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CleanEnergy 2022

ICCE 2022 27-28 JULY 2022 NEW DATE

Towards a Cleaner Earth

18TH INTERNATIONAL CONFERENCE ON CLEAN ENERGY

PROGRAM BOOK

ICCE 2022

BORNEO CONVENTION CENTRE KUCHING

BCCK

27-28 July 2022

Kuching Sarawak *Malaysia*

18th ICCE 2022

18th INTERNATIONAL CONFERENCE ON CLEAN ENERGY 2022

Hybrid Mode Conference

Borneo Convention Centre Kuching (BCCK), Sarawak

FOREWORD FROM

DEPUTY MINISTER

FOR ENERGY & ENVIRONMENTAL SUSTAINABILITY SARAWAK

I would like to welcome all the delegates to Sarawak, Land of the Hornbills in conjunction with the 18th International Conference on Clean Energy (ICCE 2022). I believe this conference is highly anticipated by proponents of clean energy as it is a platform for university researchers, policymakers, and industry players who support a major role in ensuring the sustainability of energy resources to compare notes and share experiences.

For us in Malaysia, we must work on alternative energy sources to ensure the supply of energy resources remains adequate in order to sustain the economic development and the economy of this country. According to the United Nation, about 80 percent of the global population lives in countries that are net importers of fossil fuels; equivalent to six billion people who are dependent on fossil fuels from other countries making them vulnerable to geo-political and geoeconomics shocks.

Clean and renewable energy sources are also available in all countries but their potential is still not fully utilized. Clean and renewable energy actually offers a way out of import dependency, allowing each country to diversify their economies and protect them from volatile fossil fuel price changes. This shift can also drive inclusive economic growth, create new jobs and eradicate poverty.

According to a report this alternative energy source actually is the cheapest power option in most countries. The report also says cheap electricity from clean and renewable energy sources could provide 65 percent of the world's total electricity supply by 2030. With this total supply, 90 percent of the power sector could be decarbonized by 2050, large-scale carbon emissions can be reduced and climate change can be mitigated. Furthermore, efficient and reliable renewable technologies can create systems that are less affected by market shocks, and improve durability as well as energy security with the wide range of power supply options available.

Finally, I wish you a happy conference and hope that the outputs obtained from this conference can benefit the people of the world.

Thank you.

YB. DR. HJ. HAZLAND BIN ABANG HIPNI
Deputy Minister for Energy & Environmental Sustainability Sarawak

FOREWORD FROM

DEPUTY VICE CHANCELLOR

(RESEARCH & INNOVATION) UNIVERSITI TEKNOLOGI MALAYSIA

As the host of this year's conference, I would like to welcome all delegates to the International Conference on Clean Energy 2022, (ICCE2022). On behalf of Universiti Teknologi Malaysia, I would like to take this opportunity to thank the Sarawak Convention Bureau (SCB) and the Malaysia Convention and Exhibition Bureau (MyCEB), for their contributions and support in making this conference a success. Without their support, this conference would not have been possible in the land of Kenyalang which is rich in culture and high aesthetic values.

The university is very concerned about the well-being and development of the country and the university will always play a role as a thinker to help the country to achieve optimal progress. The progress to be achieved must be harmonious and not at the expense of this endowed balance of nature. To achieve such progress, Malaysia and other countries in the world with the same vision must act immediately to replace the energy sources that result in carbon emissions into the atmosphere. It is time for us to commit and mobilize globally to create a cleaner environment by using renewable and clean energy sources.

Finally, I would like to congratulate the organizing committee for their hard work in making this conference a success.

Thank you.

PROFESSOR. DR. ROSLI BIN MD. ILLIAS
Deputy Vice-Chancellor (Research & Innovation),
Universiti Teknologi Malaysia

MESSAGE FROM

HONORARY CHAIRMAN

18TH INTERNATIONAL CONFERENCE ON CLEAN ENERGY (2022)

Early in 1973, energy crisis started. The petroleum producing countries of the Middle East stopped exporting petroleum. As a result, there were big lines in gas stations. There were few cars and buses in the streets. Many factories started working part time. The world's economy almost came to a standstill. This also brought to our attention that we were not going to have fossil fuels forever; they were not undepletable. Sooner or later, we would run out of petroleum, natural gas and coal.

We engineers are the problem solvers. We try to solve the problems facing the humankind. In order to find a solution to the depletion of the fossil fuels and the environmental problems caused by them, right after the energy crisis, I established the Clean Energy Research Institute at the University of Miami. The mission of the institute was to do research aimed at trying to find solutions to the two related global problems of the depletion of fossil fuels and the environmental problems caused by their utilization. In parallel with our research activities, we also started information dissemination activities by organizing short courses, seminars, symposia and conferences.

The grandfather of this 18th ICCE 2022 Conference was named Alternative Energy Sources Conference, and was held in Miami, in December 1977. Since then, it has been in several cities of North America, Europe and Asia. This is the first time, it is being held in Malaysia, adding Malaysia to the Clean Energy caravan!

We are lucky that fossil fuel will be depleted in the foreseeable future, and we are fortunate that we have many alternative sources of energy. The energy from the sun and the wind, the power from ocean thermal and geothermal energy, and energy from wave power and tide power. We stand on the verge of commercial nuclear breeders and thermonuclear power. We are beginning to produce cleaner synthetic fuels derived from biomass, waste and coal.

Scientists and Engineers from many countries of the world will gather at the 18th ICCE 2022 Conference to present their papers covering the recent advances in clean energy sciences and in clean energy technologies. All these will no doubt speed up the conversion to clean energies, eliminate global environmental problems, and provide the humankind with higher living standards. I congratulate the organizers of this Conference and wish all the participants a very fruitful meeting and pleasant days in beautiful Kuching, Sarawak, Malaysia.

T**. NEJAT VEZIROĞLU**
Honorary Chair, 18th ICCE 2022
President, International Association for Hydrogen Energy

MESSAGE FROM

NATIONAL ADVISOR

18TH INTERNATIONAL CONFERENCE ON CLEAN ENERGY (2022)

Assalamu'alaikum wrh. wbt. and good day to all.

First and foremost, I would like to welcome all delegates to the 18th International Conference on Clean Energy (ICCE 2022). This conference is co-organized with the Clean Energy Research Institute (CERI), University of Miami, the United States of America with the support from the industrial sponsors. After two years of postponement in 2020 and 2021 due to the Covid-19 pandemic, eventually, we manage to make it happen this year. ICCE 2022 is a platform for postgraduate students, researchers, and academicians to exchange ideas for making clean energy more meaningful to industrial people or practitioners.

Collaborative research in clean energy could enhance the use of renewable and sustainable energy, with emphasis on hydrogen as a major source of energy in the near future. ICCE 2022 emphasizes energy management and efficiency which I believe must be embedded in the studies of clean energy. To all delegates, I hope that you will maximize the benefits of being here and hope to see you again in the coming years.

Finally, my heartiest congratulations are due to the organizing committee, for working towards making this event a reality.

Thank you.

PROFESSOR DR. ARSHAD AHMAD
Director of Institute of Future Energy
Universiti Teknologi Malaysia
81310 Johor Bahru Malaysia

MESSAGE FROM

CONFERENCE CHAIRMAN

18TH INTERNATIONAL CONFERENCE ON CLEAN ENERGY (2022)

It is a great pleasure for me to welcome all the delegates to the 18th International Conference on Clean Energy 2020, (ICCE2020) here in Kuching, Sarawak, Malaysia. On behalf of the organizing committee, I would like to express our utmost appreciation and gratitude to Clean Energy Research Institute (CERI), University of Miami, for their confidence and support. We are thankful to have the privilege of holding this event here in this beautiful land of Sarawak and the first of the conference series in South East Asian. We are also indebted to Sarawak Convention Bureau (SCB) and Malaysia Convention and Exhibition Bureau (MyCEB), without their backing and excellent arrangement, this conference would have not been possible.

Malaysia has pledged to reduce the emission of greenhouse gases and has provided incentives for the utilization of renewable energy sources to further reduce the carbon emission. One of the best options is via clean energy systems. It is timely that Malaysia hosts this event to strengthen its commitment towards cleaner environment. This conference is a platform for regional policy makers, researchers, academicians, industry players and enforcement agencies to jointly explore progress in technology, research and development in clean energy. This is also a venue for them to exchange ideas and share aspiration towards sustainable and clean energy system. ICCE2020 offers the best academic symposia in this region and features exhibition for companies to showcase their products. The involvement of companies would assist them in promoting their latest invention.

The spill-effect of organizing this event would be felt in areas related to energy sectors. Such industries are the backbone of the nation's aspiration towards fully developed nation. Key players in energy sectors and technology providers are gathering here to participate in this event. Policy makers would find this event meaningful to address issues associated with pollution abatement, mitigation of environmental disaster particularly concerning air pollution control technologies. The event would also enlighten the policy makers on the state-of-the-art technologies and for drafting and amending existing regulation.

Lastly, my heartiest congratulations are due to the organizing committee for having tirelessly working towards making this event a reality.

Thank you.

ASSOCIATE PROFESSOR DR. ANWAR JOHARI
Chairperson ICCE 2022,
Centre of Hydrogen Energy
Institute of Future Energy
Universiti Teknologi Malaysia
81310 Johor Bahru

DISTINGUISHED GUESTS

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Deputy Minister for Energy & Environmental Sustainability Sarawak

PROFESSOR. DR. ROSLI BIN MD. ILLIAS
Deputy Vice-Chancellor (Research & Innovation), Universiti Teknologi Malaysia

PROF. DR. WAN HASHIM WAN IBRAHIM
Deputy Vice-Chancellor (Research & Innovation), UNIMAS

PROF. DR. MOHD HASNAIN MD HUSSAIN
Director Uni. Industry Centre (UnIC), UNIMAS

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Chief Executive Officer, MGTC

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Vice President of Human Resource and Director of Sustainability & Business Strategy Asia Pacific, INTERTEK

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Regional Director – Southeast Asia Industry Services, INTERTEK

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General Manager, OTEC Engineering Group. Xenesys Inc

MR. EIICHI SAITO
President and CEO, Sakae Koukan CO.,LTD

MR. KENICHI FUKUSHIMA
President and Representative Director, Xenesys Inc

MR. SADAYUKI JITSUHARA
Director, Xenesys Inc

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Chief Executive Officer SEB Power, Sarawak Energy

MR. POLYCARP WONG
Vice President Hyrdo, Sarawak Energy

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PLENARY SPEAKER I

TS. SHAMSUL BAHAR MOHD NOR

Chief Executive Officer
Malaysian Green Technology and Climate Change Corporation (MGTC)
Plenary Title: Hydrogen Society for Sustainability

WEDNESDAY | 09:00 AM – 09:30 AM

Ts. Shamsul Bahar Mohd Nor is the Chief Executive Officer of Malaysian Green Technology and Climate Change Corporation (MGTC), the primary driver for Green Technology and Climate Change Development under the purview of the Ministry of Environment & Water, Malaysia.Prior to joining MGTC, He was the Vice President for Sustainable Business Network Association Malaysia (SustNET), the primary driver for the integration of Sustainable Development Goals into business practices. He was previously the Chairman for Green Project Management Awards, Managing Director for Syngas Renewable Energy and was the Executive Director of Saham Utama Sdn Bhd. Prior to that, he was the CEO of Polymal Corporation, which he successfully turned around from successive losses to accumulated profits of PAT RM4mil within the fourth year and successfully repositioned Polymal Corporation into a major manufacturer and producer of extruded thermoformable plastic sheets in South East Asia with business sales in USA, Europe, Japan, Australia, India and South Africa. In 2014, Ts. Shamsul Bahar was awarded the patent approval in 40 countries for a renewable energy system that converts waste plastics into commercial Ultra Low Sulphur Diesel Oil (EN590), winning him the MOSTI's Innovation of the Year Award, Malaysian Green Technology Corporation's Catalyst Award and the United Nation's Global CleantechInnovation Award for Green Technology Renewable Energy Systems. He now directs and oversees the company's overall operational policies, initiatives, and goals to spearhead the country's climate change agenda and to drive sustainable economic development. He holds a Bachelor in Mechanical Engineering from University of Portland, USA, Applied Physics and minor in Mathematics from Linfield College, USA.

TITLE: HYDROGEN SOCIETY FOR SUSTAINABILITY

Abstract - Driving the Green economy and accelerating the green growth is now embarked as a global agenda racing towards net zero carbon. The dependency on the fossil fuel and coal are depleting exponentially. The urge for us to shift towards clean energy particularly renewable energy is also rising drastically. Malaysia has huge potential renewable energy resources in the form of biogas, biomass, small hydro, solar, and wind but most of these renewable energy resources are not fully explored and exploited. The 12th Malaysia Plan (12th MP) represents a visionary commitment to set in place the structural conditions for green investments as an integrated element of our nation's economic and sustainable. This long-term commitment is also being supported by National Prosperity Vision which targets Malaysia to become carbon neutral by 2050. Hydrogen has the capacity to boost to large-scale CO2 emission reductions in many sectors, including industrial operations, as a raw material for steel and chemical supply chains, or desulfurization in oil refining, over and above its used as a fuel for vehicles or power generation. Under the comprehensive National Energy Policy in the 12th MP, the potential for future growth in new energy from clean and sustainable source such as hydrogen, will be widely researched. This new energy would allow Malaysia to chart its long-term low-carbon vision in the energy sector.

Takayuki Watanabe
Company Director & General Manager
OTEC Engineering Department of Xenesys Inc.

Plenary Title: Xenesys's Effort for OTEC Technology

PLENARY SPEAKER II

WEDNESDAY | 09:30 AM – 10:00 AM

Takayuki Watanabe is Company Director and also General Manger of OTEC Engineering Dept. of Xenesys Inc. Prior joining Xenesys Inc, he used to be in Japanese Power Electric Company, The Chugoku Electric Power Co., Inc. and to work for thermal power plant department as an engineer. He was in charge of O&M in a thermal power plant and making new project such as for efficiency of the equipment and plant. In the course of working for thermal power plant using huge amount of seawater, he became to be fascinated in potential of ocean energy, and has joined in Xenesys. He is currently in charge of planning of OTEC project and designing the system of OTEC technology.

TITLE: XENESYS'S EFFORT FOR OTEC TECHNOLOGY

Abstract - Xenesys Inc. has focused on researching and developing OTEC in order to realize and commercialize it about for more than 20 years in collaboration with Saga University. Xenesys has also tackled with the application of OTEC technology in the other industrial areas such as waste heat and geothermal, etc. Xenesys's efforts so far regarding OTEC technology will be introduced as the tile of "Xenesys's effort for OTEC technology".

Ir. Bunyak Lunyong

Chief Executive Officer
SEB Power, Sarawak Energy
Plenary Title: Sarawak's Renewable Energy Transition

PLENARY SPEAKER III

WEDNESDAY | 11:00 AM – 11:30 AM

Ir. Bunyak Lunyong is the Chief Executive Officer for SEB Power – Sarawak Energy's generation arm. He oversees the operation of our power generation business, covering hydro, coal, gas and hydrogen. In his role, he strengthens the Company's generation operations by enhancing and maximising the value of our power generation assets – driving Sarawak Energy's growth agenda and strategic vision of becoming a regional renewable energy powerhouse. He is key to our ongoing generation transformation journey and efforts to realise our digital power plant ambition. Prior to this, he was Sarawak Energy's General Manager for Project Delivery – leading project controls and performance management to enhance project modelling. Bunyak has over 30 years of experience in electrical engineering, project management, engineering, construction, commissioning, operations, maintenance, and assets integrity from his time in various multinational corporations. He holds a Bachelor of Science in Electrical Engineering from the University of Houston and is a member of the Malaysian Institute of Engineer and Board of Engineer Malaysia.

Sunny Minhas
Associate Director,
Alternative Fuels & Renewable Energy @ Intertek

Plenary Title: Intertek Hydrogen – Global end-to-end risk-based quality, safety and sustainability solutions for the hydrogen industry

PLENARY SPEAKER IV

WEDNESDAY | 11:30 AM – 12:00 AM

Sunny Minhas is an Associate Director at Intertek Testing. In his current position at Intertek, Sunny is responsible for Intertek's global Hydrogen and Fuel Cell business, including all testing, certification, and global commercial activities related to the Hydrogen and Fuel Cell industry. With 10 years of regulatory and compliance experience, Sunny has helped Intertek develop into one of the world's most trusted testing and certification agencies in the hydrogen industry. At Intertek, Sunny has helped develop innovative and customer-centric regulatory approval programs for Hydrogen and Fuel cell related equipment, including the testing and certification of Hydrogen re-fueling stations, Electrolyzers, and high-pressure-components.

TITLE: INTERTEK HYDROGEN – GLOBAL END-TO-END RISK-BASED QUALITY, SAFETY AND SUSTAINABILITY SOLUTIONS FOR THE HYDROGEN INDUSTRY

Abstract - Hydrogen is increasingly viewed as a leading energy transition fuel providing a way to decarbonize industries and support greater efficiency within renewable energy sectors. As the global hydrogen industry expands and develops, the regulatory and safety challenges facing commercialization of this technology become more critical for our customers. Increasingly complex and time-sensitive projects offer an opportunity for customers to integrate their technologies and solutions throughout the entire hydrogen supply-chain from the early stages of front-end engineering, to production, delivery, storage, end-use, certification and beyond. In this presentation we will provide insight into how Intertek Hydrogen provides customers with access to our unmatched expertise, pioneering energy innovations and global end-to-end risk-based quality, safety, and sustainability solutions that helps them advance the hydrogen sector, successfully develop and execute hydrogen-based projects and create viable ecosystems all while overcoming safety challenges and increasingly complex regulatory requirements throughout the entire hydrogen value chain.

PLENARY SPEAKER V

Prof. Ir. Ts. Dr.
Zainuddin Abdul Manan
Professor
Universiti Teknologi Malaysia (UTM)

Plenary Title: Building Organisational Resilience Through Sustainable Energy Management

THURSDAY | 09:30 AM – 10:00 AM

Prof. Zain is a professor of chemical engineering, Faculty of Chemical and Energy Engineering, the founder of UTM Sustainable Energy Management Program, the founder of Optimal Systems Engineering (OPTIMISE), a UTM spin-off company. He started his career as an engineer in PETRONAS and Hume Industries and has been an academic leader, educator, researcher, consultant and professional coach for more than 25 years. Prof Zain is a professional engineer, professional technologist, a chartered engineer, a certified energy manager, a registered electrical energy manager and the certified lead trainer for Malaysia energy managers. He has delivered over 400 invited talks in professional courses, conferences and seminars across the world, including the 2014 Imperial College Distinguished Chemical Engineering Lecture. Zain has coached professionals from more than 500 national and multi-national companies. Prof Zain is currently the technical advisor and the co-chair of Energy Efficiency and Conservation Act (Thermal Energy) Drafting committee under the Malaysian Ministry of Energy, Science, Technology, Environment and Climate Change (MESTECC). He was a member/vice-chairman of Board of Judges of ASEAN Energy Awards (2006-2011) for the commercial and industrial sectors. He founded and spearheaded the UTM Sustainable Energy Management initiative that led UTM to achieve >USD 6 million energy savings (2011-2018), to win the ASEAN Energy Award (2012), and to be the first ASEAN Certified Energy-Efficient organisation.

TITLE: BUILDING ORGANISATIONAL RESILIENCE THROUGH SUSTAINABLE ENERGY MANAGEMENT

Abstract-Organisations across the world face massive challenges during and after the COVID19 crisis that has costed lives, threatened livelihoods, disrupted businesses and caused widespread unemployment at an unprecedented scale. There is the need for organisations to rapidly adapt, drive innovation and build resilience in order to continue to survive and eventually thrive beyond the epic crisis. This lecture highlights the experience of Universiti Teknologi Malaysia (UTM) in driving reforms through a living lab for sustainable energy management (SEM) program that created a competitive edge and built a resilient ecosystem of innovation-driven education and research. The key highlight of the presentation is the UTM 6P Energy Sustainability Transformation (Energy-STAR) Program. UTM *6P Energy STAR* strategy to drive reform and innovation began by getting the commitment of UTM top management. Doing so entailed pinpointing the specific and major pains experienced by UTM management and community. Understanding the pains allowed the team to build the definite purpose for the reform initiative. Driven by this purpose, an inclusive SEM Program was established. A key component of the program involves upskilling the people as program champions.

Prof. Dr. Hossam A. Gabbar
PEng, RAMSP Fellow, Director of Smart Energy Systems Lab
Ontario Tech University, Canada

Plenary Title: Resilient Energy Systems for Interconnected Infrastructures

PLENARY SPEAKER VI

THURSDAY | 10:15 AM – 10:45 AM

Dr. Gabbar is a full Professor in the Faculty of Energy Systems and Nuclear Science, and cross appointed in the Faculty of Engineering and Applied Science, at Ontario Tech University (UOIT), where he has established the Energy Safety and Control Lab (ESCL), Smart Energy Systems Lab, and Advanced Plasma Engineering Lab. He is the recipient of the Senior Research Excellence Aware for 2016, UOIT. He is recognized among the top 2% of worldwide scientists with high citation in the area of energy. He is leading national and international research in the areas of smart energy grids, energy safety and control systems, and waste to energy using advanced plasma technologies. Dr. Gabbar obtained his B.Sc. degree in 1988 with first class of honor from the Faculty of Engineering, Alexandria University (Egypt). In 2001, he obtained his Ph.D. degree from Okayama University (Japan). From 2001 till 2004, he joined Tokyo Institute of Technology (Japan), as a research associate. From 2004 till 2008, he joined Okayama University (Japan) as an Associate Professor, in the Division of Industrial Innovation Sciences. From 2007 till 2008, he was a Visiting Professor at the University of Toronto. He also worked as process control, safety, and automation specialist in energy and oil & gas industries. Dr. Gabbar has more than 230 publications, including patents, books / chapters, journal and conference papers.

TITLE: RESILIENT ENERGY SYSTEMS FOR INTERCONNECTED INFRASTRUCTURES

Abstract - This talk will present advances in research on planning, design and control strategies of hybrid energy systems and their applications on interconnected infrastructures. Modeling and simulation techniques are proposed to support the design and operation of resilient hybrid energy systems and their integration within water, transportation, and city infrastructures. This includes waterfront infrastructures and maritime transportation electrification. The talk will include energy-water-transportation interconnected infrastructures, and possible evaluation of performance measures for design and operation options. Analysis of resiliency and protection layers will be discussed and applied on hybrid energy systems within interconnected infrastructure.

Prof. Dr. Djoko Hartanto
Professor
Sepuluh Nopember Institute of Technology

Plenary Title: Current and Future Perspectives of Indonesian Natural Zeolite

PLENARY SPEAKER VII

THURSDAY | 10:45 AM – 11:15 AM

Prof. Dr. Djoko Hartanto is an academic staff at the Department of Chemistry, Faculty of Science, Institut Teknologi Sepuluh Nopember (ITS), Surabaya, Indonesia. He received his bachelor degree from Universitas Gadjah Mada (UGM) in Inorganic Chemistry in 1986. He then pursued his Masters in Inorganic Chemistry and graduated in 1992 from the same institution. He has also successfully completed his PhD in 'Synthesis Catalyst Heterogen of ZSM-5 from Kaolin' from Institut Teknologi Sepuluh Nopember (ITS) in 2016. He is active in Indonesian Zeolite Association and he is the President of the organization. His expertise in catalyst has been sought after through the collaboration between ITS and Universiti Teknologi Malaysia (UTM) in the field of Nano Materials and Photo-catalysis. He has also involved in projects for Surabaya city for the use of Natural Zeolite as the potential catalyst in used oil. He is one of the key members of ITS Electric Car Project for the Fabrication of ZSM-5 Composite Membrane from Bangka Kaolin with Polypropylene Polymer as Lithium-ion Battery Separator.

TITLE: CURRENT AND FUTURE PERSPECTIVES OF INDONESIAN NATURAL ZEOLITE

Abstract - Indonesian natural zeolite has been used globally in various applications such as conventional-simple application and modern-complicated application, while the potential of Indonesian natural zeolite reserve is abundant (estimated above 600 million tons) and found in Java, Sumatra, Sulawesi and NTT regions whose reserves usually in form of clinoptilolite, natrolite and mordenite zeolite. Virtually every university and research institute in Indonesia conduct (or has done) research on natural zeolite, which is widely studied the application of Indonesian natural zeolite as catalytic active material, adsorbent and molecular sieve. There is also research that studied natural zeolite usage as slow release fertilizer carrier, energy-exchanger that helps stabilize heat during day and night and also as an air conditioner in grain processing from agricultural products. Natural zeolite is olso used as energy storage material, primarily for storing hydrogen, and the most interesting utilization is radioactive materials adsorbent in nuclear reactor before waste disposal. In business field, Indonesian natural zeolite is produced in large quantities for both domestic and export demand. Natural zeolite mainly used for soil modifiers, cattle feed mixture to reduce nitrates and nitrites in manure, active adsorbents in waste treatment, slow release fertilizer carriers and additional materials in pond culture. In my research group, Indonesian natural zeolite is modified as it is usually used as a catalyst and adsorbent, energy storage material especially hydrogen storage, heat exchanger systems and other applications related to energy. The main application that supports the green energy project is fabrication catalysts for processing used oil and POME into biodiesel, in this case the Surabaya government aim to produce biodiesel and support the Indonesian government's program towards B100 from used oil. In addition to these programs natural zeolite was also developed to support "Surabayaku Hijau dan Bersih" and "Program Langit Biru".

PLENARY SPEAKER VIII

Prof. Dr. Yasuyuki Ikegami
Professor, Leader of OTEC Division Institute of Ocean Energy Saga University, Japan

Plenary Title: Blue Innovation Using OTEC for SDGS– Towards to Stable Energy and Sustainable New Business-

THURSDAY | 11:15 AM – 11:45 AM

He has done research on the optimization on OTEC system, heat exchanger (the condenser and the evaporator) for Ocean Thermal Energy Converstion (OTEC), and By-product of OTEC for OTEC Laboratory at Saga University for 26 years. Recently, he has been investigating an OTEC system using ammonia/water mixtures as working fluid. He has collaborated on the project with several countries, including the Republic of Palou, India, and Korea. He is special field is in energy conversion engineering, thermodynamic engineering and heat transfer. Other projects include the antifouling of heat exchanger, development of turbine, and control system for OTEC system. Dr. Ikegami has served as a Visiting Professor at Duke University, and Deputy Director at the Institute of Ocean Energy at Saga University. He is the recipient of numerous awards, including the Hatakeyama Award by Japan Society of Mechanical Engineers and the Global 100 Eco-Tech Award. He is a member of several organizations, including the Japan Solar Energy Society, The Heat Transfer Society of Japan, and The Japan Society of Energy and Resources.

TITLE: BLUE INNOVATION USING OTEC FOR SDGS– TOWARDS TO STABLE ENERGY AND SUSTAINABLE NEW BUSINESS

Abstract - An Ocean thermal energy conversion (OTEC) have been strongly focused again on the important one solution for expected for saving the earth and Sustainable Development Golds (SDGs) . In recent years, the technology and business have been internationally advanced to a new stage.The OTEC system produces the power from the ocean thermal energy. The typical advantage of the OTEC is the stable power generation rather than other renewables such as solar PVs and wind mills. And, OTEC could be produced the by-products and job creations using the discharged deep seawater. The OTEC facility at Kumejima, in Japan, was launched in 2013 and is continuously operating using the advanced technology, as international forefront.There are the highest potential of OTEC in the seas of Asia-Pacific. In this presentation will be shown on the feasibility of contribution on SDGs using OTEC and DOWS in Asia-Pacific.

PLENARY SPEAKER IX

Assoc. Prof. Dr.
Mehmet Suha Yazici
Associate Professor
TUBITAK Marmara Research Center, Turkey

Plenary Title: Hydrogen and Fuel Cell Research at Tubitak-Mam

THURSDAY | 11:45 AM – 12:15 AM

Assoc. Prof. Dr. Mehmet Suha Yazici is a Chief Research Scientist at TUBITAK Marmara Research Center (MAM) Energy Directorate, Turkey. Prior to that, he was director of R&D at UNIDO-ICHET (International Center for Hydrogen Energy Technologies), Istanbul, Turkey. He has lectured at Gebze Technical University and Bahcesehir University on electrochemical energy conversion, hydrogen and fuel cell systems. His other Professional experience includes Senior Research Scientist at GrafTech International (Cleveland, USA), Research Scientist at Procter & Gamble (P&G, Cincinnati, USA) and Visiting Scientist at AIST Laboratory in Japan. His research experience is in the area of electrochemical energy conversion (batteries and fuel cells) and hydrogen. He is actively working to support hydrogen &fuel cell R&D efforts. In addition to his scientific research, he had worked on project and program management for new product development, collaborative research and intellectual property management. He has several patents (15+) and publications (30+journal articles) covering electrochemical systems in power generation and energy storage applications. He is representing TUBITAK at European Commission, Joint Undertaking, Hydrogen Europe-Research and European Energy Research Alliance (EERA) Fuel Cells and Hydrogen. He is an active member of The Electrochemical Society (ECS) and the International Society of Electrochemistry (ISE). Dr. Yazici has a Ph.D from Illinois Institute of Technology (IIT, Chicago, USA) on electrochemical engineering.

TITLE: HYDROGEN AND FUEL CELL RESEARCH AT TUBITAK-MAM

Abstract - Applied research on hydrogen and fuel cell in Turkey has been carried out mostly at TUBITAK Marmara Research Centre. In addition to conventional reforming and gasification research, fuel cell and electrolyzer projects are implemented at the centre for various aspect of implementation. Research outcomes are showcased as prototype or pilot plant for further development. More details on projects will be presented.

