, A. A. "Development of a Hydrogen Gas Sensor using a Double SAW Resonator System at Room Temperature," *Sensors (Switzerland), 15*(3), pp. 4749-4765, 2015

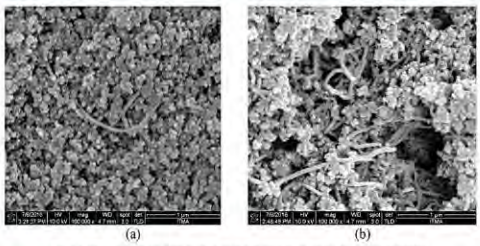
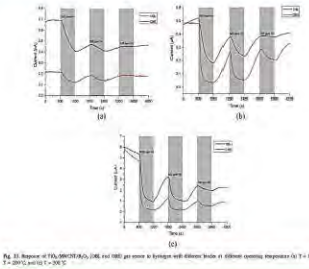
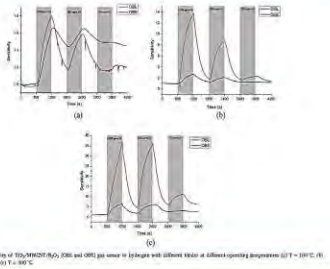
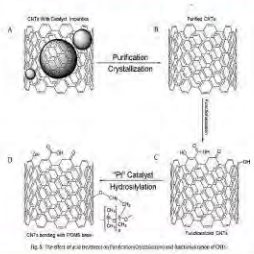


Fig. 2. FESEM image of TiO_2/MWCNT/B_2O_3 thick film annealed at 500 °C for (a) OBL and (b) OBE.





S.A. Mohd Chachuli, M.N. Hamidon, M.S. Mamat, M. Ertugrul and N.H Abdullah, "Response of TiO_2 MWCNT B_2O_3 Gas Sensor to Hydrogen using Different Organic Binder," Materials Science in Semiconductor Processing, Vol. 99, pp 140-14, 2019



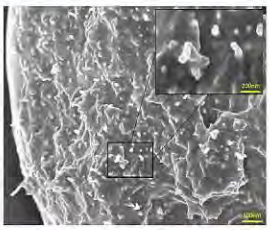


Fig. 7. Uniform dispersion of functional CNTs in PDMS.

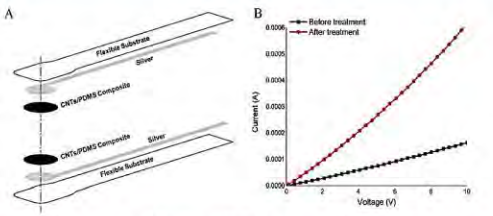


Fig. 8. (A) Design of the Piezoresistive pressure sensor; (B) I–V characteristics of CNTs/PDMS nanocomposite before and after crystallization and functionalization (average output obtained from 10 wt% and 15 wt%).

S. Azahari, H. Tanaka, M.N. Hamidon, A.T. Yousefi, A. Khajeh, K. Nicodemus and M.M. Bigdeli, "Fabrication of Piezoresistive Based Pressure Sensor via Purified and Functionalized CNTS/PDMS Nanocomposite: toward Development of Haptic Sensors," Sensors and Actuators A, Vol. 266, pp. 158-165, 2017

2. Carbon-based Ultraconductor

Ultra-conductor is defined as an electrical conductors, which have certain properties similar to present-day superconductors and can considered as a novel state of matter which using carbon-based material as the important element. Thick film technology is implemented of which a highly conductive CNT paste is screen printed on a substrate based on design such as electrodes or circuit connectors.

This work is supported by Ministry of Higher Education (MOHE) LRGS NanoMITe fund LRGS/2015/UKM-UPM/NanoMITe/04/02.

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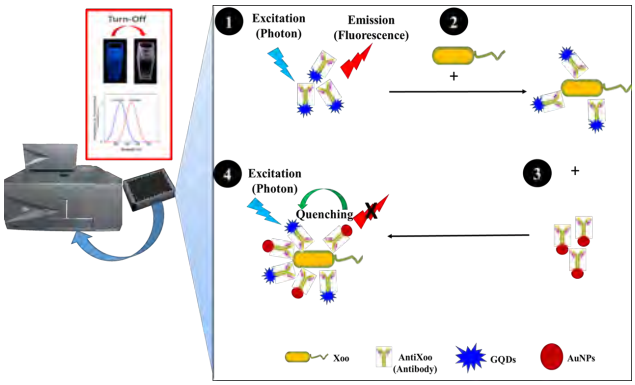
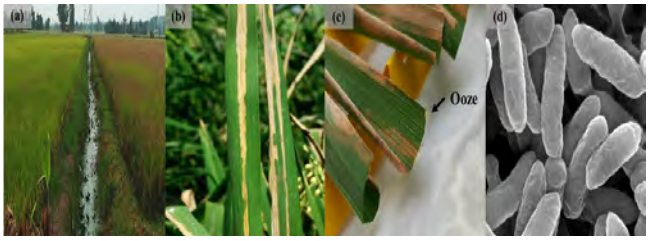
RESEARCH HIGHLIGHTS

1. Fluorescence Sensing Platform Based on Graphene Quantum Dots Based for Pathogen Detection

This research focused on the development of *turn-off* fluorescence-graphene quantum dots-based immunoassay for the early detection of *Xanthomonas oryzae pv. oryzae (*Xoo*)*, a gram-negative bacteria that causes rice bacterial leaf blight disease. The specific antibody against Xoo cells was produced as specific bio-recognition molecules. The conjugation of this antibody with graphene quantum dots and gold nanoparticles was performed and characterized respectively. The combination of these two bioprobes as fluorescent donor and metal quencher showed fluorescence signal changes which proportional to the logarithm of Xoo cells in the range of 10^0 to 10^5 CFUmL^{-1}. The limit of detection was achieved at 22 CFUmL^{-1} and the specificity test against other plant disease pathogens showed high specificity to Xoo. The detection of Xoo in real plant samples was also performed in this study and demonstrated satisfactory results.



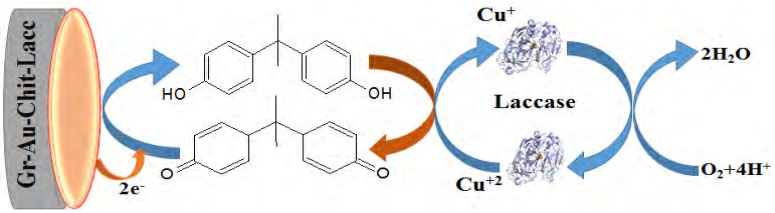
Schematic diagram of fluorescence graphene quantum dots based immunosensor that using two probes of antibody conjugated with GQDs and gold nanoparticles



Bacterial leaf blight disease in rice crops (a) A view of BLB-infected paddy field at Sekinchan, Selangor, Malaysia; (b) BLB's symptom of yellowish strip lesions along the leaf margin; (c) Bacterial ooze from BLB infected leaves (IRRI) and (d) scanning electron microscopy (SEM) image of Xoo cells

2. Electrochemical Biosensor based Graphene-gold/chitosan Composite for Phenolic Detection

Bisphenol A (BPA) is considered one of the most common chemicals that could cause environmental endocrine disrupting. Therefore, there is an increasing demand for simple, rapid and sensitive methods for BPA detection that result from BPA leaching into foods and beverages from storage containers. Herein, a simple laccase electrochemical biosensor was developed for the determination of BPA based on screen-printed carbon electrode (SPCE) modified graphene gold/chitosan. The synergic effect of graphene-gold/chitosan nanocomposite as electrode modifier greatly facilitates electron-transfer processes between the electrolyte and laccase enzyme, thus leads to a remarkably improved sensitivity for bisphenol A detection. The developed laccase biosensor offered excellent analytical performance for the detection of BPA with a sensitivity of 0.271 µA/µM and limit of detection (LOD) of 0.023 µM, respectively. Moreover, the constructed biosensor showed good reproducibility, selectivity and stability towards BPA.



The possible mechanism of bisphenol A catalyze by laccase at modified electrode

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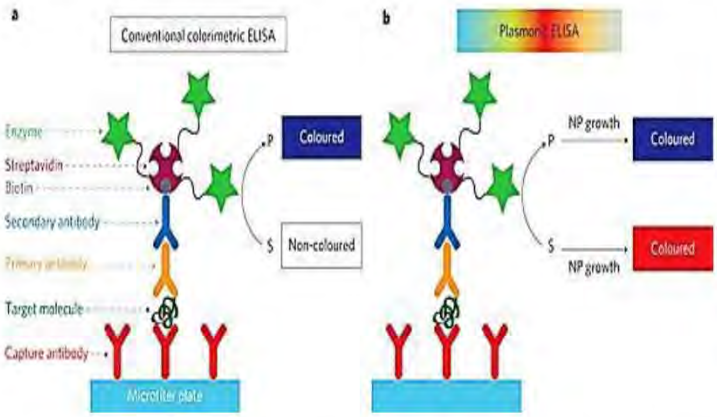
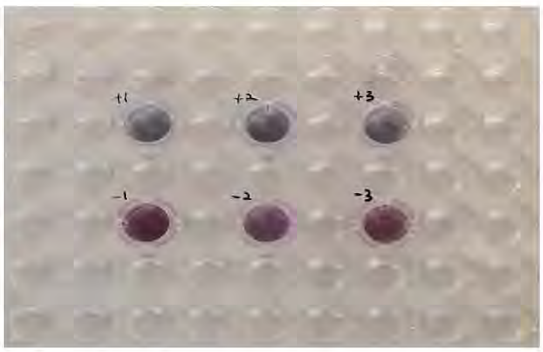
RESEARCH HIGHLIGHTS

Tuberculosis (TB) has become one of the most serious infectious diseases, causing death globally. Failure to control the spread of TB is largely due to inability to detect and treat all infectious cases of pulmonary TB in a timely fashion, allowing continued Mycobacterium tuberculosis transmission within communities. The global TB epidemic results in nearly two million deaths and nine million new cases of the disease a year. In fact, this resurgent disease has become a significant public health concern in Malaysia, with approximately 234,160 new TB cases every year and is largely related to immigration from countries with a high prevalence of TB. Currently, recommended gold-standard diagnostic tests for TB are laboratory based, and multiple investigations may be necessary over a period of weeks or months before a diagnosis is made. Delayed diagnosis has serious consequences for both the prognosis of the patient and onward transmission of M. tuberculosis.

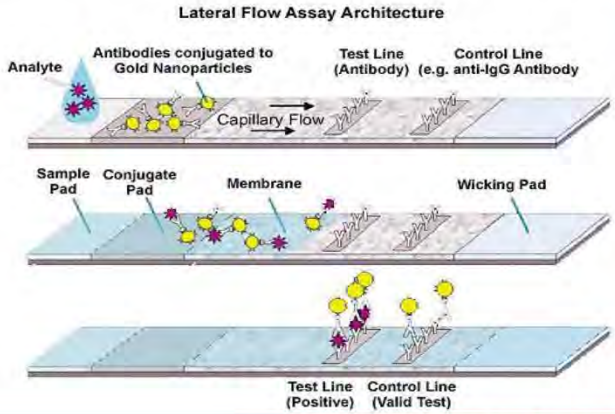
We have developed three techniques with features that suits the TB diagnosis based on nanotechnology. The first one is on Plasmonic ELISA which has proven to be very sensitive and selective in TB patient's sputum sample analysis. Graphical representation can be viewed below.

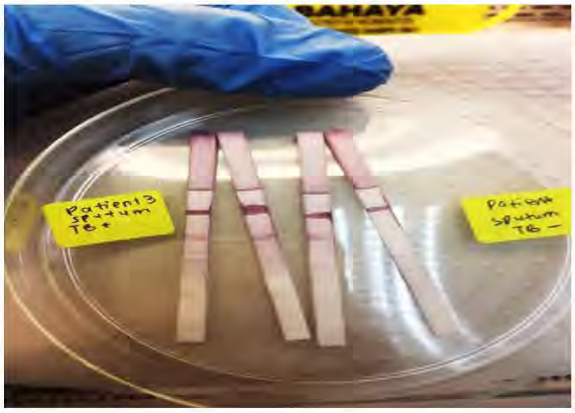
Left Figure showing the graphical representation of the sensing principal and the the right Figure showing the actual result obtained when tested with TB positive and negative patient's sputum sample.



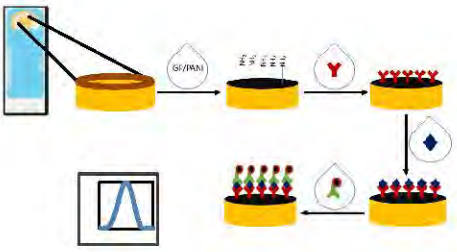


The second detection system is using Lateral Flow system which utilize gold nanoparticle. The advantages in using Lateral Flow system or commonly known as strip test is the low cost and the user friendly feature. However the sensitivity is a bit low compared to Plasmonic ELISA method. The test strip method has been tested with TB patient's sputum sample and the strip manage to show acceptable selectivity between negative and positive samples. Figures below are showing the result and the principle of the developed test strip.



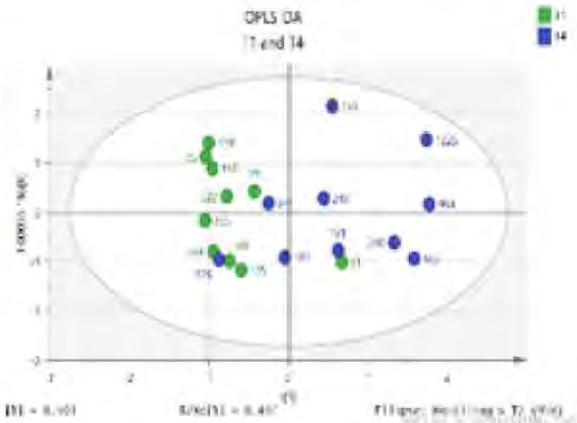


The third technique is using electrochemical reader. The reader was developed using Differential Pulse Voltammetry technique where the usage of nanomaterial has proven to enhance the current signal. This technique is very sensitive and manage to detect down to picomolar level. Figures below describe the sensing principle, the electrode modification technique and the applicability of the method on TB patient's sputum sample.



Bil	Reader Sensor						Culture method	AFB direct smear
	Trial 1	Trial 2	Trial 3	Average	SD	Conclusion		
1	58.12	64.06	56.62	59.60	3.93	Positive	Positive	Positive
2	74.88	52.77	53.29	53.03	0.37	Negative	Negative	Negative
3	55.81	56.13	70.95	60.96	8.65	Positive	Positive	Negative
4	59.82	57.53	57.43	58.26	1.35	Negative	Negative	Negative
5	53.78	57.18	44.5	51.82	6.56	Negative	Negative	Negative
6	53.37	60	63.09	58.82	4.97	Negative	Negative	Negative
7	48.39	50.54	51.94	51.24	1.79	Negative	Negative	Negative
8	55.46	47.43	59.13	54.01	5.98	Negative	Negative	Negative
9	74.61	71.98	60.52	69.04	7.49	Positive	Positive	Negative

Another highlight of our research is on our E-nose detection system for oil palm tree disease. Malaysia is currently the second main producer of palm oil in the world after Indonesia. Malaysia export palm oil of 39% of world palm oil production and 44% of world exports. But the planters of oil palm in Malaysia are facing a devastated crop disease infection called Basal Stem Rot (BSR) that mostly caused by Ganoderma boninense which is a basidiomycete white rot fungus that will disrupt the water and nutrient transport to the upper part of the palm thus causing frond wilting, yellowing of fronds, unopened spear leafs, reduce and "one sided mottling" canopy and emergence of basidiocarps on the lower stem. We have developed an E-nose system to detect an increase level of secondary metabolite when the tree is infected by Ganoderma boninense at early stage. The e-nose developed is equipped with semiconductor based sensors where it will give out changes in signal/pattern upon exposure to the leaves of the infected tree. The E-nose system is equipped with Bluetooth system and can be operated using mobile apps. The current e-nose system is currently being tested with Sime Darby plantation (one of the major producer of Malaysian palm oil) and Malaysian Palm Oil Board (MPOB) plantation.