CONFERENCE SCHEDULE

18th International Conference on Clean Energy 2022 (ICCE 2022)

Borneo Convention Centre Kuching, Sarawak

Date: 27th –28th July 2022

DAY 1

WEDNESDAY		
27-Jul-22		
8.30 - 8.40 am	**REGISTRATION**	
8.40 – 8.45 am	**Safety Briefing**	
8.45 – 9.00 am	Welcoming Speech by **Assoc. Prof. Dr. Anwar Johari** Chairman of ICCE 2022	
9.00 - 9.30 am	**PLENARY SPEAKER 1: Ts. Shamsul Bahar Mohd Nor (MGTC)** **Title: Hydrogen Society for Sustainability** **Chairperson: Prof. Dr. Arshad Ahmad**	
9.30 - 10.00 am	**PLENARY SPEAKER 2: Takayuki Watanabe (XENESYS INC)** **Title: Xenesys's Effort for OTEC Technology** **Chairperson: Prof Dato' Ir Dr A. Bakar Jaafar**	
10.00 - 10.45 am	**OPENING CEREMONY**	
10.45 – 11.00 am	TEA BREAK/ PRESS CONFERENCE	
11.00 – 11.30 am	**PLENARY SPEAKER 3: Ir. Bunyak Lunyong (SEB)** **Title: Sarawak's Renewable Energy Transition** **Chairperson: Assoc. Prof. Ir. Dr Mimi Haryani Hassim**	
11.30 – 12.00 pm	**PLENARY SPEAKER 4: Sunny Minhas (Intertek)** **Title: Intertek Hydrogen – Global end-to-end risk-based quality, safety and sustainability solutions for the hydrogen industry.** **Chairperson: Dr. Florianna Michael**	
SESSION 1: P1 **BREKOUT ROOM 1** **12.00 pm – 1.30 pm**		
Chairman: Dr. Umi Aisah Asli **Assistant Chairman: Mr. Muhammad Akmal bin Abdul Aziz** **Technical Assistant: Mr. Muhammad Bin Abdul Razak**		
12.00 -12.15 pm	**V EE1-137**	**Microstructural characteristics of laser-treated Ni-Cr alloy via low power CO_2 laser** *G. A. Lusom, D. S. A. Mahmod, K. F. Tamrin, A. A. Khan, P. Barroy*
12.15 - 12.30 pm	**V EE2-169**	**Study on the physical properties of polymer composite growing media fabricated using solution blending** *N. Adzman, N. Hairi, M . J. Kamaruddin, M. N. H. Zainal Alam, S.A. Samsudin*
12.30 - 12.45 am	**V EE9-133**	**A preliminary environmental impact assessment of a 3 kw h-otec pilot plant in Malaysia** *M.S. Chiong, M.H. Tan, H.C. Phua, A. Takada, Y.-Y. Chun, K. Tahara*
12.45 - 1.00 pm	**P EE10-146**	**Fibrous silica zirconia as a promising catalyst for CO_2 hydrogenation to methane** *A. H. Hatta, A.A. Jalil, N.S. Hassan, M.N. Haron, M.Y.S. Hamid, W. Nabgan, O. Bulliard-Sauret*

1.00 - 1.15 pm	**P ECT2-129**	**Effect of calcination temperature on fibrous silica zirconia toward enhanced removal of Cr(VI) and *p*-cresol** *F.F.A. Aziz, A.A. Jalil, N.S. Hassan, A.A. Fauzi, N.F. Khusnun, N.M. Izzudin*
1.15 - 1.30 pm	**P ECT3-128**	**Synthesis of fibrous silica ceria for enhanced visible-light driven photodegradation of ciprofloxacin coupling with sulfate radical** *A. A. Fauzi, A. A. Jalil, F. F. A. Aziz, N. S. Hassan, M. S. Azami, N.M. Izzudin*
SESSION 1: P2 BREAKOUT ROOM 2 12.00 – 1.30 pm		
Chairman: Dr. Nurul Sahida Hassan Assistant Chairman: Mr. Mansur Alhassan Technical Assistant: Mr. Mohd Hafis Ramli		
12.00 -12.15 pm	**V RETS1-119**	**A review of recent developments in wells turbine optimization** *Nurudin A.S, Shamsul S. and Hazilah M.K*
12.15 - 12.30 pm	**V RETS2-143**	**Internet of Things System Through Message Queue Telemetry Tracking Protocol for Modernizing Red Chili Agriculture** *Dalila Mat Said ,Nasarudin Ahmad , Md Pauzi Abdullah , Norzanah Rosmin , Siti Maherah Hussin, Siti Aisyah Abd Wahid*
12.30 - 12.45 am	**P RETS3-122**	**Effect of the types of alcohol used in the synthesis of bio-polyol from palm oleic acid** *Intan Suhada Azmi, Nurul Intan Syafinaz Mohd Zalman, Muhammad Raihan Mustafha, Muhammad Danish Haqeem Norazlan, Nuraisyah Mahdir, Mohd Jumain Jalil and Abdul Hadi*
12.45 - 1.00 pm	**P RETS4-157**	**Development of metal-organic frameworks and its derivatives for photocatalytic activity performances.** *N.A.Nordin, M.A.Mohamed, M.N.I.Salehmin, S.F.Mohd Yusoff*
1.00 - 1.15 pm	**P ECT7-191**	**Simultaneous photocatalytic degradation of dyes using zinc oxide modified carbon nitride catalyst** *N. W. C. Jusoh, A. A. M Rodzi*
1.15 - 1.30 pm	**P ECT10-142**	**Photoconversion of glucose using zinc oxide supported on fibrous ZSM5 (CHE-Z5) catalyst** *N.F. Khusnun, A. Ahmad, A. A. Jalil, N.S. Hassan, and P. Visvanathen*
SESSION 1: P3 BREAKOUTB ROOM 3 12.00 – 1.30 pm		
Chairman: Assoc. Prof. Dr. Syuhaida Ismail Assistant Chairman: Mr. Muhammad Hafizuddin Mohd Sofi Technical Assistant: Mr. Shahrin Bin Bahar		
12.00 -12.15 pm	**V PV6-233**	**Study on Inrush Current in PV System**

		Fitri Isnatul Avinda, Aripriharta, Mohamad Rodhi Faiz, Norzanah Rosmin
12.15 - 12.30 pm	**P PV4-215**	**Design, Installation and Physical Evaluation of 102.15KWP Floating Solar Photovoltaic (Fspv) System at Near Shore Area in Malaysia** *R. M. Jais, M. A. Elias, P. N. J Baharin, N. S. Suhaimi*
12.30 - 12.45 am	**K PV3-210**	**Artificial Intelligence Based Fire Detection in PV Systems** *A. H. Omran, D. M. Said, S. M. Hussin, N. Ahmad, Y. M. Abid*
1.00 - 2.00 pm	LUNCH	
SESSION 2: P1 BREAKOUT ROOM 1 2.00 - 5.30 pm		
Chairman: Dr. Siti Maherah binti Hussin Assistant Chairman: Mr. Muhammad Hakimi Sawal Technical Assistant: Muhammad Bin Abdul Razak		
2.00 - 2.15 pm	**V EE3-153**	**Polymer Composite as An Alternative Growing Media in Media Bed Aquaponic System** *Nuramalia Adzman, Sani Amril Samsudin, Muhd Nazrul Hisham Zainal Alam, Mohd Johari Kamaruddin*
2.15 - 2.30 pm	**V EE4-180**	**Physical characteristics of polymer composite growing media fabricated using different fabrication technique** *N. Adzman, M. J. Kamaruddin, M. N. H. Zainal Alam, S.A. Samsudin*
2.30 - 2.45 pm	**V EE5-173**	**Optimization of Biosurfactant Production by Bacillus Subtilis From Pineapple Peel Waste using Response Surface Methodology** *Nur Raudhah Azman, Umi Aisah Asli, Helmi Nadri, Ong Pei Ying, Aidee Kamal Khamis, Nor Dina Sakaria, M. Hissammuddin Shah Z. Abidin, Siti Aisyah M.Dolit*
2.45 - 3.00 pm	**V EE6-181**	**Analysis of thermal comfort and energy consumption for educational building** *Norasikin Hussin, Siti Shareeda Mohd Nasir, Nor Azirah Mohd Fohimi, Dzullijah Ibrahim, Rohidatun Mahmod*
3.00 - 3.15 pm	**V EE7-184**	**Nickel and cobalt promoted silica@Mgo core shell for dry reforming of methane** *L. P. Teh, N. Mat, A. A. Jalil, A. H. Hatta*
3.15 - 3.30 pm	**V EE8-211**	**Adsorption of CO_2 Using Activated Carbon Synthesized from Pomelo Peel at Different Heating Conditions** *N. A. Ghafar, N. W. C. Jusoh, N. R. Jamia*
3.30 - 3.45 pm	**V EE13-172**	**Hydrothermal liquefaction of food wastes for sustainable production of high-grade biocrude-oil to drop-in transport fuel** *Fatma Marrakchi, Lasse Rosendahl*

3.45 - 4.00 pm	**V EE14-165**	**Epoxidation Of Oleic Acid by The Prilezhaev Method Using Acetic Acid** *Ismail Md. Rasib, Intan Suhada Azmi, Mohd Jumain Jalil*
4.00 - 4.15 pm	**V EE17-237**	**Evaluation of diethylenetriamine functionalized polymer adsorbent for carbon dioxide capture from natural gas** *Noor Ashikin Mohamad , Mohamed Mahmoud Nasef , Roshafima Rasit Ali , Arshad Ahmad and Tuan Amran Tuan Abdullah*
4.15 - 4.30 pm	**P EE11-156**	**Synthesis of protonated fibrous silica ZSM-5 for methanol to hydrocarbons (MTH) application** *M. H. M. Sofi, M. Y. S. Hamid, A. A. Jalil, N. S. S. Suzali*
4.30 -4.45 pm	**P EE12-164**	**Effect of temperature on drying performance of stingless bee pot-pollen using swirling fluidized bed dryer** *L. A. Halim, F. Basrawi, M. W. Ibrahim, A. S. Md Yudin, N. A. M. Azman*
4.45 - 5.00 pm	**P EE15-120**	**Epoxidized vegetable oil as a potential source of lubricants** *Mohd Jumain Jalil, Intan Suhada Azmi, Mariam A. Rahmana, Mahazmi Burhanuddin Mahadi, Ismail Md. Rasib*
5.00 - 5.15 pm	**P EE16-238**	**Solid Acid Catalyst Derived from Acid Activated fly ash for methanol dehydration to Dimethyl Ether** *M.Y. Mohamud, TAT Abdullah, A Ahmed, Melissa Low Phey*
5.15 - 5.30 pm	**P ECT18-243**	**Effect of Different Precursors of Graphitic Carbon Nitride Towards Photocatalytic Conversion of Carbon Dioxide to Methanol** *A. A. Jalil, N.S. Hassan, N. Zulkifli, A. Johari*
SESSION 2: P2 BREAKOUT ROOM 2 2.00 - 5.30 pm		
Chairman: Dr. Tuan Amran Tuan Abdullah Assistant Chairman: Ms. Rubiat Sadia Mim Technical Assistant: Mr. Mohd Hafis Ramli		
2.00 - 2.15 pm	**V HE1-186**	**Solvent free synthesis of Ni/TiO_2 as highly active photocatalyst for phodecompositon of NH_3 to hydrogen gas** *C.Hee, H. Bahruji, AH. Mahadi, R. Abdullah*
2.15 - 2.30 pm	**V HE3-135**	**The readiness and safety of public to use hydrogen as fuel for vehicles in Malaysia** *T. M. Ambikabathy, N. Norazahar*
2.30 - 2.45 pm	**V HE10-239**	**Catalytic Decomposition of Methane into Hydrogen and Carbon Nanotubes: Effect Of Ni Loading** *Nur Shamimie Nadzwin Hasnan, Sharifah Najiha Timmiati, Zahira Yaakob Kean Long Lim, Yun Hin Taufiq-Yap*
2.45 - 3.00 pm	**V HE9-196**	**Risk evaluation of hydrogen dispersion from compressed hydrogen (H_2) storage vessels.**

		R. M. Kasmani, N. Norazahar, A. A. Jalil, T. A. T. Abdullah, A. Ahmad, M. F. Ahmad Kamaroddin
3.00 - 3.15 pm	**K HE2-113**	**Hydrogen production with the selective oxidation of benzyl alcohol to benzaldehyde in aqueous medium by a noble-metal-free photocatalyst VC/CdS nanowires** *Muhammad Tayyab, Yujie Liu, Shixiong Min, Rana Muhammad Irfan, Qiaohong Zhu, Liang Zhou, Juying Lei, Jinlong Zhang*
3.15 - 3.30 pm	**P HE4-145**	**Emerging techniques for photoelectrodes fabrication with porosity-enhanced photoelectrochemical solar fuel production** *A. A. Nornastasha, A. M. Mohamad*
3.30 - 3.45 pm	**P HE6-140**	**Emerging surface physicochemistry modification and structural design of graphitic carbon nitride for enhanced photocatalytic solar fuel generation and wastewater treatments** *N. S. N. Hasnan, M. A. Mohamed, Z. A. Mohd Hir*
3.45 - 4.00 pm	**P HE7-126**	**Determining most effective on dry reforming of methane over fibrous silica-alumina (FSA) via Nickel and Cobalt** *A.H.K.Owgi, A. A. Jalil, Walid Nabgan, Mansur Alhassan*
4.00 - 4.15 pm	**P HE8-171**	**Biohydrogen production from pineapple peels using immobilised co-cultured bacteria onto activated carbon sponge** *Nur Kamilah Abd Jalil, Umi Aisah Asli, Mimi Haryani Hassim, Ho Wai Shin, Mohd Johari Kamaruddin and Haslenda Hashim*
4.15 - 4.30 pm	**P FC5-170**	**Highly durable and stable Fe-N-C catalyst for oxygen reduction reaction in acidic medium** *N. H. Ahmad Junaidi, W. Y. Wong, K. S. Loh, R. Saidur, T. F. Choo*
4.30 -4.45 pm	**P FC6-189**	**Relationship between phase evolution and electrical properties of Cu-doped $(Mn,Co)_3O_4$ spinel** *J.C.W. Mah, I. Aznam, A. Muchtar, M.R. Somalu, M.J. Ghazali*
4.45 - 5.00 pm	**P FC7-205**	**Potential of Regenerative Fuel Cell in Electric Vehicle Charging Station: A Brief Review** *Nurliana Farhana Salehuddin, Noraziah Muda, Wan Muhammad Faris Wan Ramli*
5.00 - 5.15 pm	**P FC8-236**	**Influence of The Sintering Temperature on The Microstuctural and Electrochemical Behaviours of SrFe0.9Ti0.1O3−δ– Ce0.8Sm0.2o1.9 Composite Cathode** *A. J. Abd Aziz, N. A. Baharuddin, M. R. Somalu, A. Muchtar*
5.15 – 5.30 pm	**P FC4-190**	**A short review of biopolymer as an alternative membrane in direct methanol fuel cell (DMFC) application** *Yusra Nadzirah Yusoff, Norazuwana Shaari*

SESSION 2: P3 BREAKOUT ROOM 3 2.00 - 5.30 pm		
Chairman: Dr. Mahadi Bahari **Assistant Chairman: Mr. Nik Muhammad Izzudin Nik Lah** **Technical Assistant: Mr. Shahrin bin Bahar**		
2.00 - 2.15 pm	**V BB1-130**	**Production of biokerosene hydrocarbons using coconut oil and palm kernel oil with CoO-NiO/kaolin catalyst via solvent-free and inert atmosphere catalytic deoxygenation** *Anis Athirah Mohd Azli, Norazila Othman, and Mohammad Nazri Mohd Jaafar*
2.15 - 2.30 pm	**V BB2-155**	**Biopesticide Production from Pineapple Peel** *J. Y. Lim, A. Johari, A.A. Jalil*
2.30 - 2.45 pm	**V BB3-148**	**Production of bio-oil by coconut shell pyrolysis as biopesticide** *N. Ibrahim, A. Johari, A.A. Jalil*
2.45 - 3.00 pm	**V BB4-149**	**Pyrolysis treatment of sugarcane bagasse as biomass waste to produce bio-pesticide** *R. Lee, A. Johari, A.A. Jalil*
3.00 - 3.15 pm	**V BB5-150**	**Production of bio-oil as bio-pesticides from pyrolysis spent coffee grounds** *F. Akmal, A. Johari, A.A Jalil*
3.15 - 3.30 pm	**V BB6-152**	**Assessment of Polycyclic Aromatic Hydrocarbons (PAHs) in Microwaved-Biochar as a Requirement for Soil Amendment Application** *N. A. N. M. N Azman, M. Asmadi, I. J. Rusli, Nor A. S. Amin, Muzakkir M. Zainol, N. Phaiboonsilpa, H. Kawamoto*
3.30 - 3.45 pm	**V BB7-166**	**Kinetics Modelling of Green Solvents Delignified Oil Palm Empty Fruit Bunch Pyrolysis via Thermogravimetric Analysis** *A. Z. E. Ku, C. L. Yiin, B. L. F. Chin, S. S. M. Lock*
3.45 - 4.00 pm	**V BB8-188**	**Deoxygenation of palm fatty acid distillate into green diesel: optimization of process parameters using RSM historical data design** *B. S. Zainal, N. A. Abdul Razak, M. N. Saat, D. Derawi*
4.00 - 4.15 pm	**V BB9-208**	**Development And Characterization of Low-Cost Alumina-Kaolin Membrane for Removal of Glycerol from Biodiesel** *S. P. Kusumocahyo, N. Z. Az'zura, S. Yusri, Meliyanti, E. Maryani, Hernawan*
4.15 - 4.30 pm	**V BB10-209**	**Green Diesel Production from Waste Cooking Oil by Ni-Co/SBA-15 Catalyst Via Deoxygenation Reaction** *Noor Azira Abdul Razak, Darfizzi Derawi*

4.30-4.45 pm	**V BB11-224**	**Comparative Study of Yield, Composition, Reproducibility and Toxicity of Extract Quercus Infactoria Gall with Conventional Extraction and Co-Solvent Asistent in Supercritical CO2 Extraction** *R. Purbowati, T. Taufiqurahman, A. Syahrani*
4.45 - 5.00 pm	**V BB12-082**	**The Impact of TiO2 on The Combustion Characteristic, Kinetic and Thermodynamic Parameters of Microalgae Spirulina Platensis-Synthetic Waste Blend** *S. Sukarni, A. Prasetiyo, P. Puspitasari, A. A. Permanasari, S. Anis, A. Johari*
5.00 - 5.15 pm	**P BB13-136**	**Sago starch industry in Malaysia: opportunities for cleaner production** *Nurleyna Yunus, Rafiqqah, Mohd. Sabri, Daniel Chua, Mas Fairidzuan Mas Rosli and Shamsul Arsad*
5.15 – 5.30 pm	**P BB14-235**	**Performance of Biochar-Based Graphitic Carbon Nitride: Effect of Precursors** *N. A. M, Nazri, S. N. Q. S.Abd Halim, N. A. H. M. Nordin*
5.30 – 5.45 pm	TEA BREAK	
8.00 – 10.00 pm	**GALA DINNER**	

DAY 2

THURSDAY		
28-Jul-22		
8.15 -8.30 am	REGISTRATION	
SESSION 3: P1 BREKOUT ROOM 1 8.30 -9.30 am		
Chairman: Ts. Dr. Sathiabama T.Thirugnana Assistant Chairman: Mr. Abdullah Murtadha Ahmed Alhebshi Technical Assistant: Muhammad Bin Abdul Razak		
8.30 - 8.45 am	**V OTES1-177**	**An Assessment on Technical Challenges of Heat Exchangers in Hybrid Ocean Thermal Energy Conversion** *A. A. Azmi, T. Yasunaga, Y. Ikegami, K. Fontaine, S. T. Thirugnana, A. B. Jaafar*
8.45 - 9.00 am	**V OTES2-207**	**Climate Change, Water Resources, & Renewable Energy in The Bahamas** *John A. Bowleg, PE*
9.00 - 9.15 am	**P OTES8-241**	**Novel Strategies for Data Centre Waste Heat Use** *Petter Terenius, Peter Garraghan and Richard Harper*
9.15 -9.30 am	**P OTES4-134**	**Structural Analysis of Radial Turbine Impeller for OTEC** *I.Z. Suhaini, A. Abdul -Latif, M.F. Shamsudin, and S. Mansor*

SESSION 3: P2 BREKOUT ROOM 2 8.30 -9.30 am		
Chairman: Assoc. Prof. Dr. Mohd Wijayanuddin Ali **Assistant Chairman: Ms. Fazilah Farhanah Abd Aziz** **Technical Assistant: Mr. Mohd Hafis Ramli**		
8.30 - 8.45 am	**V FEP1-229**	**An assessment of the Financial Feasibility of an OTEC Ecopark: a Case Study at Cozumel Island** *E. P. Garduño-Ruiz ,J.G. Tobal-Cupul, , Emiliano Gorr-Pozzi, Jorge Olmedo-González*
8.45 - 9.00 am	**V SF1-213**	**Bibliometric analysis of global research trends on risk assessment of hydrogen production using scopus database** *M. Zainal Abidin, S.I. Ahmad*
9.00 - 9.15 am	**V SF2-132**	**Development of risk assessment model for ftj biopower plant boiler using bayesian network** *F. A. Alaw, N. S. Sulaiman*
9.15 -9.30 am	**P SF3-123**	**Green E-waste processing: identification of inherent safety and health properties** *S. I. Ahmad, M. H. Hassim, M. Zainal Abidin, M. F. Husin*
SESSION 3: P3 **BREKOUT ROOM 3** **8.30 -9.30 am**		
Chairman: Dr. Nur Farahain binti Khusnun **Assistant Chairman: Mr. Abdelrahman Hamad Khalifa Owgi** **Technical Assistant: Mr. Shahrin bin Bahar**		
8.30 - 8.45 am	**V CES1-217**	**Voltage and Current Control in Autonomous DC Microgrid using Sliding Mode Control Technique** *Babangida Modu, Md Pauzi Abdullah, SanusiMufutau Adewolu, Abba Lawan Bukar*
8.45 - 9.00 am	**V CES3-151**	**A reality checks on the pvt-pcm technology diffusion: from the bibliometric analysis perspective** *M. H. Abdul Jabar, N. Abdul Manaf*
9.00 - 9.15 am	**V CES2-179**	**Development and evaluation of a novel non combustion gas turbine for offshore platform application** *M. Fadhli B. Muhammad, Maung Maung Myo Thant, Firmansyah, Khai Chuin Ong, Jundika C. Kurnia*
9.15 -9.30 am	**P CES4-234**	**High Conductivity Lithiated Electrode as an Electrode for Symmetrical Solid Oxide Fuel Cell** *W. N. A Wan Yusoff, N. A. Baharuddin, M.R. Somalu, N. P. Brandon, A. Muchtar, S.A. Muhammed Ali*

9.30 - 10.00 am	**PLENARY SPEAKER 5: Prof. Ir. Ts. Dr. Zainuddin Abdul Manan** **Title: Building Organisational Resilience Through Sustainable Energy Management** **Chairperson: Assoc. Prof. Dr. Shanti Faridah binti Salleh**	
10.00 - 10.15 am	TEA BREAK	
10.15 - 10.45 am	**PLENARY SPEAKER 8: Prof. Dr. Hossam Gaber** **Title: Resilient Energy Systems for Interconnected Infrastructures** **Chairperson: Assoc. Prof. Ir. Dr. Md Pauzi bin Abdullah**	
10.45 - 11.15 am	**PLENARY SPEAKER 8: Prof. Dr. Djoko Hartanto** **Title: Current and Future Perspectives of Indonesian Natural Zeolite** **Chairperson: Assoc. Prof. Ts. Dr. Dalila Mat Said**	
11.15 -11.45 am	**PLENARY SPEAKER 7: Prof. Dr. Yasuyuki Ikegami (Virtual)** **Title: Blue Innovation Using OTEC for SDGS – Towards to Stable Energy and Sustainable New Business** **Chairperson: Ts. Dr. Sathiabama T.Thirugnana**	
11.45 – 12.15 pm	**PLENARY SPEAKER 5: Assoc. Prof. Dr. Mehmet Suha Yazici (Virtual)** **Title: Hydrogen and Fuel Cell Research at Tubitak-Mam** **Chairperson: Prof. Dr. Mohamed Mahmoud Nasef**	
SESSION 4: P1 BREKOUT ROOM 1 12.15 – 1.00 pm		
Chairman: Prof. Dr. Aishah Abdul Jalil Assistant Chairman: Mr. Ebrahim Mohammed Ahmed Sharaf Aldeen Technical Assistant: Mr. Muhammad Bin Abdul Razak		
12-15 -12.30 pm	**P RETS5-159**	**Optimization of the subsequent (*trans*)esterification process of mahogany (*swietenia macrophylla*) seed lipid using supercritical carbon dioxide and methanol** *J.E. Cartel, J. Auresenia*
12.30 - 12.45 pm	**P RETS6-195**	**Nickel-promoted fibrous silica mesoporous ZSM-5 as a highly selective catalyst for dehydration of methanol to dimethyl ether** *Abdullah Alhebshi, Muhamed Yusuf Shahul Hamid, Aishah Abdul Jalil*
12.45 - 1.00 pm	**P RETS7-222**	**Evaluation Of a New Approach in Selecting Aerofoil-Vortex Generator for Applications in Renewable Energy** *M. A. Ahamat, N. F. Zulkefli, F. N. Saad*
1.00-1.15 p.m	**P RETS8-247**	**An Investigation into Integration of Renewable Energy resource for Electricity Generation for rural areas in Sarawak state Malaysia** *Yonis M Buswig, Shanti Faridah Salleh, Florianna Lendai Michael, Hazrul bin Mohamed Basri, Kasumawati bt. Lias, Hani Albalawi*
SESSION 4: P2 BREKOUT ROOM 2 12.15 – 1.00 pm		

Chairman: Ts. Dr. Mohd Fadhzir Ahmad Kamaroddin **Assistant Chairman: Ms. Shi Yan Liew** **Technical Assistant: Mr. Shahrin bin Bahar**		
12-15 -12.30 pm	**V FC1-182**	**Review of Pt and Pt-based catalyst in direct borohydride fuel cell applications** *Nik Farah Hanis Nik Zaiman, Norazuwana Shaari*
12.30 - 12.45 pm	**V FC2-183**	**A review on nafion membranes for direct borohydride fuel cell (DBFC)** *Nur Ain Masleeza Harun, Norazuwana Shaari*
12.45 - 1.00 pm	**P FC3-131**	**Hydrogen production via methane pyrolysis using Ni-Cu-Mn spinel catayst for hydrocarbon fuelled solid oxide fuel cell applications** *I. Aznam, A. Muchtar, M. R. Somalu, N. A. Baharuddin*
1.00 – 1.15 pm	**P ECT11-197**	**Mesoporous silica zirconia in calcined and uncalcined states for photodegradation of 2-chlorophenol** *N. S. Hassan, A. A. Jalil, N.F. Khusnun, A.A. Fauzi, F.F. Aziz, M.S. Azami*
1.15 – 1.30 pm	**P HE5-138**	**Insight towards development of ni-based catalysts for H_2 generation via C_2H_5OH-CO_2 reforming: a short review** *M. B. Bahari, C. R. Mamat, A. A. Jalil*
SESSION 4: P3 **BREKOUT ROOM 3** **12.15 -1.00 pm**		
Chairman: Dr. Syaza Izyanni Ahmad **Assistant Chairman: Nur Izzati Hannani Hazril** **Technical Assistant: Mr. Shahrin bin Bahar**		
12-15 -12.30 pm	**P CHT1-125**	**Efficacy of Ni-doped fibrous silica-titania (FST) and TiO_2 -KCC-1 on dry (CO_2) reforming of methane** *M. Alhassan, W. Nabgan, A.A Jalil, M.Y. S. Hamid*
12.30 - 12.45 pm	**P CHT2-168**	**Effect of titania loaded of fibrous silica catalyst for n-heptane isomerization** *M. A. A. Aziz, A. A. Jalil, N. S. Hassan, M. Y. S. Hamid, A. R. Herrynaldi, A. H. Hatta*
12.45 - 1.00 pm	**P CHT3-178**	**Recent advances of siliceous material-based nanocatalysts for CO_2 reforming of CH_4 to syngas** *Liew, S.Y., Jalil, A.A., Siang, T.J.*
1.00 – 1.15 pm	**P HE11-244**	**Evaluation of Commercialized Air Compressor for Hydrogen Compression** T.A.T. Abdullah, T. Chan

1.00- 2.00 pm	LUNCH	
SESSION 5: P1 BREAKOUT ROOM 1 2.00 - 5.00 pm		
Chairman: Dr. Nurfatehah Wahyuny Che Jusoh Assistant Chairman: Mrs. Nur Fatimah binti Azmi Technical Assistant: Mr. Muhammad Bin Abdul Razak		
2.00 - 2.15 pm	**P ECT12-218**	**Visible Light Photocatalytic Activity of TiO2 Influenced by V2O5 Nanocatalyst for Methylene Blue Degradation** *Lalitha Gnanasekaran, Saravanan Rajendran, Matias Soto-Moscoso*
2.15 - 2.30 pm	**P ECT13-219**	**Cobalt Oxide Incorporated on Nickel Oxide Surface for The Degradation of Methyl Orange Dye Under Visible Light Condition** *V.Sasikala, D. Shanmugapriya, Sethumathavan Vadivel, Saravanan Rajendran, Matias Soto-Moscoso*
2.30 - 2.45 pm	**P ECT4-187**	**Contemporary assessment of silver oxo-salts as photocatalyst for remediation of dye wastewater** *M. S. Azami, A. A. Jalil, N. M. Izzudin, N. S. Hassan, N. Jamaluddin, A. A. Azmi, C. R. Mamat*
2.45 - 3.00 pm	**P ECT14-223**	**Surface Modification of Copper Oxide Over Cobalt Oxide Useful for The Degradation of Methyl Orange Under Visible Light Condition** *D. Shanmugapriya, V.Sasikala, Sethumathavan Vadivel, Saravanan Rajendran*
3.00 - 3.15 pm	**P ECT15-225**	**Enhanced Electrochemical Performance of Zeolite/Polyethersulfone (Pes) Composite Separator for Lithium-Ion Batteries** *A. I. Rozafia, K. Roziqin, W. P. Utomo, Y.L. Ni'mah, D. Hartanto*
3.15 - 3.30 pm	**P ECT16-231**	**Catalytic Performance Evaluation on Combustion of Microalgae Arthrospira Platensis-Activated Carbon Mixture at Mass Ratio of 10:1** *Sukarni Sukarni, Mas Aldi Putra, Poppy Puspitasari, Avita Ayu Permanasari, Samsudin Anis, and Anwar Johari*
3.30 - 3.45 pm	**P ECT5-144**	**Fabrication of visible-light-mediated MFE@FST photocatalyst for efficient simultaneous photocatalytic remediation of pharmaceutical products** *N. M. Izzudin, A. A. Jalil, M. W. Ali, N. N. Ali, M. S. Azami, N. S. Hassan, F. F. Aziz, A. A. Fauzi*
3.45 - 4.00 pm	**P ECT6-161**	**Fibrous silica-FeOOH photocatalyst for simultaneous removal of hexavalent chromium ion and methyl orange under visible light irradiation** *N.I.H. Hazril, A.A. Jalil, N.S. Hassan, F.F.A. Aziz, A.A. Fauzi, N.F Khusnun, N.M. Izzudin*
4.00 - 4.15 pm	**P ECT8-193**	**Effect of pH on simultaneous photoredox of chromium (VI) and methylene blue using fibrous titania silica** *R. S. Mim, A. A. Jalil, F. F. A. Aziz, N. S. Hassan*

4.15 - 4.30 pm	**P ECT9-154**	**Vanadium oxide loaded on fibrous silica titania for enhanced photodegradation of ciprofloxacin** *M. H. Sawal, A. A. Jalil, N. S. Hassan, I. C. M. Fei, N. F. Khusnun, F. F. Aziz, A. A. Fauzi*
4.30 -4.45 pm	**P ECT1-194**	**Effect of pH on simultaneous photoredox of congo red and chromium (VI) over zinc oxide loaded fibrous silica-zirconia** *E. Sharaf Aldeen, A. A. Jalil, N. S. Hassan*
4.45 - 5.00 pm	**P ECT17-242**	**Synergistic Degradation of Rhodamine B and Reduction of Cr^{6+} Over Silver (Ii) Oxide/Fibrous SiO_2/ZrO_2 Photocatalyst** *M.W. Ali, A.A. Jalil, F.F.A. Aziz, N.S. Hassan, N.M. Izzudin[1]*
5.00 - 5.15 pm	**P EMSP1-141**	**Smart home appliance scheduling considering plug-in electric vehicles** *N. S. M. Saridi, S.M. Hussin, D.M. Said, N. Rosmin, A. Nawabjan*
5.15 – 5.30 pm	**P EMSP2-185**	**Analysis of the processing coating routes and characterization of chemical and structural properties of coated ceramic foam** *N. F. Hamzah, R. M. Kasmani, and S. Chandren*
SESSION 5: P2 BREAKOUT ROOM 2 2.00 - 5.00 pm		
Chairman: Dr. Saharudin Haron Assistant Chairman: Mrs. Anees Ameera Fauzi Technical Assistant: Mr. Mohd Hafis Ramli		
2.00 - 2.15 pm	**V MSS1-139**	**Simulation of an off-board dc fast charging station for electric vehicle battery** *Zarin Tasnim, Norzanah Rosmin, Dalila Mat Said, Siti Maherah Hussin, Md Pauzi Abdullah, Aede Hatib Musta'amal*
2.15 - 2.30 pm	**V MSS2-198**	**Enhanced Control of Storage Tank, Vaporizer, And Heater in Lng Regasification Process Using Multi-Loop Pi Controllers Based on Disturbance Model** *Abdul Wahid and Alifia Rahma*
2.30 - 2.45 pm	**V MSS3-069**	**Contributing Factors of Falling from Height Accidents in Construction Site** *A. Johari, N. Norazahar, M. M. Daud, W.N.W.Ariffin*
2.45 - 3.00 pm	**V MSS4-061**	**Fatigue Among Workers in The Construction Sector for Oil and Gas Industry Facilities** *A. Johari, N. Norazahar, M. M. Daud, M. M. Yusof*
3.00 - 3.15 pm	**V MSS5-202**	**Adsorptive Optimization of Antibiotics Over Co-ZIF-67-Derived Coxoy@C: A Chemometric Approach Using Taguchi Orthogonal Array Design** *Thuan Van Tran, A. A. Jalil, Dai-Viet N. Vo, Duyen Thi Cam Nguyen*

3.15 - 3.30 pm	**V MSS6-201**	**Magnetic porous carbon nanocomposites derived from Opuntia stricta cactus for the removal of toxic dyes: Optimization of synthesis conditions using response surface methodology** *Duyen Thi Cam Nguyen, A. A. Jalil, Dai-Viet N. Vo, Thuan Van Tran*
3.30 - 3.45 pm	**V MSS7-214**	**Numerical Analysis and Comparison of PTAA And PEDOT: PSS Emitter for Sige Solar Photovoltaic** *Syafiqa Nasir, Bablu Kumar Ghosh, Chee Fuei Pien*
3.45 - 4.00 pm	**V MSS8-216**	**Thermodynamic Phase Equilibrium Composition Determination of Ethanol Steam Reforming by Direct Minimization of Gibbs Free Energy Using Peng-Robinson Property Method** *Abdullahi Nwaha Isah, Elizabeth Jumoke Eterigho, Moses Aderemi Olutoye, Mohammed Umar Garba, Umi Aisah Asli*
4.00 - 4.15 pm	**P MSS9-240**	**Optimization Study of Sapo-34/Pebax-1657 Mixed Matrix Membrane for Ethylene Recovery** *Nadia Hartini Suhaimi, Syafeeqa Syaza Rashidi, Norwahyu Jusoh, Umi Fazara Md Ali, Amir Syafiq Syamin Syah Amir Hamzah, and Syamsul Bahari Abdullah*
4.15 - 4.30 pm	**P MSS10-246**	**Hydrogen-enriched syngas production from gasification of oil palm biomass: Process simulation and optimization using Aspen Plus** *Nur Izzah Nabilah Haris, Shanti Faridah Salleh, Nurliyana Abdul Raof, Mohd Hafizz Wondi, Muhammad Syukri Imran Abdullah*
4.30 -4.45 pm	**P OTES5-192**	**Development of Advanced Hybrid Ocean Thermal Energy Conversion (OTEC) Intake Piping Filtrations System: First Experimental OTEC Plant of Malaysia** *Shamsul Sarip and Khairi Abu Husain*
4.45 - 5.00 pm	**P OTES6-212**	**Preliminary Study of Biofouling Growth and Adhesion Profile at Various Temperature Setup– A Case Study for Ocean Thermal Energy Conversion (Otec) Facility** *M. Z. Zainal Abidin, F. N. Mohd Amri, F. Hamzah, M. N. Mohd Rodhi, S. Sarip*
5.00 - 5.15 pm	**P OTES7-228**	**Assessment of potential sites for Ocean Thermal Energy Conversion (OTEC) in Sabah, Malaysia** *Ahmad Aleef Amirul Anuwa, Poh Heng Kok, Mohd Fadzil Akhir*
5.15-5.30 pm	**P OTES3-127**	**Evaluation of major components in closed cycle otec system: a review** *Hariharan Jai Karthikeyan, Sathiabama T. Thirugnana, Shreeshivadasan Chelliapan, Takeshi Yasunaga, Yasuyuki Ikegami*
SESSION 5: P3 BREAKOUT ROOM 3 2.00 - 5.00 pm		

Chairman: Assoc. Prof. Ts. Dr. Norzanah Rosmin Assistant Chairman: Mr. Abdul Hakim Hatta Technical Assistant: Mr. Shahrin bin Bahar		
2.00 - 2.15 pm	**V PV1-147**	**Impact of pv in distribution system using time-varying load data** *H. F. Jamahori, M. P. Abdullah, A. Ali*
2.15 - 2.30 pm	**V PV5-227**	**A Deterministic Approach to Maximize Accommodation of Plug - In Electric Vehicles and Improve Distribution Network Performance** *Z.A. Memon, D.M. Said, M.Y. Hassan, N. Ahmad, N.Rosmin, S.Aisyah*
2.30 - 2.45 pm	**V WTE1-204**	**A Review of Darrieus Hydrokinetic Turbine Performance Enhancement Strategies** *A. W. Mahmashani, G. Nugroho, R. Hantoro*
2.45 - 3.00 pm	**V WTE6-226**	**Symmetrical Fault Assessment of Grid Integrated Doubly Fed Induction Generator Using Modified Super-twisting Fractional Order Terminal Sliding Mode Controller** *Mansoor Soomro, Zubair Memon, Wazir Mustafa, Dalila Mat Said, Mazhar Hussain*
3.00 - 3.15 pm	**V WE2-203**	**Functionalization of Palm Waste Using Ionic Liquid for The Recovery of Gold: Fixed-Bed Column Study** *M.L. Firmansyah, I. Amalina1, I.N. Rizki*
3.15 - 3.30 pm	**K WTE2-020**	**Prediction of Solar Irradiation and Wind Speed in the Philippines using Artificial Neural Network** *Victor Sherwin G. Galamgam*
3.30 - 3.45 pm	**P WE1-200**	**Production of Green Diesel Via Hydrogen-Free and Solventless Deoxygenation Reaction of Waste Cooking Oil** *Darfizzi Derawi, Noor Azira Abdul Razak*
3.45 - 4.00 pm	**P WTE3-206**	**Study On Low-Speed Wind Energy Potential and Energy Yield Analysis for Highway Application in Malaysia** *M. A. Elias, N. Muda, N. S. Suhaimi*
4.00 - 4.15 pm	**P WTE4-117**	**Critical Factors Influencing the Implementation of Wind Turbine at the Existing Building Site** *Nur Izieadiana Abidin, Eeydzah Aminudin, Faridahanim Ahmad*
4.15 - 4.30 pm	**P WTE5-175**	**Optimization of Savonius turbine for low-velocity water streams using CFD-Taguchi approach** *Mohammed Baqer Zaki Yahya Al-quraishi, Shamsul Sarip, Mohamad Fairul Izzat*
4.30 -4.45 pm	**P EEC1-174**	**The effect of initial moisture content on drying stingless bees honey by low-temperature vacuum drying with induced nucleation boiling method** *N. F. Halim, M. F. Basrawi, A.S. Ramli, A.N. Oumer, and N.A. Azman*
4.45 - 5.00 pm	**P STE1-112**	**Evaluation of Contemporary Renewable Energy Schemes in Malaysia and its Relevancy for Photovoltaic Thermal Roof Tile Application** *Dini Kemala, J. NorRuwaida, N. A. Manaf*
5.00-5.15 pm	**P MSS11-118**	**Optimization Of Cold Flow Properties Of Diesel Blended Biodiesel** *Shivaneswar Gunasekarana, Saharudin Haron*
5.30 – 6.00 pm	CLOSING CEREMONY / TEA BREAK	

LIST OF ATTENDEE

TENAGA NASIONAL BERHAD

Mr. Joel Praveen Makenthiran
Mr. Mohamad Hakim Zainuddin
Mr. Aizuddin Mohd Sopian
Mr. Arif Hazwan Ab Wahab
Ms. Marlia Adilah Mohammad
Mr. Mohd Azlan Uda Kanardin
Mr. Muhamad Zulkifli Meah
Mr. Suhaimi Mahdar

CRAUN RESEARCH SDN BHD
Mr. Daniel Chua

ENVIRONMENT
Mr. Ong Tek Ming

UNIVERSITI TEKNOLOGI MALAYSIA
Ms. Hani Maisurah Binti Muhamad Zulkifli
Dr. Vekes Balasundram

INTERTEK
Gennive Soo
Tan Yew Hui

UNIMAS
Dr. Florianna Lendai Anak Michael Mulok
Assoc. Prof. Dr. Shanti Faridah binti Salleh

BINTULU PORT HOLDINGS BERHAD
Mr. Abdani Bin Abdul Gafor
Mr. Mohammed Emir Syazwan Bin Mohammad Medan
Mr. Jazman Bin Shabli
Ms. Nabilah Binti Abdul Salam
Ms. Lennywati Binti Bujang
Ms. Nor Mardhiah Binti Jumaludin

ITS Testing Services (M) Sdn. Bhd
Mr. Clarence Jamelus

EXTENDED ABSTRACT

RETS1-119

A REVIEW OF RECENT DEVELOPMENTS IN WELLS TURBINE OPTIMIZATION

Nurudin A.S[1,2], *Shamsul S.*[1*] *and Hazilah M.K*[1]

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Extended Abstract

Wells turbine is the most common turbine been used in the oscillating water column (OWC) system rather than impulse or Savonious turbine. As this turbine become popular, there is a lot of optimizations done and proposed starting from the born of this turbine until now. This article focuses on the recent five-year duration of the Wells turbine optimization. The comparison shows that most of the development focuses on the blade shape, profile, and modification. This paper intends to provide a brief review of the recent development of the Wells turbine optimization. An oscillating water column (OWC) system is a method of capturing wave energy by having an air turbine that rotates due to the expansion and compression of the ocean wave. This operation cycle can be seen in Figure 1. The most common air turbine, the Wells turbine was created by Arthur Alan Wells in 1976 is still being used today. In recent years many researchers focus on a different approach to getting the optimum and best blade profile to be used in the Wells turbine. Thus, this paper summarization can be used in selecting an optimized parameter to obtain the best performance for the OWC system with the Wells turbine.

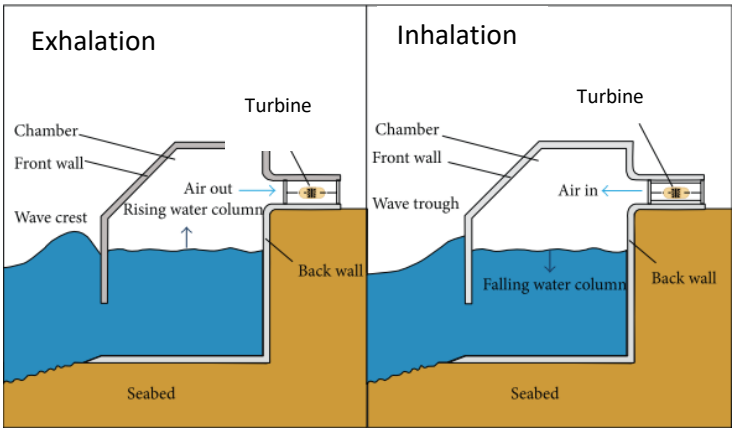

Fig. 1: Typical schematic of an OWC wave energy converter [1]

Table 1 shows the optimization of the Wells turbine done by several researchers. Abbasi et al. [2] optimized the Wells turbine by adding riblet to the blades. The analysis was done in Star-CCM+ CFD simulation showing that the riblet will increase the torque and the efficiency of the turbine. The separation will be reduced as well as delayed. As for optimizing the Well turbine by adjusting the edge to become radiused, Kumar et al. [3] show that this modification can increase the operating range of the turbine. The peak torques were increased significantly. Other than that, the radiused edge blade also will enhance the stall condition of the turbine. This outcome was based on the simulation done in Ansys CFX. Alves et al. [4] run an experimental work for mid-plane guide vanes for biplane Wells turbine. They conclude that mid-plane guide vane for biplane Wells turbine will increase the efficiency of the turbine system. K. Geng et al. [5] introduce a stall cylinder to be placed at the end of the Trailing edge of the Wells turbine blade. Using Ansys CFX as the CFD software, they found that the existence of the stall cylinder at the optimal location will improve the operating range and the torque.

Table 1. Wells turbine Optimization used by the researchers

Year [Ref]	Optimization	Output	Type
2022 [2]	Riblets covered blades	Delay and reduction in separation, Increase 18.4% of torque, Increase 16.8% of efficiency	C
2021 [3]	Radiused Edge Blade Tip	Increase operation range of 25% Peak torque increases up to 37% Stall margin enhanced up to 25%	C
2021 [4]	Mid-plane guide-vanes	Peak efficiency increases up to 7%	E
2021 [5]	Stalling cylinder	Increase operation range of 19% Peak torque increases up to 27%	C

Type: C-Computational fluid dynamics (CFD)/ simulation, E – Experimental

In a conclusion, there is still much room for improvement that can be done to optimize the Wells turbine for the OWC system. Many suggestions were given by the researcher to increase the efficiency, torque and improve the stall conditions. But it can be seen that most of the researchers are focusing on the improvement of the blade profile to the Wells turbine.

Keywords: Wells turbine; oscillating water column (OWC); optimization

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RETS2-143

INTERNET OF THINGS SYSTEM THROUGH MESSAGE QUEUE TELEMETRY TRACKING PROTOCOL FOR MODERNIZING RED CHILI AGRICULTURE

Nik Mohd Syahirruddin bin Jusoh[3], Dalila Mat Said[1,2], *Nasarudin Ahmad*[2], *Md Pauzi Abdullah*[1], *Norzanah Rosmin*[1,2], *Siti Maherah Hussin*[1,2], *Siti Aisyah Abd Wahid*[1]

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Extended Abstract

In recent years, the country has continued to increase its food imports, especially red chilies. The majority of Malaysians spend most of their income on food. Meanwhile, domestic food production for certain foods continues to decline. The result of this is that the country will have low-income ability and will need to continue importing food from abroad. According to a study in 2018, the Malaysian population's import dependence (IDR) for red chili is 73.1%. Although specific plans have been put in place through the National Agricultural Policy, food imports are still on the rise. With the advent of 4.0 industrial revolution, the country's agricultural sector needs to follow this revolution in order to maximize production and meet the demands of Malaysia's society. Farms in remote areas that lack facilities, especially electrical power, find it difficult to operate in accordance with the current development era. In order to equip plantations with modern equipment that requires electricity to work, renewable energy, namely solar energy, must be used as a primary energy source. In this study, smart farming method is proposed to study the root growth rate according to soil factors namely pH and moisture. Data from pH sensors and moisture sensors will be transmitted via MQTT to the cloud. Raspberry Pi will analyze the data, and the system will determine whether irrigation and fertilization should be applied to increase root growth. It will continuously monitor the environment crops, including the sources of electricity supply, which will include photovoltaic (PV) systems. Two (2) zones have been set up at the planting site in order to facilitate monitoring and control operations. As a result of the study conducted, the system will ensure that the soil pH rate is suitable for chili cultivation, which is between 5.5 and 6.5, and the soil moisture is between 55% to 70%. If that value is not reached, the system will automatically turn on the pump. A manual control mode is also available for user convenience. Users can also view the system using web access or Android applications.

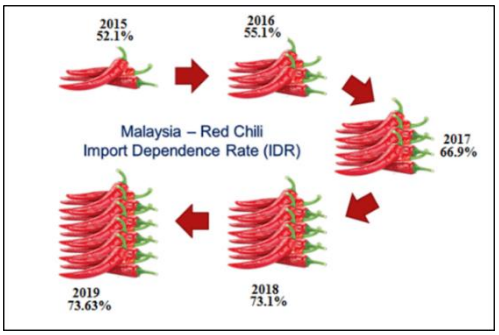

Fig. 1: Red chili – Malaysian Import Dependence Rate (IDR)

Table 1. MQTT test data range

10	100%	100%
20	100%	100%
50	100%	100%
100	100%	100%
500	100%	100%
1000	100%	100%
5000	100%	100%
10000	100%	100%

Keywords: IoT; MQTT; Raspberry Pi; soil moisture; soil pH.

Acknowledgement

The authors would like to express the appreciation to the Ministry of Higher Education Malaysia (MOHE), the support of the sponsors [Vot Number = Q.J130000.3551.07G53] and also to the Universiti Teknologi Malaysia (UTM) for providing the best education and research facilities to achieve the aims and goals in research studies and works.

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RETS3-122

Effect of the Types of Alcohol Used in the Synthesis of Bio-Polyol from Palm Oleic Acid

Intan Suhada Azmi[*1], Nurul Intan Syafinaz Mohd Zalman[2], Muhammad Raihan Mustafha[3], Muhammad Danish Haqeem Norazlan[4], Nuraisyah Mahdir[5], Mohd Jumain Jalil[6] and Abdul Hadi[7]*

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[6,7]School of Chemical Engineering, College of Engineering, Universiti Teknologi MARA, Cawangan Pulau Pinang, Kampus Permatang Pauh, 13500 Permatang Pauh, Pulau Pinang.

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Abstract. In recent years, many efforts have been made to epoxidize palm oil in response to rising demand for environmentally safe epoxides that generated from vegetable oils. Polyols are polymers that contain hydroxyl groups in their structure. They have a relevant commercial value as building blocks, intermediates in organic synthesis, or precursors for production of polyurethanes. The most common method used for synthesis of polyol is via epoxidation and hydroxylation method. Beginning with the palm oleic acid, the double bonds are functionalized by the introduction of epoxy groups and ring-opened to form hydroxyl groups. The aim of this research is to investigate the type of alcohol used during hydroxylation process which are methanol and butanol. The epoxidation and ring-opening process was elucidated by relative conversion to oxirane (RCO) and FTIR analysis. After 1 hours of reaction time, methanol was found to have a low RCO value and a more widened peak for hydroxyl (OH) functional groups in the FTIR spectrum compared to butanol. As a result, methanol is more preferred for polyol production.

RETS4-157

Photocatalytic active metal-organic framework and its derivatives for solar-driven environmental remediation and renewable energy

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Extended Abstract

Research on metal-organic frameworks (MOFs) has been extensively utilized in various photocatalytic applications due to the synergism of properties like high crystallinities, controllable dimensions, and tuneable textural properties [1,2]. Recently, many studies have improved the light absorption capacity of MOFs and promoted photogenerated charge separation by the modification of MOFs and their derived photocatalytic materials [3,4]. Thus, the alterations have influenced their optical and electronic properties, enhancing the performance of photocatalysts for a sustainable solar-driven environment and renewable energy applications [5,6]. Despite some advancements in this field, a deep understanding of PA-MOF remains to be explored in attempt to comprehend the correlation between the morphologies, properties, and photocatalytic performance. To bridge the gap, this review comprehensively addresses the current discoveries in multiple synthesis methods, surface functionalization and grafting, elemental doping, ligand modification, and heterojunction interfacial construction techniques for improving both the physical and catalytic features of the PA-MOF structures. The state-of-the-art progress in the applications of PA-MOFs in photocatalytic water splitting for H_2 production, photocatalytic CO_2 reduction, and photodegradation of emerging hazardous pollutants is comprehensively discussed **(Fig. 1)**. Thus, the future directions of PA-MOFs were discussed in order to make them more useful for environmentally and energy-related applications.

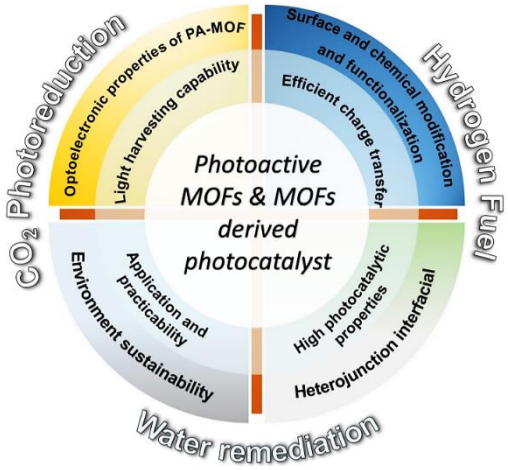

Fig. 1: Summary of PA-MOFs and MOFs derived photocatalyst.

Keywords: Photoactive metal-organic framework; modified strategy; photocatalyst; photocatalytic activity

Acknowledgement

The authors would like to acknowledge Universiti Kebangsaan Malaysia (UKM) for their financial support under the Dana Impak Perdana research grant (DIP-2020-011). The authors would also like to acknowledge the Centre for Research and Instrumentation (CRIM), UKM for providing technical and management support.

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RETS5-159

OPTIMIZATION OF THE SUBSEQUENT (*TRANS*)ESTERIFICATION PROCESS OF MAHOGANY (*SWIETENIA MACROPHYLLA*) SEED LIPID USING SUPERCRITICAL CARBON DIOXIDE AND METHANOL

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Abstract

Subsequent (*trans*)esterification (STE) technique is a subsequent process of uncatalyzed *in-situ* (*trans*) esterification followed by a catalyzed (*trans*)esterification process to convert the seed lipid into fatty acid methyl esters (FAME). Cheap, indigenous, and non-edible Mahogany (*Swietenia macrophylla*) seed was considered in this study in response to issues of feedstock sustainability and economic viability in biodiesel production. This technique was enforced with supercritical carbon dioxide, methanol, and a catalyst to produce fatty acid methyl ester. This study investigated the effect of temperature, pressure, and carbon dioxide flowrate on the type of catalysts which are activated multi-walled carbon nanotubes namely, MWCNT-H, MWCNT-OH, and the MWCNT-H + MWCNT-OH. The design of experiment and optimization analysis were done using Taguchi method. During the investigation, it was found that the reaction temperature has the least contribution on the FAME yield. The maximum biodiesel yield was obtained when parameters are set at 90°C, 30 MPa, and 15 ml/min CO_2 flowrate using MWCNT-H. The investigation has provided low-cost feedstock and simpler STE technique to produce biodiesel.

Keywords: Taguchi, *Swietenia macrophylla, in-situ* (*trans*)esterification, supercritical carbon dioxide

INTRODUCTION

Arising issues need to be addressed with regards to some promising technology in biodiesel production. Most of the direct (*trans*)esterification studies have been subjecting their systems at supercritical conditions or by using large catalyst dosages which translates to the severity of chemicals usage, post-reaction processing and heating requirements, despite promising product results (Park *et al.*, 2015; Saifuddin *et al.*, 2015; Tabatabaei *et al.*, 2015). At supercritical operating conditions, comparative results can still be obtained without using an additional catalyst, but there is still lack of study for this technology (Chen *et al.*, 2015; Go *et al.*, 2016; Park *et al.*, 2015; Raskar *et al.*, 2017; Rubi *et al.*, 2019; Saifuddin *et al.*, 2015; Stephen and Periyasamy, 2018; Tabatabaei *et al.*, 2015).

This study aims to utilize Taguchi analysis in identifying optimum conditions in the subsequent process of uncatalyzed *in-situ* followed by a catalyzed (*trans*) esterification of Mahogany (*Swietenia macrophylla*) seed oil (MSO) under supercritical conditions for biodiesel production using two reactors in-series

METHODOLOGY

The experiments were performed using the subsequent (*trans*)esterification (STE) technique. Independent parameters such as the type of catalyst, temperature, pressure, and CO_2 flowrate, all at three-levels were considered. Parameters were kept varying using the L9 Taguchi approach to achieve the optimum MSO biodiesel yield (%). The design of experiments (DOE) is shown in Table 1, columns 1 to 5. The experimental set-up used is illustrated in Figure 1.

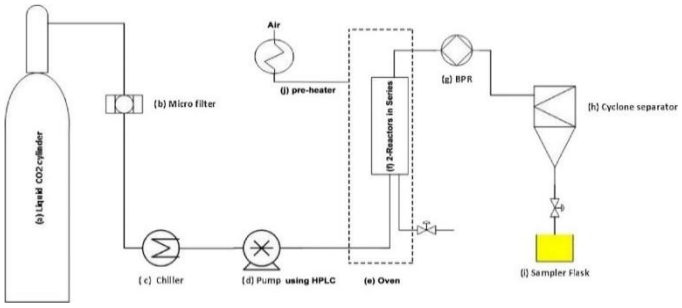


Fig. 1: Schematic diagram of the subsequent (*trans*)esterification (STE) process using supercritical carbon dioxide, alcohol, and a catalyst.

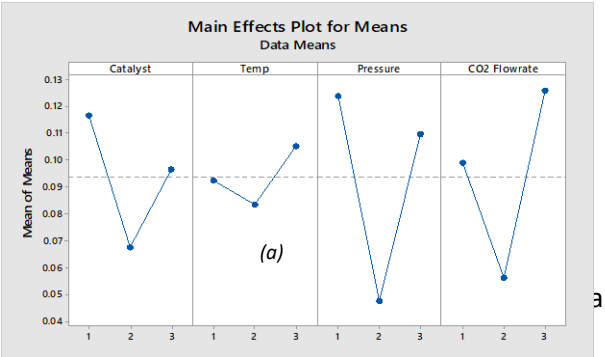
RESULTS AND DISCUSSIONS

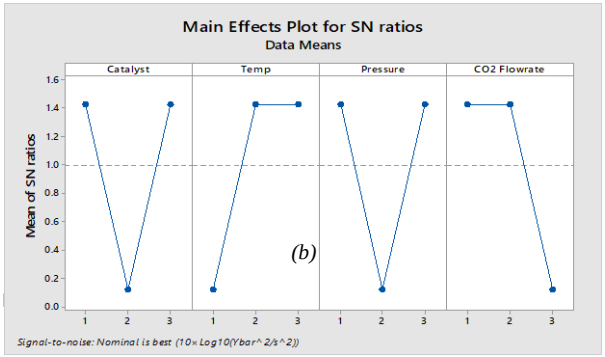
Table 1. The observation table using the L_9 Taguchi approach.

Run Order	Type of Catalyst	Temperature (°C)	Pressure (MPa)	CO_2 Flowrate (ml/min)	FAME Yield (%)
	(A:A)	(B:B)	(C:C)	(D)	(R1)
1	MWCNT-H+ MWCNT-OH	80	30	8	24.09
2	MWCNT-OH	85	30	2	3.68
3	**MWCNT-H**	**90**	**30**	**15**	**28.19**
4	MWCNT-H+ MWCNT-OH	85	20	15	10.22
5	MWCNT-OH	90	20	8	12.55
6	MWCNT-H	85	25	8	11.52
7	MWCNT-H+ MWCNT-OH	90	25	2	11.86
8	MWCNT-OH	80	25	15	23.78
9	MWCNT-H	80	20	2	10.80

Note: $$FAME\,Yield\,(\%) = \frac{Wt\ of\ crude\ biodiesel\ \ (g)\ \times\ FAME\ concentration}{Wt.\ of\ dry\ \ biomass\ \ (g)}$$

The maximum biodiesel yield was obtained when parameters are set at 90°C, 30 MPa, and 15 ml/min CO_2 flowrate using MWCNT-H (Table 1).





The main effect plots were shown for each influencing parameter (Fig. 2). Using the integrated L9 Taguchi approach, it was observed that (a) with the change of catalyst type, and reaction temperature, pressure and the CO_2 flowrate, the MSO biodiesel yield (%) was initially decreased and then increased considering the main effects for means (Fig. 2a). On the other hand, change in the type of catalyst, and increase in the pressure decreased the MSO biodiesel yield (%) and then increased it back to the same level (Fig. 2b), considering the main effects for signal-to-noise ratios. In addition, increase of MSO biodiesel yield (%) was observed when temperature was increased, but no further effect was observed as these were increased one-level higher (Fig. 2b).

CONCLUSION

The maximum biodiesel yield was obtained when parameters are set at 90°C, 30 MPa, and 15 ml/min CO_2 flowrate using MWCNT-H. In reference to the main effects plot for means, it is therefore concluded that MWCNT-H is the best type of catalyst to use since saponification is eliminated. Reaction temperature and CO_2 flowrate will give a relative increase in biodiesel yield when their levels are increased by two levels since these are vital in the simultaneous (*trans*)esterification and diffusion process.

Acknowledgment

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RETS6-195

NICKEL-PROMOTED FIBROUS SILICA MESOPOROUS ZSM-5 AS A HIGHLY SELECTIVE CATALYST FOR DEHYDRATION OF METHANOL TO DIMETHYL ETHER

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Extended Abstract

Nowadays, Dimethyl ether (DME) is primarily used as an aerosol propellant in olefin or liquid fuel synthesis. DME has gained increased attention as a sustainable alternative fuel for diesel engines over the last decade due to its high cetane number (>55) and significant reduction of NO_x, SO_x, and particulate matter emissions in exhaust gases. It is reported that 65% of global DME production is mixed with liquefied petroleum gas (LPG) [1]. DME/LPG blends are of significant interest in combustion because they emit 30–80% less CO_2 and 5–15% less NO_x. Zeolites such as ZSM-5, beta, mordenite, and ferrierite have been extensively employed to improve methanol conversion and DME selectivity. Additionally, zeolites enable precise control of the catalyst's properties (acidity, specific surface area, crystal size and shape selectivity). Despite these advantages, reactions at (260–300°C) shifted selectivity away from favorable reactions and forming coke [2]. Acid adjustment is the most significant impacting factor for product distribution and selectivity [3]. Numerous longitudinal studies employing KCC-1 have documented its exceptional performance in solid acid-catalyzed processes such as isomerization [4], carbon dioxide methanation [5], and methane carbon dioxide reforming [6]. Using a microemulsion method followed by nickel (5wt.%) wet impregnation, a novel nickel-promoted fibrous silica mesoporous ZSM-5 (Ni/FSZSM5) catalyst with a unique core-shell morphology was successfully synthesized for methanol to dimethyl ether (MTD) reaction. The catalysts were characterized using XRD, nitrogen physisorption and 2,6-dimethylpyridine adsorbed Fourier-transform infrared spectroscopy (FTIR). Catalytic performance of the as-synthesized catalyst was examined using a micro catalytic pulse fixed bed reactor at reaction temperatures ranging from 200-400°C and compared with the FSZSM5 and KCC-1. Based on the nitrogen physisorption result, a decrease in surface area by 15% was observed compared with pristine FSZSM5, while inherent mesopores at 4-40 nm. A significant reduction of Bronsted acid sites in Ni/FSZSM5 was observed by pyridine FTIR results as compared to pristine FSZSM5 catalysts. This phenomenon is expected to reduce the side reaction while increasing hydrocarbon selectivity. As shown in Fig. 1, among all the investigated catalysts FSZSM5 catalyst promoted with 5 wt.% Ni exhibited the highest selectivity towards DME with a complete 100% methanol conversion coupled with an incredibly enhanced DME yield of 98% at 350°C, fivefold higher than that of FSZSM5 catalyst. Remarkably, at 400°C Ni/FSZSM-5 exhibited 100% selectivity towards DME, nearly eightfold higher than that of FSZSM5 catalyst. On the other hand, KCC-1 catalyst also showed promising DME selectivity, however at lower conversion of methanol owing to low acidity of pure silica material. The correlation between acidity and the enhanced performance have been reported by many researchers and thus cannot be ruled out [7-9]. It is hypothesized that a reduction in the number of strong Bronsted acid sites could lead to higher catalytic activity, as hydrocarbon production and catalyst deactivation by coke will be more likely to be facilitated on strong Bronsted acid sites. The present findings are in agreement with this claim as the superior performance of Ni modified FSZSM5 catalyst was greatly enhanced as a result of partial substitution of Ni in FSZSM5

resulting in the prevention of coke and/or hydrocarbon formation. Finally, the present study confirms the superiority of the as-synthesized catalyst and contributes additional evidence for the influence of metal addition. Moreover, it is expected to stimulate future research to investigate the true potential of tuning the properties of solid acid catalysts for sustainable and selective DME production.

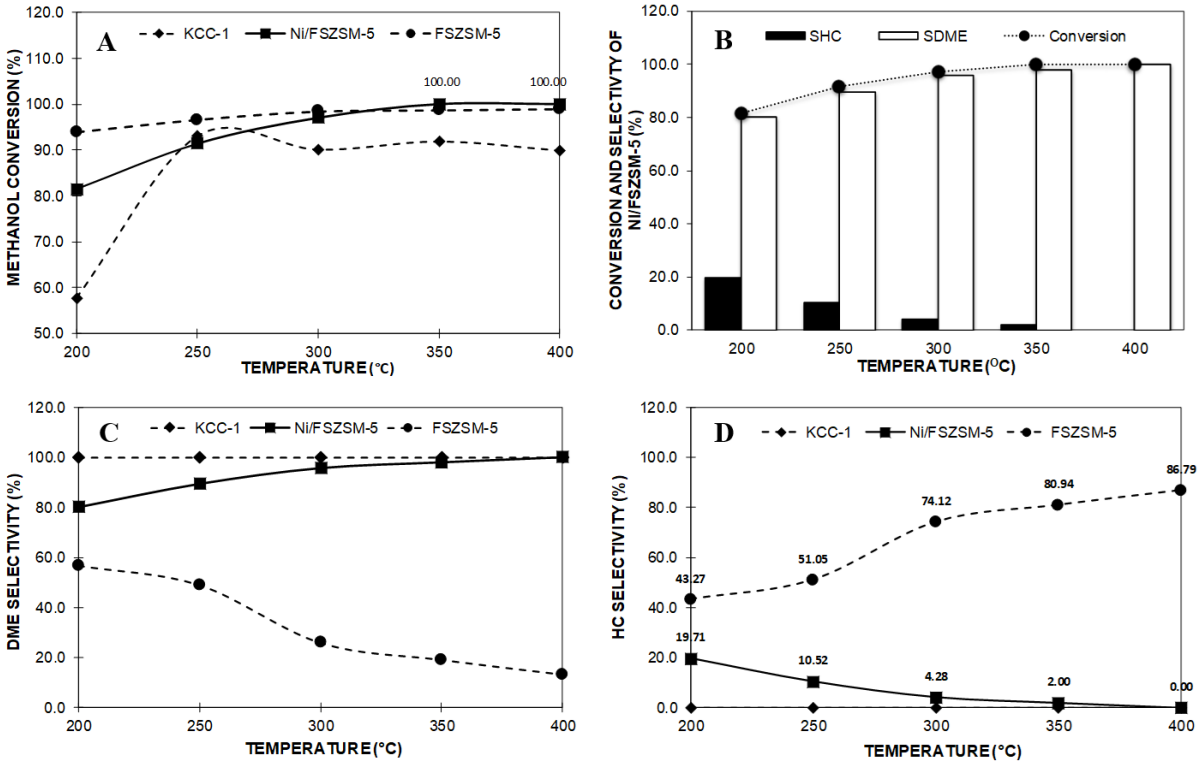

Fig. 1: (A) Methanol conversion, (B) overall performance of Ni/FSZSM5, (C) DME selectivity, (D) HC selectivity.

Keywords: Methanol conversion; Dimethyl ether; Methanol dehydration; ZSM-5 zeolite; fibrous zeolite; Nickel supported

Acknowledgement

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RETS7-222

EVALUATION OF A NEW APPROACH IN SELECTING AEROFOIL-VORTEX GENERATOR FOR APPLICATIONS IN RENEWABLE ENERGY

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Extended Abstract

Aerofoil is widely used in the wind power generation to capture energy from moving fluid. Vortex generators are usually attached to the upper surface of aerofoil to increase the lift coefficients. The addition of vortex generators also increases the drag coefficients. Thus, the objective of this paper is to evaluate three approaches that could be adopted in selecting the most appropriate aerofoil-vortex generators for wind power generation. The three approaches used differences in lift coefficients, drag coefficient and lift to drag ratio between aerofoil with vortex generators and aerofoil without vortex generators. The merit of each airfoil-vortex generator was evaluated at a chosen range of angles of attack. Several hypothetical lift and drag coefficients curves were used to evaluate the outcomes of these approaches. The shaded area in Fig. 1 represents additional cumulative lift coefficient for aerofoil with vortex generators, compared to the airfoil with no vortex generators. The range of angles of attack was selected according to common operating conditions for wind power generation system. The results show that the selected approach, the chosen range of angles of attack, and the shape of lift and drag coefficient curves influence the recommendation of the most appropriate aerofoil-vortex generator. These findings will contribute to a better approach in selecting the aerofoil-vortex generators for wind power generation. Future works include validation of these findings by conducting wind tunnel and field tests.

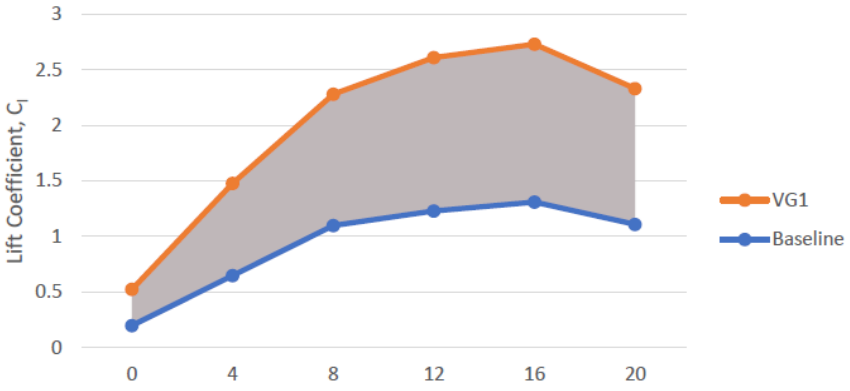

Fig. 1: A hypothetical lift curves to demonstrate the area between airfoil with no vortex generator (baseline) and aerofoil with vortex generator (VG1

Keywords: Wind energy, aerofoil, vortex generators, lift, drag.

Acknowledgement

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RETS8-247

An Investigation into Integration of Renewable Energy resource for Electricity Generation for rural areas in Sarawak state Malaysia

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The challenges in the extension of conventional grid electricity to remote locations elicit increased application of renewable energy (RE) sources in such locations. As for the locations that are within proximity to rivers or streams, it can be observed that micro-hydro hybrid RE systems (HRES) are employed. Similarly, hybrid photovoltaic (PV)/Micro-hydro generator/battery configurations exist. This study used a software known as Hybrid Optimization of Multiple Energy Resources (HOMER) to simulate and obtain the optimal size and configuration of a hybrid PV/Micro-hydro/Battery storage system for rural areas in Sarawak state in the east of Malaysia. The techno-economic comparison of the hybrid system is done with different combinations and configurations of renewable energy resources (PV/Micro-hydro/Battery storage) and a standalone diesel generator (DG) system. The levelized cost of energy (LCOE) and the total net present cost (NPC) are the primary indices used for comparison purposes. The optimal configuration from simulations has 89.9 kWp of PV, two 3.5 kW Micro-hydro generators and 132 kWh of battery storage. The economic results obtained indicated that the LCOE of 1.21 RM/kWh and NPC of RM 1,431,000 for the PV-Microhydro-battery configuration outperformed PV-battery and standalone DG systems by 165 % and 27 % respectively. This optimal configuration is found to be more environmentally friendly, and it highlights the role of Micro-hydro generators in reducing battery usage and wear. In addition, it also contributes to achieving lower LCOE and NPC values.

CLEAN ENERGY SYSTEM (CES)

CES1-217

Voltage and Current Control in Autonomous DC Microgrid using Sliding Mode Control Technique

Babangida Modu, Md Pauzi Abdullah, SanusiMufutau Adewolu, Abba Lawan Bukar

Abstract

The rapid adoption of renewable energy technology has made the microgrid concept to be widely accepted in modern power systems. Renewable energy resources in DC microgrids operate intermittently which affects the power supply and the load. Moreover, this has made the bus voltage control to become very difficult. Linear controllers, such as PI and PID, are mature and widely used for controlling the microgrid bus voltage, nonetheless, their performance is not optimal when system parameters change. This paper proposed a strategy for controlling the DC bus voltage using a sliding mode controller. The devised strategy is tested on a DC microgrid incorporating a PV system, Battery storage system, and load. The effectiveness of the proposed methodology has been verified in a Matlab/Simulink environment.