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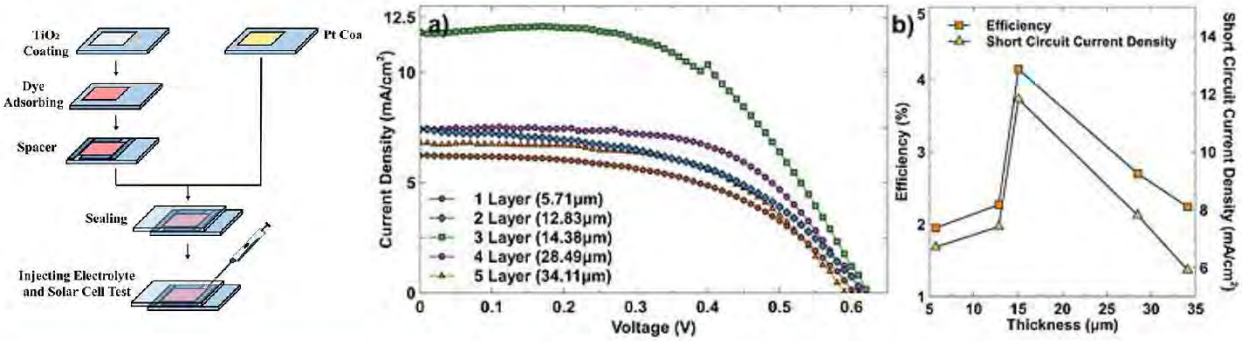
RESEARCH HIGHLIGHTS

1. Enhancing Photocurrent Performance Based on Photoanode Thickness and Surface Plasmon Resonance Using Ag-TiO_2 Nanocomposites in Dye-Sensitize Solar Cells

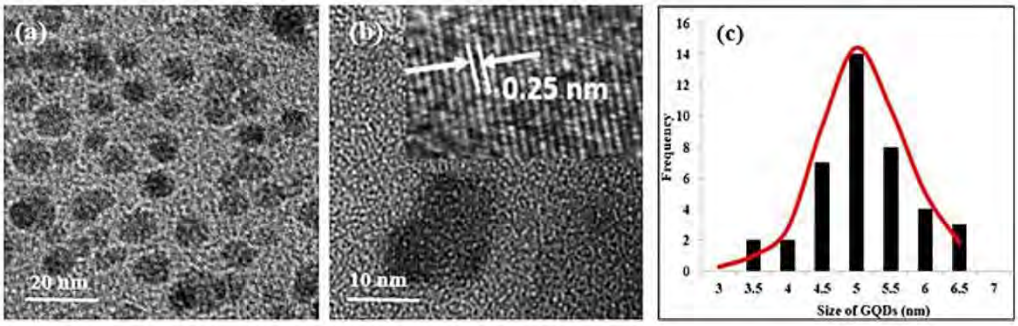
The three-layer Scotch tape, with thickness of 14.38 µm, achieved a high efficiency of 4.14%. This results showed that three layers was the optimal thickness to improve dye loading and to reduce the charge recombination rate. As for the Ag-TiO_2 nanocomposites, 10mM of AgNP, with a mean diameter of 65.23 nm and high efficiency of 6.92%, proved that SPR can enhance the absorption capability of dye and improve the photon-to-electron generation.



Lokman, M.Q.; Shafie, S.; Shaban, S.; Ahmad, F.; Jaafar, H.; Mohd Rosnan, R.; Yahaya, H.; Abdullah, S.S. Enhancing Photocurrent Performance Based on Photoanode Thickness and Surface Plasmon Resonance using Ag-TiO_2 Nanocomposites in Dye-Sensitized Solar Cells. *Materials* **2019**, *12*, 2111.

2. Charge transport and electron recombination suppression in dye-sensitized solar cells using graphene quantum dots

GQDs increased light absorption of TiO_2 photoelectrode at visible spectrum in the range of λ=375 nm to λ=600 nm, resulting highest current–density, Jsc and photon-to-current conversion efficiency, Ƞc. Solar cell sensitized in 7.5 mg/ml concentration of GQDs shown the highest reading by 15.49 mA/cm2 and 6.97%, which indicated an improvement by 28.07% and 70.83% for Jsc and Ƞ compare to pristine TiO_2 DSSC.



N. Fadzilah M. Sharif, M.Z.A.A. Kadir, Suhaidi Shafie, Suraya Abdul Rashid, W.Z. Wan Hasan, Suraya Shaban, Charge Transport and Electron Recombination Suppression in Dye-sensitized Solar Cells using Graphene Quantum Dots, Results in Physics, Volume 13, 2019, 102171.

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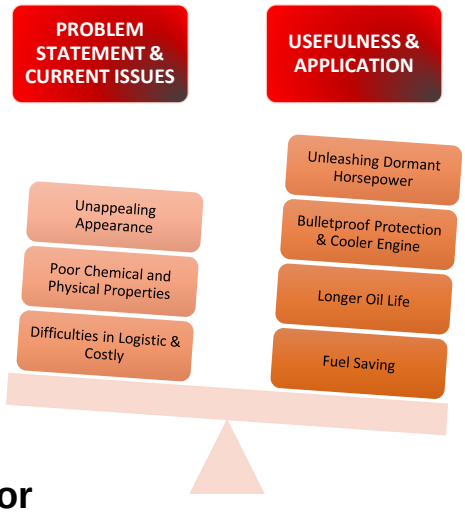
RESEARCH HIGHLIGHTS

1. GrafinTok®

GrafinTok® provides the benefits of patented graphene technology for engine oil. It is compatible with all types of vehicles. It is an engine oil enhancer that revives your car by

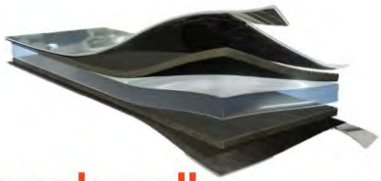
1. Unleashing dormant horsepower.
2. Providing bulletproof protection.
3. Extending oil life.
4. Promoting cooler engine.
5. Saving fuel.
6. Improving engine combustion efficiency.
7. Reducing noise and vibration for a smoother, silent drive.



2. Graphene Battery & Graphene Supercapacitor

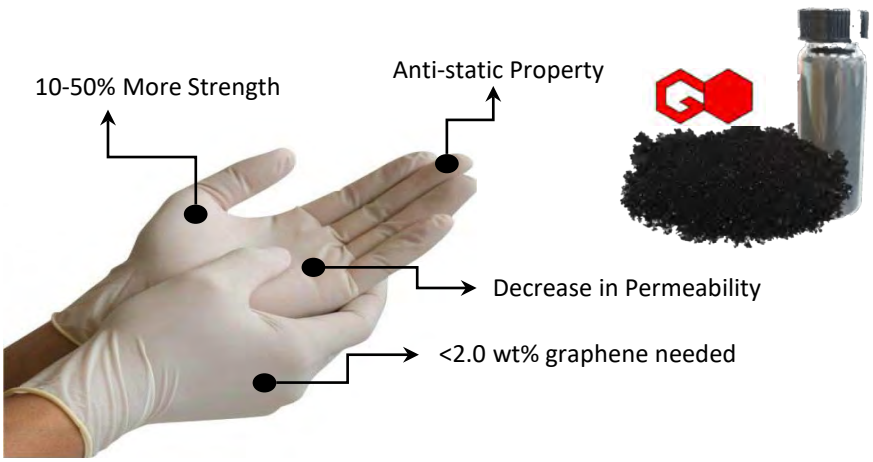
Graphene is used as an electrode material for energy storage devices.

Coin Cell



Pouch cell

3. Graphene Gloves



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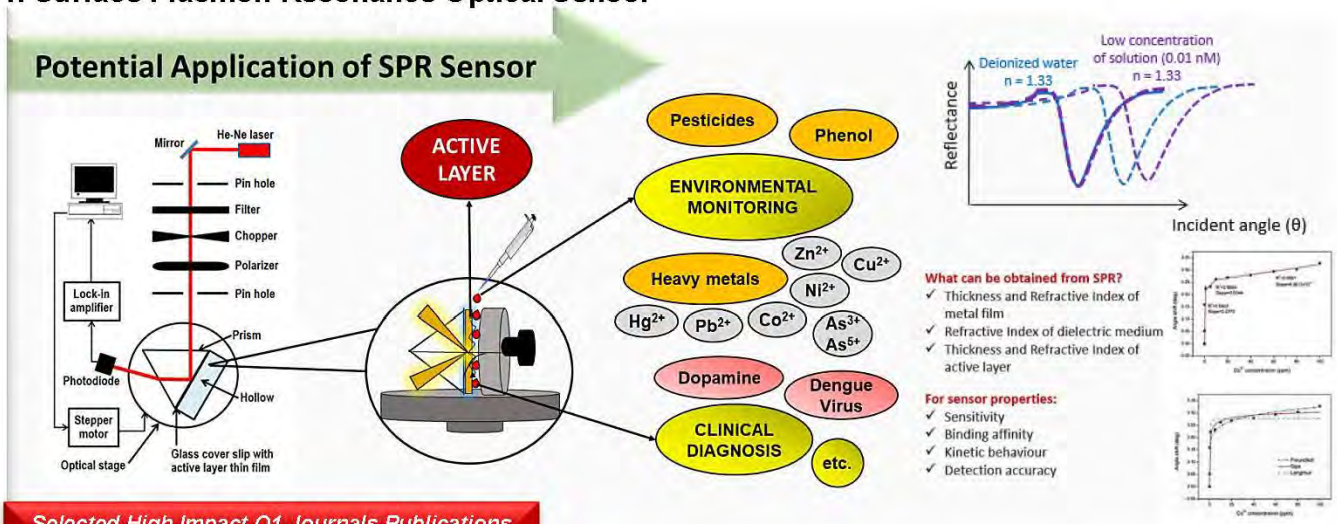
RESEARCH HIGHLIGHTS

FIELDS OF RESEARCH: SENSOR TECHNOLOGY, OPTICAL SENSOR, BIOSENSOR, OPTICAL MATERIALS

1. Surface Plasmon Resonance Optical Sensor

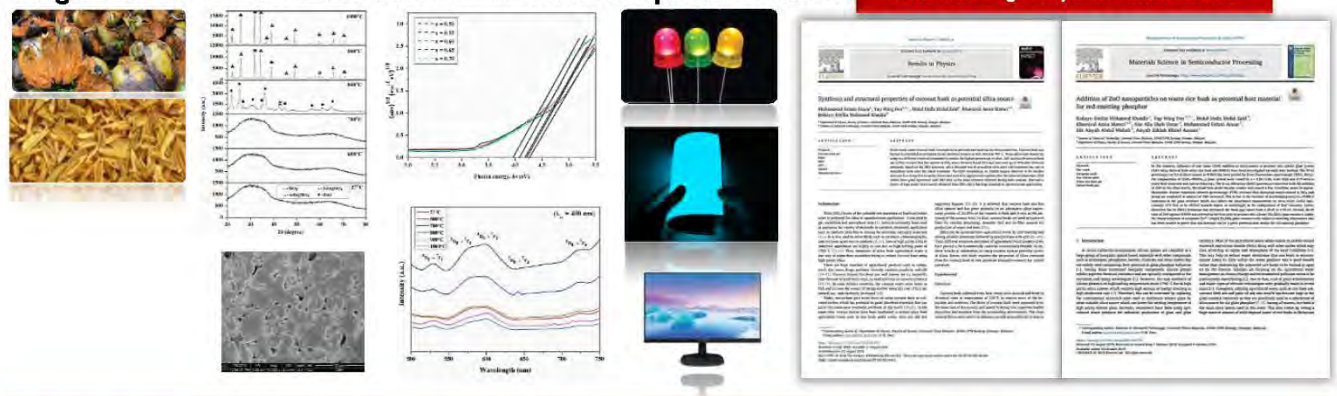


Selected High Impact Q1 Journals Publications

Supported by Putra Grant & Ministry of Higher Education (MOHE) - FRGS/1/2019/STG02/UPM/02/1 & PRGS/1/2020/STG07/UPM/02/1

2. Agriculture Waste - ZnO Based Functional Optical Devices

Selected High Impact Publications



Supported by Putra Grant & Ministry of Higher Education (MOHE) - FRGS/1/2019/STG07/UPM/02/1

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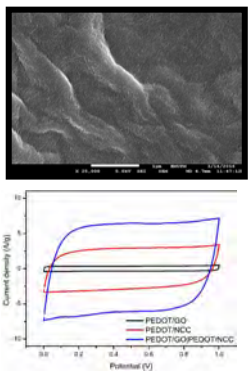
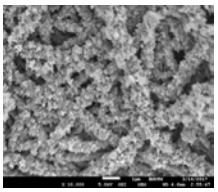
RESEARCH HIGHLIGHTS

1. Energy Storage Devices (Supercapacitors, Electrochromic-supercapacitor)

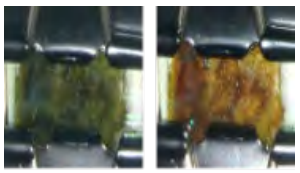


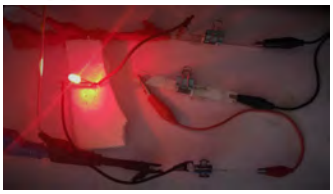
Layer-by-layer



Nanofiber composite

Coin-cell

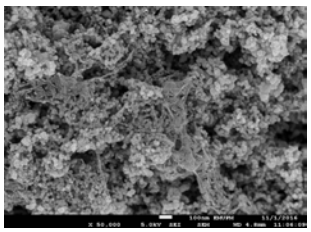




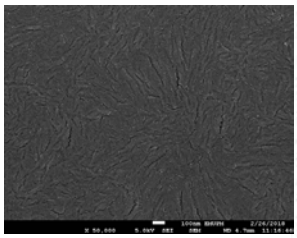
Electrochromic-supercapacitor

Electrochimica Acta 259 (2018) 466, Journal of Electroanalytical Chemistry 867 (2020) 114188, Journal of Energy Storage 48 (2022) 103954
Patent: PI2018702018, PI2021007033

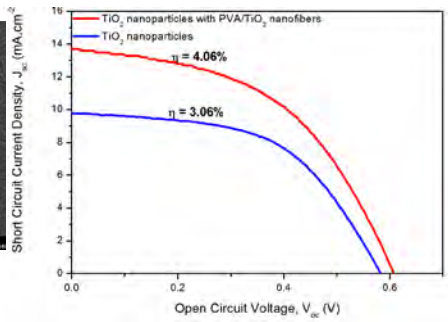
2. Solar Cells

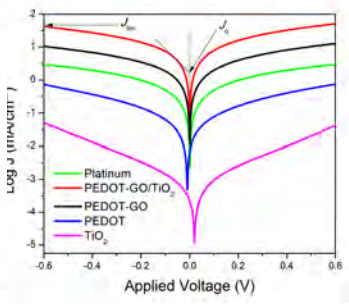


Nanocomposite



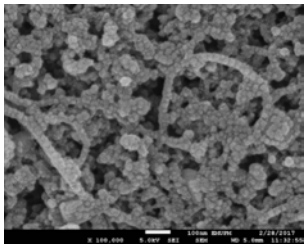
Compact layer



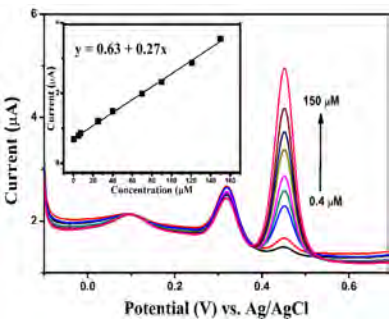


Optical Materials 120 (2021) 111475, Solar Energy 212 (2020) 332-338
Patent: PI20190055

3. Sensors



Nanocomposite modified electrode



Sensor kit

Synthetic Metal252 (2019) 76, Microchimica Acta 186 (4) (2019) 261, RSC Advances 8 (2018) 15522.
Patent: PI 2018700001, PI 2018700606

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RESEARCH HIGHLIGHTS

Nanotechnologies in Dielectric Insulating Fluids for Application in High Voltage Equipment

The aim of this research is to examine the dielectric and physiochemical performances of either mineral or vegetable based nanofluids with and without surfactants. Several objectives are identified for the research.

1) To examine the AC and withstand breakdown voltages of either mineral or vegetable based nanofluids with and without surfactants and identification the suitable nanoparticles that can provide the optimum improvement.

2) To investigate the lightning breakdown voltage and streamer properties of either mineral or vegetable based nanofluids with and without surfactants under uniform and non-uniform fields.

3) To examine the partial discharge properties of either mineral or vegetable based nanofluids with and without surfactants with consideration on the light analysis.

4) To evaluate the heat transfer properties of either mineral or vegetable based nanofluids with and without surfactants and its impact on the thermal ageing of paper and pressboard.

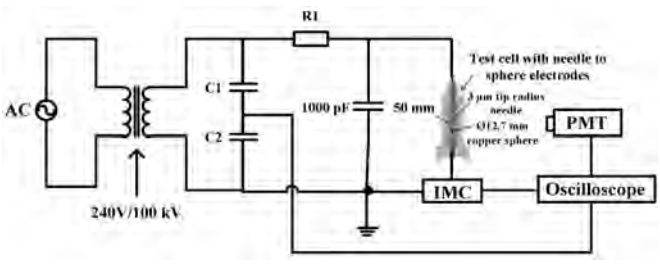

Figure 1. Configuration for partial discharge (PD) and photo multiplier tube (PMT) measurement.

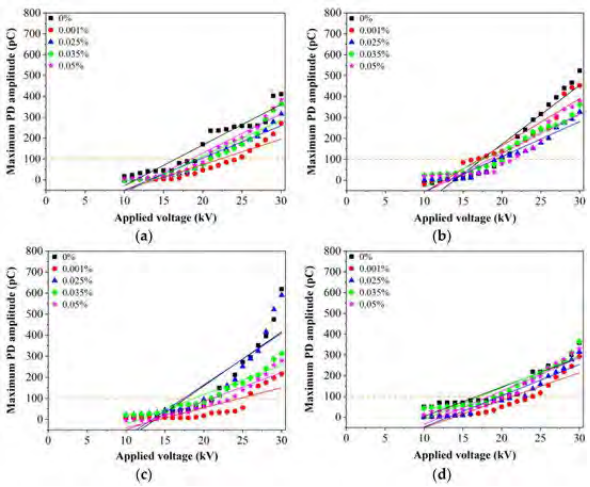

Figure 2. Maximum PD amplitude versus applied voltage for (**a**) RBDPOA, (**b**) RBDPOB, (**c**) CO and (**d**) MO based Al_2O_3 with SDS.