CES2-179

DEVELOPMENT AND EVALUATION OF A NOVEL NON COMBUSTION GAS TURBINE FOR OFFSHORE PLATFORM APPLICATION

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Extended Abstract

Electricity is a critical element in offshore facilities globally. For low power application below 1 MW, platform operators rely on solar panel, Thermoelectric Generator (TEG), Mini Turbine Generator (MTG) and in certain instance, Diesel Generator (DEG), to provide power to the facility. Adoption of automation technology has made energy availability more critical as the facility requires more energy to power additional equipment and sensor. A reliable and cost-effective power generator is required to deliver 1 kW of power as most offshore platforms currently generate electrical power for their own utilization without any power supply from onshore facility [1]. Solar panel and TEG which are currently used as the primary choice at remote platforms to supply the electrical power demand are found to be uneconomical due to their large footprint and relatively high cost. Solar panel for instance will require large battery back-up for about 7 to 21 days [2] as typical peak sunshine hours ranging from 3 to 8 hours in tropical region [3]. Thus, significant effort has been devoted to explore new technologies that offer electricity at relatively low cost and small footprint. One of the candidates is micro gas turbine. Here, a novel impulse gas turbine generator has been designed to work based on the pressure differential between two gas line passes through offshore platform. The basic principle is simple where internal energy of the gas is extracted when the high pressure is reduced through isentropic expansion which rotate an expander turbine that is couple with a generator [4].

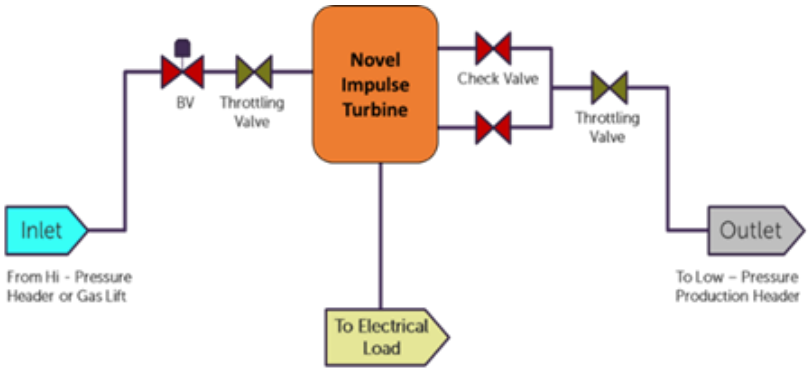

Fig. 1: Process Flow Scheme of a Novel Impulse Turbine Installed in an Offshore Facility

A series of steps of design and fabrication is undertaken to develop the impulse turbine. In a typical high-speed turboexpander application, there are many aspects that act as the main enablers of the

technology [5] which affect the overall performance of the impulse turbine. Critical components of the turbine that will impact power generation performance of the impulse turbine is identified. To achieve efficient high-speed generator in a novel compact impulse turbine generator system, the dynamic of the turboexpander-based turbine needs to be studied [6]. Upon fabrication, the impulse gas turbine generator is then tested with methane-rich gas by utilizing a gas flow loop system. The purpose of the test is to obtain performance data and later to validate CFD model prior deployment at offshore facility [7].

Table 1. Impulse Gas Turbine Expected Performance Based on Flow Loop Test Parameters

Pressure In (bar)	Pressure Out (bar)	Flowrate (MMscfd)	Speed (rpm)	Power (W)
35	35	0.8	0	0
35	20	0.8	2,247	315
35	15	0.8	4,290	583
35	10	0.8	6,143	734
35	20	1.2	3,114	423
35	15	1.2	6,008	700
35	10	1.2	9,136	1,035

Based on the observation made from the test result, the turbine manages to generate targeted 1kW by increasing the flowrate from 0.8MMscfd to 1.2 MMscfd with no observable choking on the flow. The highest speed of 9,136 rpm is still within the design limit of the rotor and bearing used in the construction. Aside from manipulating the process condition such as gas flowrate and pressure, further optimization shall be analyzed such as improvement to certain aspects that serves as the main enablers that affect the overall performance of the turbine is to be identified such as flow characteristics and rotor dynamic of the turbine [6].

Keywords: Impulse turbine; generator; flow loop; design; fabrication.

Acknowledgement
The authors gratefully acknowledge the facility and financial support from PETRONAS Research Sdn Bhd and Universiti Teknologi PETRONAS through MRA GR&T grant no 015MD0-067 (PRSB no: E.025.JRD.02020.004).

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CES3-151

A REALITY CHECKS ON THE PVT-PCM TECHNOLOGY DIFFUSION: FROM THE BIBLIOMETRIC ANALYSIS PERSPECTIVE

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Extended Abstract

Solar technology features an awaited game changer and soon to be the new king of energy generation surpassing the first- and second-generation fossil fuels. Traditionally, single solar photovoltaic (PV) and solar thermal (T) systems were utilized to harvest solar energy and convert it to electrical and heat energy independently. However, with rapid technology evolution, integration of PV and T exhibit an increased demand due to its dual operation in a compact design. This hybrid PVT system enables a simultaneous conversion of solar radiation into both electricity and heat with less space and solar source. Nevertheless, the efficiency of PV decreases as the panel cell temperature increased which might affect the performance of PVT system. The emergence of phase change material (PCM) that has ability to absorb/store and release the heat has attracted many researchers to address the technological limitation of PVT system. PCM can be used to mitigate the changes in energy demand between peak and off-peak periods especially for thermal energy. Integration of PVT-PCM is predicted to increase the efficiency of the system by enhancing the electrical and thermal energy. At present, PVT technology has successfully enroute to large scale commercialization. However, the technology readiness of PVT-PCM is still vague and uncertainty from academic and industrial point of views.

Thus, this study is conducted to analyse the progression of PVT-PCM from bibliometric analysis perspective. A total of 255 publications were obtained when the search phrase ("photovoltaic thermal" OR "PVT") AND ("PCM" OR" phase change material*") AND (performance* OR efficienc*) were used in the WOS database. However, 56 review articles were then removed leaving only 199 publications to be analyzed. Subsequently, to do a quick reality check on the technical relevant of PVT-PCM technology. The focus of data search was set on performance and efficiency studies of PVT-PCM systems to evaluate the potential of PVT-PCM systems and their advantages in contributing to the efforts of decarbonisation of energy sector. The publication year was set to be between the range of 2011 until 2021. The ten-year period was chosen as PVT-PCM technology is relatively new. Web of Science (WOS) database was selected for this study due to its stability and established status as an international and multidisciplinary research database (Joshi, 2016). It covers publications from various fields where over 15 000 journals and 50 000 000 classified publications in 251 categories are included (Merigó & Yang, 2017). Furthermore, WOS database is also chosen as it provides data for various solar technologies bibliometric analysis that contributed to the development of solar energy research (de Paulo & Porto, 2017)

Figure 1 shows the top 20 most prolific countries by taking account of the total number of publications and citations. The country in the first place is China with 46 total publication and 831 total citations. Among the factors affecting this matter is the state-directed subsidies for renewable energy technology development initiated under the country's 12th Five Year Plan. The plan also targets to set China as a global dominant in the solar and wind sectors in less than a decade. Apart from that, its convenient geographical conditions also enable solar harvesting process to be done (Gulzar et al., 2020). This can justify by the increased interest and investment in China to utilize solar energy for developing sustainable PVT-PCM system. The other countries, such as Iran, India, Malaysia, Oman, Iraq and USA are also productive as shown in Figure 1. The academic collaboration networks between the associated countries in PVT-PCM studies are shown in Figure 2. Under these condition, 46 countries have been identified and only 34 countries are shown in the Figure 2. It can be seen, China has the highest number of publications with a strong collaboration with Iran. This collaboration influenced by economic interest of both countries (Green & Roth, 2021). Furthermore, there is a remarkable collaboration between India and England. The collaboration is driven by the join UK-India flagship program namely Newton Bhabha Fund, which supports the UK and Indian scientific research that provide solutions to the challenges facing India's economic and social welfare. Based on the preliminary result, it can be seen that the PVT-PCM technology has actively been studied and explored by the researchers all over the global. Which evident, the potential of PVT-PCM to go through the actual market domain.

Rank	Country	NP	TC
1	China	46	831
2	Iran	41	686
3	India	35	454
4	Malaysia	31	697
5	England	24	361
6	Australia	16	417
7	Saudi Arabia	16	340
8	Turkey	13	64
9	Oman	12	432
10	Iraq	11	427

Rank	Country	NP	TC
11	USA	8	254
12	Egypt	6	14
13	Bangladesh	5	133
14	Italy	5	67
15	Canada	4	25
16	France	4	73
17	Pakistan	4	203
18	Vietnam	4	11
19	Ireland	3	158
20	Spain	3	11

Fig. 1: Top 20 publishing countries in PVT-PCM performance and efficiency study (Note: NP = Number of publications, TC = Total citations)

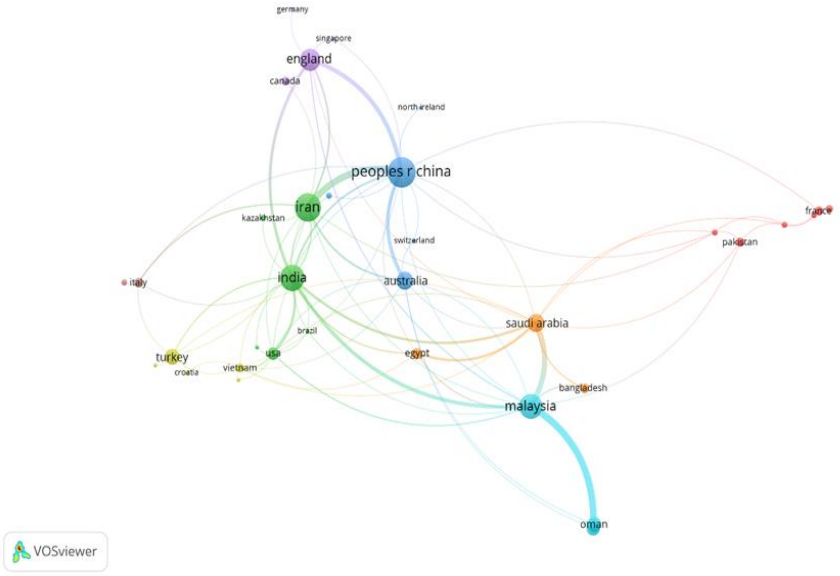

Fig. 2: Countries collaboration networks in PVT-PCM studies

Keywords: Solar PVT: Bibliometric analysis; VOSviewer; Renewable energy

Acknowledgment

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CES4-234

HIGH CONDUCTIVITY LITHIATED ELECTRODE AS AN ELECTRODE FOR SYMMETRICAL SOLID OXIDE FUEL CELL

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Extended Abstract

Global warming and the sustainable supply of energy, water and food are key societal challenges, within which the development and use of clean energy resources and technologies is an important objective [1]. In light of their high efficiency fuel dependent, fuel cell applications have received a significant deal of interest in recent years [2]. A symmetrical solid oxide fuel cell (S-SOFC) with a simple design was recently presented, with single materials utilized for both electrodes [3]. Developing S-SOFCs may accelerate the deployment of SOFCs because it offers decreased manufacturing costs and improved thermomechanical compatibility between electrolytes and electrodes[4]. Thus, this article presents the results of an investigation into the phase structure, morphology, and electrical behaviors of $LiNi_{0.8}Ru_{0.2}O2$ (LNR2), which has been proposed as a possible electrode for S-SOFCs. LNR2 electrode material was synthesized using the sol-gel technique and further calcined at 900 °C in air before being subjected to X

Ray Diffraction, Energy Dispersive X-Ray and Scanning Electron Microscopy analysis. Fig. 1 exhibit the morphology image of LNR2 bulk form besides the enhanced images of exhibiting the porosity of the pellet. LNR2 powder was then dry pressed using a 13mm die size to form a bulk pellet and further treated at 700 °C for two hours. Then, the electrical conductivity of LNR2 was investigated in the presence of air, a combination of hydrogen and a nitrogen-only environment. The peak electrical conductivity of LNR2 pellet in air recorded at temperature of 550 °C is 260.42 S cm^{-1} and the activation energy of the LNR2 in both working environement was presented in Fig. 2. Meanwhile, in H2:N2 mixture environment the highest recorded electrical conductivity was 2079.56 S cm^{-1} at 600 °C. The electrical conductivity shown by LNR2 in both environments met the electrode characteristic especially on electrical conductivity need to be at least 100 Scm-1 required for SOFC operation. As a result, $LiNi_{0.8}Ru_{0.2}O_2$ may be regarded a potential contender as an electrode material for SOFC application, to be explored in operative configurations in terms of both fuel cell performance and durability. However, LNR2 electrode materials must be further investigated for the creation of single-phase materials, either by using a different synthesis technique, optimising the various options throughout the synthesis process, or re evaluating the LNR2 materials' calcination temperature. Further research on the morphology and phase structure of LNR2 in a reduced environment is required to verify the chemical stability.

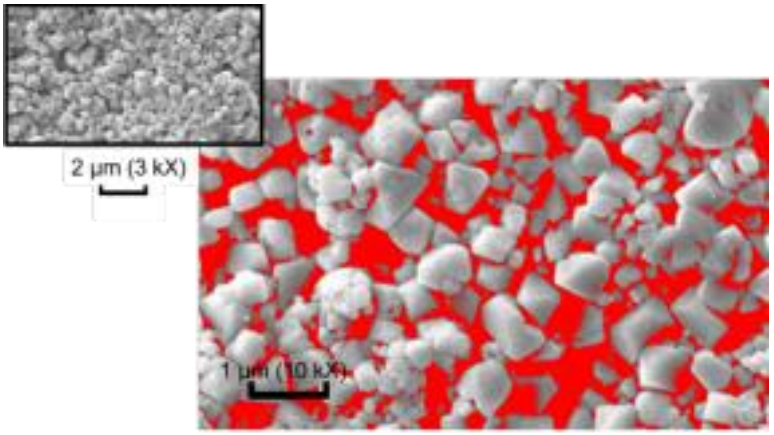

Fig. 1: SEM surface images of LNR2 bulk pellet sintered at 800 °C in air.

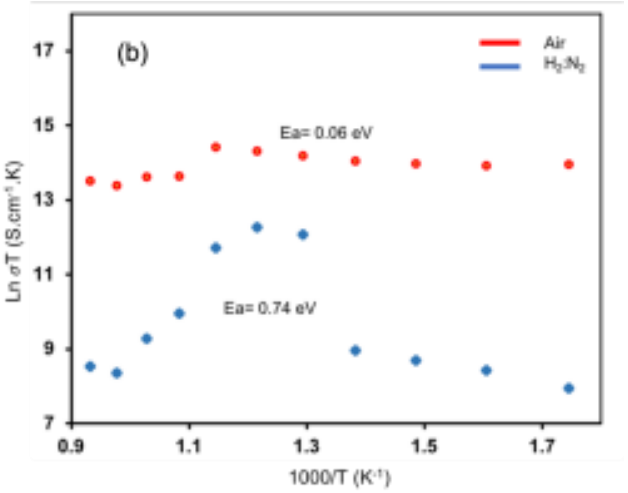

Fig. 2: Arrhenius plot of LNR2 Ln/T against 1000/T.

Keywords: Electrode; conductivity; lithiated; microstructure; symmetrical solid oxide fuel cell.

Acknowledgement

This work was supported by Ministry of Higher Education, Malaysia for the funding support via the research sponsorship under Fundamental Research Grant Scheme grant number FRGS/1/2019/TK07/UKM/02/1. Authors would like to acknowledge Universiti Kebangsaan Malaysia for providing insights and expertise that greatly assisted this research as well as fellow SOFC group members of Fuel Cell Institute UKM.

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CLEAN HYDROCARBON ENERGIES (CHT)

CHT1-125

EFFICACY OF Ni-doped FIBROUS SILICA-TITANIA (FST) AND TiO_2 -KCC-1 ON DRY (CO_2) REFORMING OF METHANE

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Extended Abstract

Concerns about global oil dependence are increasing interest in efficient natural gas energy harvesting. Wet (steam) reformation converts methane to synthesis gas (CO and H_2) which suffers side reactions and poor products ratio. Dry reformation solves the issue, although it consumes more energy, it produces superior products and requires less separation. Noble-metal dry methane reforming catalysts are active but expensive. Ni counterparts are affordable but unstable and produce too much coke. The current work produced, calcined, characterised (using XRD, KBr-FTIR, and BET techniques) and evaluated Ni/FST and Ni/TiO_2-KCC-1 for methane (CH_4) dry (CO_2) reforming at 723K – 1073K . The KBr-FTIR analysis indicated peaks at 460, 796, 19095, 1220, 1640, and 3450cm^{-1} in all catalysts except Ni/TiO_2-KCC-1. The Ni/FST catalyst has excellent CO_2 but poor CH_4 conversion.

Introduction

Due to the emission of greenhouse gases (GHGs), especially CO_2 and CH_4, climate change is considered one of the most disturbing challenges[1,2].CO_2 sequestration, as well as low-carbon energy fuel alternatives, become inevitable. CH_4 reforming generally involves the utilization of either oxygen, steam or carbon (IV) oxide as co-reactant with CH_4 and is being studied as an alternate method for producing syngas energy, which could reduce the world's reliance on fossil fuels[3]. Although dry methane reforming produces a product ratio closer to 1 (which is optimal) and has minimal treatment and cleaning process compared to steam reforming, its biggest drawbacks to date are high-temperature requirements [4] and catalysts deactivation due to coke accumulation and metal sintering [5–7]. Thus, many studies were conducted to enhance carbon resistance as well as catalytic reforming;[8] reported that during natural gas dry reforming, carbonaceous deposits are usually associated with high temperatures, relative CO_2/CH_4 concentrations, or the catalyst system. Coking can deactivate a catalyst by attacking its metallic, acidic/basic, or reactive species sites. The dry reforming reaction has been studied using noble metal (Ru, Rh, Palladium, Iridium) and nickel-based catalysts. While nickel-based catalysts are less active and more sensitive to coke formation than noble metal-based catalysts, they are more readily available and less expensive. The industrialization of nickel-based methane dry reforming is hampered by the rapid deactivation of nickel-based catalysts due to coke deposition on active sites and/or sintering of metallic active phases[7,9–11].

Methodology

Ni-loaded catalysts were prepared by mixing CTAB, distilled water, and urea for 5 minutes at 850rpm. After 30 minutes of stirring, toluene and butanol were added. Then came TEOS, drop-by-drop (tetraethylorthosilicate). Pre-aged, aged, and dried at 6h, 8h, and 110°C respectively. After calcining at

550°C for 6h, 1g dry powder and a small amount of $Ni(NO_3)_2.6H_2O$ calcined at 350°C. Prior to adsorption-desorption treatment, the samples were outgassed for 1 hour at 573K in the SA3100 surface area analyzer. A small amount of the catalyst was pelleted with KBr-FTIR. With a CO_2:CH_4 ratio of 1:1 and a temperature range of 723-1073K, 0.2g of the catalyst pellets were used in this study.

Results and Discussion

Table 1: Summary of Textural Attributes of the Prepared Catalysts

Catalyst	BET Surface area (m^2g^{-1})	Average CH_4 conversion (%)	Total Pore Volume (cm^3 g-1)	Micropore volume (nm)	Average CO_2 conversion (%)
Ni/TiO_2-KCC-1	290.95	83.247	0.5696	0.00000	19.933
Ni/FST	281.25	72.590	0.6380	0.00239	51.969

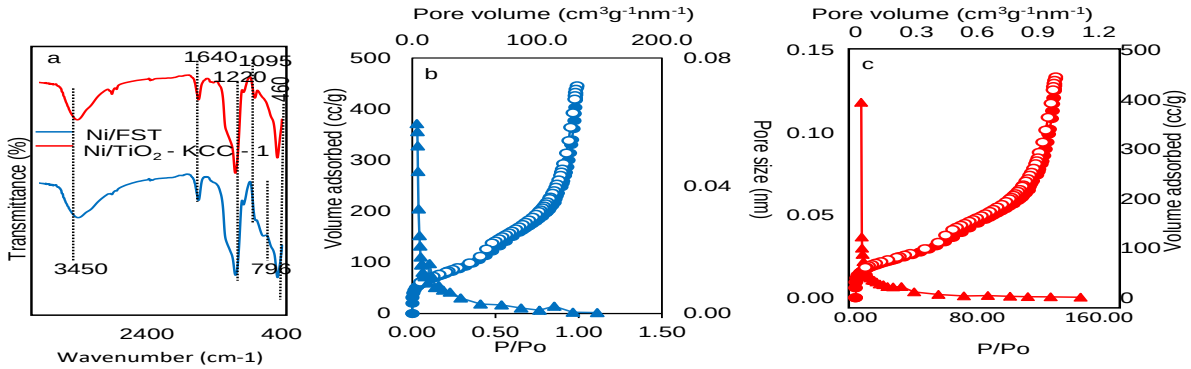

Fig. 1: Profiles of KBr-FTIR (a), N_2 adsorption-desorption of Ni/FST (b) Ni/TiO_2-KCC-1 catalysts

Table 1 summarises the catalyst's textural attributes. Clearly, Ni/TiO_2-KCC-1 has the largest surface area (290.95 m^2g^{-1}) and highest CH_4 conversion (83.247). The small micropore volume of Ni/TiO_2-KCC-1 and the high CO_2 conversion (51.969%) in Ni/FST suggest that the catalyst pore size has little effect on the reaction. Although particle size and support properties affect reaction product, Woo et al.[12] claim that lower nickel concentrations have the most adverse effect on reaction product A peak at 460, 796, 1095, 1220, 1640, and 3450 cm-1 was observed in all of the catalysts in Fig. 1(a). However, the peak at 460 and 540 cm^{-1} in Ni-TiO_2/KCC-1 is crystalline, as reported by Hambali[13]

Conclusion Titania-supported KCC-1, Ni catalyst activity has been established. Its CH_4 conversion was superior to that of highly loaded Ni/FST catalyst. However, at temperatures above 700°C, Ni/FST has surpassed it in activity.

Keywords: Dry reforming, Synthesis gas, Ni-catalysts, clean energy.

Acknowledgement
We are thankful to High Impact Reseearch Grant (08G92) from Universiti Teknologi, Malaysia.

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CHT2-168

EFFECT OF TITANIA LOADED OF FIBROUS SILICA CATALYST FOR n-HEPTANE ISOMERIZATION

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Extended Abstract

Hydroisomerization of n-alkane has been one of the critical processes in the petrochemical industry for increasing the octane number of gasoline and produce clean gasoline with a low level of hazardous elements such as aromatic compounds [1]. Therefore, a viable alternative catalyst is required in this process to produce clean gasoline with a high octane number which contains high selectivity of isomers and less undesirable cracking products. Despite the fact that the number of catalysts used in isomerization processes is growing, there is still a need for improved catalysts to enhance the catalytic performance, particularly at low temperatures [2], [3]. In recent years, fibrous nano-silica (KCC-1) developed by Polshettiwar and co-workers possesses high surface area, mesoporosity, and thermal stability which owing to its well-ordered dendrimeric silica fibers as shown in Fig. 1 [4]. However, KCC-1 has low acidity due to its natural characteristics. Hence, a metal is required for the acid catalyst reaction in order for it to function as a bifunctional catalyst. Traditionally, platinum has been utilised as an active component in catalysts for alkane isomerization, however, titanium dioxide (TiO_2) has also demonstrated comparable catalytic performance [5]. Nevertheless, the use of TiO_2 as a heterogeneous catalyst has several drawbacks due to its small specific surface areas and low absorption capability, thus, required new approach to overcome those shortcomings.

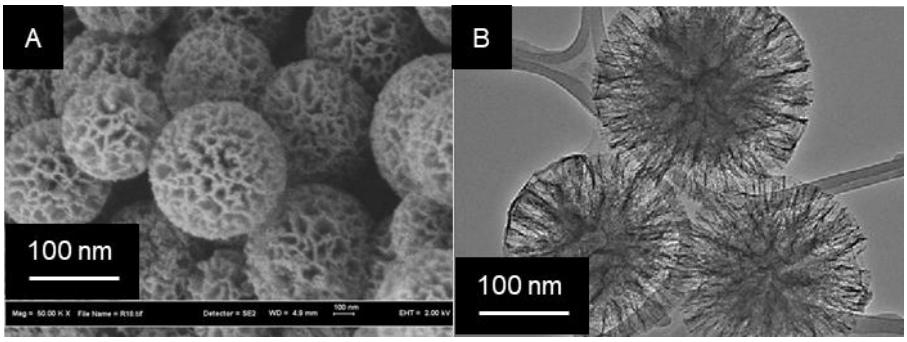

Fig. 1: FESEM images (A) and TEM images (B) of KCC-1 [6]

In this study, a fibrous silica catalyst, namely Centre of Hydrogen Energy silica (CHE-Si) was successfully synthesized by using micro-emulsion technique via self-assembly process. Meanwhile, TiO_2 supported CHE-Si were prepared by using impregnation method. The catalytic performance of the prepared catalysts for n-heptane isomerization has been conducted in a micro catalytic pulse reactor at temperature range of 150-400 °C in the presence of hydrogen as carrier gas. The physicochemical properties were evaluated by x-ray diffraction (XRD), fourier transform infrared spectroscopy (FTIR) and N_2-physisorption. Fig. 2 illustrated that the CHE-Si exhibited higher n-heptane conversion of 92 % and isomerization yield of 90 % at 450 °C, as compared to TiO_2/CHE-Si. It can be seen that the addition of TiO_2 on CHE-Si decreases the catalytic activity of isomerization, however, possessed higher selectivity towards isomerization product. This might be due to higher amounts of Lewis acid sites which requires detailed investigation on the effect of TiO_2 loaded on support.

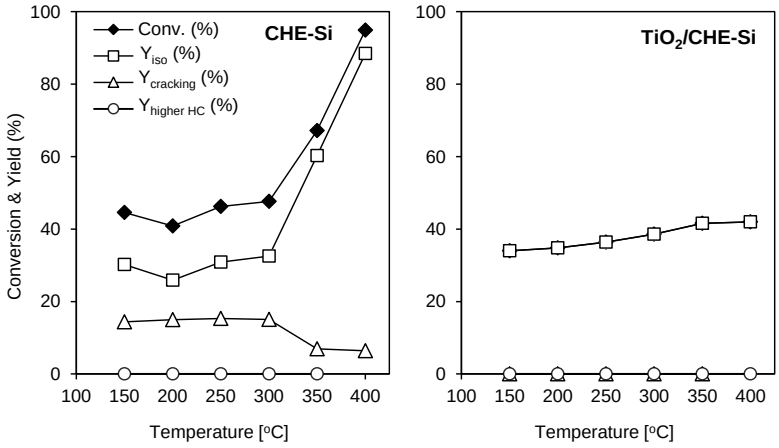

Fig. 2 : Isomerization of n-heptane over both catalysts

Keywords: n-hexane; hydroisomerization; fibrous silica; Lewis acid site; TiO_2

Acknowledgement
The authors are very grateful to the financial support from Universiti Teknologi Malaysia through Research University Grant (Grant No. 08G92) and the award of UTM Zamalah Scholarship.

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CHT3-178

RECENT ADVANCES OF SILICEOUS MATERIAL-BASED NANOCATALYSTS FOR CO_2 REFORMING OF CH_4 TO SYNGAS

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***Keywords**: siliceous materials; silica-based supports; catalyst structures; CO_2 reforming of methane; dry reforming of methane*

ABSTRACT

The carbon dioxide (CO_2) reforming of methane (CRM) significantly offers the benefits of industrialization and commercialization for the production of value-added syngas via Fischer-Tropsch process. Growing interests to commercialize CRM technology has driven the development for novel siliceous material-based catalysts with various hierarchical structures, namely two-dimensional and ordered mesoporous silica, core-shell and yolk-shell nanocapsules. The structure-reactivity relationship between different silica-based catalysts topologies are comprehensively reviewed and compared. Moreover, the advantages of different topologies for silica-based materials on the catalytic performance and selectivity are also scrutinized and summarized. Additionally, comprehension of CRM pathways induced by different siliceous material structures and the corresponding pictorial depiction are discussed and provided in this paper.

INTRODUCTION

Recent excessive generation of greenhouse gasses (GHG) due to anthropogenic activities and energy demand have negatively impacted our global climate [1]. About 36.3 gigatonnes (Gt) of global energy-related CO_2 emission has been generated in 2021 corresponding to a 6% rise from 2020, mainly due to combustion of fossil fuel sources [2]. As part of our global commitment with the Paris Agreement pact, a roadmap has been outlined for the global energy industry to promote transitions into low-carbon energy technologies to reduce GHG and maintain global temperature rise below 2 °C [3]. Therefore, interest in sustainable energy development for cleaner energy fuel has motivated in-depth research towards low-carbon hydrogen (H_2) technologies, with more than 50% of natural gas expected to be utilized to produce low-carbon hydrogen by 2050 [2]. Currently, H_2 production can be synthesized via reforming technologies such as steam reforming of methane (SRM), CO_2 reforming of methane (CRM) and partial oxidation of methane (POM) to produce syngas which consists of H_2 and carbon monoxide (CO). CRM have shown some promising environmental benefits for CO_2 utilization and methane (CH_4) conversion with an ideal syngas gas H_2/CO ratio close to unity as feedstock for Fischer-Tropsch for downstream production of synthetic fuels [4]. However, industrial implementation of pure CRM is still not viable due to its energy intensive process requiring high reaction temperature conditions (i.e > 800 °C) to overcome the CO_2 activation barrier and achieve near complete conversion of CH_4 as shown in Eq. (1). Consequently, this would also result to the sintering effects of the active metal.

$$CO_2 + CH_4 \rightarrow 2H_2 + 2CO \qquad \Delta H^{\circ}_{298K} = 245 \text{ kJ/mol} \qquad (1)$$

Simultaneously, CRM process also suffers from carbon deposition issues due to methane decomposition Eq. (2), Boudouard reaction Eq. (3) and reverse carbon gasification Eq. (4) which could lead to reactor blockage and deactivation of the metal phase and catalytic activity. In addition, the syngas ratio can be influenced by the occurrence side reaction reverse water gas shift (RWGS) Eq. (4) which can lower down H_2/CO ratio.

$$CH_4 \rightleftharpoons C + 2H_2 \qquad \Delta H^{\circ}_{298K} = 75 \text{ kJ/mol} \qquad (2)$$

$$2CO \rightleftharpoons C + CO_2 \qquad \Delta H^{\circ}_{298K} = -171 \text{ kJ/mol} \qquad (3)$$

$$CO + H_2 \rightleftharpoons C + H_2O \qquad \Delta H^{\circ}_{298K} = -131 \text{ kJ/mol} \qquad (4)$$

$$CO_2 + H_2 \rightleftharpoons CO + H_2O \qquad \Delta H^{\circ}_{298K} = 41 \text{ kJ/mol} \qquad (5)$$

The bottlenecks of the CRM process can be alleviated through advanced catalyst design and material selection with the aim of being cost-effective, high coking, sintering and thermal resistance. Recently, academic interest in silica-based catalyst have grown owing to its low cost, environmentally friendly, thermal and mechanically stable as well as chemically inert properties. The trade-off between structure-reactivity relationship have expanded a wide hierarchical of silica-based support across literature with various topologies ranging from Santa Barbara Amorphous (SBA-15), KAUST Catalysis Centre (KCC-1), folded sheet silica (FSM-16), Korean Institute of Science and Technology (KIT-6), silicalite-1, core-shell and yolk-shell.

DEVELOPMENT OF HIERARCHICAL SILICA-BASED CATALYST FOR CO_2 REFORMING

SBA-15

Santa Barbara amorphous-15 (SBA-15) has been studied widely across literature attributed to its confinement effect of hexagonal pore structures and high thermal stability. The pore channels promote anti-sintering effects of Ni due to high metal dispersion meanwhile suppressing coke deposition [5, 6]. It also exhibits large internal surface area which can provide abundant sites for metal adhesion and homogeneous pore size distribution acting as molecular sieves [7].

KCC-1

KCC-1 has garnered considerable attention due to its fibrous morphology, high specific surface area and thermal stability. It was discovered that the defect sites found on the KCC-1 give rise to oxygen vacancies which may promote better catalytic activity [8]. The concentration of BrØnsted acid sites and oxygen vacancies in KCC-1 are two-folds more than Mobil Composition of Mater 41 (MCM-41) and silica (SiO_2) [9].

INFLUENCE OF HIERARCHICAL STRUCTURE OF SILICA-BASED CATALYST ON CO_2 REFORMING

Silica-based catalyst has been employed for CO_2 reforming owing to its ability to maintain superb mechanical and thermal stability and enhancing the catalytic stability. Table 1 is summarizes the catalytic performance of recent silica-based catalysts for CRM process.