Mohamad, N.A.; Azis, N.; Jasni, J.; Kadir, M.Z.A.A.; Yunus, R.; Yaakub, Z. Experimental Study on the Partial Discharge Characteristics of Palm Oil and Coconut Oil Based Al_2O_3 Nanofluids in the Presence of Sodium Dodecyl Sulfate. *Nanomaterials* **2021**, *11*, 786. https://doi.org/10.3390/nano11030786

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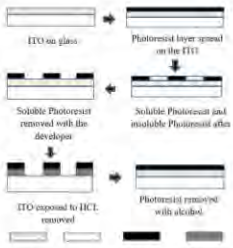
RESEARCH HIGHLIGHTS

1. Biomedical Microelectronic Engineering

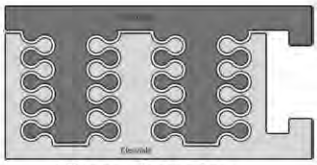
This research focused on the development of **electrohydrodynamic** on **lab on a chip** (LoC) for particles manipulation of biological or non biological origin. Particles have certain reaction to electric field generated by electrode with specific geometry when introduced to electrical signal or behave in certain manner when moving with fluid flow induced by the system. The sensor is electrode base fabricated by **photolithography** technique. The sample is colloidal particles suspended in various type of fluid. The electrode size and shape, the medium conductivity and permeability, the particles surface charge and the electrical signal frequencies and potential are the parameters that determine the behavior of the medium and the particle either **dielectrophoresis** or **electroosmosis** when subjected to the electric field. The research has been successfully maneuver carbon origin particles (Carbon Nanotubes, Graphene, Graphene Quantum Dots) and also successfully manipulate biological origin particles (Malaria Virus, Dengue Virus).

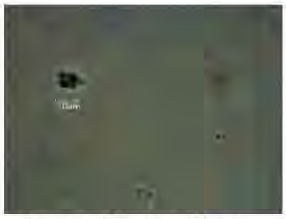
Furthermore the manipulation is done using **surface aquatic wave** (SAW) technique. Piezo material generate wave when introduce with electrical signal. The wave manipulate particles. The capillary channel were fabricated for placing the sample work in a way that particles can be trapped or channel for manipulation.



Photolithography


Particles trapped

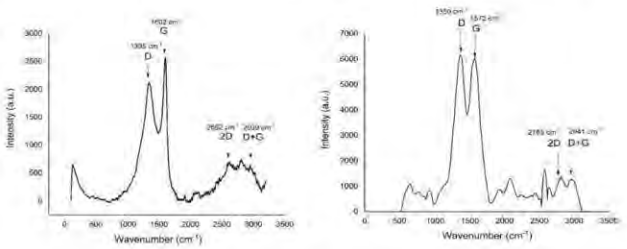

Zipper electrodes


Trapped Dengue Virus

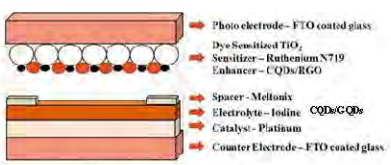
2. Energy optimization

The research focus on optimization of energy. It concentrate on **green technology**. **Energy harvesting** cell were develop not limited to dye-sensitized solar cells (DSSCs) but also microbial fuel cells (MFCs). The harvested energy is control by the system design to optimize the acquired energy. The energy harvesting panels were place together with aquaponic systems.

Furthermore the research also work on the backbone of the system to develop management of the electrical signal using **Organic Thin Film Transistor** (OTFT). To further stretch the research, the **conductive polymer** is fabricated to be applied not only as flexible but also transparent material.



Raman spectrum for CQD and GQD



Structure of DSSC

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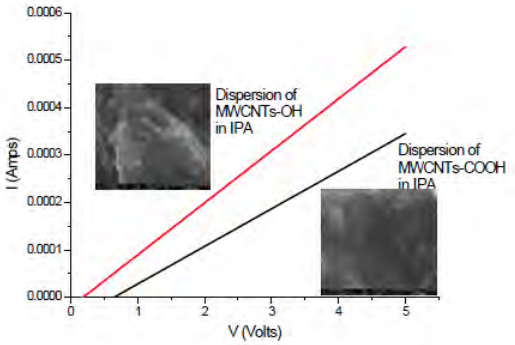
RESEARCH HIGHLIGHTS

1. Behaviour of Functionalized Multi-Walled Carbon Nanotubes (MWCNTs) as Conductive Nano-ink in Isopropyl Alcohol Solvent

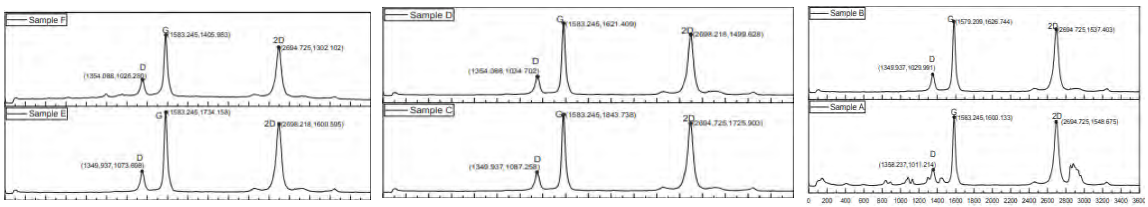
MWCNTs functional groups, carboxyl (-COOH) and hydroxyl (-OH) groups were dispersed in isopropyl alcohol (IPA) solvent. MWCNT-OH has better conductivity with lower resistance of 11.3 kΩ compared to MWCNT-COOH of 15.1 kΩ. MWCNTs have a good behaviour as a filler to produce high stablity and



N. H. A. Aziz, H. Jaafar, R. M. Sidek, S. Shafie, M. N. Hamidon, and R. Wagiran, Behaviour of Functionalized Multi-Walled Carbon Nanotubes (MWCNTs) as Conductive Nano-ink in Isopropyl Alcohol Solvent. J. Nanoelectron. Optoelectron. 16, 569–576 , 2021.

2. Raman Study on Dispersion of Carbon Nanotube in Organic Solvent as The Preparation of Conductive Nano-ink

Dispersion of Carbon Nanotube with acetone and THF organic solvents are not stable and higher defect compared to other organic solvents (chloroform, ethanol, methanol, and propanol).



N. H. A. Aziz, R. M. Sidek, M. N. Hamidon, S. Shafie, H. Jaafar, Raman Study on Dispersion of Carbon Nanotube in Organic Solvent as The Preparation of Conductive Nano-Ink, IEEE Regional Symposium on Micro and Nanoelectronics (RSM), Full Paper, Citation-Indexed - Scopus, IEEE Xplore @ Digital Library, International, 9781728104607 , [100 - 104], MALAYSIA, 2019.

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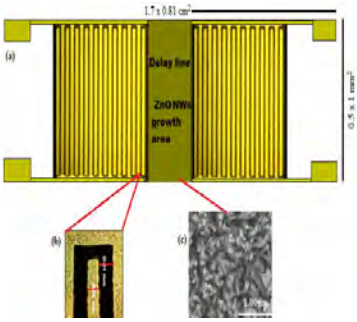
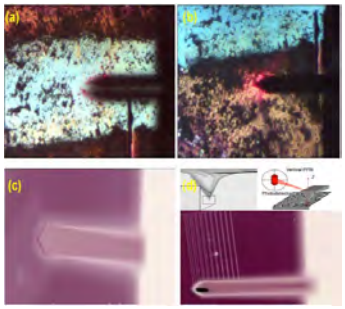
RESEARCH HIGHLIGHTS

1. Piezoelectric Properties of Zinc Oxide Nanostructures

Optimization of ZnO nanowires growth and *d33* parameter towards piezo-nanogenerators (PENG/TENG) applications.





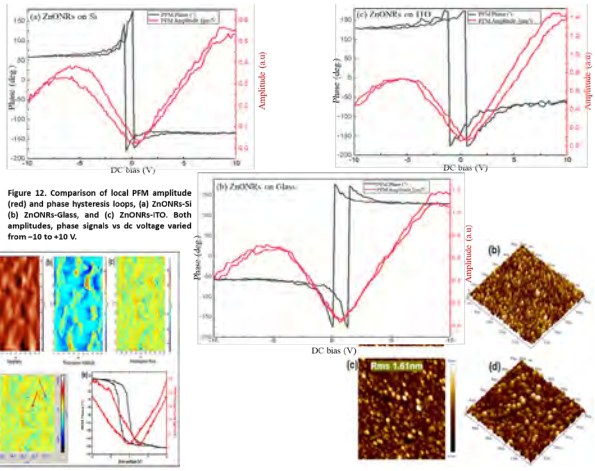


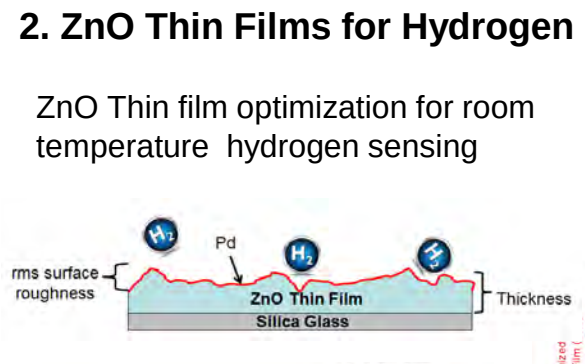
Figure 12. Comparison of local PFM amplitude (red) and phase hysteresis loops, (a) ZnONRs-Si (b) ZnONRs-Glass, and (c) ZnONRs-ITO. Both amplitudes, phase signals vs dc voltage varied from −10 to +10 V.

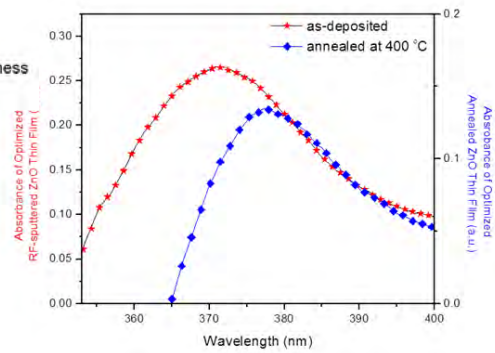
S Abubakar, JLY Chyi, ST Tan, S Sagadevan, ZA Talib, S Paiman, Nanoscale domain imaging and the electromechanical response of zinc oxide nanorod arrays synthesized on different substrates, Journal of Materials Research and Technology 14, 2451-2463, 2021

S. Abubakar, N. Khalid, S.F. Abd Rahman, T. S. Tee, M. N. Hamidon, Z. A. Talib, S. Sagadevan, S. Paiman, Fabrication and characterization of nanostructured zinc oxide on printed microcontact electrode for piezoelectric applications, Journal of Materials Research and Technology, 9 (6), 15952, 2020

2. ZnO Thin Films for Hydrogen Gas Sensor

ZnO Thin film optimization for room temperature hydrogen sensing





Siti Nor Aliffah Mustaffa, Nurul Assikin Ariffin, Ahmed Lateef Khalaf, Mohd Hanif Yaacob, Nizam Tamchek, Suresh Sagadevan, Suriati Paiman, Sensing mechanism of an optimized room temperature optical hydrogen gas sensor made of zinc oxide thin films, Journal of Materials Research and Technology, 9 (5), 10624-10634, 2020

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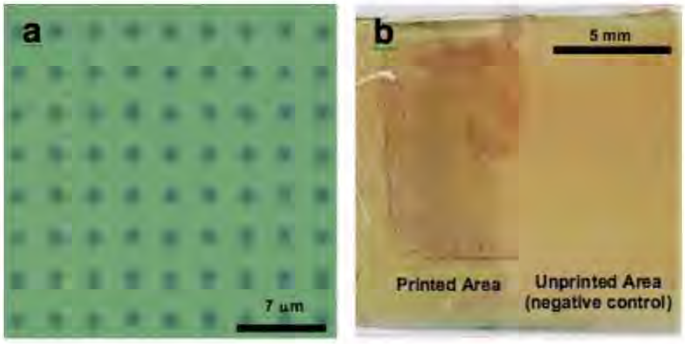
RESEARCH HIGHLIGHTS

1. Nanotechnology Derived Chip

The oil palm, Elaeis guineensis has been a significant contributor to Malaysia's economy in agricultural sector. However, the greatest current threat to the production of palm oil is the basal stem rot (BSR) diseases caused by Ganoderma boninense. Since there is no effective treatment for BSR disease, early detection is a proactive measure to avoid it. Collaborative work with researchers from University of Manchester and MARDI focused on the development of nanotechnology derived chip-based DNA/RNA detection platform that is applicable to be used in Malaysian agricultural setting. The research activities involved the development of nanoparticle assay with local biological materials and fabrication of arrays by using polymer pen lithography.



Optical image for immobilisation experiments on arrays with capture DNA-AuNPs and genomic DNA extracted from G. boninense mycelia. b) Photographic image of glass slide post hybridisation (10 pM of target ssDNA). Reprinted from Polymer Pen Lithography-Fabricated DNA Arrays for Highly Sensitive and Selective Detection of Unamplified Ganoderma Boninense DNA, by Ekta Rani et al. Polymers 2019, 11, 561.

2. Modification of Quantum Dots

Quantum dots (QDs), typical sizes ranges from 1 to 20 nm, are among the most interesting nanocrystals and have attracted more attention due to their special characteristics such as broad absorption spectra coverage, narrower and symmetric emission spectra and capability of tuning the optical properties by controlling the size of particles and surface functionalization. To enhance the performance of nanomaterials in particular applications, the surface of quantum dots require modification. Our recent work reported the modification of PbS QDs with antibody as a label for the quantitative detection of HER2 breast cancer biomarker and generated adsorbent for the removal of organic dye removal from waste water.

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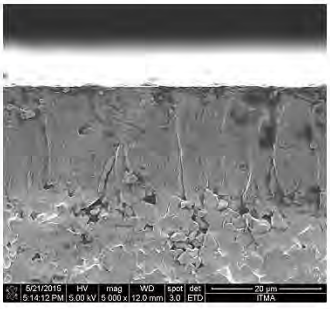
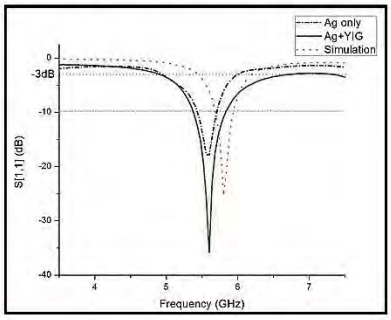
RESEARCH HIGHLIGHTS

1. Ferrites based Thick Film for Performance Enhancement of Patch Antenna

This project proposed a novel ferrite thick film paste using nanosized ferrite powder and linseed oil based organic vehicle which have never been reported before. By utilizing thick film technology, microstrip patch antenna has been able to fabricate with improved performance using common FR4 substrate. Thick film technology also contributes in terms of ease of fabrication, with ability to screen print prepared thick film paste on any desired substrate.

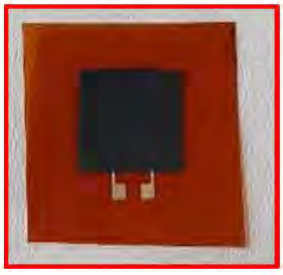


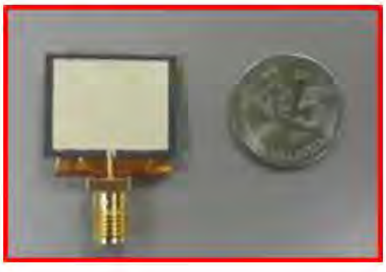


Intan Helina Hasan, Mohd Nizar Hamidon, Alyani Ismail, Ismayadi Ismail, Anwer Sabah Mekki, Muhammad Asnawi Mohd Kusaimi, Saman Azhari,and Rosiah Osman, 'YIG Thick Film as Substrate Overlay for Bandwidth Enhancement of Microstrip Patch Antenna', IEEE Access, 6 (1): 32601-32611, 2018.

2. Carbon-based Thick Film With Organic Binder For Printable Flexible Electronic Devices

This project aims to explore the possibilities of using nanosized carbon materials as conductive elements for thick film paste for fabrication of flexible devices, such as patch antenna and gas sensor. The main contribution or novelty of this project is the development of flexible, dual functioning wireless gas sensor using carbon-based materials, which also can be a hybrid of CNT-graphene or graphenated CNTs.





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RESEARCH HIGHLIGHTS

1. Synthesis and Photoluminescence Properties of Hybrid ZnO and Carbon Nanomaterials for Solar Cell

Solar cell is too expensive for large scale electricity generation. Cost is important factor in the success of any solar technology. Potential of advancement in nanotechnology can produce cheap and more efficient solar cell. The increase of the conversion efficiency of solar cells is the use of thin film. Proposed solar cell properties has high efficiency, flexible, low cost, short installation and can cover large space. Transparent and highly conducting oxide films have attracted many researchers due to their wide range of applications in industry. Thin films are layers of a material whose thickness ranges from fractions of a nanometer to several micrometers. Thin films are especially appropriate for applications in microelectronics and integrated optics. Most of the functional materials are applied in thin film form due to their specific electrical, magnetic, and optical properties, or wear resistance.

2. Formation Carbon Nanostructures within Various Liquid Media in Pulse Laser Ablation

Graphene is 200 times stronger than a steel. Graphene is the thinnest ,material which is one atom thick. Graphene have fascinating physical properties and suitable for applications in nanoelectronics. It has band structure suitable for electronics properties. The band structure is very sensitive to its geometry, size, and edge structures, especially when the size of graphene is below the quantum confinement limit [1]. On top of that, graphene is an excellent conductor of heat and electricity and has interesting light absorption abilities [2].

Reference;

1. Tingting Zhang et al. Graphene: Nanostructure engineering and applications, Front. Phys. 12(1), 127206 (2017)
2. https://www.graphene-info.com/graphene-introduction

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RESEARCH HIGHLIGHTS

The effect of Chenodeoxycholic acid (CDCA) in flexible dye-sensitized solar cell (Flexible DSSC) based on pre-dyed zinc oxide (ZnO) nanoparticles have been researched. Due to the aggregation, the ZnO surface cannot be absorbed, and the electrons are deactivated by the interaction between dyes and dyes that cannot contribute to power generation. Further, reverse electron transfer occurs from the portion where the dye is not adsorbed. Addition of CDCA as a co-adsorbent can suppress dye aggregation and reverse electron transfer. This will make the improvements of density current (J_{sc}) and open circuit voltage (V_{oc}) values. In this research, the used of D149 dyed and simple pre-dyed ZnO (pd-ZnO) composite has been applied with the coating CDCA method. Also, the comparison between the hot press and without hot press method has been made. The value of efficiency, J_{sc}, and V_{oc} shows improvements to 2.70%, 6.37mA/cm2 and 0.70V respectively.

NANOMATERIALS SYNTHESIS & CHARACTERISATION

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RESEARCH HIGHLIGHTS

- Chemical and Green Synthesis of Carbon Nanomaterials
- Chemical and Green Synthesis of Metal & Metal Oxides Nanomaterials
- Applications of Nanomaterials in Health and Environment
- Applications of Nanomaterials in Industrial and Agriculture
- Synthesis of Biomaterials from Natural Sources and Its Applications in Tissue Engineering

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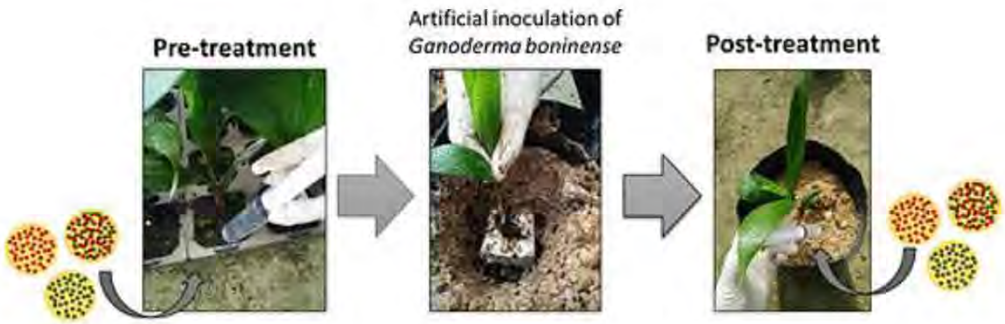
RESEARCH HIGHLIGHTS

1. A potent agronanofungicides for basal stem rot diseases treatment of oil palm

The rise of environmental and health concerns due to the excessive use of the conventional fungicide urges the search for sustainable alternatives of agronanofungicides, to enhance plant uptake and minimize the volatilization, leaching, and runoff of fungicides. Fungicides were encapsulated into chitosan nanoparticles for the formulation of the agronanofungicides and used as potent antifungal agents in combating the basal stem rot (BSR) disease caused by Ganoderma boninense and were evaluated via artificial inoculation. The agronanofungicides were found to be superior compared to their conventional counterparts.

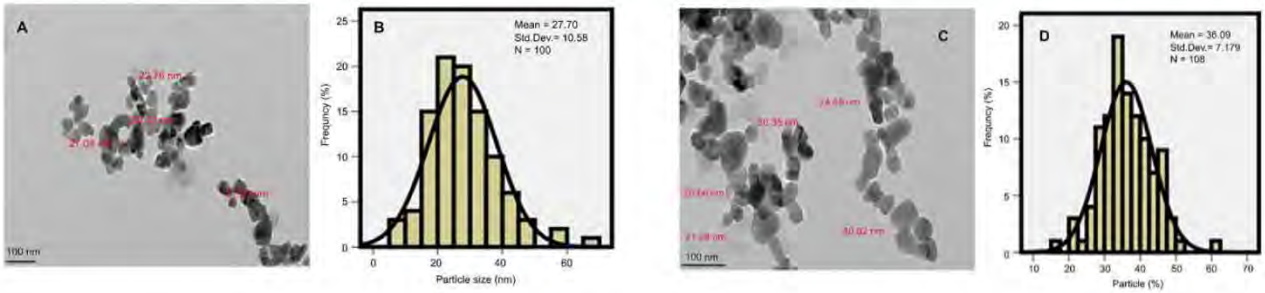
Farhatun Najat Maluin, Mohd Zobir Hussein, Nor Azah Yusof, Sharida Fakurazi, Abu Seman Idris, Nur Hailini Zainol Hilmi and Leona Daniela Jeffery Daim, Chitosan-Based Agronanofungicides as a Sustainable Alternative in the Basal Stem Rot Disease Management, J. Agric. Food Chem. 2020, 68, 15, 4305–4314.



2. Magnetic nanoparticles for nanotheranostics application

Cancer treatments are being continually developed for more effective and better-targeted to improve the outcomes. Magnetic iron oxide nanoparticles were coated with polyethylene glycol, layered double hydroxide and drug to generate the nanotheranostics with the superparamagnetic property. These unique core-shell nanoparticles synthesized with the presence of multiple functionalities are hoped can be used as a multifunctional nanocarrier with the capability of targeted delivery using an external magnetic field and can be exploited as hypothermia for cancer cells in addition to the chemotherapy property.

Mona Ebadi, Bullo Saifullah, Kalaivani Buskaran, Mohd Zobir Hussein and Sharida Fakurazi, Synthesis and properties of magnetic nanotheranostics coated with polyethylene glycol/5-fluorouracil/layered double hydroxide, International Journal of Nanomedicine, 2019:14 6661–6678.



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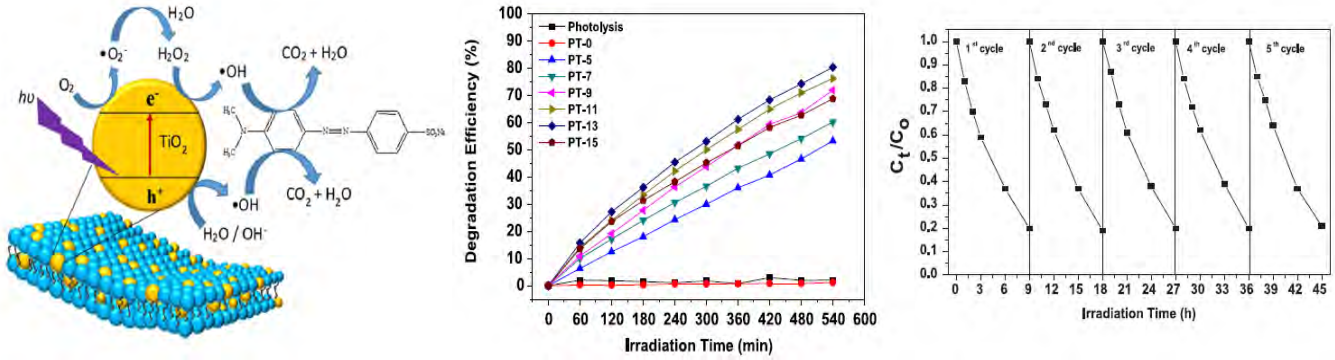
RESEARCH HIGHLIGHTS

1. Immobilization of TiO_2 into polyethersulfone matrix as hybrid film photocatalyst for effective degradation of methyl orange dye.

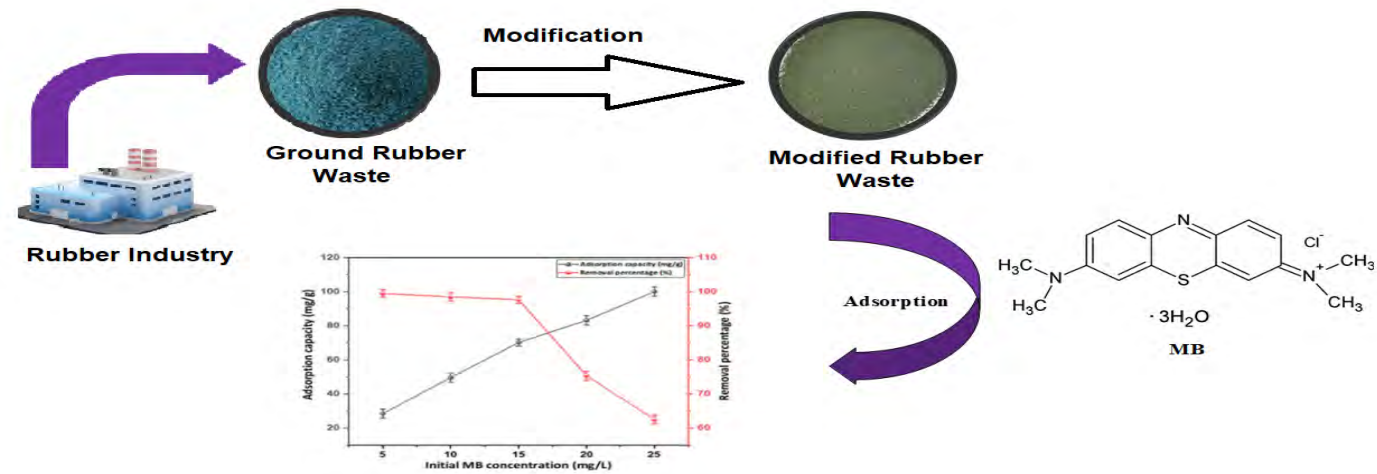
Photodegradation of methyl orange dye using TiO_2 photocatalyst immobilized on polyethersulfone film exhibit good photocatalytic performance under UV irradiation and retained high photocatlytic efficiency up to 5 cycles of photodegradation experiments.



Hir, Z.A.M., Moradihamedani, P., Abdullah, A.H., Mohamed, M.A. Materials Science in Semiconducting Processing, 57, 2017, 157-165.

2. Converting Rubber Waste into a Low-Cost Polymeric Adsorbent for Dye Removal from Aqueous Solution.

Rubber waste collected from glove manufacturing industries was modified using H2SO4 to introduce sulfonate group on the rubber waste. Both unmodified and modified rubber waste was used to remove methylene blue dye from aqueous solution. Modified rubber exhibit superior adsorption capacity compared to unmodified rubber waste.



Aliyu, M., Abdullah, A.H. and Mohamed Tahir, M.I., Indones. J. Chem., 2022, 22 (3), 653 – 665.

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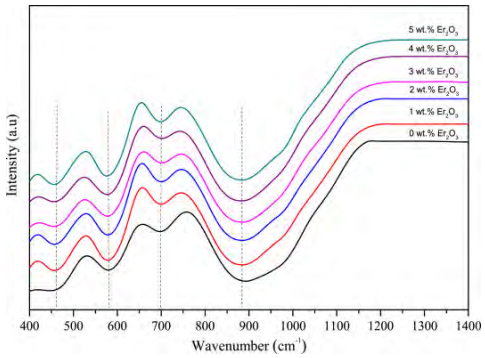
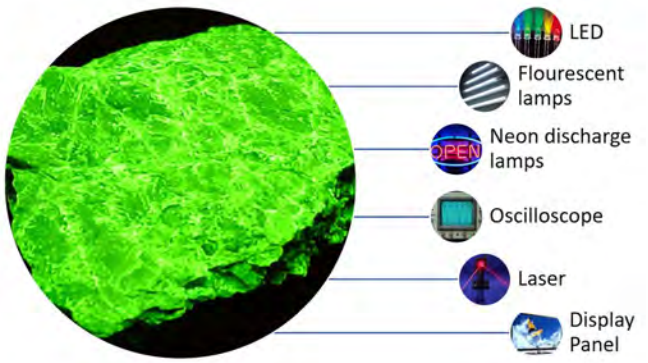
RESEARCH HIGHLIGHTS

1. Willemite Composite Phosphor for Potent Optoelectronic Applications

Luminescent materials such as phosphors are the substances that emit light in the electromagnetic wave's spectrum after the conversion of the absorbed energy from an energy source. The interests in willemite phosphor also due to their interesting properties, having good thermal and chemical stability, excel in water resistance with better resistance to nuclear radiation as well as exhibits excellent luminescence properties when homogenously grows with an inorganic oxide crystal.

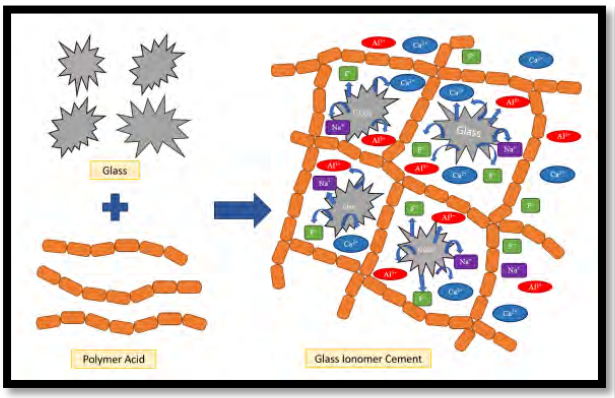




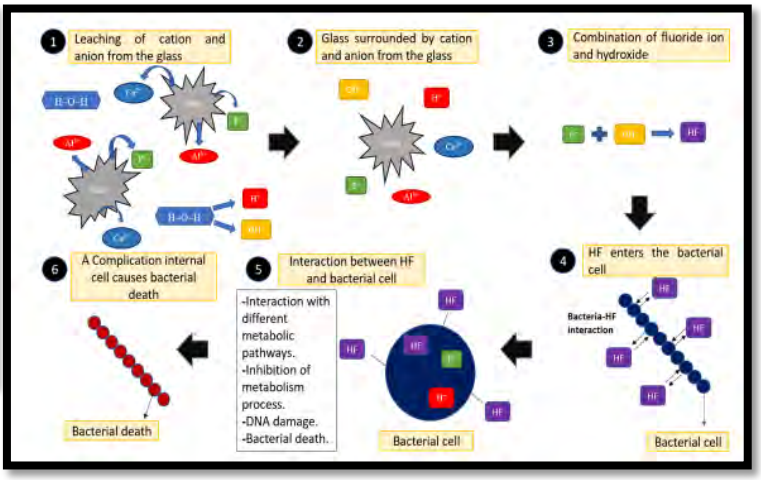
$Zn_2SiO_4:Er^{3+}$ absorption spectra with variations of Er_2O_3 concentration

2. Glass Ionomer Cement Derived from SiO_2-CaO-CaF_2-Al_2O_3-P_2O_5 glass system

The fabrication of glass ionomer cement, GIC derived from SiO_2−CaO−CaF_2−Al_2O_3−P_2O_5 shows the additive of fluoride ion in the CFAS glass system act as an anti-cariogenic agent which can prevent the formation of plaque on the surface of the enamel. The calculated Ca:P ratio between 1.31 and 2.18 shows CFAS has high potential for biological implantation material.