Table 1. Listing of catalytic performance for recently employed catalysts in CO_2 reforming of methane reaction

Catalyst	CH_4:CO_2 ratio	T (°C)	GHSV (Lgcat^{-1}h^{-1})	CH_4 conversion (%)	H_2/CO ratio	Reference
Ni/Silicalite-1	1:1	850	108	86	0.92	[10]
Ni@SiO_2	1:1	850	108	73	0.88	[10]
Ni@Silicalite	1:1	850	108	95	0.96	[10]
Ru@SiO_2	1:1	700	34.8	65	0.88	[11]
Ni/MCM-22	1:1	700	30	69	0.91	[12]
Ni/ITQ-2	1:1	700	30	76	0.94	[12]

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ENERGY MANAGEMENT, SAFETY AND POLICY (EMSP)

EMSP1-141

SMART HOME APPLIANCE SCHEDULING CONSIDERING PLUG-IN ELECTRIC VEHICLES

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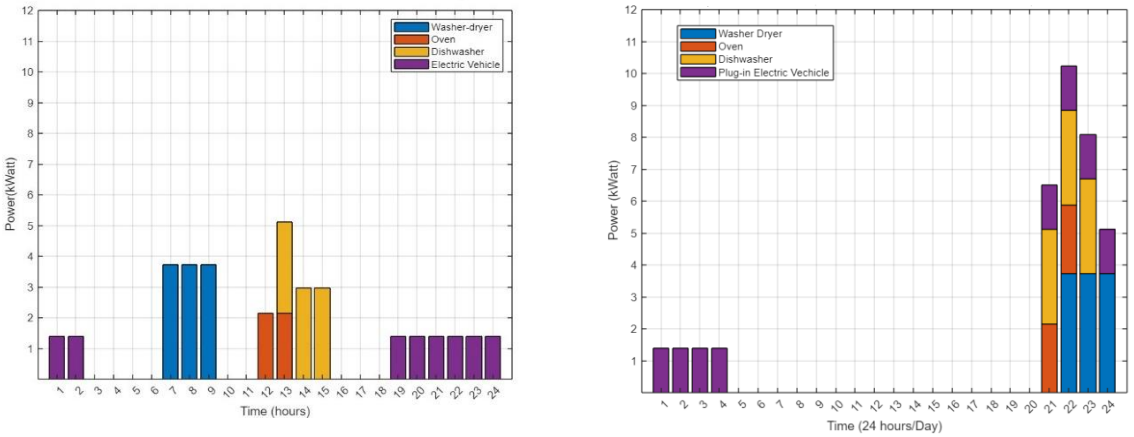
Extended Abstract

Manual scheduling has increased electricity bills as users operate their appliances without considering the Time of Use (TOU) tariff. As a consequence, they tend to operate most of their appliances during peak hours where the cost is at its highest. This paper presents a mixed integer linear programming (MILP) approach to enable optimal appliance scheduling. The main aim of this work is to shift the load from the peak period to an off-peak period. The objective of the optimization is to minimize electricity costs which restricted to the user's time preferences, continuous operation, and energy constraints. The proposed MILP is formulated using MATLAB software and the planning interval is chosen to be 24 hours with hourly resolution. The proposed optimization problem contains 96 decision variables represented by $X_{i,j}^{k}$. In this case, matrix A is in the form of 29 x 96 matrices that refer to the power of each appliance and user-time preference. Meanwhile b indicates the power limit in 24-hour slots and the operating hours of each appliance in the form of 1 x 29 vectors. Aeq demonstrates the continuous operation constraint and beq represents the total operating hours. Since the variable $X_{i,j}^{k}$ is binary, $lb = 0$ and $ub = 1$. Four types of appliances are considered: washer dryers, ovens, dishwashers, and plug-in electric vehicles. To evaluate the proposed optimization problem, scheduling before and after optimization has been done. The scheduling before and after optimization has been shown in Fig.1. The results show that shifting the load from peak to off-peak periods gives a cost saving of about 42.81% as shown in Table 1. By having proper scheduling of the appliances, the user could make significant savings on their electricity bills.



(a) (b)

Fig. 1: Appliance Scheduling (a) Before Optimization (b) after Optimization

Table 1. Comparison in Terms of Cost Before and After Optimization

Content	Before optimization	After optimization
Total load (kW/day)	35.558	35.558
Total cost (cents/day)	452.278	258.672
Cost saving (cents/day)	193.61	
Cost reduction (%)	42.81%	

Keywords: Appliance Scheduling; Mixed Integer Linear Programming; Optimization; MATLAB.

Acknowledgement

The authors would like to express their deepest gratitude upon Universiti Teknologi Malaysia for valuable financial support under specific grant, GUP-Tier2 with the cost center number, Q.J130000.2651.17J06. Appreciation also goes to the Centre of Electrical Energy Systems (CEES) and Power Department, School of Electrical Engineering, Universiti Teknologi Malaysia, Skudai Johor.

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EMSP2-185

ANALYSIS OF THE COATING TECHNIQUES AND INTERACTIONS BETWEEN THE CERAMIC FOAM AND METAL NANOPARTICLES AS A FLAME FILTER

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Extended Abstract

Porous materials are regarded as one of the effective flame resistance structures due to their outstanding flame quenching performance [1]. Therefore, it has been used widely in the petrochemical, distilleries, and biogas industries where flammable mixtures are present. In comparison to the commercial flame filter such as the crimped-ribbon type, wire mesh, metal foam, perforated plates, parallel plates, and wire gauze, a new approach to replace the existing commercial flame filter with ceramic foam has been studied. It is typically used for gas filters or flame holders but also represents a novel material that can be used for flame arrester applications. Even though the ceramic foams are known to be very brittle, however, it has a very excellent heat-resistant properties and hence, it is essential to address the ceramic properties challenges to be used as a potential candidate for flame arrester. The present work describes the innovative approach on ceramic foam to be applied as flame arrester application by introducing physical and chemical modification on ceramic foam by coating technique with metal nanoparticles (NPs) of Nickel (Ni) and Copper (Cu) to enhance the properties of the ceramic foam. Thus, this proposed work aims to characterize the coated nano particles-ceramic foam using in terms of mechanical strength, porosity, and stress to determine how efficient is the coating technique applied. Further, it is essential to investigate the synergetic effect of metal deposition on ceramic foam, which, when combined, results in higher porosity, mechanical stability, higher heat resistance, and adhesion to the ceramic support, reducing blocking due to smaller microchannels at high temperatures and aggressive environments.

This approach adopts the subsequent loading of dispersion of Ni nanoparticles and a Cu colloidal solution with and without the presence of silanizing agents to enhance the coating strength. Coating techniques employed in this study are spray-coating and dip-coating which are then used to deposit the metal particles onto the ceramic foam. The methodology involves sample pretreatment, surface modification, dispersion of metal particles, synthesis of metal particles, deposition techniques, and instrumental analysis. Alumina porous ceramic foams with dimensions of 70 mm diameter x 25 mm thickness were pretreated with acetone before rinsing with ethanol and distilled water to remove impurities on the substrate surface. Surface modification was done on the ceramic foams using 3-aminopropyltrimethoxy silane (APTMS) as a silanizing agent that chemically bond dissimilar materials (metals and ceramic foam) together even in challenging environments. This characteristic makes silane coupling agents useful for improving the mechanical strength of ceramic materials, improving adhesion, and for surface modification. In this study, Ni NPs were commercially purchased in the form of metallic nano powder with a specific size of 70 nm and the size has been controlled by dispersing 2% w/v Ni powder through ultrasonic dispersion in a solvent containing a surface stabilizer before the coating process was done onto the ceramic substrates. In contrast, 2% w/v of a copper colloidal solution has been synthesized through chemical reduction by hydrazine hydrate in the presence of a stabilizer to produce Cu NPs. The coated metals-ceramic foam are analyzed for

its physical properties (i.e. tensile strength and stress), phase identification, morphology, porosity, and density as well as experimental tests for its application as a flame filter. The samples were characterized by X-ray Fluorescence (XRF) for the determination of the elemental composition of the solid materials. Field Emission Scanning Electron Microscopy-Energy Dispersion X-ray (FESEM-EDX) will be used to monitor the surface morphology and surface elemental analysis of the samples. Fourier-transform infrared-attenuated total reflectance (FTIR-ATR) spectroscopy is used to identify the functional group present on the surface of the coated ceramic foams. Based on the XRF results obtained, the data on the concentration of Ni NPs are tabulated in Table 1. From the results, it can be found that Sample B1 has the highest concentration of Ni present on the ceramic foam which was 171.6 ppm as compared to other samples with no traces of Ni found. This can be supported by the FTIR spectrum shown in Fig. 1 which the functional group of Ni compounds appeared at 766.11 cm^{-1} (in red box). It can be said that the presence of silanizing agents of APTMS assists to strengthen the deposition of the metals on ceramic foam by the spray-coating method.

Table 1. Concentration of Ni nanoparticles on ceramic foam from XRF results

Sample	Surface modification with APTMS	Method	Concentration (ppm)
A1	No	Spray-coating	0.0
A2	No	Dip-coating	0.0
B1	Yes	Spray-coating	171.6
B2	Yes	Dip-coating	0.0

Fig. 1: FTIR analysis for Ni

Keywords: ceramic foam; metal nanoparticles; deposition; flame filter

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ENERGY AND ENVIRONMENT (EE)

EE1-137

MICROSTRUCTURAL CHARACTERISTICS OF LASER-TREATED NI-CR ALLOY VIA LOW POWER CO2 LASER

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Extended Abstract

Low laser surface treatment has barely been investigated on Ni-Cr alloy, particularly on improving morphological structures. Hence, a study on the impact of low power laser treatment on Ni-Cr alloy was presented in this paper. An attempt to densify the Ni-Cr alloy via low laser power might lead to the enhancement of mechanical properties. The strength of a normal metal composite can be reduced over time due to exposure to extreme heat and impulsive external force. This will cause alterations to the atomic structure of the composite, and it will lead to changes in its physical and mechanical properties. The irradiation of the CO2 laser aimed to densify the microstructures of the alloy by melting the surface of the composite. The alloy composites were prepared by mixing Ni powders with 20 wt% of Cr powders and pelletizing it before sintering at 1400°C. The laser treatment was conducted with the variation of three different magnitudes of low laser power of 10, 20, and 30 Watt respectively by keeping the speed of the laser constant at 10 mm/s. The observation was made by using Scanning Electron Microscopy (SEM). The results displayed that the surface of the alloy was visibly densified after laser irradiation. Fig.1 represented the untreated Ni-Cr alloy meanwhile Fig. 2 the laser-treated Ni-Cr alloy. Currently, it foresees the possibility of a low-power CO2 laser being potentially employed to enhance the morphological structure of an alloy that might lead to obtaining complex structural parts using this alloy.

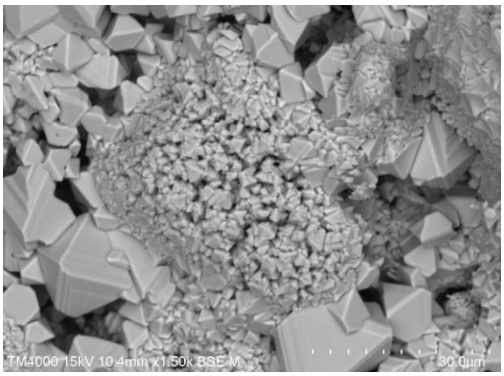

Fig. 1: Untreated Ni-Cr alloy

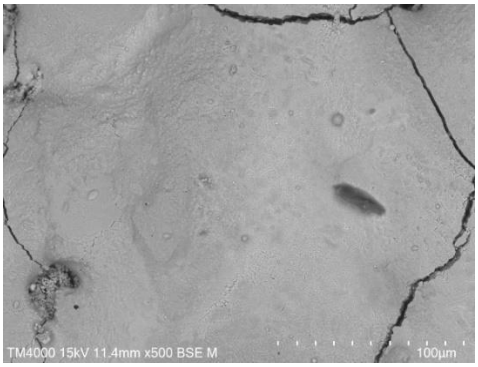

Fig. 2: Laser-treated Ni-Cr alloy

Keywords: Ni-Cr alloy; microstructure, low power, CO_2 laser; irradiation.

Acknowledgement
The authors are grateful to the financial support from the Universiti Malaysia Sarawak, the Small Grant Scheme (Project ID: F02/SGS/1972/2020).

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EE2-169

STUDY ON THE PHYSICAL PROPERTIES OF POLYMER COMPOSITE GROWING MEDIA FABRICATED USING SOLUTION BLENDING

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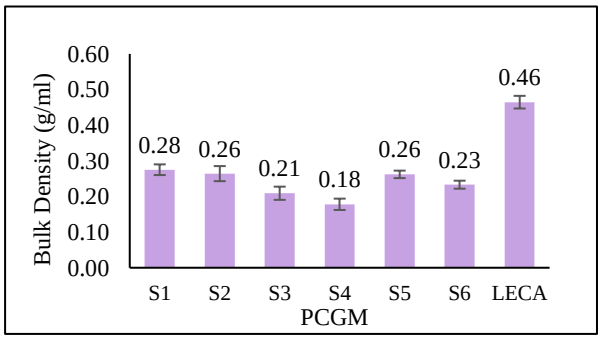
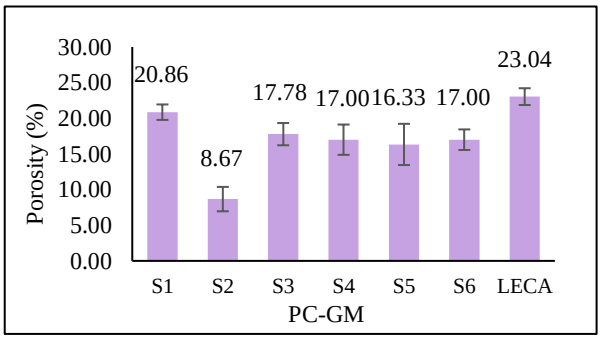
Extended Abstract

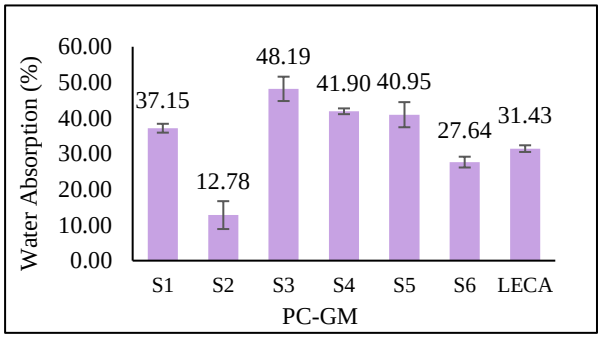
Polymer composite-growing media (PC-GM) made from the combination of HDPE, calcium carbonate (CC) and rice husk (RH) were fabricated using the solution blending method to be used as an alternative growing media in media-bed aquaponic system. There were three categories (Cat.) of PC-GM produced, (1) Cat. HDPE/CC (S1 and S2), (2) Cat. HDPE/RH (S3 and S4) and (3) Cat. HDPE/CC/RH (S5 and S6). The oil bath method was used in solution blending [1] to dissolve HDPE in xylene before mixing with either CC or RH. The samples were vacuum oven for 24 h [2, 3] at 80°C [4] to remove xylene. Prepared PC-GM were further tested for their physical properties [5] (bulk density, porosity, water absorption and pH) and compared to the existing growing media; light expanded clay aggregate (LECA). IBM SPSS Statistics 20 (Independent sample t-test) was used to determine the statistically significant result (p<0.05) between PC-GM and the control. The result showed that the bulk density, porosity and water absorption increased with an increasing percentage (w/w) of either RH or CC. Hence, higher bulk density, porosity, and water absorption can be seen when using a lower percentage of HDPE (w/w), i.e., 20% HDPE compared to 30% HDPE. However, pH of water-soaked PC-GM depend on the combination of HDPE with either CC or RH. pH value of Cat. HDPE/CC was slightly alkaline but Cat. HDPE/RH was slightly acidic. The Independent t-test showed a statistically significant result (p<0.05) for bulk density, porosity, water absorption and pH of all PC-GM produced using solution blending when compared to the control (LECA). The bulk density (g/ml) and porosity (%) of all PC-GM produced were lower than LECA. However, the water absorption (%) was higher than LECA except for S2 and S6. The result shows that PC-GM fabricated using the solution blending method might not be suitable for a media-bed aquaponic system because the bulk density is too low. The PC-GM would float and might be flush away from the system. Figure 1 below showed the result for bulk density, porosity, water absorption and pH for all samples tested.



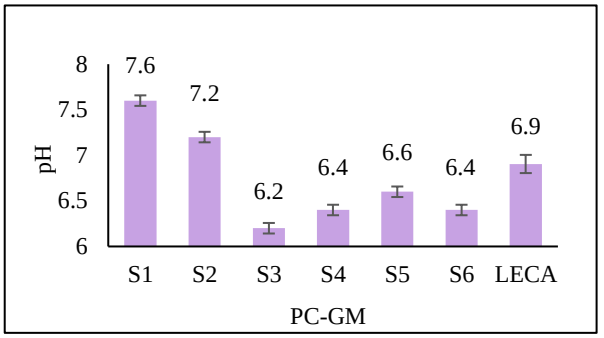
(a)



(b)



(c)



(d)

Fig. 1: Graph showed physical characteristics result of PC-GM for various test, (a) Bulk Density, (b) Porosity, (c) Water Absorption and (d) pH.

Keywords: Polymer-composite growing media; HDPE/calcium carbonate/rice husk; physical properties; solution blending

Acknowledgement
The research work was financially supported by Universiti Teknologi Malaysia (UTM), Research University Grants (UTMFR), VOT No. Q.J130000.2551.21H27

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EE3-153

POLYMER COMPOSITE AS AN ALTERNATIVE GROWING MEDIA IN MEDIA BED AQUAPONIC SYSTEM

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Extended Abstract

This research investigated the effect of fabricated-polymer composite (FPC) made from combination of high-density polyethylene (HDPE), calcium carbonate (CC) and rice husk (RH) as an alternative growing media for media bed aquaponic system. FPC is an effort made to make use of plastic waste generated to ensure sustainable development. Three different types of FPC are (a) C1, made from HDPE+CC, (b) C2, made from HDPE+RH and (c) C3, made from HDPE+CC+RH. The control for this study was LECA, purchased from the nearby local store. Four aquaponic units were installed to accommodate 4 treatment groups i.e., C1, C2, C3 and LECA. Water filtration system (compacted in a tank) with both mechanical and biological filtration sections were installed for each aquaponic units [1]. The experiment was conducted for 12-weeks in duplicate, using tilapia and *Gynura procumbens* (*G.procumbens*) as the fish and plants grown in the aquaponic system [2]. Water quality of the system (temperature, pH, dissolved oxygen (DO), total suspended solids (TSS), ammonia, nitrite and nitrate) were measured weekly at three sampling points: (A) in the fish tank, (B) at the effluent of filtration tank and (C) at the effluent of plant tank. Plant and fish survival rate and weight gain, increment in plants' number of leaves and height were measured prior to the experiment and at the end of the research. IBM SPSS Statistics 20 (ANOVA and Independent sample t-test) was used to determine the statistically significant result ($p < 0.05$) between treatment groups and the control. The result revealed that the average values at all sampling points for water temperature (25.7 ± 0.2), pH (7.5 ± 0.05) , DO (8.2 ± 0.2), TSS (26.2 ± 4.5), ammonia (0.6 ± 0.1), nitrite (0.2 ± 01) and nitrate (71.0 ± 14.1) were within the acceptable range for cultivation of *G.procumbens* and growing tilapia. Fish survival rate is 100% for all treatment groups. Plants survival rate is the highest in the control, LECA (73%) and lowest in C1 (20%). The weight of fish per tail was the highest in LECA (87 ± 2 g) and lowest in C1 (56 ± 3 g). Likewise, the weight of plants survives was the highest in LECA (2.09 ± 0.07 kg) and lowest in C1 (0.10 ± 0.04 kg). The average height of plants survived was the highest in LECA (70 ± 5.8 cm) and lowest in C1 (28 ± 5.9 cm). Similarly, the average number of leaves from plants survived was the highest in LECA (64 ± 1.6) and lowest in C1 (14 ± 0.4). Table 1 below summarize the result for fish and plants growth using FPC. The result showed that the growing media (LECA) was the best compared to FPC (C1, C2 and C3). Nonetheless, C2 performance was better compared to other FPC as most of the result for all parameters studied were not statistically significant compared to the control. Therefore, minor changes made in the composition of C2 might produce growing media with the most similar characteristic to LECA and could be used as an alternative to LECA.

Table 1. Result of the fish and plants grown in media bed aquaponic system

Parameters	Types of Growing Media			
	C1	C2	C3	LECA
Fish survival rate (%)	100	100	100	100
Average weight of a fish (g)	56	80	80	87
Plants survival rate (%)	20	37	28	73
Average Weight of plants survived (kg)	0.10	0.33	0.33	2.09
Average Height of plants survived (cm)	28	31	31	70
Average Number of leaves of plants survived	14	17	16	64

Keywords: Polymer composite; HDPE; rice husk; calcium carbonate; media-bed aquaponic

Acknowledgement
The research work was financially supported by Universiti Teknologi Malaysia (UTM), Research University Grants (UTMFR), VOT No. Q.J130000.2551.21H27

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EE4-180

PHYSICAL CHARACTERISTICS OF POLYMER COMPOSITE GROWING MEDIA FABRICATED USING DIFFERENT FABRICATION TECHNIQUE

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Extended Abstract

An alternative growing media was fabricated from the combination of high-density polyethylene (HDPE), calcium carbonate (CC) and rice husk (RH) using two different fabrication techniques: (1) Internal Mixing (IM) and (2) Solution Blending (SB). This alternative growing media is called Polymer Composite-Growing Media (PCGM) and was intended to be used in the media-bed aquaponic system. There were three categories (Cat.) of PCGM produced, (1) Cat. 1 (HDPE/CC ~ sample C1 and S1), (2) Cat. 2 (HDPE/RH ~ Sample C2 and S2) and (3) Cat. 3 (HDPE/CC/RH ~ Sample C3 and S3). There was only one sample composition for each category. The sample with abbreviation C means the samples were fabricated using the IM technique, while abbreviation S means the sample was made from the SB technique. In the IM technique, samples were prepared using Brabender Measuring Mixer (50 rpm, 180°C). Meanwhile, for SB, HDPE was dissolved in xylene using the oil bath method [1] before mixing with CC or RH. The samples were oven-dried to remove xylene using a vacuum oven [2, 3] at 80°C [4]. Prepared samples were tested for their physical characteristics [5] and compared to the existing growing media, light expanded clay aggregate (LECA). Physical tests conducted were the bulk density, porosity, water absorption and pH. An independent sample t-test (using IBM SPSS Statistics 20) was run to determine the statistically significant result ($p < 0.05$) between each sample and the control for all physical tests conducted. The result showed that the IM technique produced PCGM with a higher bulk density than SB. PCGM produced via SB were lightweight and floated when soaked in water. Moreover, PCGM produced via SB (S1, S2 and S3) were easily broken, unlike those fabricated using IM (C1, C2 and C3). The porosity of PGCM with CC was higher in SB (8.67%), but PCGM with RH was higher using IM (23.54%). Porosity was almost the same in both techniques for Cat.3 PCGM. Water absorption of PCGM was higher in SB than IM as the PCGM produced were soft and easily broken into pieces, allowing for more spaces for water absorption. The pH of water-soaked PCGM was higher in IM. Figure 1 below shows the comparison result between IM and SB techniques for bulk density, porosity, water absorption and pH tests. In conclusion, the IM technique was the best in producing PCGM, which is harder to break and has comparable physical characteristics to LECA.

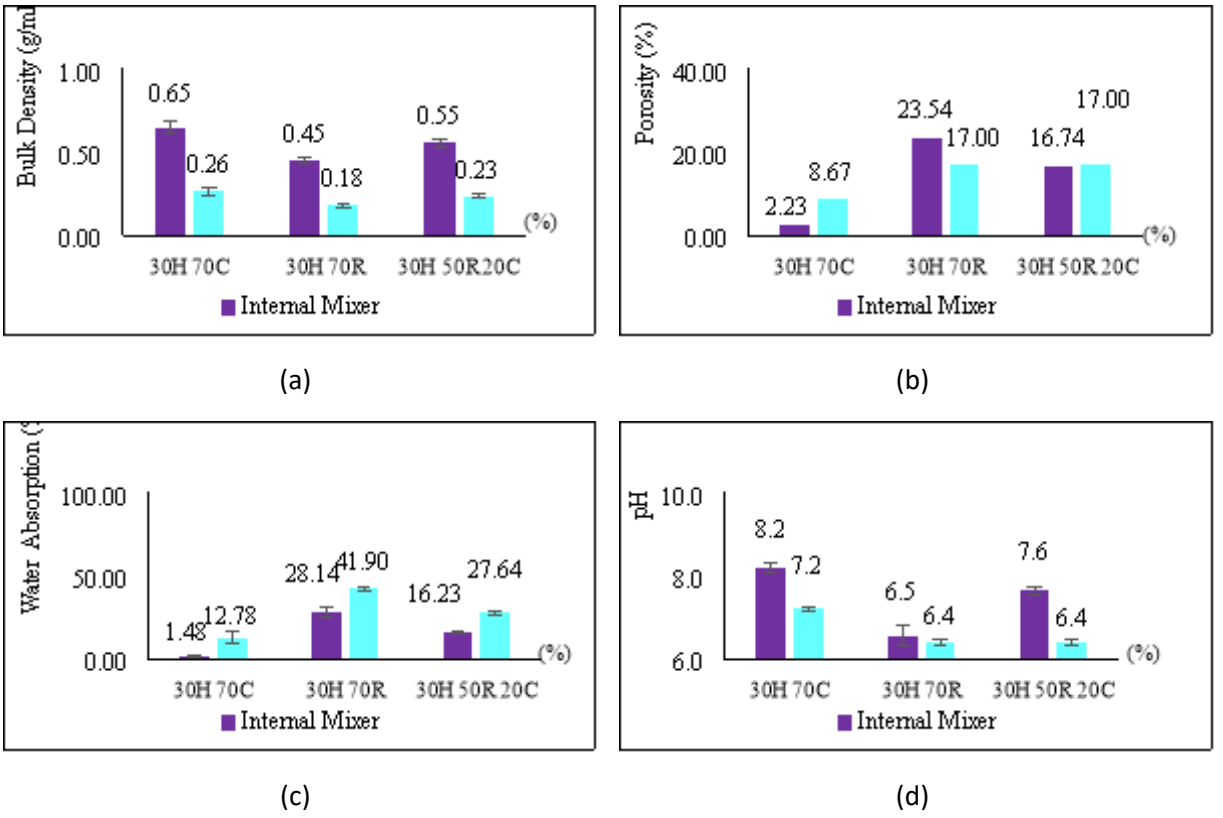

Fig. 1: Comparison between Internal mixing and Solution Blending for (a) Bulk Density, (b) Porosity, (c) Water Absorption and (d) pH. Samples in the graph were C1, S1, C2, S2, C3 and S3 (from left to right for all graphs).

Keywords: Polymer-composite growing media; internal mixing; physical properties; solution blending

Acknowledgement
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EE5-173

Optimization of Biosurfactant Production by Bacillus Subtilis From Pineapple Peel Waste using Response Surface Methodology

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Biosurfactant is one of the value-added products in the technology field, especially in the surfactant world. Bioconversion of the agriwaste as a substrate medium for the production of the biosurfactant using biosurfactant-producing microorganisms is striving since a few decades ago, with the improvement of the culture medium optimization to maximize the yield of the production. Furthermore, there is a growing interest in the utilization of cheap and abundant agricultural waste to substitute the usage of the oleochemical or petrochemical sources in the production of biosurfactants. The utilization of the agriwaste substrate such as pineapple waste for biosurfactant production is due to the abundance of carbon and nitrogen sources [1,2]. However, there is a need to optimize the culture medium with the modification to improve biosurfactant production, contributing to the viability of biosurfactant production and the long-term development of the agricultural waste industry. The biosurfactant facing a challenge in where it has difficulties maximizing the yield of production due to the culture medium and higher cost of production. Thus, it is essential to optimize the production of biosurfactants for scaling up the purpose of the application in the market worldwide.This study is focusing on the optimization and establishment production of the biosurfactant using *Acinetobacter calcoaceticus* utilizing pineapple peel waste as a substrate medium through Plackett-Burman Design (PBD), Box-Behnken Design (BBD) and Response Surface Methodology (RSM).

In this study, eleven variables with range comprised the pineapple peel (5-30 g/L), Minimal Salt Medium MSM (10-25 ml), Magnesium Sulphate $MgSO_4$ (0.2-0.6 g/L), Sodium Chloride NaCl (3-5 g/L), Di-potassium Hydrogen Phosphate K_2HPO_4 (1.25-2.5 g/L), Potassium Di-hydrogen Phosphate KH_2PO_4, (0.75- 1.5 g/L), *A. calcoaceticus* (5-30 ml), temperature (25-50 °C), agitation (100-200 rpm), the incubation period (60-96 hours) and peptone (3-5 ml) were chosen to study the individual variable effect on the biosurfactant production. The statistical design used in this study for the screening of the significant variables was Plackett Burman Design with 15 runs and 3 center points. All variables were screened in the Plackett-Burman Design to assess the parameters that influence the biosurfactant production, further analysis of the Box-Behnken Design (BBD) was done for the optimization of the culture medium. Experimental design and data analysis were conducted using the software package DESIGN EXPERT (Version 9.0; Stat-Ease, Minneapolis, MN).

From the 11 variables that have been chosen in the Plackett Burman Design, three variables that exhibited the most significant value, which is the p-value ($p< 0.05$) are pineapple peel, temperature, and incubation period. The effects of factors on the response variable showed that temperature had the most significant effects on the yield of the production. This fact was also validated using analysis of variance (ANOVA) as the p-value is less than 0.05 ($p< 0.05$) considered a significant result. [3] stated that in the fermentation of bioproducts, the temperature has an important influence.

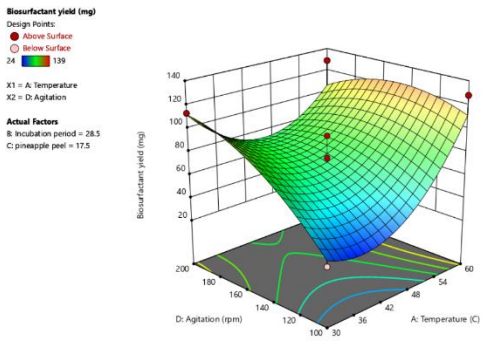

Figure 1: The interaction between temperature and agitation in the Box-Behnken Design (BBD)

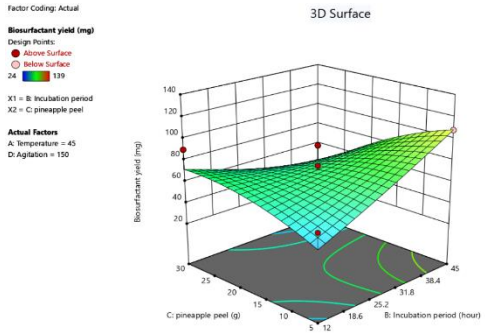

Figure 2: The interaction between pineapple peel and incubation period in the Box-Behnken Design (BBD)

Based on the results of the Box-Behnken Design (BBD), the interactions of the significant variables were observed based on the interactions between temperature-agitation and incubation period-pineapple peel. The results were validated through ANOVA analysis with the value (p-value<0.05) was 0.0294 for the interaction temperature-agitation, and (p-value<0.05) 0.0110 for the interaction of incubation period and pineapple peel. In conclusion, the optimization of the biosurfactant from *A. calcoaceticus* showed significant variables and was able to maximize the yield of the biosurfactant through Response Surface Methodology (RSM).

Keywords: Biosurfactants; Pineapple waste; Optimization; Agriwaste; Culture Medium

Acknowledgments

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EE6-181

ANALYSIS OF THERMAL COMFORT AND ENERGY CONSUMPTION FOR EDUCATIONAL BUILDING

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Extended Abstract

Building envelope maintenance and management which has a very close relationship with building energy consumption and indoor thermal comfort. Thus, the proper of building envelope maintenance and management is essential to reduce energy losses [1] and increasing occupant comfort and satisfaction. Providing a building condition with comfortable and healthy environment without any building defects is one the main function in educational building due to affect students' academic performance, productivity and students' health [2]. The issues of building defects are related with a weak maintenance management and reflects to a poorly building condition, create discomfort and danger environment to the building users [3]. The primary objective of this study is to investigate the building condition and thermal comfort of FKM classroom buildings. This paper also develops and energy consumption analysis through building simulation, IES VE software. Figure 1 shows the 4 multi storey building that is specially constructed as FKM classroom building. The building is located on the Permatang Pauh campus. In this case study, questionnaire and walkthrough assessment were carried out to gather information and data collection. First, a set of questionnaires has been distributed to the 1000 respondents in order to acquire data on the building conditions and obtain feedback from the respondents on their satisfaction level with the indoor environment in FKM classroom building. It was found that 743 respondents of different age and gender are participated in the survey. The results of the conducted survey distributed to the respondents revealed that there is a high degree dissatisfaction with the air conditioning system in the FKM classroom. The majority of the respondents claim that the room temperature as dissatisfactory (74.3%). Most of the respondents wanted to be cooler. The air quality in the surveyed of FKM classroom is rated as disappointing and unsatisfactory, (75.1%), and 24.9% rated as acceptable. Secondly, walkthrough assessment has been carried out to recognize the building condition in the FKM classrooms. The findings shows that the FKM classrooms has a building defect such as the window sliding too tight and cannot closing properly, dirt or debris in the window sliding, vertical blind curtain not function, interior ceiling defect and damage. The occurrence of building defects is usually caused by poor design, poor construction, poor workmanship, lack of care and weather factors [4]. Indoor environmental parameters such as temperature and relative humidity of FKM classroom buildings were recorded. The Barometer, temperature and humidity data logger was used to carry out the measurements. The range of indoor temperature and relative humidity of utilized and non-utilized with and without occupant were recorded. Table 1 shows the range of indoor temperature and relative humidity for FKM classroom. Based on the observation and measurement, there have 4 types of case study; 1) utilized without occupants, 2) utilized with occupants, 3) non-utilized without occupants, and 4) non-utilized

with occupants. The numbers of occupants are between 20 to 35 persons in a classroom. The analysis of energy consumption was performed by using building simulation, IES VE software. The results indicate that the case study (2) was 1,819 kWh/month, while the case study (4) was about 1,936 kWh/month. It was found that the room type; non-utilized with occupant is higher compared to utilized with occupant. By comparing the average value for each case study, the FKM classroom can be classified as a very inefficient building in terms of energy consumption. The maintenance and management of the FKM classroom were suggested to improve the energy performance. The optimizing maintenance of the building is to increase the performance of the system and maximization of energy efficiency [5].

Fig. 1: FKM classroom building

Table 1. Range of temperature and relative humidity on different case study

Case study (room type)	Relative humidity (%)	Temperature (°C)
1) Utilized without occupants	80 - 85	22 -23
2) Utilized with occupants	55 - 65	23 - 25
3) Non-utilized without occupants	65 - 70	24 - 26
4) Non-utilized with occupants	50 - 55	27 - 32

Keywords: building maintenance; classroom building; energy consumption; thermal comfort

Acknowledgement

The authors are particularly grateful for the help of the professionals who took part in the survey sessions.