The illustration of GIC during setting time reaction



The mechanism of GIC in inhibition of the bacterial by leaching the fluoride ion

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RESEARCH HIGHLIGHTS

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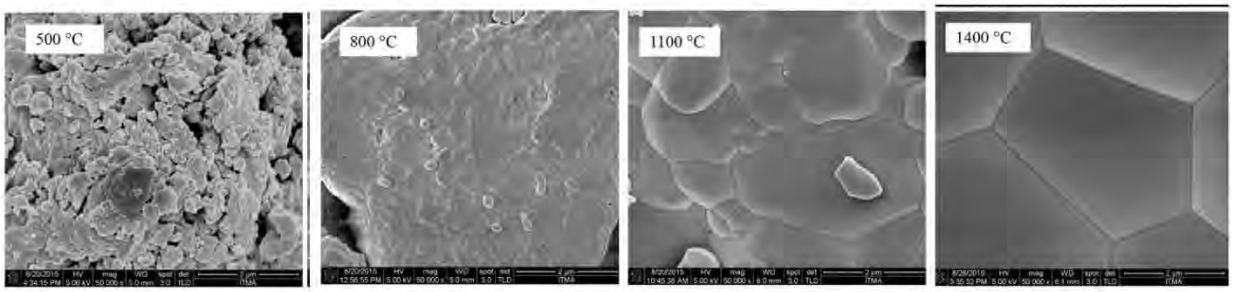
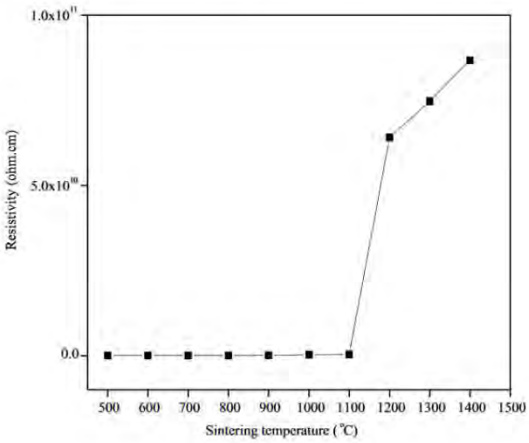
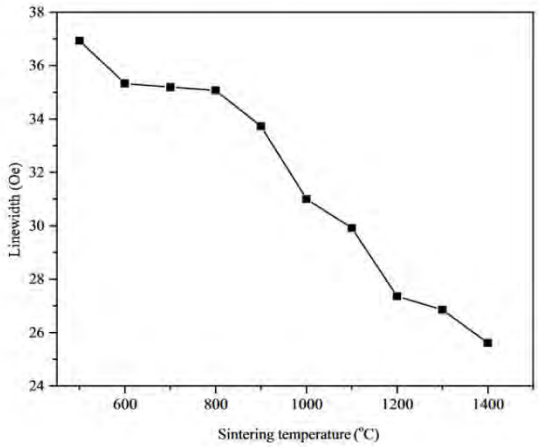
Her current research interest are on the advanced materials related to the magnetic materials, nanostructure, nano-magnetism, composites and ceramics. She is working on magnetic nanoparticles, nanocomposite and nanomaterials for ferrites, permanent magnet, soft magnets, and microwave absorber applications. She also working on the nanomagnetic particles for water treatment application.

She has published and coauthored more than 100 papers with 428 citations and h index of 16 on Google Scholar. Her present research interests are in nanoscale magnetism, magnetic materials, exchange coupling of soft-hard ferrites and novel nanomaterials for water treatment process and electromagnetic absorber applications.







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RESEARCH HIGHLIGHTS

1. Magnesium Diboride (MgB_2) superconductor

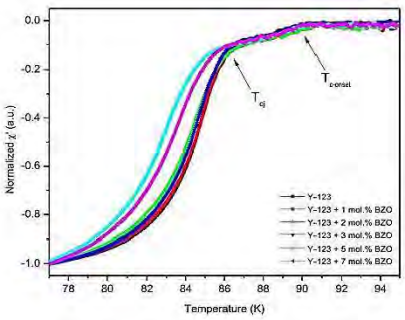
Materials processing and chemical modification for enhancing critical current density, especially at 20 K.

2. Fe-based superconductor – Doped FeTe, FeSe, FeS

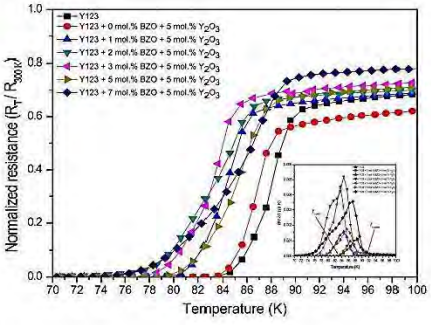
Synthesis and characterization, compositional non-stoichiometry, and phase formation.

3. High temperature superconductor - $YBa_2Cu_3O_{7-\delta}$

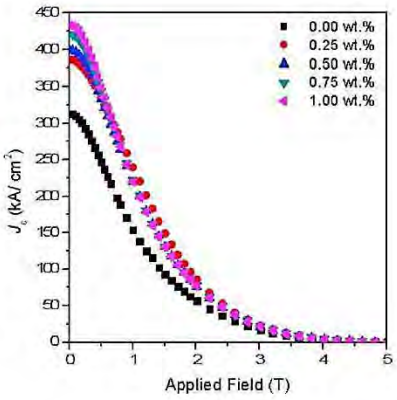
Chemically engineered flux pinning for enhancing critical current density.



Real part of ACS for Y-123 +x mol.% of BZO samples



Normalized resistance versus temperature of Y-123 with co-addition of 5.0 mol% Y2O3 + x mol% of BZO



Field dependence of critical current densities at 20 K for MgB_2 co-added with x wt.% Dy_2O_3: x wt.% La_2O_3

Selected recent publication:

• N. M. Hapipi et al., Enhancement of critical current density for MgB prepared using carbon encapsulated Boron with co-addition of Dy_2O_3 and La_2O_3, *Ceramics International* ***46 23041 2020.***

• N. M. Hapipi et al., AC susceptibility of $BaZrO_3$ nanoparticles added $YBa_2Cu_3O_{7-\delta}$ prepared via coprecipitation method, *Journal of Superconductivity and Novel Magnetism* ***32 1191,*** 2019.

• N. M. Hapipi et al., Superconductivity of Y_2O_3 and $BaZrO_3$ nanoparticles co-added $YBa_2Cu_3O_{7-\delta}$ bulks prepared using co-precipitation method, *Journal of Materials Science: Materials in Electronics* ***29*** 18684, 2018.

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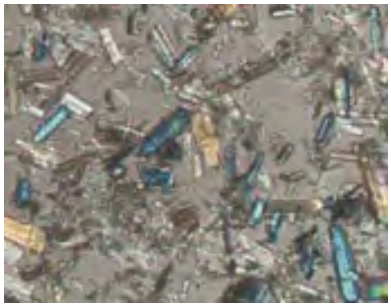
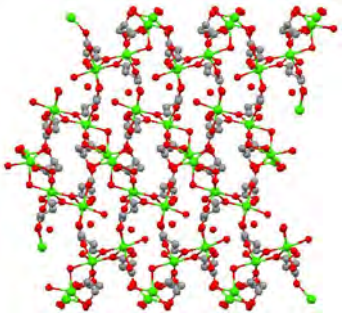
RESEARCH HIGHLIGHTS

1. Biocompatible Reticular Materials

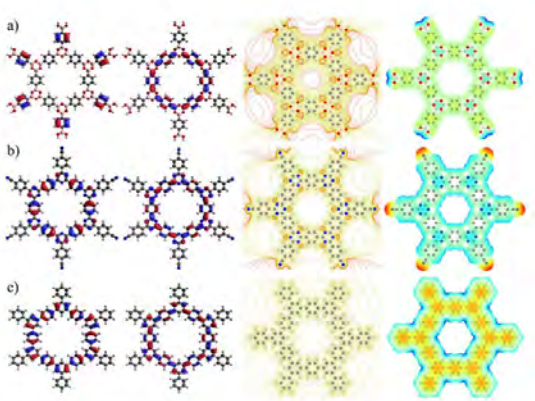
Biocompatible Metal Organic Frameworks (MOFs) particularly of s-block MOFs are newly developed or modified as potential nano-carriers for targeted pulmonary therapeutic against lung cancer and the controlled release of pesticides and fertilizers for sustainable agriculture.

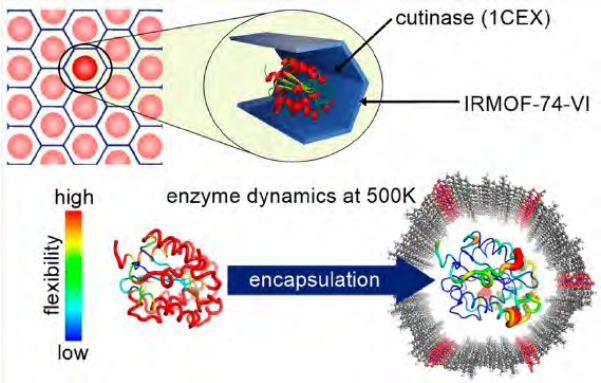


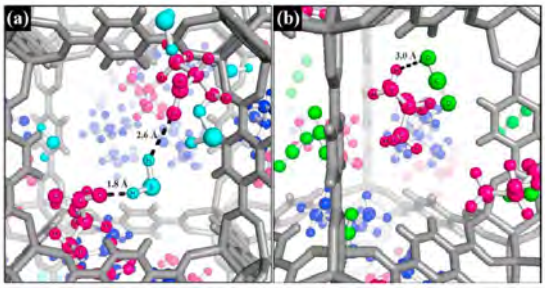


2. Digital Reticular Materials

Computational prediction and simulation of Metal Organic Frameworks (MOFs), Zeolitic Imidazolate Frameworks (ZIFs) and Covalent Organic Frameworks (COFs) for various chemical reactions, and pharmaceuticals and agricultural applications.







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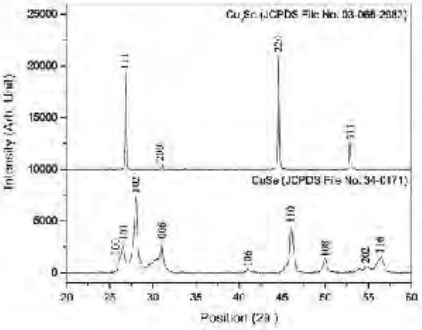
RESEARCH HIGHLIGHTS

1. Synthesis (nanoparticles compound/composites, quantum dots, thin film):

- Polycrystalline chalcogenide semiconductor
- Organic-inorganic perovskite semiconductor
- Metal organic framework

Using physical and chemical approach



Josephine Ying Chyi Liew, Zainal Abidin Talib, Zulkarnain Zainal, Mazliana Ahmad Kamarudin, Nurul Huda Osman and Han Kee Lee, Structural and transport mechanism studies of copper selenide nanoparticles, Semiconductor Science and Technology, Volume 34, Number 12, 2019.

2. Characterization:

- Structural (XRD, EDX, FTIR, Raman Spectroscopy, defect and impurities)
- Morphological (FESEM, HRTEM, AFM)
- Electrical (electron-phonon transport properties, conduction mechanism, CAFM, PFM)
- Optical (linear and nonlinear optics, UV-Vis Spectroscopy, Photoluminescence)
- Thermal (photothermal, photoacoustic, DSC, TGA)

3. Application testing:

- Solar cell efficiency
- Light Emitting Diode (LED)
- Themoelectric power

4. Development and modification of experimental setup:

- Electrical conductivity measurement setup
- Thermal diffusivity measurement setup
- Heat capacity measurement setup
- Thermoelectric power measurement setup
- Thermal conductivity measurement setup

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RESEARCH HIGHLIGHTS

1. Field of Expertise:

- Nanobiotechnolgy
- Drug delivery
- Material science

2. Current research work:

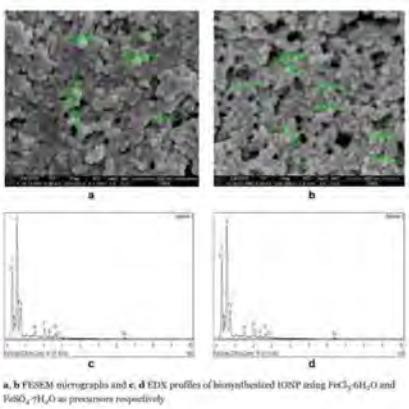
- Development of target-specific nanomaterials for enhanced delivery of biomolecules
- Microbial nanofactories as reservoirs for green synthesis of nanomaterials
- Smart-feed nanosystems for agriculture and aquaculture applications.

Selected Publications:

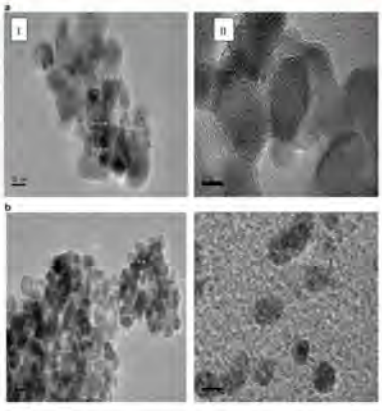
Masarudin, M. J., Cutts, S. M., Evison, B. J., Pietersz, G. A., Phillips, D. R., Pigram, P. J. (2015). Factors determining the stability, size distribution, and cellular accumulation of small, monodispersed chitosan nanoparticles as candidate vectors for anticancer therapy: application to the passive encapsulation of [14C]-doxorubicin. Nanotechnology, Science and Applications 8: 67-80

Yee Kuen, C., Masarudin, M. J., Otman, S. S., Fakurazi, S. (2017). Increased loading, efficacy and sustained release of silibinin, a poorly soluble drug using hydrophobically-modified chitosan nanoparticles for enchanced delivery of anticancer drug delivery systems. Nanomaterials 7: 39.

Jacob, P. J., Masarudin, M. J., Hussein, M. Z., Abdul Rahim, R. (2017). Facile aerobic construction of iron based ferromagnetic nanostructures by a novel microbial nanofactory isolated from freshwater wetlands. Microbial Cell Factories 16:175.



a, b FESEM micrographs and c, d EDX profiles of biosynthesized IONP using $FeCl_3 \cdot 6H_2O$ and $FeSO_4 \cdot 7H_2O$ as precursors respectively



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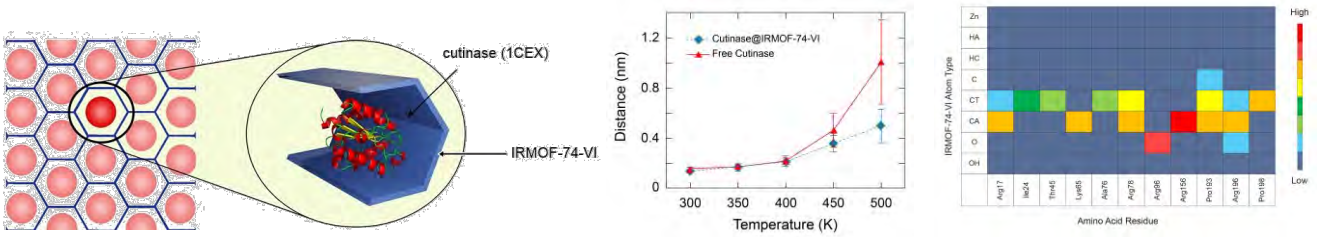
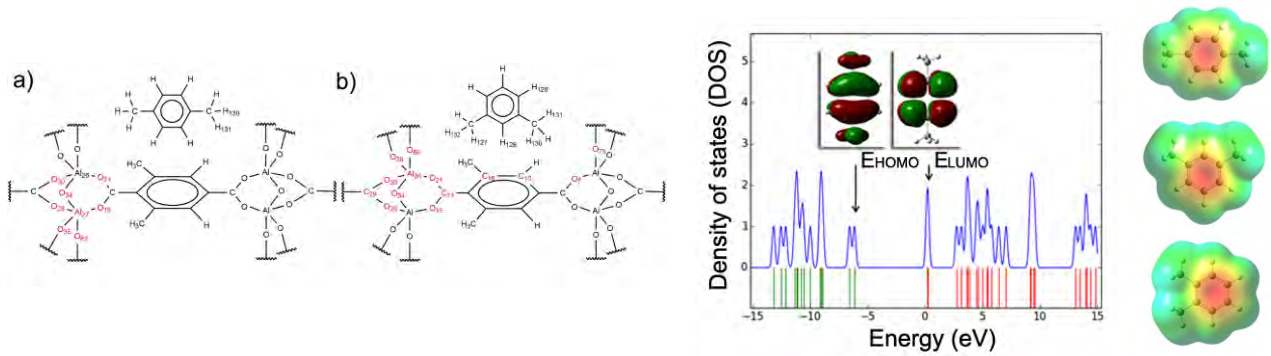
RESEARCH HIGHLIGHTS

1. Advanced Biomaterial Design

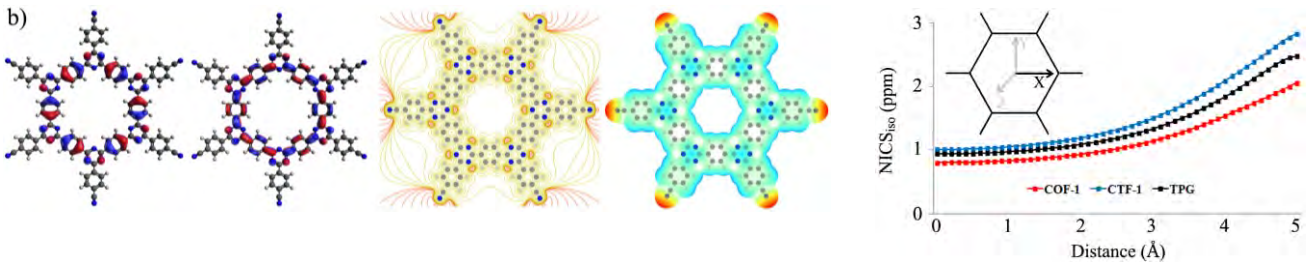


Tuan Kob T.N.A., Ismail M.F., Abdul Rahman M.B., Cordova K.E., Latif M.A.M. "Unraveling the Structural Dynamics of an Enzyme Encapsulated within a Metal-Organic Framework," *J. Phys. Chem. B*, 2020, 124(18), 3678-3685.