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EE7-184

NICKEL AND COBALT PROMOTED SILICA@MGO CORE SHELL FOR DRY REFORMING OF METHANE

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Extended Abstract

The use of fossil fuels has led to the production of large amount of greenhouse gas-CO_2 (>400 ppm) and contributed to the global warming [1]. Dry reforming of methane (DRM) over metal catalysts represents an economically feasible method to convert the greenhouse gases CO_2 and CH_4 into clean energy of hydrogen production [2]. In recent years, the core-shell structured catalysts presenting superior activity and durability compared to the conventional supported counterparts in DRM application [3]. Besides, the Ni- and Co-based catalysts are intensively researched in DRM because of their ease of availability. In DRM, the Ni-based catalysts demonstrated high activity. While Co-based catalysts showed coking resistance attributed to the greater affinity between Co and oxygen [4]. In this study, we developed a series of Ni and Co promoted silica@MgO core-shell through hydrothermal and ultrasonic-assisted impregnation method. Several techniques including XRD, FTIR, N_2 physisorption were employed to characterize physicochemical properties of catalysts. The catalytic performance of DRM was carried at 800°C. The as-produced Ni and Co promoted silica@MgO core-shell catalyst effectively enhanced the catalytic performance of DRM than those of both the unsupported Ni and Co catalysts. Among various core–shell structured catalysts, Ni/SBA15@MgO showed the superior H_2 yield with the CO_2 conversion of 80% and CH_4 conversion of 95%, owing to the well-balanced property of metal-support interactions.

Table 1. Catalytic performance of the catalysts at 800°C

Catalysts	CO_2 Conversion (%)	CH_4 Conversion (%)
Ni/SBA15@MgOO	80	95
Ni/FS@MgO	76	85
Co/SBA15@MgO	78	90
Co/FS@MgO	84	96

Keywords: DRM; silica@MgO; core-shell; nickel; cobalt.

Acknowledgement
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EE8-211

ADSORPTION OF CO_2 USING ACTIVATED CARBON SYNTHESIZED FROM POMELO PEEL AT DIFFERENT HEATING CONDITIONS

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Extended Abstract

The global warming phenomenon is mainly caused by an excessive presence of greenhouse gases in the atmosphere where carbon dioxide (CO_2) is a major constituent of these greenhouse gases. The high concentration of CO_2 in the atmosphere is mostly emitted from fossil fuels burning for heat and electricity generation. It is an absolute necessity to reduce the emission of CO_2 to the atmosphere by capturing it from major CO_2-producing sources, especially industrial power plants. Adsorption is one of the most promising methods in separating CO_2 from the industrial flue gas due to it being highly effective, inexpensive, and non-corrosive to the equipment[1]. Amongst the various adsorbents available for the adsorption process, activated carbon (AC) is deemed as one of the most effective adsorbents for CO_2 adsorption owing to its remarkable porosity. However, AC that is available commercially is still stamped as an expensive adsorbent. Hence, AC that can be synthesized from a low-cost precursor is highly preferred. Pomelo peel (PP) is an excellent candidate for AC precursor since it is a zero-cost and abundantly available biowaste. Its high porosity attribute as AC is evident from past studies done for applications such as supercapacitor[2], methyl dye[3] and carbamazepine adsorption[4]. Therefore, in this study, PP is used as a precursor for the synthesis of AC, whereby it is synthesized at various heating conditions during the carbonization and activation process. The effect of the different heating conditions on the CO_2 adsorption performance of the pomelo peel-based activated carbon (PP-AC) is investigated in this study. The CO_2 adsorption isotherms are also studied using Langmuir, Freundlich, and Temkin models.

Three sets of PP-ACs were prepared at different heating conditions during the carbonization and activation process inside the furnace. The three different heating conditions are atmospheric, vacuum and inert (argon gas) conditions. The samples are named PP-AC(air), PP-AC(vacuum), and PP-AC(argon) respectively. These PP-ACs were synthesized through a chemical activation method that employs potassium hydroxide (KOH) as its activation agent. In a typical procedure, PP was firstly carbonized inside a furnace under different heating conditions (atmospheric, vacuum and inert) at a temperature of 600°C for 2 hours, which was then followed by KOH impregnation at a KOH:char ratio of 2:1. After that, it was activated inside a furnace under different heating conditions (atmospheric, vacuum and inert) at 600°C for 1 hour. The final dried form after washing is the PP-AC. These PP-ACs at different heating conditions were subjected to gravimetric CO_2 adsorption analysis at a temperature of 25°C, gas composition of 15% CO_2 and 85% N_2, and a variation of gas pressure from 1 to 10 bar.

The effect of heating conditions on the CO_2 adsorption performance of the PP-ACs adsorbent was represented in Fig. 1. Based on Fig.1, PP-AC(argon) shows significantly higher CO_2 adsorption performance than PP-AC (air) and PP-AC(vacuum) at every pressure reading (1 to 10 bar). The root cause of this is probably because of the complete removal of oxygen inside the furnace of PP-AC(argon)

during the carbonization and activation process. Since PP-AC(argon) was carbonized and activated inside a furnace that was devoid of oxygen, the over-heating of the sample was prevented and the structural damage of the pores was minimized[5]. In addition, the absence of oxygen also means there is a reduction in ash content since the excessive composition of ash in the sample can lead to the blockage of pores[6]. This further signifies that PP-AC(argon) probably possessed higher pore availability for CO_2 adsorption sites than PP-AC (air) and PP-AC(vacuum).

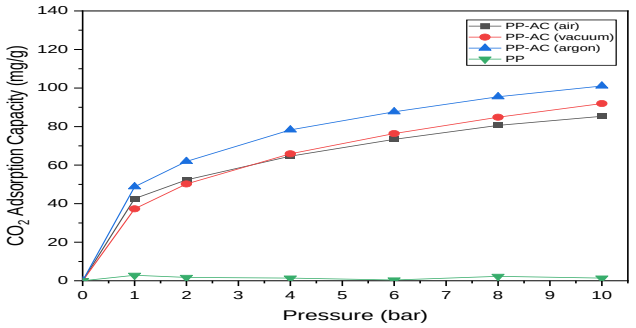

Fig.1: CO_2 adsorption performance of PP-ACs adsorbent at different heating conditions

In conclusion, PP-AC that was synthesized at an inert heating condition is proven to be the best adsorbent in adsorbing CO_2 in comparison to the PP-ACs that were synthesized at an atmospheric and vacuum heating conditions. This is probably due to the higher availability of pores in PP-AC(argon) since lesser pore structural damage and ash content are expected for PP-AC(argon) compared to PP-AC(air) and PP-AC(vacuum).

Keywords: Activated carbon, pomelo peel, adsorption, carbon dioxide, heating condition

Acknowledgement

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EE9-133

A PRELIMINARY ENVIRONMENTAL IMPACT ASSESSMENT OF A 3 KW H-OTEC PILOT PLANT IN MALAYSIA

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Extended Abstract

The environmental impact of a power plant is typically expressed in Greenhouse Gas (GHG) emissions throughout its life stages, accounting from raw material extraction for manufacturing, through the operation of the plant and finally, the end-of-life of it. Typical fossil fuel power plants are associated with high GHG emissions during their operational life stage due to the combustion of fossil fuel. Ocean Thermal Energy Conversion (OTEC) is a renewable energy technology that utilizes the temperature difference between the ocean surface and deep seawater to generate electricity [1], emitting zero GHG emissions throughout its operation. It is desirable in Malaysia due to the near equator geographical location and ease of access to deep seawater. The attractiveness of an OTEC power plant can be better shown when comparing its life-cycle GHG emissions to the conventional combustion power plants. Therefore, the purpose of this project is to conduct a preliminary environmental impact assessment of a 3kW OTEC pilot plant in Malaysia, compared to conventional fossil fuel power plants, via a Life Cycle Assessment (LCA). The methodology of an LCA study consists of 4 steps, viz, 1) defining the functional unit, goal and scope, 2) inventory analysis, 3) life cycle impact assessment (LCIA), and 4) life cycle interpretation [2]. The functional unit for this study is taken as 1 kWh of electricity generation; the goal is to assess the environmental impact – i.e., GHG emissions, while the scope of the study is limited to cradle-to-operation. The inventory data is obtained by analyzing the design blueprint of the 3 kW H-OTEC pilot plant – divided into the pilot plant building and the equipment of the H-OTEC system. Japanese Inventory database – IDEA v2 is chosen for this analysis, seeing the equipment of the H-OTEC system will be fully imported from Japan, and ILCD 2011 impact assessment method is used to evaluate the corresponding environmental impacts. The overall cradle-to-operation GHG emissions of the 3 kW H-OTEC pilot plant is 164,357 kg CO_2-eq. Figure 1 shows that the manufacturing phase of the H-OTEC pilot plant is responsible for 86.8% of its overall GHG emissions, with the raw material for pilot plant building accounting for 40.6% of that and the remaining by the raw materials for the equipment of the H-OTEC system. The transportation of these raw materials contributed to 13.2% of the pilot plant's overall GHG emissions. Since the equipment of the H-OTEC system is to be imported from Japan, it is responsible for 90.9% of the transportation GHG emissions. Meanwhile, the operation of the H-OTEC plant does not emit any GHG emissions. The comparison of environmental impact with other power plant types [3] in Figure 2 indicates that the current 3 kW H-OTEC pilot plant has 400.9 g CO_2-eq/kWh of carbon footprint, which is lower than conventional fossil fuel power plant. Furthermore, the environmental impact of H-OTEC is expected to reduce exponentially with capacity, hence will become more comparable to the other renewable energy sources.

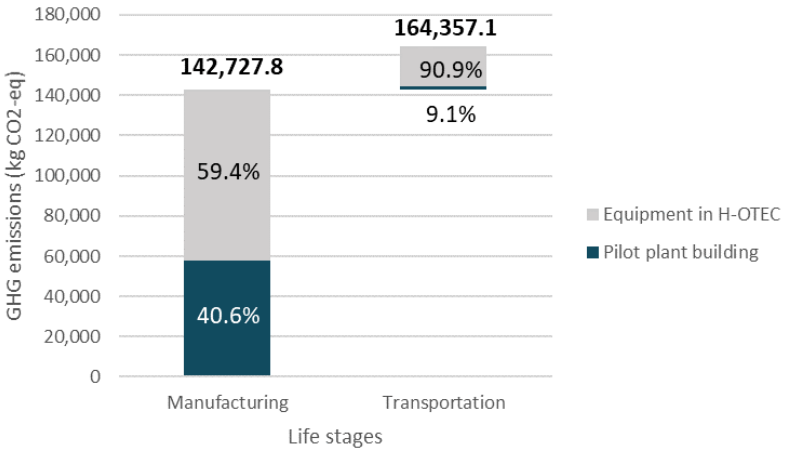

Fig. 1: Overall environmental impact (GHG emissions) of the 3 kW H-OTEC pilot plant in Malaysia

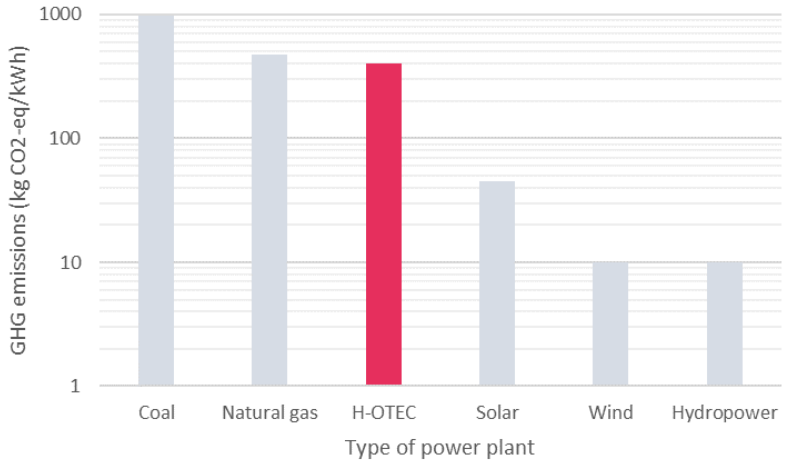

Fig. 2: Environmental impact comparison of the 3 kW H-OTEC with other power plant types [3]

Keywords: H-OTEC, Life Cycle Assessment, environmental impact, greenhouse gas emission.

Acknowledgement

This research was funded by the Japan Science & Technology Agency (JST) and Japan International Cooperation Agency (JICA), and the Ministry of Higher Education Malaysia (MoHE) — registered program cost centre: #R.J130000.7851. 4L893.

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EE10-146

FIBROUS SILICA ZIRCONIA AS A PROMISING CATALYST FOR CO_2 HYDROGENATION TO METHANE

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Extended Abstract

In this new contemporary era, in which everything has progressed at an exponential rate, global energy supplies have been subjected to a significant stress due to the enormous demand for energy. Synthetic natural gas (SNG) is a revolutionary energy resource obtained mostly from hydrogen and carbon dioxide. Amongst the most essential processes in the production of synthetic natural gas (SNG) is CO_2 methanation. This paper presents the successful synthesis of fibrous silica zirconia (FSZr) utilizing the microemulsion process, which was then employed for CO_2 methanation. The catalyst was characterized by Field-Emission Scanning Electron Microscope (FESEM), Fourier Transform Infrared (FTIR) spectroscopy, X-ray Diffraction (XRD) and N_2 adsorption-desorption. FSZr demonstrated superior catalytic capability compared to the commercial ZrO_2 with the CO_2 conversion and CH_4 yield of 38.98% and 35.25% at 500ºC, respectively. This finding was attributed to the unique fibrous morphology and high surface area. FSZr has a larger surface area, which enables for better accessibility to the active sites and hence improved the catalytic capability of CO_2 methanation. This study has a great potential for further understanding the correlation between fibrous morphology and zirconia for methanation processes to help fulfil the global energy demand.

Introduction

Since the discovery of methane synthesis by the interaction between carbon oxide and hydrogen in 1900s by Sabatier and Senderens, the methanation reaction has been extensively established and is frequently utilized in chemical manufacturing, comprising the elimination of trace quantities of CO_x from feed gas containing a rich amount of hydrogen, refining of the reformate gas for fuel cells, and production of new energy sources, which is synthetic natural gas (SNG) [1]. It is feasible for SNG to be carried and distributed using the present pipeline infrastructure, which is favourable from a cost-effectiveness standpoint. Natural gas has also become more fairly priced in recent years, which is another positive development [2]. Due to the fact that natural gas does not contain any minerals, it

burns cleaner than air and leaves no residue of ashes behind when burned, making it a more environmentally friendly fuel than coal [3]. Hence, natural gas has the potential to outperform coal and other liquid fuels, which contain higher concentrations of carbon. [3]. CO_2 methanation is one of the efficient processes that produced methane, the key component for natural gas. Because the process is very exothermic, the existence of a catalyst is normally essential to reduce the activation energy. The presence of a catalyst to this reaction can speed up the rate at which CO_2 is converted to methane. In recent years, ZrO_2 has emerged as among the most significant transition metal oxides among heterogeneous catalysts, owing to the unique features of this material, which include increased activity, excellent thermal resistance and stability, and low deposition of carbon, on account of the abundance of active sites, basic sites, and oxygen vacancies in the catalyst [4, 5]. It has been a constant focus of research to further increase the activity of ZrO_2 through the use of new catalyst production methods and the addition of other promoters. However, further work needs to be done to increase the activity of ZrO_2. Zirconia alone is insufficient because it lacks a large enough specific surface area, resulting in poor active component dispersion. Recently, a novel fibrous silica sphere (KCC-1) with an extraordinary exterior area, a huge open pore structure, and tremendously good thermal and hydrothermal stabilities was produced by Polshettiwar, Cha, Zhang and Basset [6], and this motivated numerous researchers to employ it for CO_2 methanation [7-9]. The development of a fibrous silica-based catalyst with a high surface area and having both micro- and meso- porosity is expected to greatly improve CO_2 methanation catalytic activity. It will also provide a platform for high metal particle dispersion, resulting in a cooperative effect between metal particles and active support sites to boost CO_2 methanation activity. Consequently, stimulated by that evidence, this research aimed to investigate the effectiveness of fibrous silica zirconia (FSZr) for CO_2 methanation.

CO_2 methanation performance

The catalytic capability of the catalyst towards CO_2 methanation was examined in a fixed-bed reactor at temperatures ranging from 150 °C to 500 °C while maintaining atmospheric pressure throughout the experiment. Figure 1 depicts the catalytic capability of CO_2 methanation activity with regards to catalyst's CO_2 conversion and CH_4 yield.

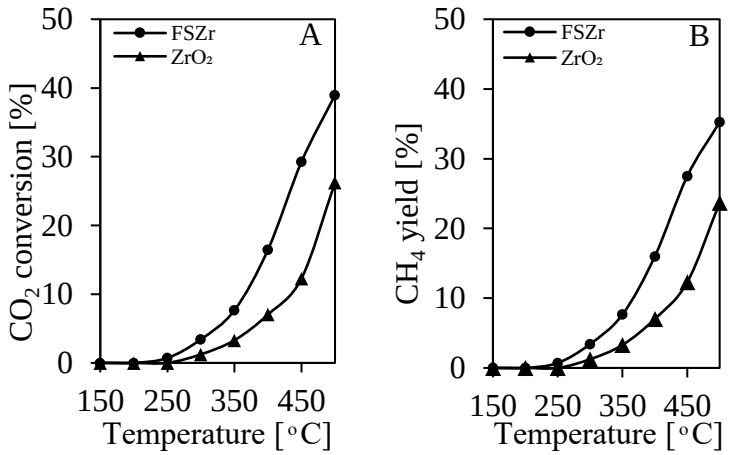

Figure 1 (A) CO_2 conversion and (B) CH_4 yield of FSZr and ZrO_2 catalysts for CO_2 methanation.

It was discovered that FSZr outperformed ZrO_2 in respect of conversion of CO_2 and yield of CH_4 for CO_2 methanation activity. FSZr starts to activate at 250 °C which then gradually improved as the reaction temperature was raised from 250 to 500 °C. ZrO_2 became active a little later, when the temperature reached 300 °C. Possibly, the internal energy of the system should be sufficient to cooperate with and dissociate both carbon dioxide and hydrogen molecules, resulting in the formation of CH_4. CO_2 methanation is an exothermic reaction, therefore lower temperatures are favorable thermodynamically but detrimental kinetically because of the slow reaction rate. As a result, higher temperatures are required in order to achieve significant CO_2 conversion and CH_4 selectivity. FSZr demonstrated 38.98% of CO_2 conversion and 35.25% of CH_4 yield at 500 °C, superior to ZrO_2, indicating that FSZr catalyst could effectively enhanced the CO_2 methanation activity. Moreover, it is worth mentioning that the catalyst's surface area was followed by the performance order; the larger the surface area, the greater the effectiveness of CO_2 methanation. This suggests that surface area had a significant impact on this outstanding performance, as larger surface areas allowed for greater access to the active sites.

Keywords: CO_2 Methanation; Carbon Dioxide; Methanation; Fibrous Silica Zirconia.

Acknowledgement
The authors are grateful for financial support provided by the UTM High Impact grant (UTMHR) from Universiti Teknologi Malaysia (Grant No. 08G92).

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EE11-156

SYNTHESIS OF PROTONATED FIBROUS SILICA ZSM-5 FOR METHANOL TO HYDROCARBONS (MTH) APPLICATION

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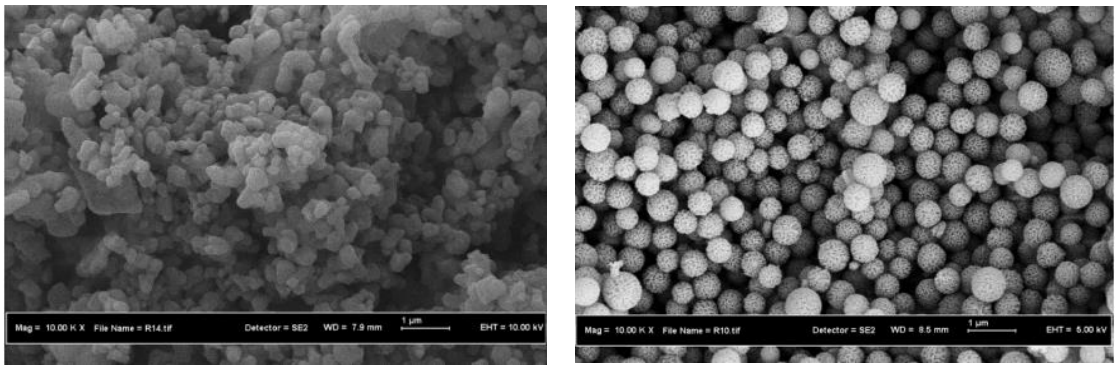
Extended Abstract

The increase of energy demand as a result of fast industrial development and rapid depletion of fossil fuel resources, as well as the concerns of global warming induced by the combustion of these resources, have increased attempts to find an alternative for clean fuel options. For instance, approximately 400 Mt of CO2 were produced and emitted by fossil fuel consuming processes and industry emissions in 2021 [1]. For that reason, an innovative and nontraditional carbon-based feedstock will be needed to fulfil the world's need for fuels and chemicals [2]. Methanol to hydrocarbons and dimethyl ether (DME), which can be obtained from non-petroleum alternatives energy sources such as biomass, waste, coal, natural gas and carbon dioxide [3], has recently gained attention due to its broad application. In this reaction, zeolite catalyst plays a critical role as the properties of the catalyst can influence the product distribution and selectivity of this reaction. In recent times, unique core-shell fibrous silica mesoporous zeolites with the large surface area have gained interest because of their remarkable performances in solid acid-catalyzed reactions such as isomerization [4], carbon dioxide methanation [5], and carbon dioxide reforming of methane [6,7]. Using a microemulsion method, a novel ZSM-5 catalyst with a silica fibrous shape (HSi@ZSM-5) was effectively synthesized for methanol to hydrocarbon (MTH) reaction.

Catalytic performance of the as-synthesized catalyst was examined using a continuous fixed bed reactor at reaction temperatures ranging from 200-400°C and compared with the commercial HZSM-5, HB and HY zeolites. The catalysts were characterized using FESEM, nitrogen physisorption, and pyridine adsorbed FTIR. FESEM results revealed the spherical morphology with equally distributed dendrimeric silica fibres of HFZSM5 catalyst. Based on the nitrogen physisorption result, an increase in surface area by 68% was observed compared with commercial HZSM5, while inherent mesopores at 4-18 nm and 20-70 nm. A significant reduction of Brønsted acid sites in HSi@ZSM-5 as observed by pyridine FTIR results also reduced the side reaction while increasing hydrocarbon selectivity. Overall, this work could lead to developing a high-efficiency catalyst for the MTH process.

Table 1. Product distribution from methanol to hydrocarbon and DME reaction

	Temperature (°C)				
	200	250	300	350	400
			HZSM-5		
Methanol conversion (%)	87.85	93.73	95.81	97.28	97.41
DME selectivity (%)	88.71	74.47	61.17	57.44	45.06
Hydrocarbon selectivity (%)	11.29	25.53	38.83	42.56	54.94
			HSi@ZSM-5		
Methanol conversion (%)	93.87	96.62	98.48	98.74	99.03
DME selectivity (%)	56.73	48.95	25.88	19.06	13.218
Hydrocarbon selectivity (%)	43.27	51.05	74.12	80.94	86.79



(a) **(b)**

Fig. 1. FESEM image of (a) HZSM-5 and (b) HSi@ZSM-5

Keywords: Fibrous Silica ZSM-5, Methanol, Dimethyl ether, Hydrocarbon

Acknowledgement

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EE12-164

EFFECT OF TEMPERATURE ON DRYING PERFORMANCE OF STINGLESS BEE POT-POLLEN USING SWIRLING FLUIDIZED BED DRYER

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Extended Abstract

Stingless bees or also called “Kelulut” in Malaysia are magnificent insect mainly known for its unique honey with mixture of sweet and sour taste [1]. Besides honey, pollen from flowering plants is also collected by worker bees, mixed with nectar and bee enzymes before storage in their hives [2]. This bee product is called bee bread or pot-pollen where the latter refers exclusively to stingless bees, where they kept the pollen in cerumen pots [3]. Pot-pollen is difficult to store owing to its high moisture content[4]. This encourages microbes and fungi growth which will lead to spoilage. Thus, suitable drying method is required to preserve the pot-pollen for consumption. Swirling fluidized bed dryer is a promising method for drying pot-pollen [5] . Usually, drying performance is dictated by mainly by temperature such as in drying of soybean meal, mint leaves, and carrots [6][7][8]. However, the significance of temperature on drying performance of stingless bee pot-pollen particularly using a swirling fluidized bed dryer has not been explored previously. Hence, the objective of this paper is to study the effect of temperature on the drying performance of stingless bee pot-pollen in a swirling fluidized bed dryer. Drying experiment is carried out a lab scale swirling fluidized bed dryer as shown in Fig. 1. Pot-pollen sample with weight of 50 g is inserted into the drying chamber of a lab-scale swirling fluidized bed dryer with 67° swirling distributor, and the sample weight is taken every 5 minutes. The temperature tested is at 30 °C and 40 °C while the velocity is set at 1.5 m/s and 2.0 m/s. The results of the drying performance for each configuration are illustrated in Fig. 2. Increasing temperature will lead to faster drying at all velocities tested especially at the earlier stages of drying. The air velocity increase will also lead to higher drying rates. However, the effect of velocity is diminished at higher temperature, indicating temperature being more significant parameter. On the other hand, the temperature increase should be minimal to prevent deterioration of pot-pollen composition. Thus, it can be concluded that temperature has a positive effect on the drying performance of stingless bee pot-pollen in a swirling fluidized bed dryer. Hence, a swirling fluidized bed dryer is proposed as a rapid drying method of stingless bee pot-pollen.

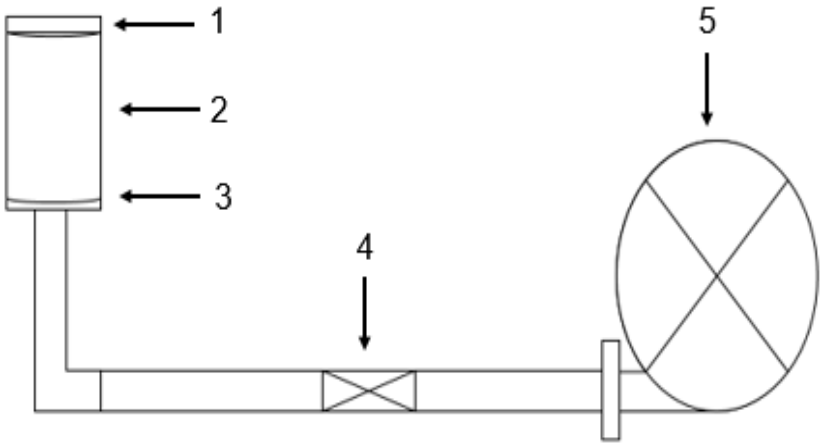

Fig. 1: Schematic diagram of the swirling fluidized bed dryer setup consisting of; 1) filter, 2) drying chamber, 3) swirling distirbutor, 4)control valve, 5)air blower

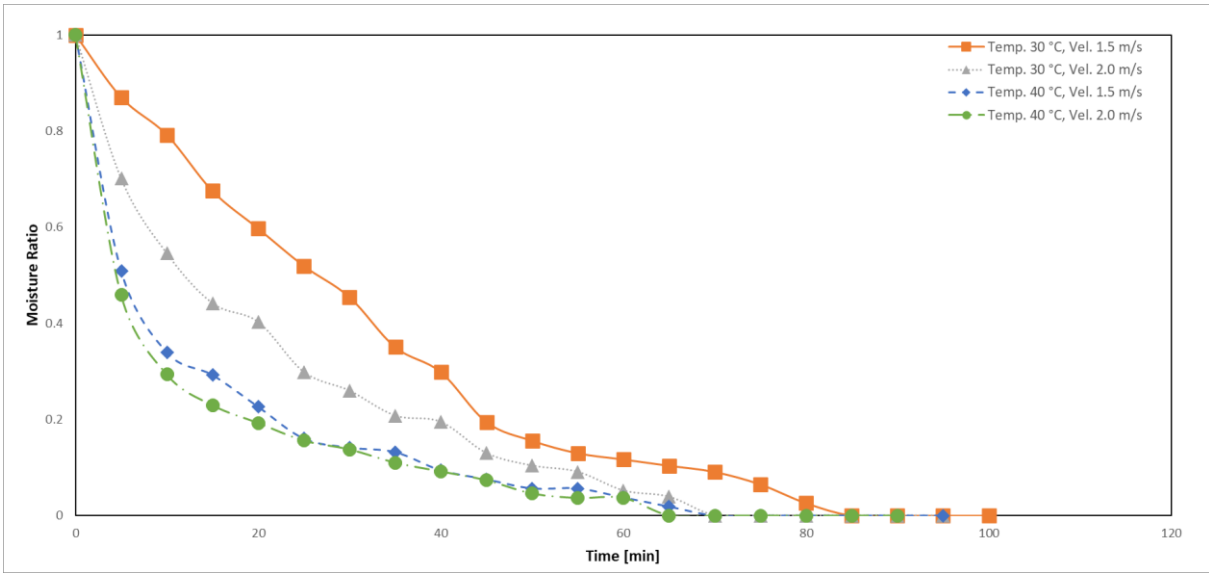

Fig. 2: The drying curves of pot-pollen in swirling fluidized bed dryer at temperatures of 30 °C and 40 °C, and velocities of 1.5 m/s and 2.0 m/s

Keywords: stingless bee, pot-pollen, swirling fluidized bed dryer, drying

Acknowledgement
The authors would like to thank Ministry of Education Malaysia and Universiti Malaysia Pahang for providing assistance via access of grant FRGS/1/2018/TK03/UMP/02/25 (RDU190192) and Centre of Excellence for Advanced Research in Fluid Flow (CARIFF), Universiti Malaysia Pahang for access of grant RDU190381.

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EE13-172

HYDROTHERMAL LIQUEFACTION OF FOOD WASTES FOR SUSTAINABLE PRODUCTION OF HIGH-GRADE BIOCRUDE-OIL TO DROP-IN TRANSPORT FUEL

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Extended Abstract

The transport sector is the highest consumer of fossil fuels accounting for 96% of the global energy, which correspond to 65% of the global crude oil consumption. The escalating consumption of fossil fuel causes deleterious environmental pollution by releasing > 7 billion tons of CO_2 in the atmosphere. The awareness to transition from conventional fossil fuel to eco-friendly options has resulted in several decarbonization strategies with Europe's priority to develop new alternative and carbon-neutral energy sources based on a cost-effective biomass-based thermochemical conversion. Hence, the objective of CO-HTL4BIO-OIL is to develop commercially viable catalytic co-hydrothermal liquefaction (CO-HTL) that converts 2G wet solid food wastes into a sustainable transport fuel with potential 100% atom efficiency, low production costs, and zero CO_2 emissions. An in-depth study on the HTL parameters, optimization of the CO-HTL process, and techno-economic assessment are expected to provide an outlook scenario of the industrial-scale process for high biofuels production capacity. The project will respond to the Renewable Energy Directive (RED, 2009/28/EC) targeting-20-20-20 by 2020: 20% reduction in greenhouse gas emissions, 20% increase in energy efficiency, and 20% of the EU's energy consumption originating from renewable sources. Hence, it will have a positive and pioneering impact in bringing together the knowledge-based economy and society of Europe toward sustainable and green transportation.

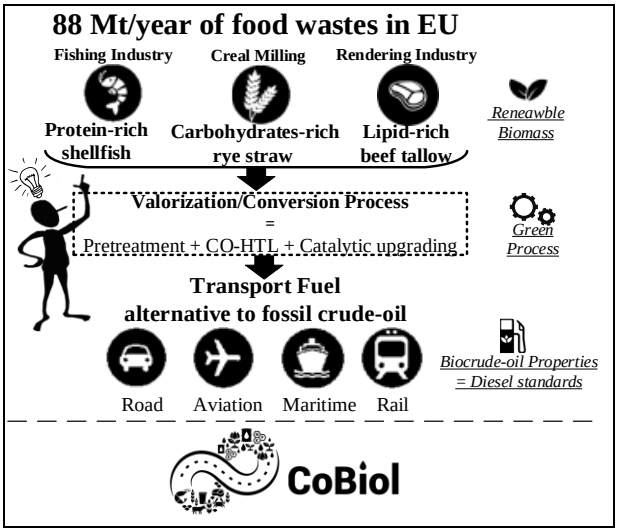

Fig. 2: CO-HTL4BIO-OIL project overview

Acknowledgement

CO-HTL4BIO-OIL Project (Brand name CoBiol) has received funding from the European Union´s Horizon 2020 Research and innovation programme (MSCA-IF-EF-ST) under grant agreement no. 895710 for 24 months (01/03/2021– 28/02/2023)

EE14-165

Epoxidation Of Oleic Acid by The Prilezhaev Method Using Acetic Acid

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Abstract

Currently, palm oil research is not particularly popular because researchers prefer to focus on other vegetable oils such as canola seed or soybean. Because palm oil is abundant in Malaysia, which is the world's second largest supplier, a study of palm oil is required to extend the number of research to improve the quality of palm oil production. In order to achieve the goal, palm-based oleic acid was epoxidized using performic produced using prilezhaev method. The existing epoxy group is determined using Fourier Transform Infrared (FTIR) Analysis on epoxidized oil samples at wavenumber 816 cm^{-1}.

EE15-120

Epoxidized vegetable oil as a potential source of lubricants

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Abstract

The potential utility of epoxidized vegetable oil in industrial applications has begun to be appreciated, raising the concern of research to generate value-added products from accessible vegetable oil. Oleic acid, one of the unsaturated fatty acids derived from vegetable oils, can be converted into epoxidized oleic acid by chemical oxidation. Epoxidized oleic acid is a bifunctional monomer that has the potential to act as a raw material in the synthesis of fatty acid-based polyesters. Epoxidized oleic acid was characterized and tested for degradation. Formic acid ($HCOOH$)or acetic acid, ($CH3COOH$) as oxygen carrier and hydrogen peroxide, ($H2O2$) as an oxygen donor in the reaction system. The combining parameters which are effect of agitation speed and effect of molar ratio of oleic acid to formic acid based on the optimum value of each parameter on epoxidation reaction RCO analysis were determined by using FTIR analysis.