2. Porous Materials Characterization



Borzehandani M.Y., Abdulmalek E., Abdul Rahman M.B., Latif M.A.M. "First-principles investigation of dimethyl-functionalized MIL-53 (Al) metal–organic framework for adsorption and separation of xylene isomers," *J. Porous. Mater*., 2021, 28, 579-591.



Borzehandani M.Y., Abdulmalek E., Abdul Rahman M.B., Latif M.A.M. "Elucidating the Aromatic Properties of Covalent Organic Frameworks Surface for Enhanced Polar Solvent Adsorption," *Polymers*, 2021, 13(11), 1861.

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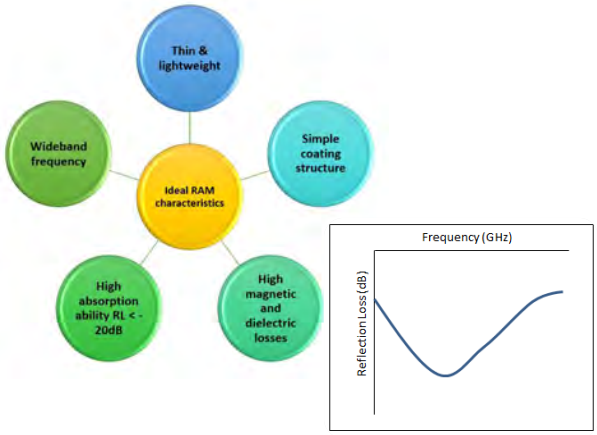
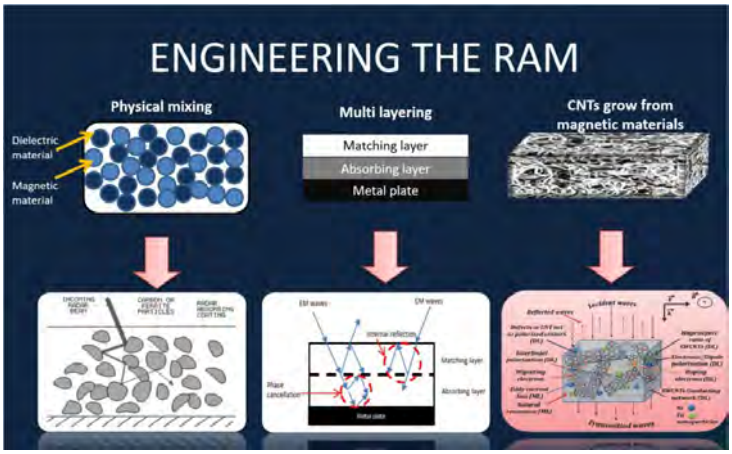
RESEARCH HIGHLIGHTS

1. STEALTH TECHNOLOGY: Fabrication and Characterisation of Microwave Absorbing Nanomaterials-Containing Paint

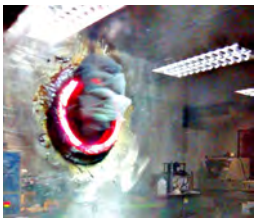
Radar absorbing materials (RAM) are particularly used in stealth technology for antiradar system by suppressing the reflected EM energy incident on the surface of the absorber and dissipating the EM wave into heat. The more effective RAM, the reflected EM wave become lower to be detected by radar (more invisible). Radar absorbing material (RAM) is designed aiming to improve their performance in terms of high absorption level by effectively reduce the reflection of electromagnetic signals, operating in a broad frequency range, have simple coating-layer structure, thin and lightweight as possible.

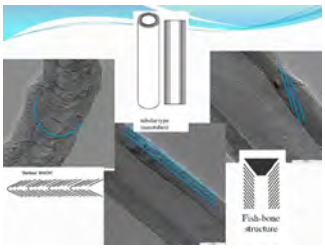


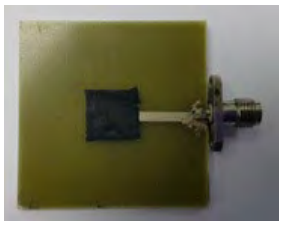


2. Bio-based Carbon Nanotubes (CNT) Cotton for Smart Textiles

We have recycled waste cooking oil as carbon source for synthesizing carbon nanostructures via CVD floating catalyst method by using waste cooking oil as the carbon source, ferrocene as the catalyst and thiophene as the growth rate enhancer. A process for bio-based CNT cotton synthesis has been developed in a close collecting chamber via a batch process. The CNT cotton was then used to develop an improved microstrip patch antenna. The bio-based CNT cotton was pressed and turned into film form. It was then cut into a certain shape and used as microstrip patch antenna. Variations of parameter were used to study its performance in absorbing the electromagnetic signal. The CNT cotton can also be used as a host for embedding other sensing nanomaterials and works as smart textiles.







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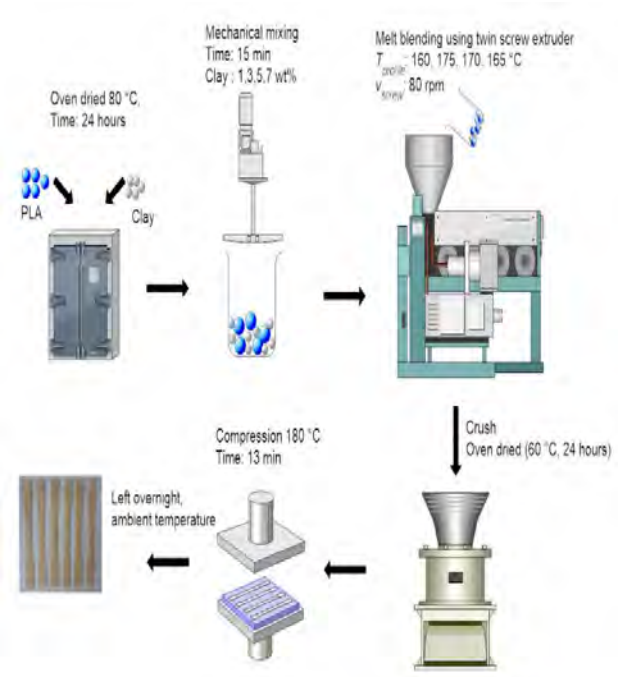
RESEARCH HIGHLIGHTS

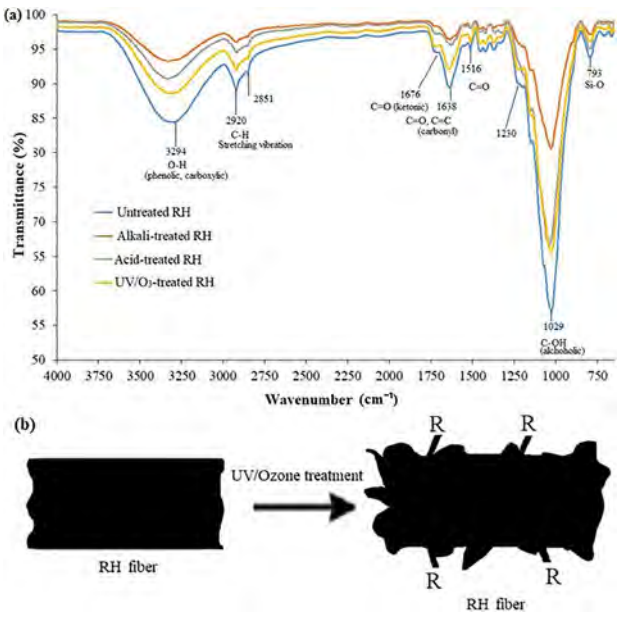
1. Effects of polylactide-nanoclay (PLA/MMT) surface modification on non-isothermal crystallization green nanocomposites.



Polylactide (PLA) is a biodegradable thermoplastic material that exhibits superior mechanical properties, excellent transparency and processability, non-hazardous degradation, and renewability. Due to the synthetic nature of biodegradable polymers, current production of biodegradable plastic is expensive. PLA has notable demand because of inherent versatility of applications in aforementioned fields. Montmorillonite (MMT) is emerging as a potential alternative material due to its low cost, biodegradability, and availability. However, the incompatibility of MMT (hydrophilic) fillers with PLA (hydrophobic) matrices continues to be a significant barrier to progress in the research. The new UV/O_3 compatible clay-reinforced PLA composite is expected to improve mechanical strength, reduce applied weight, and retain biodegradability, making it suitable for a variety of low-cost short-term applications.

2. UV/O3 treatment as a surface modification of rice husk towards preparation of novel biocomposites

Surface modification of the fiber surface was carried out to improve the adhesion between fiber and matrix. In this study, the effect of surface modification of RH via alkali, acid and ultraviolet-ozonolysis (UV/ O_3) treatments on the properties of composites recycled high density polyethylene (rHDPE) composites was investigated. The untreated and treated RH were characterized by Fourier Transform Infrared (FTIR). As compared to untreated RH, all surface treated RH exhibited rougher surface and showed improved adhesion with rHDPE matrix. UV/O_3 treatment can be served as an alternative new method to modify RH surface in order to improve the adhesion between hydrophilic RH fibre and hydrophobic rHDPE polymer matrix.



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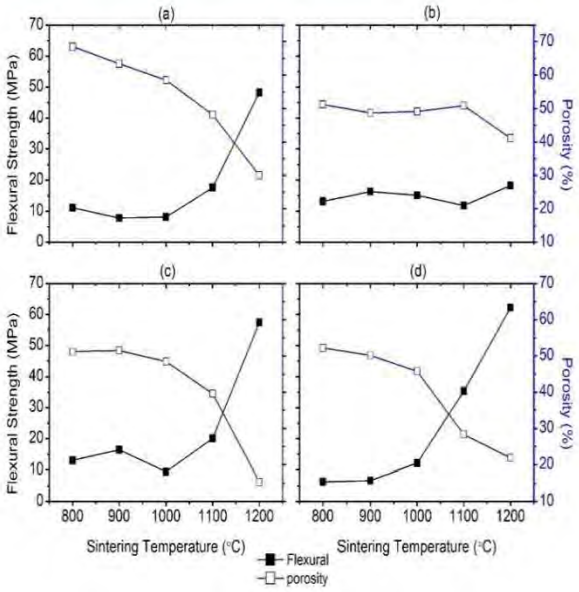
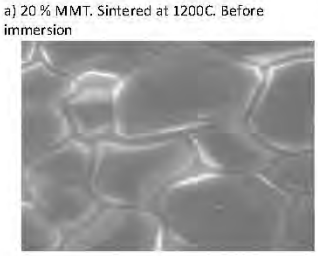
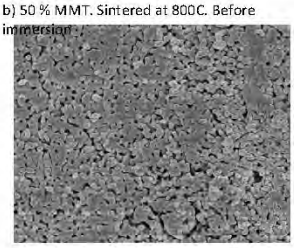
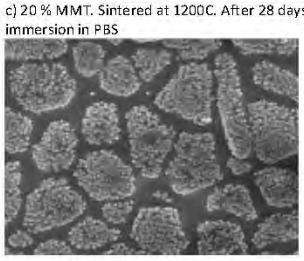
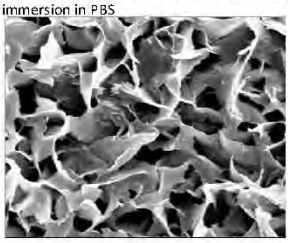
RESEARCH HIGHLIGHTS

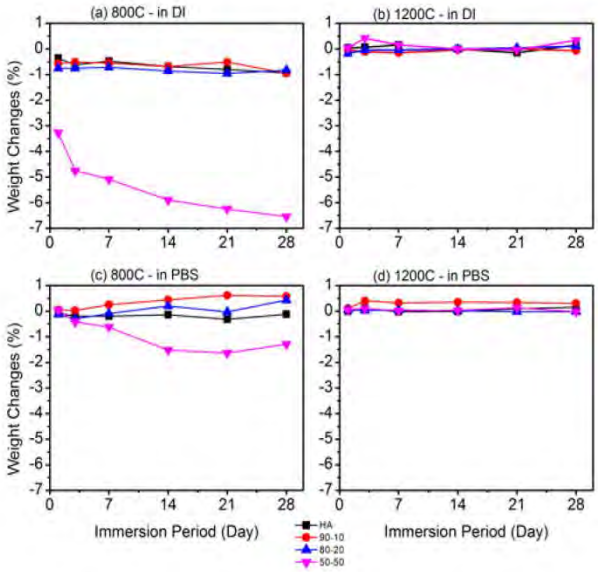



a) 20 % MMT. Sintered at 1200C. Before immersion


b) 50 % MMT. Sintered at 800C. Before immersion


c) 20 % MMT. Sintered at 1200C. After 28 days immersion in PBS


d) 50 % MMT. Sintered at 800C. After 28 days immersion in PBS



Hydroxyapatite/ montmorillonite nanocomposite was prepared by using powder sintering technique. Results showed that the addition of montmorillonite clay at a certain ratio and sintering of the sample at a certain temperature can improve the mechanical properties and bioactivity of the nanocomposite. The nanocomposite can be applied as a bone substitute material. It also has a potential to be used as a carrier for bone anticancer drugs.

NANOMATERIALS PROCESSING & TECHNOLOGY

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RESEARCH HIGHLIGHTS

Carbon Dots Photosynthesis Enhancer: An Innovation From Nanotechnology

This 'Photosynthesis Enhancer' contains the Carbon Dots (CDs), which is produced using bio-char (an organic charcoal). They have optical properties very similar to chlorophyll; which are the green pigments responsible for photosynthesis. When 'Photosynthesis Enhancer' solution is sprayed onto foliage, it penetrates leaves and interacts with chloroplasts (which contain chlorophyll). This interaction assists in the electron transfer mechanism of the photosystems, which leads to enhanced photosynthesis.

Through this innovation, photosynthesis rate increases between 20 to 80 percent depending on the types of crop. The CDs help to transfer electron during the photosynthesis process, which can directly increase the rate of photosynthesis rapidly. The technology is focused on accelerating photosynthesis rate that can yield a better harvest compared to other plant growth enhancers available in the market which focus more on plant nutrient requirements and root growth. The photosynthesis rate also reduces the use of light and water consumption during the photosynthesis process. This technology has potential to be used in indoor and vertical farming as the photosynthesis process can be supported under visible light, minimizing the need for expensive LED lighting.

This simple and green innovation helps to increase growth rate, shortens growth cycle, increases leaf growth and hastens flowering, fruiting as well as yield. Our researchers also diversify CDs applications in research such as solar cells and supercapacitors as well as various sensor systems. Its special electrical and optical properties help in the transfer of electrons that indirectly makes the process more effective. Hopefully more innovations can be produced in the future.

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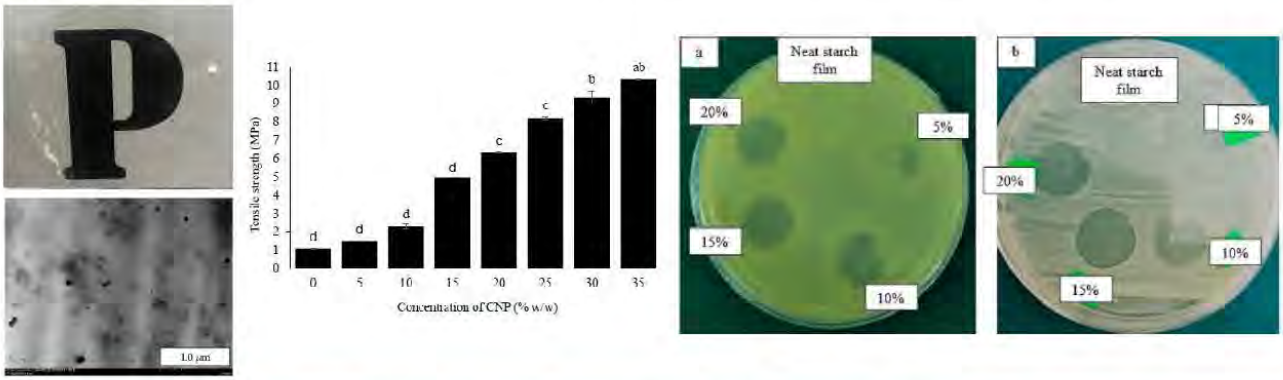
RESEARCH HIGHLIGHTS

1. Active Starch/CNP Bionanocomposite Films

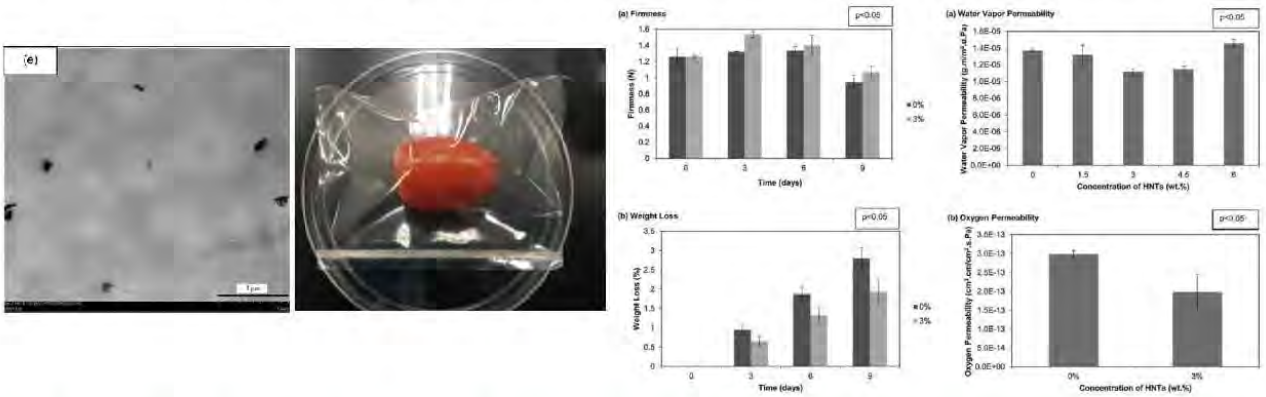
The starch/chitosan nanoparticles (CNP) bionanocomposite films were successfully developed and applied as antimicrobial packaging. The films exhibit improvement in terms of mechanical, thermal, and barrier properties. The mechanical properties of the films were comparable to the commercial packaging material, thus promising for application.