EE16-238

Solid Acid Catalyst Derived from Acid Activated fly ash for methanol dehydration to Dimethyl Ether

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Abstract

This study synthesised an efficient solid acid catalyst from fly ash collected from a palm oil mill in Kota Tinggi, Johor, Malaysia. The fly ash was pretreated with mechanical and thermal activation before being transferred into a Teflon-lined stainless steel reactor for hydrothermal. A 4-h alkali dissolution hydrothermal reaction occurred at 95 °C, followed by chemical activation using 2M for H_2SO_4 and HNO_3 at 110ºC. The prepared solid acid catalyst was characterized using several techniques, including surface area and Pore Volume (BET), chemical analysis (XRF), morphology by Scanning Electronic Microscopy (SEM), Bulk Structure and Particle size by Powder X-ray Diffraction(XRD), Chemical Bonding and Molecular Structure by FTIR, Mechanism of Acid-base sites and Strength by Temperature Programmed Desorption NH_3-TPD and CO_2-TPD for the fresh catalyst and Thermal Gravimetric Analyzer (TGA) for coke formation evaluation of used catalyst. The catalytic activity was carried out in a fixed-bed reactor (i.d. 9 mm) placed inside a vertical furnace. The reaction was carried out in a nitrogen atmosphere in a temperature range of 250–450 °C, and 0.5 g of catalyst was used. Pure methanol was fed to the system using a syringe pump. All the lines were heated up to 120 °C to avoid condensation of any compound. The reaction products were analyzed using online gas chromatography (GC) equipped with a thermal conductivity detector (TCD) and HP-PLOT Q capillary column. The methanol conversion and DME yields were 53.86 to 70.20% and 95%, respectively. Results showed that the performance of the SO_4@FA catalyst was better than the NO_3@FA in terms of methanol conversion, and they were almost the same for DME selectivity.

Keywords: Solid acid; Fly ash; Acid Activation; Methanol, Dimethyl ether;

Introduction

The palm oil (PO) solid waste generated in Malaysia has continued to grow with the increase in demand for palm oil and the increase in plantations developed for palm oil cultivation[1].In Malaysia, PO industries produce more than 100 million tonnes per year of solid waste, including Palm frond (PF), empty fruit bunch (EFB), mesocarp fibre (MF), palm trunk (PT), and palm kernel shell (PKS)[2]. In addition, solid waste material residuals such as shells, MF, PKS, and EFB are utilized as a fuel in the PO mill's boiler, and Palm oil fuel ash(POFA) is generated[3, 4]. Fly ashes (FA) constitute about 5% of the total solid waste that may generate problems of discarding as well as environmental degradation due to its nature of causing air and water pollution on a large scale[5].

In order to reduce environmental consequences and recycle materials, various studies have been conducted to look into the beneficial applications of FA as raw material, such as construction material[6], adsorbent[7], fertilizer[8], polymer composite[9] and catalysis[10]. Furthermore, due to its unique chemical composition, mainly composed of mixed metal oxides predominantly of amorphous silica and alumina oxide, as well as excellent texture and morphology, FA is a promising candidate as either catalyst or catalyst support material for many chemical reactions[11, 12]. In the past decades, literature reported the use of FA heterogeneous catalysts and supported many chemical reactions such as transesterification reactions[12], Friedel-Crafts reactions[13], condensation reactions[11], and heavy oil cracking[14].

The use of next-generation environmentally friendly fuels has recently been increasingly popular. For example, dimethyl ether (DME) is an excellent, efficient alternative fuel for use in a diesel engine, with almost smoke-free combustion[23,24]. Dimethyl ether can be synthesized using a solid acid catalyst via methanol dehydration or directly from CO/CO2 hydrogenation over a bifunctional catalyst. However, methanol dehydration to dimethyl ether is a potentially significant method that is more advantageous in terms of thermodynamics and economics[15]. Therefore, developing a low-cost and efficient solid acid catalyst for methanol dehydration to dimethyl ether was necessary. In this study, palm oil FA was pretreated hydrothermally, followed by sulfuric acid activation to prepare an excellent solid acid catalyst. In addition, The solid acid catalyst was characterized by XRD, FT-IR, TGA, BET, TPD-NH3 and SEM. Finely the activity of the catalyst was evaluated using a fixed bed reactor.

Result and Discussion

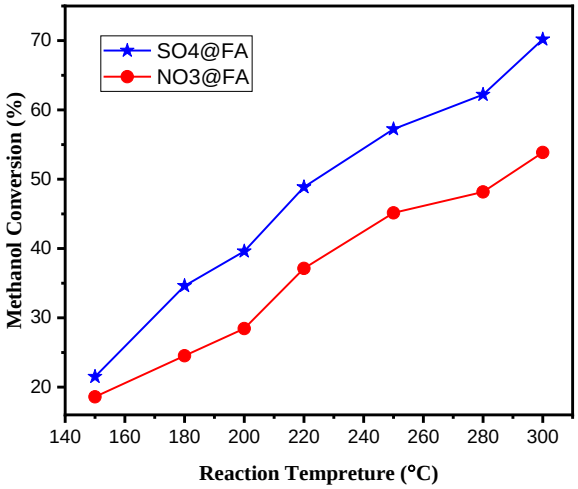

Figure 1: Catalyst performance in term of methanol conversion

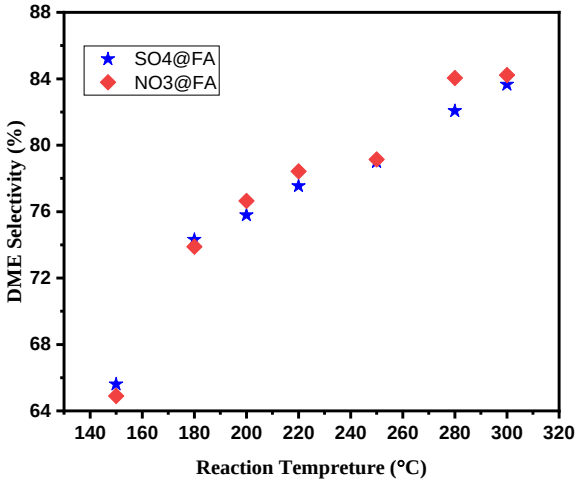

Figure 2: Catalyst activity in term of DME selectivity

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EE17-237

Evaluation of diethylenetriamine functionalized polymer adsorbent for carbon dioxide capture from natural gas

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ABSTRACT. The presence of CO_2 at high contents (up to 70 mol%) in natural gas (NG) is undermining its transportation and application. Thus, removal of CO_2 is an essential step in NG refining not only to protect the pipelines and plant equipment but also to bring NG to the quality necessary for downstream processing and sales. In this study, diethylenetriamine (DETA) amine covalently bonded to fibrous adsorbent made of polyethylene/polypropylene (PE/PP) non-woven sheet grafted to vinyl benzyl chloride (VBC) was investigated for CO_2 capture. The physical and chemical properties of the adsorbent were evaluated using Fourier transform infrared spectroscopy (FTIR), thermogravimetric analysis (TGA), scanning electron microscopy (SEM), and Brunauer-Emmett-Teller (BET). The effects of pressure and concentration of CO_2 in its binary mixture with CH_4 on the adsorption capacity were studied using gravimetric sorption system. The immobilization of DETA amine groups onto the poly (VBC) grafted adsorbent yielded an excellent fibrous adsorbent with 3.49 mmol/g CO_2 adsorption capacity when amine content was 5.23 mmol/g, which is 5 folds higher than the poly (VBC) grafted counterpart at 30 bar and 30 °C. The increase in pressure and CO_2 content in the gas mixtures led to an increasing trend in the CO_2 adsorption capacity. The results obtained from this study suggests that DETA containing fibrous adsorbent has a strong potential for application in CO_2 capture from natural gas. Further work is currently underway to test the new adsorbent in a packed bed column under dynamic conditions.

Keywords: Polyethylene/polypropylene (PE/PP); Amine-functionalized solid adsorbent; CO_2 capture; natural gas

ENERGY AND ECONOMICS (EEC)

EEC1-174

THE EFFECT OF INITIAL MOISTURE CONTENT ON DRYING STINGLESS BEES HONEY BY LOW-TEMPERATURE VACUUM DRYING WITH INDUCED NUCLEATION BOILING METHOD

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Extended Abstract

Low-Temperature Vacuum Drying with Induced Nucleation Boiling (LTVD-NB) is a new and efficient method to reduce the moisture content (MC) of honey without altering or damaging its nutritional content [1]. However, the effect of initial MC to dewater stingless bees honey (SBH) is not fully discovered. Therefore, the objective of this research is to investigate the effect of the initial MC of SBH on the dewatering rate. 200 g of SBH with three different initial MC which were 22.5 %, 24.5 % and 27.5 % were heated at 45 °C at a pressure 5 kPa. The honey sample was dewatered for 5 minutes, and each condition was repeated three times. The final MC was measured by a digital refractometer. Figure 1 shows the reduction of MC for each initial MC. It shows the highest reduction of MC occurred at initial MC 27.5 %, where 1.7 % of MC was reduced. While the lowest reduction was 1.1 % for initial MC of 22.5 %. Figure 2 shows the dewatering rate of SBH for each initial MC. The result shows consistent trend with the reduction of MC. It shows that the highest dewatering rate was also obtained at initial MC 27.5 % which was 0.34 %/min. While the lowest dewatering rate was obtained at initial MC 22.5 % which was 0.22 %/min. This is due to the removal of moisture by breaking of hydrogen bond was slower at low moisture [2]. Therefore, the lowest initial MC resulting in a low dewatering rate, and this is correlated with the bond strength between molecules.

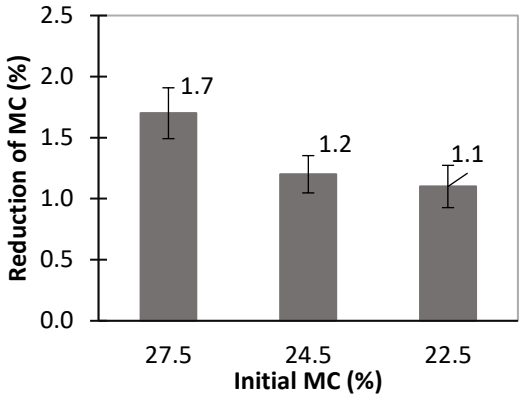

Figure 1: The reduction of MC for each initial MC after dewatering process.

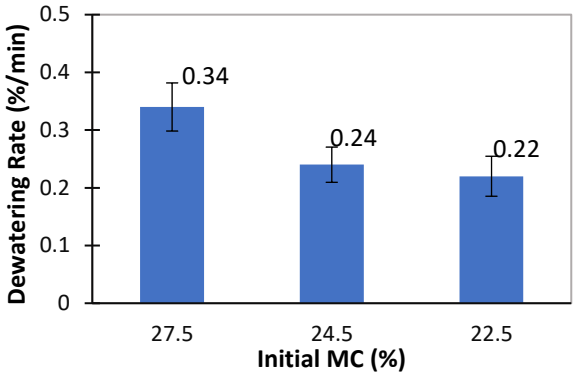

Figure 2: The dewatering rate for each initial MC.

Keywords: stingless bee honey; dewatering; vacuum drying; nucleate boiling; moisture content

Acknowledgement

The authors would like to thank the Ministry of Higher Education (Malaysia) and Universiti Malaysia Pahang for funding this work FRGS/1/2018/TK03/UMP/02/25 (RDU190192) and RDU190381.

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FUEL CELL (FC)

FC1-182

Review of Pt and Pt-based catalyst in direct borohydride fuel cell applications

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Abstract

The direct liquid fuel cell (DLFC) is a promising application. However, the fuel cell system has a poor kinetic reaction, requiring the system to use a large number of catalysts to generate catalysts with low power densities. As a result, DBFCs has caught the interest of researchers due to their unique qualities, which include high power density, low operating temperature, and high open circuit potential. Generally, platinum and platinum-based catalyst have received a substantial amount of attention and are the most popular catalysts for DBFC. However, Pt is a relatively expensive metal and quickly dissolved and aggregated in bad operating conditions, resulting in an expensive catalyst with poor electrocatalytic activity and stability. This review discusses the evolution and recent improvements of Pt and Pt-based electrocatalysts. The main focus of the discussion is on the structure and morphology, which considerably improve the catalytic activity and stability of the catalyst. Finally, recent studies have focused on the use of electrocatalysts such as Pt single metal, Pt alloy catalyst (including binary alloys, multi-composited platinum alloys, and platinum and metal oxides), as well as platinum and non-metals (including platinum/metal-nitrogen doped carbon and platinum and other non-metals), which have intrigued the interest of researchers due to their significant properties that can contribute to excellent BOR and DBFC performance.

Keywords: Platinum; electrocatalyst; morphology; BOR; DBFC

Introduction

Direct liquid fuel cells (DLFC) have some benefits over hydrogen-based fuel cell devices. In general, liquid fuels are simpler to store and organize than compressed gases. Furthermore, the adaption of current fossil-based fuels requires far lower capital costs. Among several alcohols, most notably methanol, borohydride emerges as an intriguing and viable DLFC fuel choice. Therefore, the majority of publications on borohydride as a hydrogen storage chemical and direct borohydride fuel cells (DBFCs) have increased dramatically during the previous decade [1]. The invention of an efficient, stable, and cost-effective borohydride oxidation catalyst is a critical problem in the development of cost-effective DBFCs. Catalysts for DBFC anodes are classified into four categories: transition metals (Cu, Ni), precious metals (Pd, Pt, Au), hydrogen storage alloys, as well as bimetallic catalysts. For example, Pd, Pt, and Ni exhibit high electrode kinetics, high power density, and fuel utilization. As a result, it enhanced the power efficiency for power conversion efficiency. Yet, in DBFCs, carbon-supported platinum catalysts are still the most widely utilized and high-performance electrocatalysts for both BH_4^- oxidation and oxygen reduction [2].

Pt-based catalyst

In the early stage of fuel cells' development, only black Pt NPs were utilized as anode and cathode catalysts. Pt catalysts have higher activity and endurance than any other single noble metal catalyst for fuel cells, even though a high loading of Pt catalyst is necessary to obtain good power density due

to the Pt catalyst's substantial over potential. However, in the absence of support materials, increased Pt concentration causes agglomeration of Pt NPs and, as a result, a decrease in surface area, impeding catalytic activity [3]. Olu et al. stated that the goal of this work is to investigate several forms of anodes for use in DBFC and DABFC systems, employing various types of catalysts (Pt/C or Pd/C) or different morphologies. SEM photographs of the anodic active layer in Figure 1 show a broken morphology when Pt/C is pasted on the 3D carbon cloth matrix, but the Pt/C active layer sprayed on the flat Nafion® membrane exhibits a smooth surface [4].

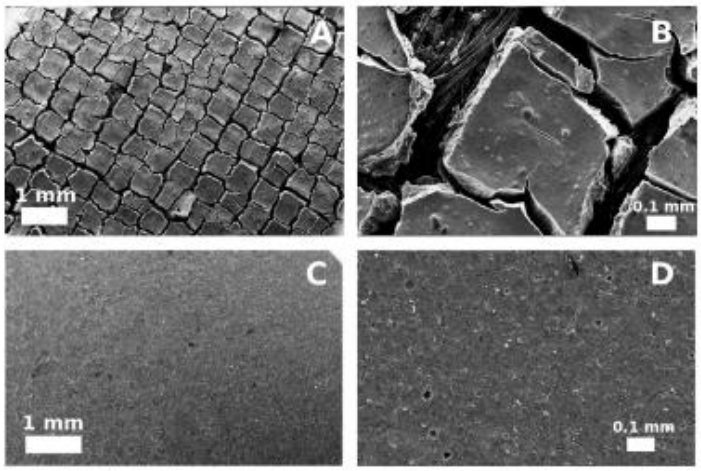

Fig. 1: SEM images of a homemade anodic Pt/C active layer placed on carbon cloth (A and B), as well as a standard anodic Pt/C active layer painted on the Nafion® surface [4].

Conclusion

In summary, Pt-based catalysts exhibit extremely high catalytic activity and stability in direct borohydride fuel cells. Different catalyst compositions, topologies, and morphologies can encourage active site exposure, increasing catalytic activity as well as long-term stability. Furthermore, there are significant challenges in the creation of Pt-based catalysts. Based on the findings of this work, we anticipate that with continual developments in technology and material characterization, together with ongoing theoretical research, the catalytic activity and stability of the catalyst can be improved, contributing to outstanding BOR and DBFC performance.

Acknowledgements

This work was supported by Universiti Kebangsaan Malaysia (UKM) via research sponsorship DIP-2020-015.

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FC2-183

A REVIEW ON NAFION MEMBRANES FOR DIRECT BOROHYDRIDE FUEL CELL (DBFC)

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Extended Abstract

Direct borohydride fuel cell (DBFC) is a promising future power source for low operating temperatures, easy transportation, and the possible use of non -precious metal catalysts. DBFC supplies electricity through the reduction of liquid or gaseous oxides and the oxidation of borohydride ions (BH_4^-). Sodium borohydride ($NaBH_4$) is used as a non -hydrocarbon liquid fuel, thus avoiding the release of carbon dioxide, as occurs in alcohol -fed fuel cells. The main advantages of sodium borohydride as a fuel are long -term stability and high energy density. The membrane is used as a separator in the fuel cell between the cathodic and anodic compartments and allows good ion transport to maintain the charge balance in the fuel cell. The Nafion membrane is the most widely used polymer electrolyte membrane in fuel cells. This is so because Nafion has the ability to carry protons, high chemical stability, and good structural and mechanical strength. This review paper discusses the Nafion membrane, as well as the modified Nafion membrane. The properties of the Nafion membrane such as proton conductivity, thermal stability, borohydride crossover, water uptake and surface morphology are also discussed in this review.

***Keywords**: Fuel cell; Direct borohydride fuel cell; membrane; Nafion*

Introduction

Fuel cells are the most potential alternative energy converters for eliminating many of the challenges associated with traditional direct combustion energy converters. Fuel cells are also regarded as a very sustainable technology because they do not produce pollutants like SO_x, NO_x, or CO_2 [1]. However, some challenges that stand in the way of their commercialization, such as material performance and durability issues, as well as high costs, must be addressed. A fuel cell is an electrochemical energy conversion device that transfers chemical energy directly into electrical energy as long as fuel and oxidants are present, making it a battery-based version of continuous operation. There are several different types of fuel cells, which are classed mostly according on their electrolytes. The proton exchange membrane fuel cell (PEMFC) is the most developed and researched class. PEMFC are divided into several subclasses based on the fuel utilised, such as direct methanol fuel cells (DMFC) and DBFC. The non-toxic, high volumetric energy density, and ease of oxidation of the fuel at its core have attracted interest to DBFC [2].

Nafion Membrane

Fabrication of PEM is an important part of the fuel cell manufacturing process [3]. Commercial Nafion membranes are commonly employed as solid electrolytes, and they have a number of advantages, including good chemical stability, outstanding thermal stability, a significant level of conductivity, mechanical qualities that are good as well as long lifespan [4], [5]. Nafion is a fluorinated polymer with a polytetrafluoroethylene (PTFE) backbone as well as a lengthy chain of long perfluorovinyl ether pendants that are regularly spaced and terminated with a sulfonic as well as carboxylic ion functional

group. Thermal and chemical stability are provided by Nafion PTFE, whereas proton conducting groups are provided by hydrophilic perfluorinated side chains [6].

Conclusion

In fuel cells like the DMFC, nafion membranes are frequently employed as PEM. This is due to Nafion's excellent performance. Nonetheless, there are few research on the usage of Nafion membranes in DBFC. Furthermore, because this Nafion membrane is relatively expensive, its use in fuel cells is restricted. Nafion membranes can be mixed with inorganic materials to lower the cost of the membrane and increase its mechanical stability.

Acknowledgement

The authors gratefully acknowledge the financial support from Universiti Kebangsaan Malaysia (UKM) under DIP-2020-015.

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FC3-131

HYDROGEN PRODUCTION VIA METHANE PYROLYSIS USING NI-CU-MN SPINEL CATAYST FOR HYDROCARBON FUELLED SOLID OXIDE FUEL CELL APPLICATIONS

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Introduction

Materials used to develop solid oxide fuel cell (SOFC) components, namely, electrolyte, anode and cathode are the key criteria to enable electrochemical reactions to take place in the device. The materials typically made of solid oxides, where spinel is among the materials that is widely studied for SOFC applications. The flexibility of the spinel structure under redox environment allows the material to be developed as SOFC components, including catalyst for hydrocarbon reforming [1,2]. Thus, this study aims to evaluate the ability of the Ni-Cu-Mn spinel for hydrogen production via methane reforming. The three elements were chosen due to their unique contribution in enhancing catalytic reaction and stability.

Methodology

A simple and efficient technique namely the glycine nitrate process was used to produce homogeneous spinel powders. All the metal nitrates were mixed in deionized water for 30 min prior to mixing with glycine with different mixing time (e.g., A=1 h, B=12 h, C=24 h, D=36 h, E=48 h) to ensure complete binding of the nitrates. Then, the temperature of the mixtures was slowly increased until the point of combustion and dried in the oven for 18 h at 200 ° to eliminate water content. Calcination temperature was fixed at 900 °C for all the precursor powders to allow the formation and crystallization of spinel phase. All the spinels were reduced under H_2:N_2 (1:9) environment with 100 ml/min flowrate at 800 °C for 1 h, followed by exposure to dry CH_4 for 1 h. Reformed gas was collected using Tedlar sampling beg and analyzed using gas chromatography-thermal conductivity detector. The spent spinel catalysts were characterized via thermogravimetric analysis to evaluate the carbon formation rate.

Results and discussion

Fig. 1 shows hydrogen can be produced around 6-8 % when spinel catalyst were present, indicating the potential of spinel to act as catalyst. The main reforming reaction that took place on the catalyst was determined to be hydrogen pyrolysis due to the dry condition of CH_4. The low amount of hydrogen production was due to unfavorable temperature for methane pyrolysis and the absence of reforming agents such as steam or carbon dioxide to increase the reforming rate. Thus, future study will include steam to allow steam reforming, which is a dominant reforming reaction at 800 °C.

Fig. 2 shows the carbon reformation rate was the highest for sample A. Such high rate indicates sample A have high catalytic activity and reflected with high hydrogen production, but low stability due to slow rate of carbon oxidation. On the other hand, sample C with average hydrogen production exhibits stable carbon formation rate and expected to have longer lifetime compared to other samples. The main

reason for the difference is due to the favorable microstructure properties on sample C, which influences overall active surface area and metal-support interaction during the reforming reaction.

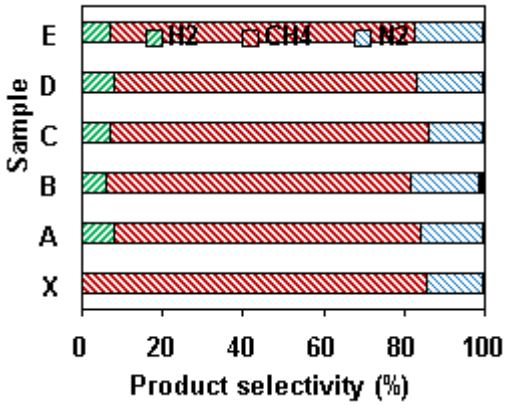

Fig. 1: Hydrogen production via methane pyrolysis for Ni-Cu-Mn spinels at 800 °C (X=No catalyst)

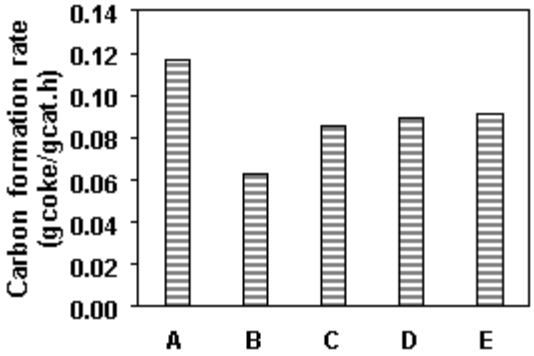

Fig. 2: Carbon formation rate for Ni-Cu-Mn spinels at 800 °C after 1 h exposure to methane

Conclusion

Preliminary results showed Ni-Cu-Mn spinel can act as a hydrogen production catalyst. However, reforming agents such as steam and carbon dioxide are needed due to the operating temperature that is unfavorable for methane pyrolysis.

Keywords: Spinel catalysts; hydrogen production; methane pyrolysis; solid oxide fuel cell; performance.

Acknowledgement

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FC4-190

A SHORT REVIEW OF BIOPOLYMER AS AN ALTERNATIVE MEMBRANE IN DIRECT METHANOL FUEL CELL (DMFC) APPLICATION

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Abstract

Chitosan and alginate are promising biopolymers as alternative membrane in fuel cell applications. However, membranes produced by chitosan or alginate alone have a limited range of applications due to their fragility, poor mechanical stability, low water resistance, and lack of specialized functional features. Numerous techniques have been investigated in order to enhance the characteristics of these biopolymer membranes, including the incorporation of plasticizers or crosslinker, compositing, mixing and controlling temperature in the drying process. This short review will provide an insight of general properties of chitosan and alginate, chitosan and alginate modification usage in DMFC application and propose new perspectives for future studies with these biopolymers.

Introduction

Direct methanol fuel cell (DMFC) is an electrochemical device that converts directly liquid methanol into electrical energy and regarded as a potential power source for the next generation portable devices due to its low emissions, high energy density, ambient operational environment and convenience of liquid fuel replenishment. However, numerous important issues must be resolved before the DMFC system can be commercialized as a viable energy source such as high cost, low durability and fuel crossover. Among those issues, improving fuel crossover is one of the most critical issues. The main goal of this research is to produce biopolymer-based electrolyte membrane for fuel cell applications.

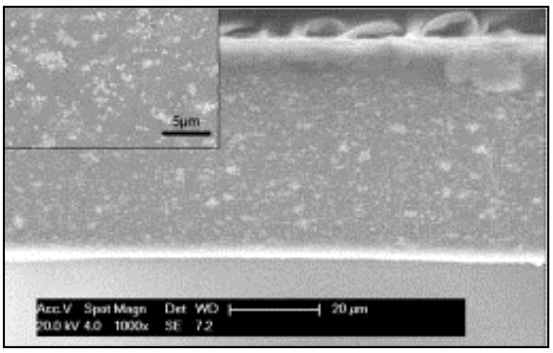
Chitosan is a biodegradable compound that is widely used biomaterial in a variety of applications, including the pharmaceutical sector, fuel cells, and wastewater treatment. Owing to its biodegradable, biocompatible, antibacterial, and hydrophilic qualities, it is also employed in food packaging. Despite its benefits, chitosan has a number of disadvantages that restrict its applicability. Chitosan is a fibrous material with limited mechanical stability and electrical conductivity. Additionally, it is extremely brittle because to its high glass transition temperature [1].

Alginate is a prominent water-soluble polymer derived from brown seaweed. It has been widely studied and employed various applications because to its biocompatibility, low toxicity, low cost, and moderate gelation when divalent cations such as Ca^{2+} are added. However, this polymer also has some drawbacks such as low mechanical strength and high water solubility. The disadvantages of chitosan and alginate can be overcome through several approaches such as blending with other polymers, doping with inorganic filler and incorporated with plasticizers or crosslinking agents [2].

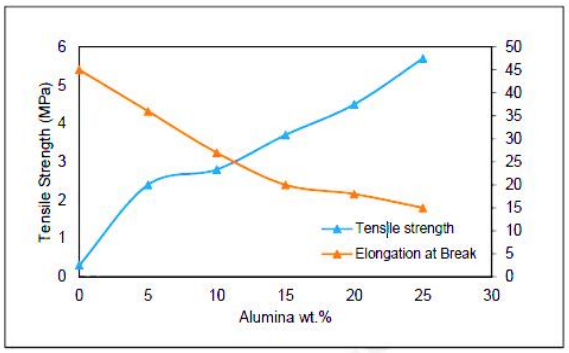
Current advances of chitosan and alginate as electrolyte membranes in fuel cell

Modification of chitosan were designed in order to enhance proton conductivity and mechanical stability. Wua et al. [3] studied the incorporation of organophosphorylated titania submicrospheres (OPTi) as promising inorganic fillers into chitosan polymer matrix. The presence of ionic crosslinking agent such as NH_2 and PO_3H_2 could improve the compatibility between inorganic fillers and polymer

matrix. Figure 1 displayed the FESEM image that proved the OPTi were homogenously dispersed in chitosan.



Shaari et al. [4] investigated the addition of alumina as inorganic filler into sodium alginate membrane. The findings showed that the composite membrane improved membrane performance much better than pure sodium alginate membrane. The mechanical properties also increased due to the good interaction between alumina filler and the polymer. Figure 2 showed the mechanical stability of sodium alginate/alumina composite membranes.



Keywords: Chitosan; alginate; biopolymer; fuel cell

Acknowledgement

The authors would like to express their gratitude to Universiti Kebangsaan Malaysia (UKM) and the Ministry of Higher Education for providing financial assistance through a Fundamental Research Grant Scheme FRGS/1/2021/STG05/UKM/02/10.

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FC5-170

HIGHLY DURABLE AND STABLE Fe-N-C CATALYST FOR OXYGEN REDUCTION REACTION IN ACIDIC MEDIUM

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Extended Abstract

In 2015, the United Nations (UN) introduced 17 Sustainability Development Goals (SDG17) as the blueprint to achieve a better and sustainable future. One of the targets of SDGs is to ensure access to affordable, sustainable, reliable, and modern energy for all. Therefore, it is vital to reduce the dependency on non-renewable fossil fuel-based energy generation to achieve the goals. Fuel cells are one the promising energy generation devices that are clean and environmentally friendly and use alternative fuels such as hydrogen and methanol by converting chemical energy to electrical energy through a pair of redox reactions. However, its large-scale application is hindered by its sluggish oxygen reduction reaction (ORR) at the cathode and requires a highly active yet expensive Pt/C catalyst. To overcome this, researchers have started to look at the use of non-noble metal as the ORR catalyst. Therefore, this work is intended to introduce Fe-based non-noble metal catalyst and investigate the effect of different Fe-N-C morphologies prepared from different precursors on the catalyst's durability and stability during the operation of ORR in an acidic medium. Three different morphologies, namely hollow sphere (HS), amorphous bulky structure (B) and needle-like structure (N) of Fe-N-C were synthesised at the fixed Fe precursor composition. ZIF-8, poly(aniline) and 10,10'-Dibromo-9,9'-bianthry were used as the respective synthesis precursor to produce N-doped carbon with the aforementioned morphologies. The morphology study, crystal structure, pore characteristics and elemental compositions were determined on the samples. To investigate the electrocatalytic activity of the catalysts towards the ORR, a three-electrode setup was used for the electrochemical analysis with 0.1 M $HClO_4$ as the acidic electrolyte. Accelerated durability test (ADT) and chronoamperometry test were used, respectively for the durability and stability study of the catalyst. From the electrochemical test, Fe-N-C_HS shows the highest onset potential (E_{onset} = 0.83 V vs RHE) compared to Fe-N-C_B (E_{onset} = 0.8 V vs RHE) and Fe-N-C_N (E_{onset} = 0.7 V vs RHE). Fig. 1 shows that Fe-N-C_HS demonstrated active sites activation with increase in half wave potential after 5,000 ADT cycles. This is also observed from the increase in the current density of ORR in cyclic voltammogram. Meanwhile, this sample demonstrating the highest current retention of 80%, compared to other samples and Pt/C, after the 10,000 s chronoamperometry test, as shown in Table 1. The highly active and durable Fe-N-C_HS catalyst is attributed to the presence of both micro- and mesoporous structure with abundant stable Fe-N_x active sites which is less prone to surface deactivation. This work shows that the hollow sphere structure mimicking the pristine ZIF-8 structure possesses the key characteristics for an ORR catalyst in acidic medium, which is able to provide a good catalytic activity and

maintain good stability and durability during the long-term operation in the proton exchange membrane fuel cell.

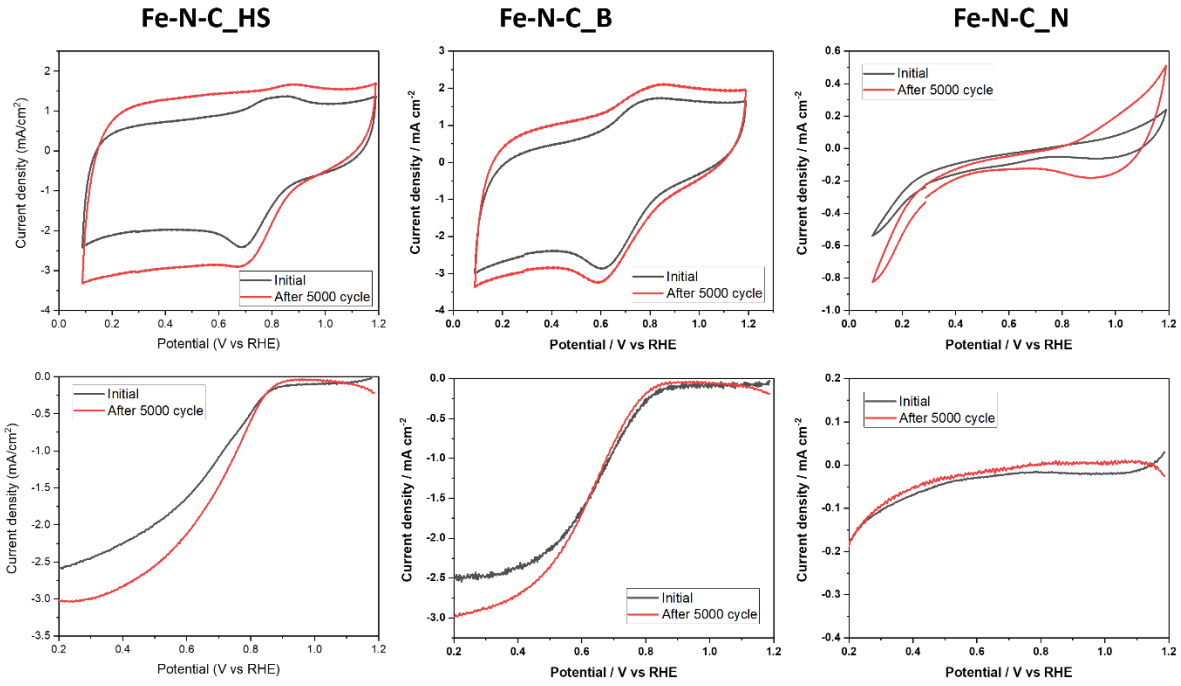

Fig. 1: CV and LSV before and after 5000 cycles ADT in 0.1M $HClO_4$

Table 1. Current remains after 10 000s chronoamperometry test

Catalysts	Performance (%)
Fe-N-C_HS	80
Fe-N-C_B	75
Fe-N-C_N	35
Pt/C	61

Keywords: Fuel Cells; Electrocatalyst; Oxygen Reduction Reactions; Durability.