R.A. Shapi'i, *S.H. Othman, N. Nordin, R.K. Basha, M.N. Naim. Antimicrobial Properties of Starch Films Incorporated with Chitosan Nanoparticles: In Vitro and In Vivo Evaluation, Carbohydrate Polymers, 230(115602), 2020.

2. PLA/Halloysite Bionanocomposite for Food Packaging

The limited properties of polylactic acid (PLA) biopolymer films were encountered by the incorporation of halloysite nanoclay to produce PLA/halloysite bionanocomposite films. The bionanocomposite films exhibit improvement in terms of mechanical, thermal, and barrier properties apart from able to extend the shelf life of food packaged with the films.



N.P. Risyon, *S.H. Othman, R.K. Basha, R.A. Talib. Characterization of Polylactic Acid/Halloysite Nanotubes Bionanocomposite Films for Food Packaging Application, Food Packaging and Shelf Life, 23(100450), 2020.

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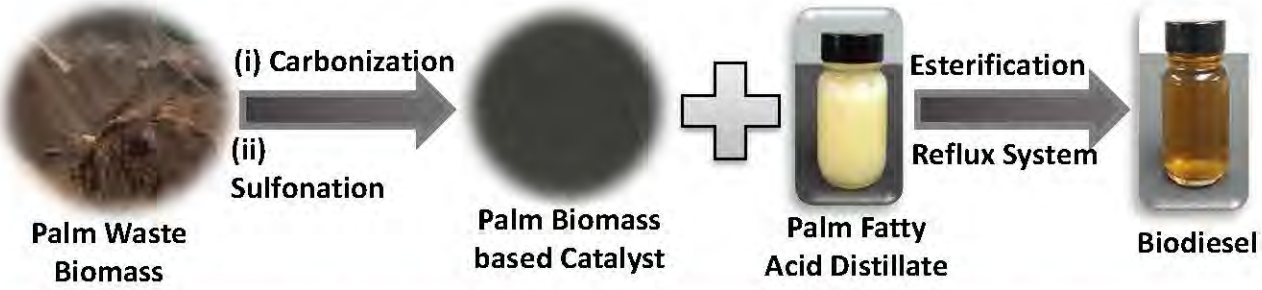
RESEARCH HIGHLIGHTS

1. Waste Biomass-based Catalyst for Biodiesel Production

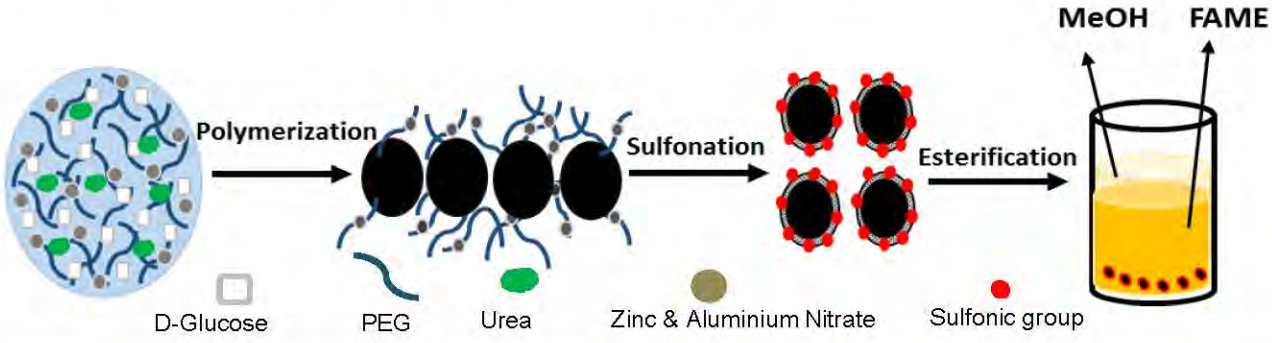
New sulfonated palm seed cake catalyst was synthesized for the catalytic performance of palm fatty acid distillate for biodiesel production. The produced catalyst offers benefits including green process, highly stable, recyclable and reusable, energy efficient, single pot and shorter reaction system for biodiesel synthesis with no contribution to saponification.



S.-I. Akinfalabi, **U. Rashid**, R. Yunus, Y.H. Taufiq-Yap. (2017). Synthesis of Biodiesel from Palm Fatty Acid Distillate using Sulfonated Palm seed Cake Catalyst. Renewable Energy, Vol. 111, Pages 611-619. Q1 Journal; IF= 6.274

2. Sulfonated Mesoporous Catalyst for Esterification

The main purpose of the study was to develop the carbonaceous mesoporous catalyst to enhance the conversion rate for methyl esters production, especially for high free fatty acid (FFA) waste feedstocks. The synthesized mesoporous catalyst possessed unique textural properties and better acid strength. The spent mesoporous catalyst had excellent recyclability of catalyst with high catalytic activity for esterification of palm fatty acid distillate (PFAD) to methyl esters.



S. Soltani, **U. Rashid**, R. Yunus, Y.H. Taufiq-Yap. (2016). Biodiesel Production in the Presence of Sulfonated Mesoporous $ZnAl_2O_4$ Catalyst via Esterification of Palm Fatty Acid Distillate (PFAD). Fuel, Vol. 178, Pages 253-262. Q1 Journal; IF= 5.578

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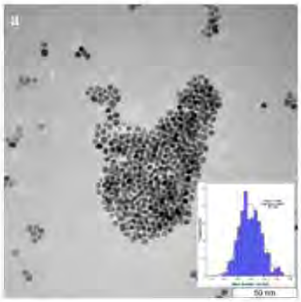
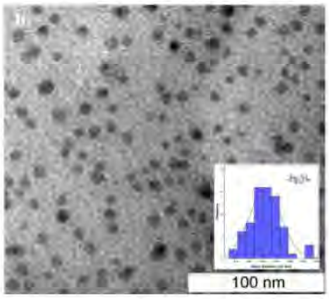
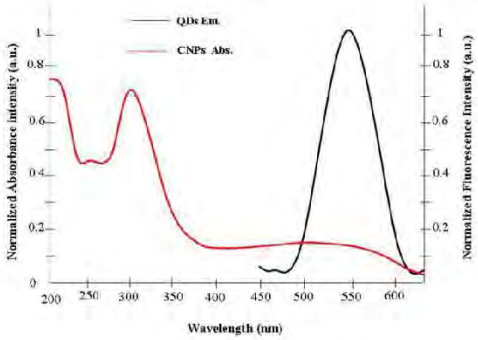
RESEARCH HIGHLIGHTS

1. Multivariable Optimization of Carbon Nanoparticles Synthesized from Waste Facial Tissues by Artificial Neural Networks, New Material for Downstream Quenching of Quantum Dots

In this study, water-soluble carbon nanoparticles (CNPs) were synthesized by using waste facial tissue as a non-recyclable waste and the efficiency of CNPs in quenching mechanism of cadmium-telluride quantum dots (QDs) was investigated.







2. Modified Cenospheres as Non-sacrificial Pore-forming Agent for Porous Mullite Ceramics

Porous mullite ceramics were produced using mullite precursor and modified cenospheres as a non-sacrificial pore-forming agent. The cenospheres used are aluminosilicate hollow spheres with high silica and alumina content, which are obtained from coal-fired power plant. In this study, the cenospheres were modified using aluminum trichloride hexahydrate (AlCl3·6H2O), alkali/acid leaching and heat treatment. Various types and amounts of the modified cenospheres were mixed with mullite precursor to produce porous mullite ceramics for subsequent firing at 1500 °C.

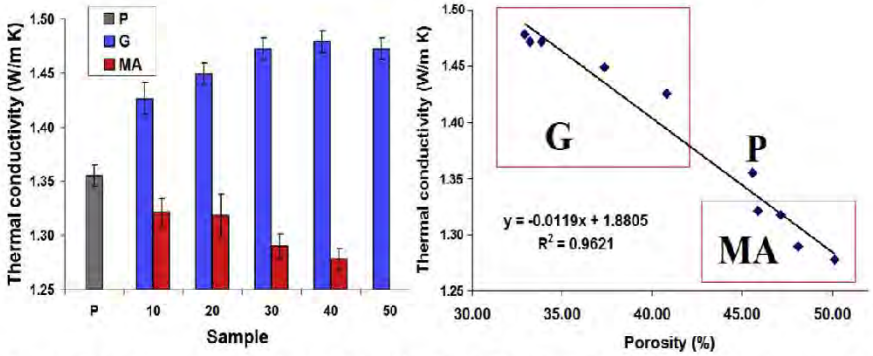


Fig. 7. Thermal conductivity of porous mullite ceramics with added graphite 'G' and modified cenospheres 'MA' (left graph), and their correlation with porosity (right graph).

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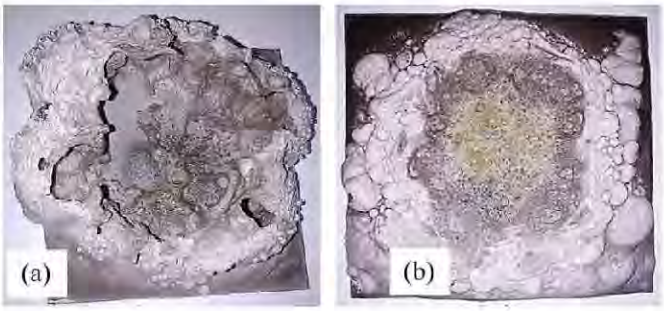
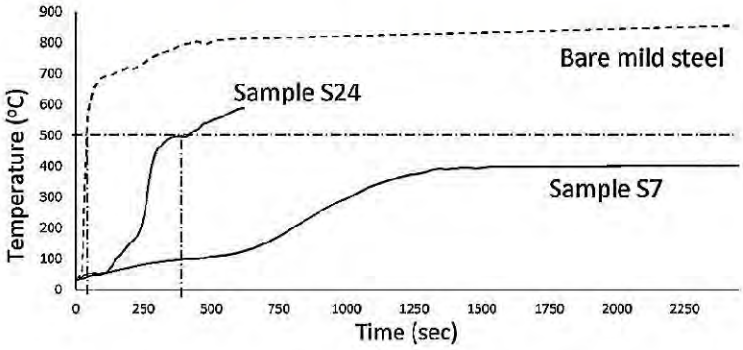
RESEARCH HIGHLIGHTS

Development of Geopolymer Nanocomposite for Agriculture and Aerospace Applications:

i) The interior part of the aircraft should made of lightweight and fire retardant materials. When in flight-fire occurs, there is a limit time for passenger and crews to evacuate from aircraft. Thus the aircraft interior should be made not only lightweight but also fire retardant materials. Geopolymer nanocomposite based on rice husk ash has been developed as a potential fire retardant composite material. Inclusion of flame retardant nanofillers is expected to improve further the flame retardant properties and increased the time for evacuation when fire takes place.





ii) Ganoderma Boninense (g. boninense) is the pathogen culprit of Basal Stem Rot (BSR) in a palm oil tree. Once infected, young palm would usually die within 1 or 2 years while mature trees would survive for around 3 years. Thus, providing precise watering with sufficient amount of fungicide will promote downward root growth and reduce the rot problem. Therefore, research on the sub irrigation nanoporous geopolymer pipe was currently being conducted to overcome this problem.

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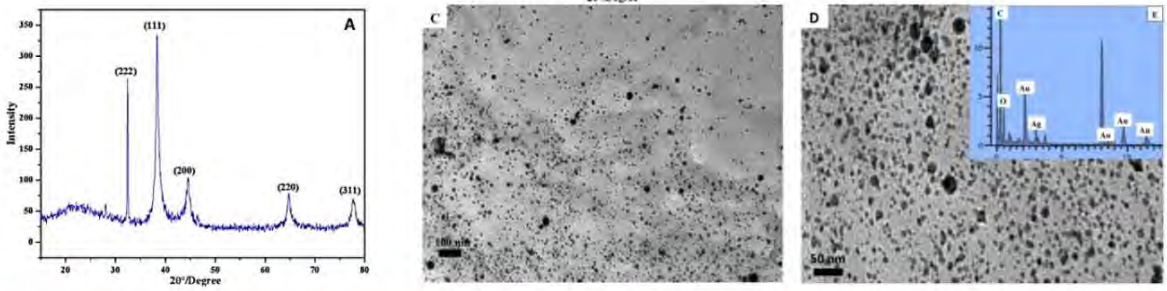
RESEARCH HIGHLIGHTS

1. Metal/bimetallic decoration of carbon nanomaterials for sensor application.

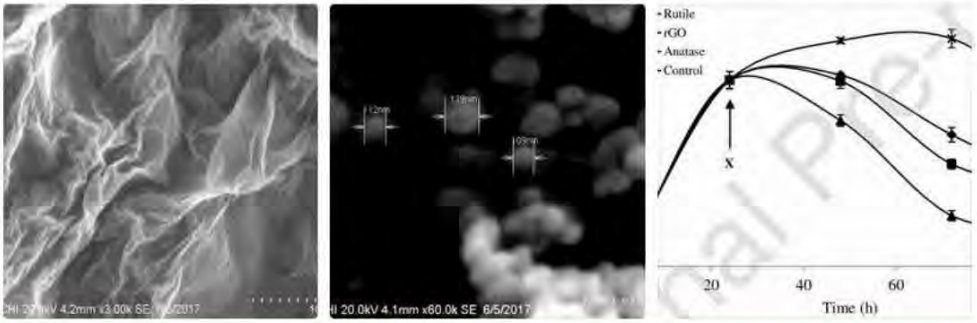
Graphene, carbon nanotubes and carbon nano onions were decorated with Au, Ag, Pd and Pt for H2, VOC and glucose sensor. Other than metal decoration, carbon nanomaterials is also functionalised with carboxyl, carbonyl, amide and amine group to enhance the sensing properties.



Ali, N. A., & Yasin, F. M. (2019). Synthesis and characterization of silver and gold nanoparticles decorated reduced graphene oxide. NANOSCIENCE AND NANOTECHNOLOGY: NANO-SciTech. doi:10.1063/1.5124647

2. Toxicity study and anti-bacterial activity of carbon nanomaterials.

The studies were carried out using zebrafish embryo and microbial culture.



Ahmad NS, Abdullah N, Yasin FM, Toxicity assessment of reducedgraphene oxide and titanium dioxide nanomaterials on gram-positive and gram-negativebacteria under normal laboratory lighting condition,Toxicology Reports(2020),doi:https://doi.org/10.1016/j.toxrep.2020.04.015.

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RESEARCH HIGHLIGHTS

1. Electrospun Polymer Nanofibers

Electrospun polymer nanofibers were prepared using electrospinning technique. The nanofibers were utilized in many applications such as sensors [1], scaffold for tissue engineering [2], production of carbon nanofibers [3] and controlled release of drug [4].

References
[1] Synthetic Metals 191 (2014) 151–160
[2] Synthetic Metals 160 (2010) 2015–2022
[3] Molecules 2020, 25, 3081
[4] Fibers 2019, 7, 56

This works obtained financial support from Ministry of Higher Education (MOHE) FRGS/2/2014/ST01/UPM/02/4.

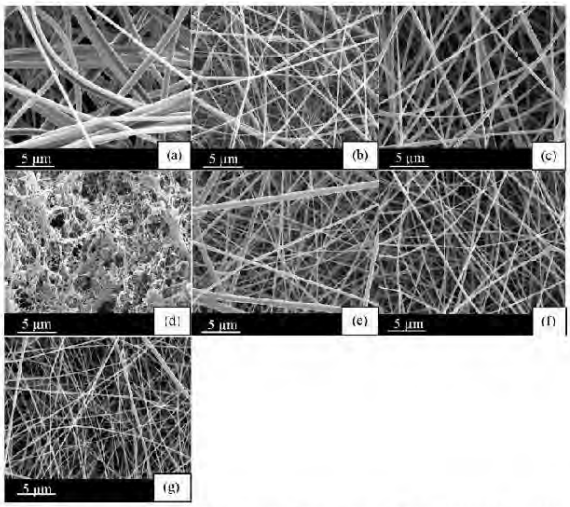

Fig. 5. SEM images of the products of electrospinning solutions of (a) PLA, (b) PLA/PANI (0.64 wt%), (c) PLA/PANI (3.27 wt%), (d) PLA/PANI (5.13 wt%), (e) PLA/P(ANI co m ABA) (6/4-40) (1.57 wt%), (f) PLA/P(ANI-co-m-ABA) (60/40) (2.99 wt%), and (g) PLA/P(ANI-b-m-ABA) (60/40) (5.86 wt%).

2. Polymer Composite

Autonomic self-healing materials, where initiation of repair is integral to the material, are being developed for engineering applications. This bio-inspired concept represents the forefront of recent developments in the material in chemistry and engineering. In this study, synthesis of self-healing natural rubber (NR) will be prepared by compositing NR with other substance.

This ongoing research is supported by Ministry of Higher Education (MOHE) FRGS/1/2019/STG01/UPM/02/7

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RESEARCH HIGHLIGHTS

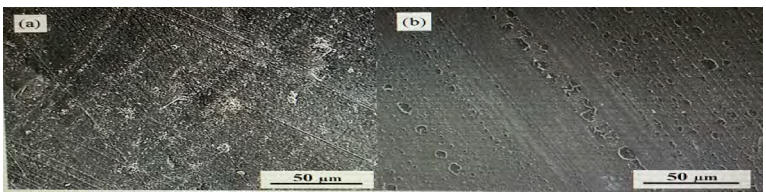
1. Bioactive Glass for Bone Scaffolding

One of the major work on the bioactive glass synthesis via sol-gel approach is the inclusion of nanomaterial into the formulation for a production of highly intercalated and porous glass material. The synthesis process can be easily tailored, and the synthesis temperature is quite low as well. The produced glass shows a promising reaction, *i.e.,* good formation of hydroxyapatite when immersed in simulated body fluid.

M. Sarmast Sh, S. George, A.B. Dayang Radiah, D. Hoey, N. Abdullah, S. Kamarudin. Synthesis of bioactive glass using cellulose nano fibre template. Journal of the Mechanical Behavior of Biomedical Materials, Volume 130, 2022, 105174,

2. Phenol Formaldehyde Resole Resin with Plant-based Tannin

This work focuses on the safe inherent design of materials by reducing the consumption of hazardous chemical and substituting it with a more environmentally friendly material. Hence, dissolved tannin was used to minimize the use of phenol and formaldehyde in the resole resin synthesis. However, the utilization of tannin powder in the preparation of resole resin is quite challenging due to the low dissolution rate of tannin in the liquid formulation. There are various challenges addressed in the study including the dissolution behavior of tannin in the selected solvent, the runaway reaction that occurred due to slow heat dissipation process and high latent heat released, and sudden viscosity changes that degrade the quality and pliability of the polymer. The resole resin was designed for laminate applications.



Cured Tannin Phenol Formaldehyde resin

Cured Dissolved Tannin Phenol Formaldehyde resin

N. Kamarudin, D. R. A. Biak, Z. Z. Abidin, F. Cardona and S. M. Sapuan, "Rheological study of phenol formaldehyde resole resin synthesized for laminate application", *Materials (Basel).*, vol. 13, no. 11, pp. 14-19, 2020.

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RESEARCH HIGHLIGHTS

Corrosion inhibitor is a promising method of protection towards acid corrosion due to its capability of adsorbing onto the metal surface to form a protective film. Organic inhibitors, also known as green inhibitors, are the best substitute for conventional corrosion inhibitors due to their economic advantage and high efficiency. Plants are one of the sources of organic compounds that contain heteroatoms; oxygen, nitrogen, sulfur, and phosphorus that are crucial for corrosion inhibition. The compounds protect the metal by adsorption of the active compounds on the surface that forms a protective barrier between corrosive media and metal surface. Oil palm empty fruit bunch (OPEFB) biomass is produced in a considerable amount by oil palm industries with up to 23% OPEFB per ton of fresh fruit bunch. Due to the massive buildup of OPEFB waste, the disposal issue is becoming a serious problem. Oil palm empty fruit bunch (OPEFB) in the form or raw, HCl treated and NaOH treated powders were investigated for their inhibitive effects on mild steel in 1 M hydrochloric acid medium via gravimetric approach and surface analysis. Weight loss analysis revealed that the inhibition efficiency is the highest for HCl treated powder (85.66 %), followed by raw OPEFB powder (80.75 %) and NaOH treated powder (62.31%). Surface morphology results showed that the compounds formed protective film on the steel surface and shield it from the acid attack. The inhibition efficiency of HCl treated OPEFB powder was further optimized using response surface methodology (RSM), quantum chemical calculation and molecular dynamics simulation. Optimum inhibition efficiency of HCl treated OPEFB powder was 84.38 % at optimum operating conditions. The adsorption of the inhibitor on a mild steel surface is a mixed adsorption involving both physisorption and chemisorption, and obeys Langmuir's adsorption isotherm. Computational studies on xylose, glucose and arabinose, which are present in the inhibitor, suggest strong adsorption interaction between inhibitor compounds and the metal surface.

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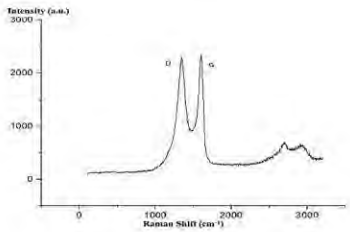
RESEARCH HIGHLIGHTS

1. Development of Non-precious Metal Catalyst Proton Exchange Membrane Fuel Cell (PEMFC)

This research focus on seeking for cheaper materials to replace commercial precious platinum catalyst as oxygen reduction reaction (ORR) at cathode side of PEMFC. Material such as nitrogen-doped (N-Gr) or Iodine-doped graphene nanoplatelets could be potential candidates to synthesize them in a larger scale using simple preparation technique, ball milling.

FIGURE 1. Graphene suspensions from samples prepared at differ ball milling speeds for 30 min. (1) at speed 100 rpm, and (2) at 5(rpm. Pictures taken for composite samples dispersed in DW after 1 sonication



(B)

FIGURE 4. Raman spectra measured for (A) Sample A1 (1:1, 100 rpm) and Sample D2 (1:10, 500 rpm)

Sains Malaysiana, 2020, 49(7), pp. 1745-1754
Supported by Gakken Education (Malaysia Sdn. Bhd/ 6300220

N-Gr prepared by ball milling

D and G peak indicate the existing of N-Gr

2. Development of Hybrid Proton Exchange PEMFC for Hydrogen Production Using Electrolysis of Copper Chloride-Hydrochloric Acid (CuCl-HCl).

This research focus on development hybrid membrane for CuCl-HCl electrolysis with higher durability and lower copper cross over the membrane. Additionally, electrolysis at higher temperature (>100 °C)) will promote higher hydrogen production. Polybenzimidazole (PBI) and Polyether ether ketone (PEEK) based membrane are type of potential materials to be used for this attempt to replace commercialized Perfluorosulforic (Nafion@) membrane which is adaptable for lower temperature and facing copper cross over problem.

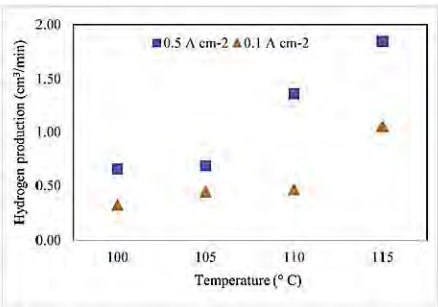


Fig. 8 – Effect of process temperature on hydrogen production for Nafion 117 at 0.5 A.cm^{-2} and 0.1 A cm^{-2} current density, 0.05 M CuCl.

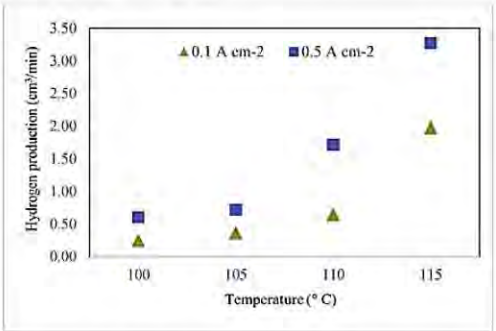


Fig. 9 – Effect of electrolysis temperature on hydrogen production for PBI/ZrP composite membrane at 0.5 A.cm^{-2} and 0.1 A cm^{-2} current density, 0.05 M CuCl.

Comparison of hydrogen production versus temp. between Nafion(@) and PBI based membrane

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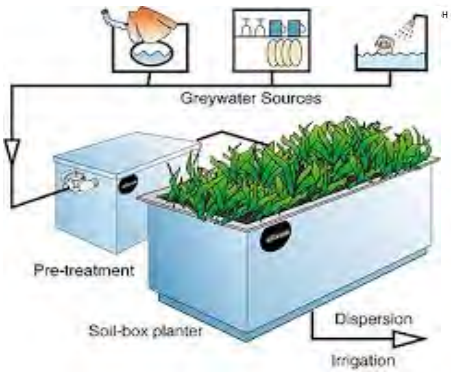
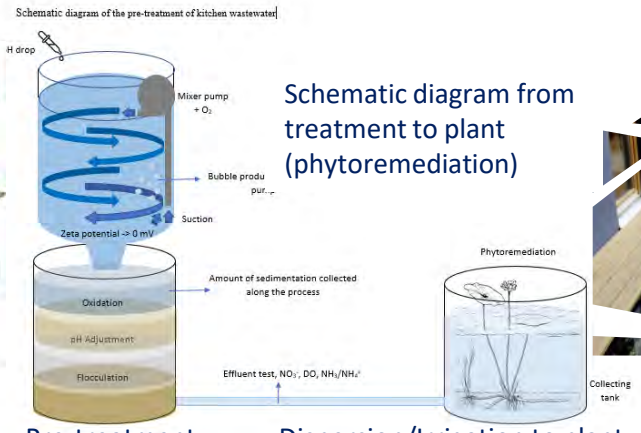
RESEARCH HIGHLIGHTS

Kitchen greywater green solution with phytoremediation process



Greywater sources



Pre-treatment

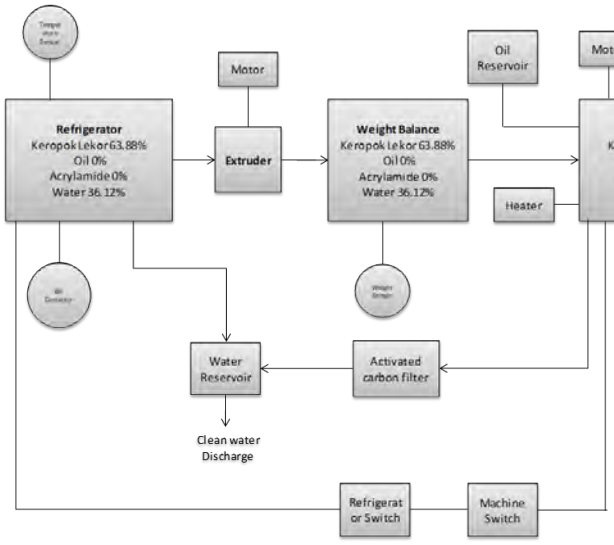
Schematic diagram from treatment to plant (phytoremediation)

Dispersion/Irrigation to plant

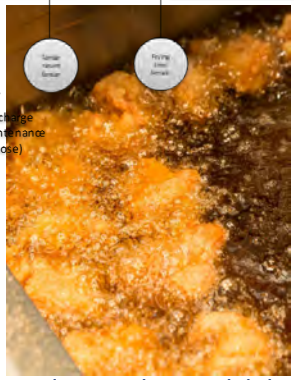
Final approach to residence landscape

Mohd Zaini, N.S., Abdelazim Elkwiee, A.A., **Naim, M.N.**, Abu Bakar, N.F., "Role of nanoclay surface charge for phytoremediation process enhancement",
Journal of Water Process Engineering, 2021, 40, 101850. doi.org/10.1016/j.jwpe.2020.101850

Development of 1st in the world of Fried-food Vending Machine for local street food



Keropok lekor frying process flow diagram inside prototype machine



Hot and crispy keropok lekor prepared inside the machine

Prototype vending machine in UPM

Lua H. Y., **M. N. Naim**, M. A. P. Mohammed, F. Hamidon, N. F. Abu Bakar, K. Vangnai, W. Jittanit, and Teh H. F., "Inhibition of acrylamide formation in potato strip by ultrasonic-treated methylcellulose batter".
International Journal of Food Science and Technology, 2022. doi:10.1111/ijfs.15652

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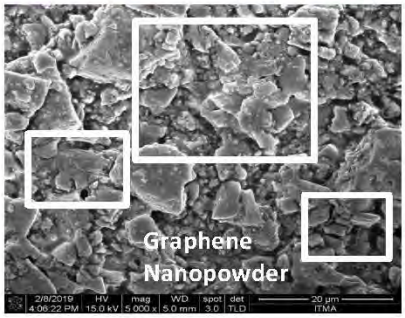
RESEARCH HIGHLIGHTS

Ester-based Drilling Fluid with Nanomaterials

The oils producers are currently looking for a cost-efficient drilling operation in marine sensitive area, encourage researchers to focus on the wonders of nanotechnology in the drilling fluids. A few carbon nanomaterial have tested to investigate the effects on rheology, emulsion stability and filtration properties of the ester-based drilling fluid. Ester with improved properties has been synthesized in the laboratory and prepared as green synthetic drilling fluids. Laboratory testing after 16 hours of rolling under 360 °F showed that different types and concentrations of nanomaterial yielded different effects on the ester-based drilling fluids.

FORMULATION

Ester
Primary Emulsifier
Secondary Emulsifier
Viscosifier
Fluid loss agent
Lime
Brine
Barite
Graphene



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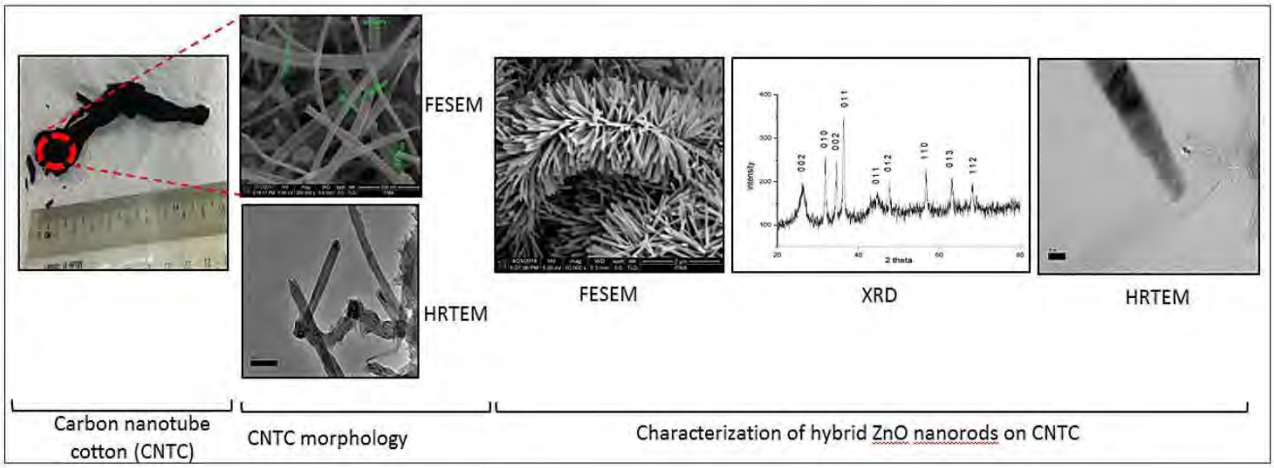
RESEARCH HIGHLIGHTS

ZNO/CNTC Hybrid for Nanoscale Electronic Devices

Preparation and characterization of zinc oxide (ZnO) nanostructures on green carbon nanotubes cotton (CNTC) was investigated. CNTC from waste cooking palm oil (WCPO) was synthesized via floating catalyst chemical vapor deposition (FCCVD). Prior to hybridization, ZnO buffer layer for growth patterning localization was deposited on CNTC using 99.9% ZnO target. ZnO nanostructures were grown on CNTC using chemical bath deposition method. It was observed that the average diameter and length of the nanostructures increased given the highest aspect ratio of 12. The I-V curve of the hybrid showed that conductivity increased with the increased of synthesis temperature. Higher temperature at 120 ℃ gives the best conductivity value as compared to the other heat level. The grown nanostructures on CNTC are comparable to those grown on other substrate such as glass and alumina. In addition, this hybrid offers promising future as CNTC is flexible, readily available and incurs low cost than those substrates. Characterization of the hybrid material showed promising characteristics that can be further explored in the application of small nanoscale electronic devices and others such as electromagnetic absorbing material, piezoelectric nanogenerator and sensors.



Related publications on the synthesis and characterizations of the hybrid materials can be found in the manuscripts below.

1. Yusof, J. M., Ismail, I., Yusop, M. R., Rashid, S. A., Nong, M. A. M. & Ali, M. H. M. 2020. Effect of Zinc Oxide Nucleation on Flexible Bio-based Carbon Nanotube Cotton via Chemical Bath Deposition Method. *Microelectronic Engineering* 234.

2. Ismail, I., Yusof, J. M., Mat Nong, M. A. & Adnan, N. L. 2018. Synthesis of Carbon Nanotube-cotton Superfiber Materials. *Synthesis, Technology and Applications of Carbon Nanomaterials*. 61–76. Elsevier.

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