Acknowledgement
The authors thank the Ministry of Higher Education Malaysia for the financial support through the Fundamental Research Grant Scheme (project code: FRGS/1/2019/STG01/UKM/02/2) and analysis facilities from Malaysian Nuclear Agency.

FC6-189

RELATIONSHIP BETWEEN PHASE EVOLUTION AND ELECTRICAL PROPERTIES OF Cu-DOPED $(Mn,Co)_3O_4$ SPINEL

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Introduction

The Cu-doped $(Mn,Co)_3O_4$ spinel exhibits great potential in mitigating Cr migration from metallic interconnects to the cathode material [1]. Spinel materials are generally represented by the formula AB_2O_4, in which oxygen anions are in the face-centered-cubic lattice sites, A and B are the divalent, trivalent, or quadrivalent cations in the tetrahedral and octahedral sites [2]. The tetragonal and cubic structures that co-exist in $Mn_xCo_{3-x}O_4$ spinel with x between 0.25 and 1.25 undergo a cubic ↔ tetragonal phase transition upon heating and cooling, caused by the displacement of its oxygen ions that increase the symmetry of its tetragonal phase structure [3]. The lattice parameters of the $Mn_xCo_{3-x}O_4$ spinel oxides with cubic and tetragonal structures increase as the Mn-content increases, thus, leading to the compression of empty octahedral sites that promotes electrical conduction [4,5]. This paper aims to elucidate how the electrical properties of the Cu-doped $(Mn,Co)_3O_4$ spinel material can be influenced by the phase transition phenomenon.

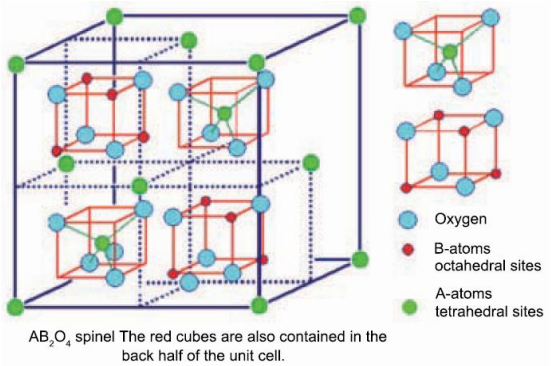

Fig 3: Unit cell of spinel oxides [2].

Methodology

Cu-doped $(Mn,Co)_3O_4$ spinel powders prepared through Pechini sol-gel technique were uniaxially pressed into pellet form. The green pellets were then sintered at 1000 °C, 1100 °C, 1200 °C, and 1300 °C for 4 h with a heating rate of 5 °C/min. X-ray diffractometer was used to examine the phase evolution of the Cu-doped $(Mn, Co)_3O_4$, pellets. The DC conductivity of the pelletized Cu-doped (Mn,

$Co)_3O_4$ was then used to measure the between 400 and 800 °C in air using a four-probe DC conductivity measuring system.

Results and discussion

XRD results in Fig. 2 shows the phase evolution of Cu-doped $(Mn,Co)_3O_4$ spinel sintered at four different sintering temperatures. As the sintering temperature increases from 1000 °C to 1100 °C, the dual phase $(Cu,Mn,Co)_3O_4$ spinel consisting of cubic CuMnCoO and tetragonal Mn_2CoO_4 structure transformed into $MnCo_2O_4$ and $Cu_{1.5}Mn_{1.5}O_4$, both of which exhibit cubic forms. Since the electrical conductivity of the $(Cu,Mn,Co)_3O_4$ spinel is driven by the hopping mechanism of cations with different valence states between the octahedral sites, the phase transformation results in better electrical conduction. The electrical conductivity of Cu-doped $(Mn,Co)_3O_4$ spinel increases from 49 S cm^{-1} to 116 S cm^{-1} as the sintering temperature increases from 1000°C to 1200°C, whereas their activation energy obtained from the slope of the Arrhenius plot is nearly identical (Table 1). A cubic Cu_3O_4 phase observed when the sintering temperature further increases to 1300 °C is attributed to the decomposition of CuO. Despite providing the highest electrical conductivity of 135 S cm^{-1}, the Cu-doped $(Mn,Co)_3O_4$ spinel sintered at the 1300°C requires the highest activation energy of electrical conduction (0.418 eV).

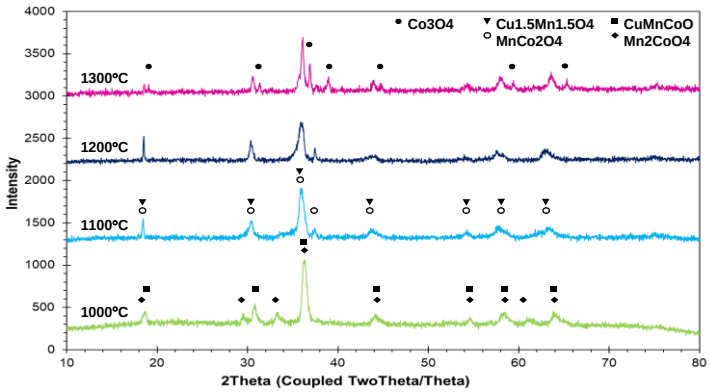

Fig. 2: XRD patterns of the Cu-doped $(Mn,Co)_3O_4$ pellets sintered at different temperatures

Table 1: Electrical properties of the $(Cu,Mn,Co)_3O_4$ spinel sintered at different temperatures

Parameters	**Sintering temperature**			
	1000 ºC	**1100 ºC**	**1200 ºC**	**1300 ºC**
Activation energy (eV)	0.399	0.398	0.400	0.418
Conductivity (S cm^{-1})	49	90	115	135

Conclusion

Considering that Cu-doped $(Mn,Co)_3O_4$ spinel is chemically unstable as the temperature increased above 1000 °C, the material can only be considered for application in intermediate-temperature solid oxide fuel cell that operates below 800 °C.

Keywords: Spinel; phase transition; electrical properties; solid oxide fuel cell.

Acknowledgement

The study was funded by the Ministry of Higher Education, Malaysia, through GUP-076-2019. The authors would like to extend their gratitude to the Centre for Research and Instrumentation Management, Universiti Kebangsaan Malaysia for their excellent facilities.

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FC7-205

Potential of Regenerative Fuel Cell in Electric Vehicle Charging Station: A Brief Review

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Extended Abstract

The increasing number of electric vehicles (EVs) on the road demands more charging infrastructure to be built in Malaysia. However, the design of available EV charging stations is still reliant on fossil fuels for electricity sources. This defeats the purpose of having EVs for zero-emission and green mobility. Thus, attention has been shifted towards the use of renewable energies to power the EV charging stations. One of the alternatives that has received a lot of attention is the regenerative fuel cell (RFC), which can function as both an energy storage device for the intermittent RE supply and an electricity generator to charge the EVs. This paper attempts to review recent studies on the development of electric vehicle charging stations powered by regenerative fuel. First, it discusses the difference between two types of regenerative fuel cells, namely discrete-RFC and unitized-RFC. Then, it presents the potential design of an EV charging station with the integration of RFC. Finally, the issue and challenges in developing the RFC powered charging station are provided.

Introduction

Malaysia has introduced a low-carbon mobility blueprint in the 12th Malaysia Plan (12MP) to guide the planning, implementation, monitoring, and evaluation of green mobility initiatives [1]. Promoting the transition from internal combustion engines (ICEs) to electric vehicles (EVs) is part of the initiatives done by the government to reduce GHG emissions. Currently, the number of EVs in Malaysia is increasing but at a slow rate. The lack of EV charging infrastructure is one of the factors that prevent the country from expediting the adoption rate and instilling confidence among locals. Thus, the government targets to establish a more comprehensive charging infrastructure by installing 10,000 EV charging stations by 2025 [2]. These charging stations, however, are still dependent on fossil fuels to operate, which defeats the purpose of having the EVs for a cleaner environment and causes carbon-zero road travel hard to achieve.

Hence, there is an effort to utilize renewable energies (REs) like solar and as the source of energy for EV charging stations. Renewable energy has the advantages of low-carbon emissions and competitive power generation costs, but the uncertainty and intermittency of renewable energy sources will result in randomness and volatility of energy supply and usage [3]. Therefore, batteries are commonly utilized together with REs as a storage system. They are preferred due to their high performance, versatility, low maintenance, and affordability. Somehow, the utilization of rare elements in batteries has a negative impact on the environment [4]. It is expected that the global electronic mobility demand will increase battery production to around 1725 GWh by 2030, with nickel being the dominant raw material in lithium-ion batteries [5,6]. Currently, battery demand accounts for 4% of annual global nickel production, and the gradual scenario predicts that nickel demand will rise to 34% of current mining production by 2030. Even though the batteries can be recycled, the process is costly and requires sophisticated equipment to treat harmful emissions. As a result, they are most likely to end up in landfills. The heavy metals from the batteries may leak into the ground, causing environmental pollution as well as direct threats to human health [7].

Regenerative fuel cell (RFC) is one of the promising alternatives to batteries for energy storage technology. Compared to fuel cells used in vehicles that have separate hydrogen production systems, the RFC is an integration of a water electrolyzer (WE) and hydrogen fuel cell (FC) in one system [8]. Therefore, it can store energy in the form of hydrogen and concurrently generate electricity. This cut off the need for hydrogen transportation to the EV charging stations which are known to be costly. The integration of RFC with renewable sources to power EV charging stations helps to reduce the dependency on the grid for charging. It can also be used as a microgrid concept, which is useful in remote areas [9]. A number of studies have examined the potential of renewable energies as the electricity source for EV charging stations, but there is still limited research conducted on the integration of RFC with the REs [6,10]. An insight into the types of RFC available, applicable design for the charging station as well as issues and challenges for the deployment, may contribute to the development 100% clean electricity for future EV charging. This work may also benefit the EV charging station developer as it provides an alternative design that could speed up the adoption of green mobility.

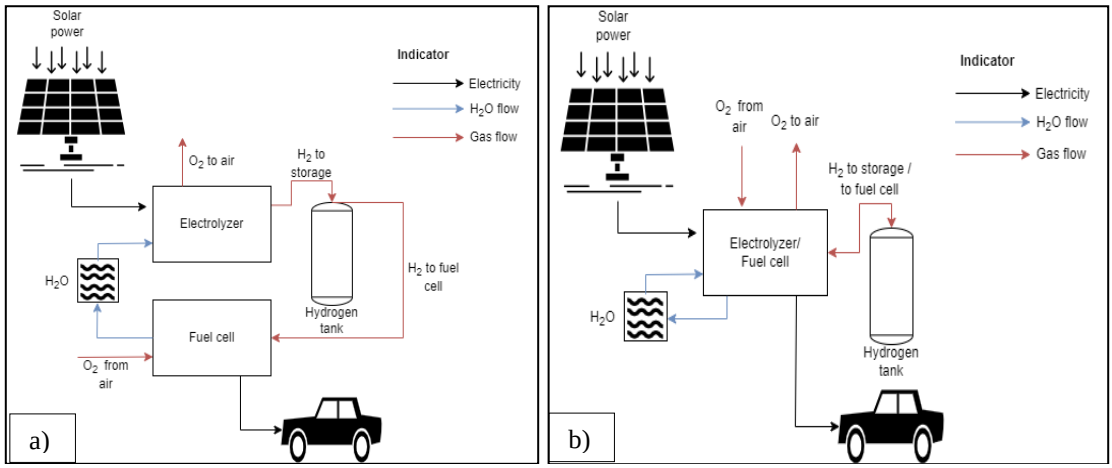

Fig.1 Schematic diagram of a) Discrete-RFC and b) Unitized-RFC

Keywords: Electrolyzer; hydrogen; battery; renewable energy; green technology

Acknowledgement
The authors would like to offer their utmost appreciation to Tenaga Nasional Berhad Research for funding and supporting the project.

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FC8-236

INFLUENCE OF THE SINTERING TEMPERATURE ON THE MICROSTUCTURAL AND ELECTROCHEMICAL BEHAVIOURS OF $SrFe_{0.9}Ti_{0.1}O_{3-\delta}$– $Ce_{0.8}Sm_{0.2}O_{1.9}$ COMPOSITE CATHODE

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Extended Abstract

To improve the performance of cathode for solid oxide fuel cell (SOFC), it is essential to understand the effect of sintering conditions, especially temperature. During sintering, the triple-phase boundaries (TPBs) will forms accordingly and later, the length of TPB formed will be influenced the the charge-transfer reaction and the activation polarisation loss. Concerning all these factors, thus it is crucial to choose the best condition of the sintering process [1]. In this paper, the effect of sintering temperature on the microstructural and electrochemical characteristecs was studied. The lowest area-specific resistance, ASR values indicate a week's resistance toward ion movement at the cathode [2]. The 90 wt % $SrFe_{0.9}Ti_{0.1}O_{3-\delta}$ (SF_9T_1) and 10 wt % $Ce_{0.8}Sm_{0.2}O_{1.9}$ (SDC) ($9SF_9T_1$-1SDC) were mixed togehter to form $9SF_9T_1$-1SDC composite cathode (9SFT-1SDC) powders and inks. An electrolyte-supported (SDC) symmetrical cells were prepared using the printing techniques using the as-produced $9SF_9T_1$-1SDC cathode inks. The symmetrical cells were sintered at five different temperatures range from 1200, 1250, 1300, 1350, and 1400 °C. Then, the performance test was run at 600 °C – 800 °C. The structural and morphological characteristics of sintered cathode films were evaluated using the field Emission Scanning Electron Microscopy with Energy Dispersive X-Ray Spectroscopy. The ASR-values was obtained from the electrochemical impedance spectroscopy analysis. From the analysis, $9SF_9T_1$-1SDC cathode film sintered at 1250 °C gave the lowest ASR-value of 1.17 Ω cm^2 when operated at 800 °C. This value correlated with the sufficient porosity and densification that allows higher kinetic of the oxygen reduction reaction.

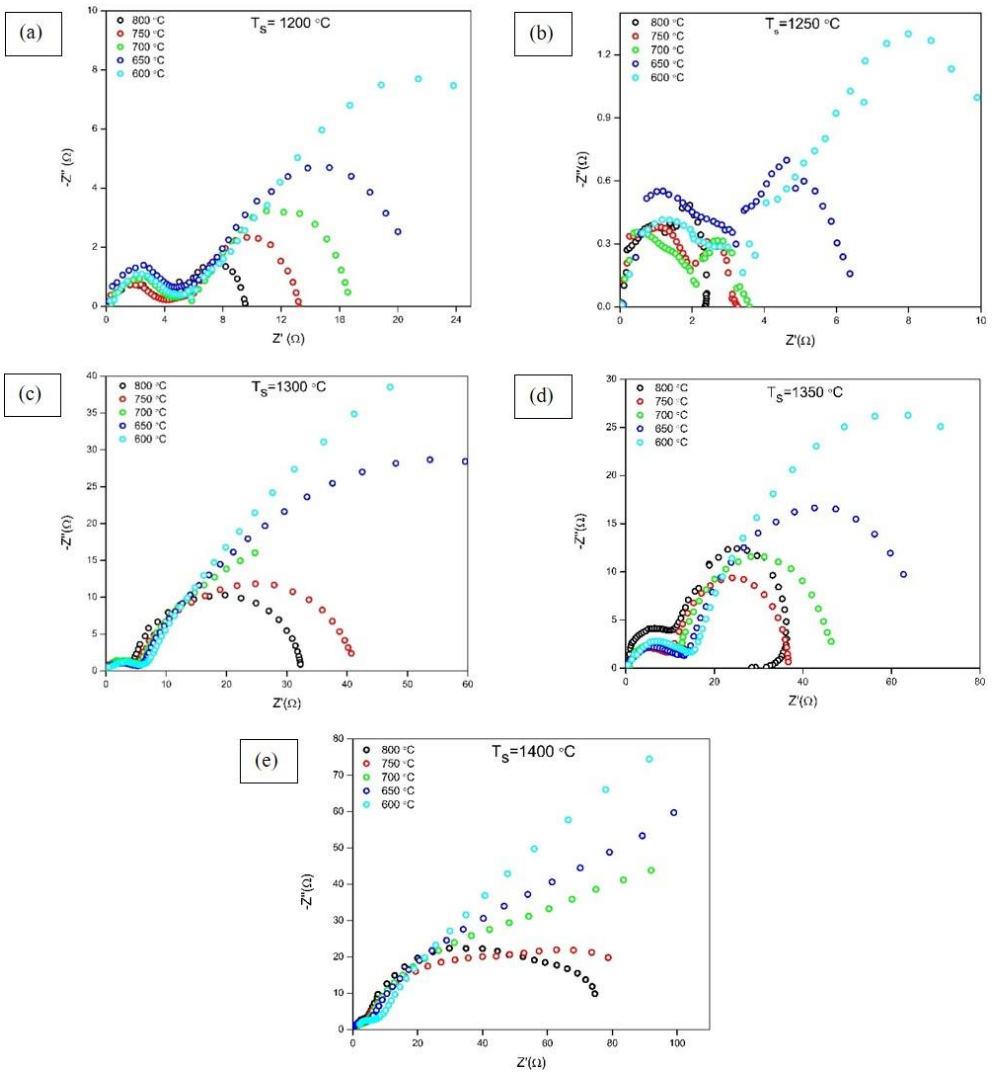

Fig. 1. Impedance spectra of 9SFT-1SDC cathodes sintered at (a)1200 °C, (b) 1250 °C, (c) 1300 °C, (d) 1350 °C, and (e) 1400 °C.

Keywords: Microstructural; electrochemical performance; area-specific resistance; sintering, solid oxide fuel cell

Acknowledgement

This work was funded by the GUP-2020-080 grant number of Universiti Kebangsaan Malaysia (UKM). The authors also recognize their support for using their excellent test equipment by the Center for Research and Instrumentation Management (CRIM) in UKM.

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HYDROGEN ENERGY (HE)

HE1-186

SOLVENT FREE SYNTHESIS OF Ni/TiO_2 AS HIGHLY ACTIVE PHOTOCATALYST FOR PHODECOMPOSITON OF NH_3 TO HYDROGEN GAS

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Extended Abstract

Photocatalytic decomposition of ammonia into green hydrogen production with low energy consumption has been an alternative route to produce zero carbon-free energy. However, yielding a high concentration of hydrogen at low temperatures using a low-cost catalyst remains an extensive challenge to researchers. Most studies have shown that the Ruthenium-based catalyst has proven to produce great activity in ammonia decomposition. However, the high price of ruthenium becomes the main challenge for researchers. Hence, in this study, a photocatalyst consisting of Ni nanoparticles on TiO_2 was synthesized via chemical vapour impregnation to produce an active photocatalyst for NH_3 decomposition to H_2. Chemical vapour impregnation is a solvent-free method based on sublimation of the metal-organic precursor (Nickel (II) acetylacetonate) on Titanium (IV) oxide support in a controlled vacuum system. This study will investigate the effect of sublimation conditions by varying the temperature at 140°C-150°C and time in producing a highly active photocatalyst.

The performance of Ni/TiO_2 photocatalysts is also determined by the effect of calcination and reduction prior to photocatalytic reaction. The photocatalytic ammonia decomposition was carried out in an aqueous ammonia solution (19.1 g/L) under the UV-visible chamber at room temperature for 3hour. The activity was also compared to Ni/TiO_2 produced from wet impregnation, incipient wetness impregnation and photo-deposition to further elucidate the benefit of chemical vapour impregnation to synthesis a highly active catalyst. Since the nickel loading is considerably low on the TiO_2 support, XRD analysis, as shown in Figure 1, showed no transformation in the diffraction of peaks compared to the pure TiO_2. The anatase and rutile forms of Ni/TiO_2 have also remained at approximately the same diffraction angles.

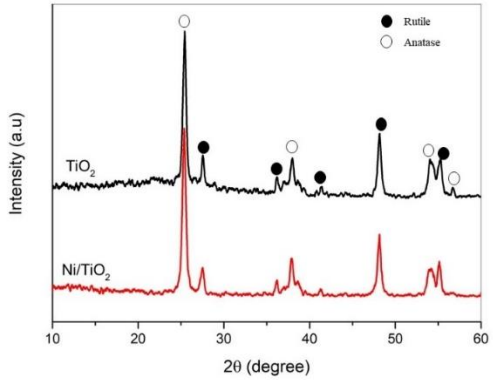

Fig.3: XRD patterns of TiO_2 and Ni/TiO_2.

The optical property of the Ni/TiO_2 was characterized using diffuse reflectance UV-visible spectroscopy. The absorption spectrum of the Ni/TiO_2 has shifted toward the longer wavelength, which is the visible light region when Ni is loaded on TiO_2. Table 1 shows that all photocatalysts have the absorption edge at 379-389 nm with a band gap within 3.22 - 3.31 eV.

Table 1. Optical absorption edge and bandgap energies of TiO2, Ni/TiO2 at different loading.

Photocatalyst	Optical absorption edge	Bandgap
TiO_2	379 nm	3.31 eV
0.4% Ni/TiO_2	383 nm	3.26 eV
0.5% Ni/TiO_2	389 nm	3.22 eV
1% Ni/TiO_2	382 nm	3.27 eV

The photocatalytic hydrogen production via ammonia decomposition varies according to the Ni metal loading from 0.4% to 1.0%. The activity has been shown to decrease as Ni metal loading increases, attributed to the less absorption of UV radiation on the surface of the TiO_2. Hence, this has been demonstrated that photocatalytic decomposition of ammonia works better at 0.4% and 0.5% Ni precursor on TiO_2, as shown in Figure 1.

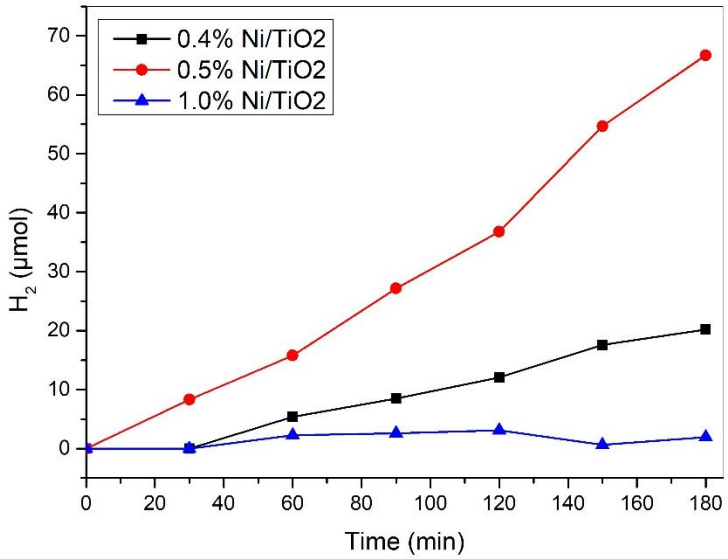

Fig. 4: Hydrogen production from photocatalytic ammonia decomposition of Ni/TiO_2 as a function of time at different loading.

Keywords: Ammonia decomposition; Photocatalytic; Hydrogen; TiO_2

HE2-113

Hydrogen production with the selective oxidation of benzyl alcohol to benzaldehyde in aqueous medium by a noble-metal-free photocatalyst VC/CdS nanowires

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Abstract:

The simultaneous production of the storable and renewable hydrogen with high value-added organic chemicals in a single aqueous system by photocatalysis is an environmentally-friendly and emerging strategy. Here we used CdS NWs (nanowires) with vanadium carbide (VC) attached via facile electrostatic self-assembly. The results showed that compared to pristine CdS NWs, the photocatalytic activity of CdS NWs loaded with the particular amount of VC was dramatically enhanced. Among them, the VC/CS-15 indicated the highest enhancement for simultaneous production of H_2 with selective oxidation of benzyl alcohol into benzaldehyde. The highest hydrogen evolution rate of 20.5 mmol g^{-1} h^{-1} was obtained with more than 99% selectivity for BD production under visible light ($\lambda > 420$ nm) irradiation for 2 h, which was almost 661 times higher than the pristine CdS NWs. This enhancement of photocatalytic activity is due to the VC, which provides a favorable attraction for BO by lowering the zeta potential, along with the active site for hydrogen production, and retard the recombination of electron-hole pairs by increasing the conductivity of the photocatalyst. Moreover, the apparent quantum efficiency (AQE) of VC/CS-15 for BD and H_2 production at monochromatic 420 nm is about 7.5%. At the end of the hydrogen evolution test, the selective oxidation with more than 99% selectivity was obtained. It hopes this work will prove its future significance and move scientific community toward a more economical way for achieving the commercialization of H_2 by photocatalysis.

Keywords:

Hydrogen production, Selective oxidation, Benzaldehyde, Noble-metal-free, Visible light

HE3-135

THE READINESS AND SAFETY OF PUBLIC TO USE HYDROGEN AS FUEL FOR VEHICLES IN MALAYSIA

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Extended Abstract

Global warming due to climate change has greatly motivated and opened the eyes of the world's countries in order to adopt sustainable alternative energy options. One of the aims in Kyoto Protocol (1997) is to reduce the emission of carbon dioxide promotes increase in awareness on environmental protection and motivates the world to find new renewable energy innovations to minimize the world's dependence on fossil fuels. High consumption of fossil fuels in transportation and power sectors increase the emission of carbon gases into the atmosphere and lead to serious negative externalities and environmental degradation.

The effect of global climate change and depletion of fossil fuels lead many countries to start a transition from traditional energy to alternative energies. Technologies of alternative energy include solar panels, hydrogen fuel cells, biomass processors and windmills which are developed, commercialized and utilized to generate energy. Many developed countries pay attention to hydrogen energy because it is abundant, sustainable and environmentally friendly. Hydrogen is a clean energy and can be used as a fuel for any vehicle. Transportation is one of the sectors contributing to high carbon emission in Malaysia. Decarbonizing of the transportation sector could occur using hydrogen as a fuel to minimize the effects of climate change.

Safety and public acceptance are two critical factors influence the implementation of hydrogen as a fuel for vehicles. There is numerous research on the acceptance and safety of the public to use hydrogen-powered vehicles in other countries but few in Malaysia. Therefore, this study assesses the public acceptance, the factors contributing to public acceptance and the safety of using hydrogen as fuel for vehicles in Malaysia. A set of questionnaires was prepared in Google Forms and distributed to respondents through social platforms such as WhatsApp, Facebook, Messenger, Instagram and also Telegram. A pilot study was done to check on the reliability of the questionnaire produced by generating the desired results. 31 respondents were involved in this study. To test the reliability of the scales which represent the independent variables and dependent variables as a group, Cronbach's Alpha was employed. Questions in section 2, knowledge on hydrogen with 11 items has 0.276 alpha value which is less than accepted value 0.7. Hence, all the questions in this section were revised.

The actual data collection was conducted from November 2021 until December 2021. 176 respondents from many parts of Malaysia participated in the questionnaire study. The data collected were analyzed using non-parametric statistical tests such as Chi-Square Test and Spearman Correlation in the SPSS software version 27. The highest number of respondents comes from Peninsular Malaysia about 155 (88.07%) followed by Sarawak with 14 respondents (7.95%). Sabah with 7 respondents (3.98%) showed the least number of respondents. Majority of the respondents were professionals (50%) followed by students (47.16%) and unemployed (2.84%).

Although the number of samples is not totally representative of the population, it can provide a good basis in order to study the factors that influence the public acceptance of vehicles that use

hydrogen fuel. Chi-Square test and Spearman Correlation were used to assess the relationship between hypotheses. The results of statistical analysis indicated that environmental awareness, knowledge on hydrogen energy, safety and socio-demographics are the factors that influence the public acceptance towards hydrogen-powered vehicles. There are high chances of hydrogen explosion occurrence in confined areas and lead to damages.

In conclusion, Malaysians who have technical or engineering knowledge can accept the hydrogen-powered vehicles and knowledge regarding hydrogen energy, awareness of the natural environment, safety concerns and socio-demographics are the factors that influence their acceptance towards it. Hydrogen safety in confined areas need get special attention as hydrogen released from vehicles is trapped and accumulated inside the space and can lead to severe explosions if contacted with air. All in all, this study is contributes useful inputs to researchers, automobile manufacturers, policy makers, and regulators to introducing an effective hydrogen fuel economy for transportation.

Keywords: Hydrogen energy; safety; public acceptance; clean energy; vehicles; Malaysia.

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In preparing this project report, I was in contact with many people, researchers, academicians, and practitioners. They have contributed towards my understanding and thoughts. In particular, I wish to express my sincere appreciation to my project report supervisor, Dr. Norafneeza Binti Norazahar, for encouragement, guidance, critics and friendship. Without their continued support and interest this proposal would not have been the same as presented here. My fellow postgraduate student should also be recognized for their support. My sincere appreciation also extends to all my colleagues and others who have provided assistance at various occasions. Their views and tips are useful indeed. I am grateful to all my family member.

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HE4-145

EMERGING TECHNIQUES FOR PHOTOELECTRODES FABRICATION WITH POROSITY-ENHANCED PHOTOELECTROCHEMICAL SOLAR FUEL PRODUCTION

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Extended Abstract

It is widely accepted that to achieve a sufficient supply of energy based on solar energy, we need an efficient strategy including less time consuming and economical to store and transform sunlight into chemical fuels. The latest nine years have seen a rush into promising semiconductors that can be used as photoelectrode in photoelectrochemical (PEC) devices. This review commences with a fundamental understanding of solar fuel production via PEC devices and the concept of porous photoelectrode materials as a main component in PEC water splitting devices. We also describe various configuration systems for solar fuel production, including liquid state PEC and solid-state PEC. Recent progress on techniques for the fabrication of porous photoelectrodes is highlighted in this review. The applications of porous photoelectrode in solar fuel production also has been discussed. As a conclusion, modifications of semiconductor properties is the foremost concern in developing PEC solar fuel production materials.

Keywords: Porous photoelectrode; charge transfer; photoelectrochemical; solar fuel.

Table 1. List of research on photoelectrodes modification for solar fuels production.

Type of photoelectrode	**Highlights**	**(Year)**	**Ref.**
Without porous structure	α-$SnWO_4$/NiO_x photoanodes for solar water splitting	2021	[1]
	CZTS/$BiVO_4$ tandem cells for solar water splitting	2021	[2]
	Carbon coating and doping of TiO_2 for water splitting	2020	[3]
	Sb_2S_3 nanobars for solar cell application	2020	[4]
	Mn-doped CdS nanostructured thin films	2020	[5]
	TiO_2 nanotube photoelectrodes for dye-sensitized solar cells	2020	[6]
With porous structure	Hematite photoanodes on CuO-Sb_2O_5-SnO_2 ceramic	2021	[7]
	Porous Cu_2O photocathodes for PEC water splitting	2021	[8]
	Porous hierarchical Cu_2ZnSnS_4 (CZTS) film for PEC water splitting	2020	[9]
	3D sponge-like microporous CdS film for PEC water splitting	2020	[10]

Acknowledgement

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HE5-138

INSIGHT TOWARDS DEVELOPMENT OF Ni-BASED CATALYSTS FOR H_2 GENERATION VIA C_2H_5OH-CO_2 REFORMING: A SHORT REVIEW

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Extended Abstract

ABSTRACT

C_2H_5OH-CO_2 reforming has been hailed as an enticing and promising technology since it utilizes greenhouse gases, CO_2, and the renewable bio-component of C_2H_5OH to form value-added materials. Among investigated catalysts, Ni-based catalysts are the typical C_2H_5OH-CO_2 reforming catalysts due to their significant cleaving C-C and C-O bonds. Indeed, this sort of catalyst is broadly available, relatively inexpensive, and even recorded a high catalytic activity. Hence, this paper reviewed the development of Ni-based catalyst and their challenges in producing H_2 via C_2H_5OH-CO_2 reforming.

INTRODUCTION

Heavy utilization of fossil energy linked with rapid industrial expansion has resulted in many critical concerns, including depleting crude oil reserves and global warming [1]. For this motivation, tremendous efforts have been developed in the research field, focusing on lessening the CO_2 emission and producing better sustainable fuels to substitute conventional fossil fuels. As a result, H_2 generation by C_2H_5OH-CO_2 reforming lately has garnered substantial interest in the research field since it exploits the disfavored greenhouse gas CO_2 along with C_2H_5OH, leading to a decreased net emission of greenhouse gas [2]. Remarkably, C_2H_5OH utilization within this approach is attractive since the source could be easily attained from fermenting renewable and highly abundant biomass [3]. Since C_2H_5OH-CO_2 reforming is an endothermic process, ideal catalysts are crucial to reducing the temperature for activation. In literature, the most active metal employed in C_2H_5OH-CO_2 reforming is Ni-based catalysts since this material recorded superior catalytic activity in other catalytic reforming routes, cost-effective and readily available [4, 5]. However, since this technology is still relatively new, no review in the literature focused on the effectiveness of Ni-based catalysts in the C_2H_5OH-CO_2 reforming. Thus, it is critical to review the development of Ni-based catalysts and their efficacy in the C_2H_5OH-CO_2 reforming for H_2 generation.

C_2H_5OH-CO_2 REFORMING

In the C_2H_5OH-CO_2 reforming, an equal molar ratio of CO_2 and C_2H_5OH are required to generate only equimolar CO and H_2 ($CO_2 + C_2H_5OH \rightarrow 3CO + 3H_2$). However, several unfavorable parallel side reactions as depicted in Fig.1 could occur, giving rise to intermediate carbon-containing products including CH_4, CO, coke, and CH_3CHO. Indeed, the ratio of H_2 to CO (syngas) generated may vary due to those parallel side reactions. Thermodynamic analysis via Gibbs free energy approach carried out by Wang et al. (2009) revealed that high operating temperatures and high CO_2:C_2H_5OH feed ratio (>1.2) capable of leading towards more significant CO_2 and C_2H_5OH conversions as well as lessened the coke deposition [6].

Ni-BASED CATALYST DEVELOPMENT

Ni-based catalysts have obtained many appeals in recent years for reforming technologies ascribed to their effectiveness in catalytic activity and cost [7]. Additionally, Ni-based catalysts are well-known for their capacity to scission C-C and O-H bonds during reforming [8]. Ni-based catalysts (such as NiAl, NiCe, NiMg and NiZr) were employed in the C_2H_5OH-CO_2 reforming process by Zawadzki et al. (2014) at temperature 1023 K and feed ratio CO_2:C_2H_5OH of 1:1 [5]. The NiCe catalyst was found as an optimal catalyst with the conversion of CO_2 and C_2H_5OH obtained at about 80.0% and 99.7%, respectively. Although high catalytic activity, literature highlighted that these catalysts are susceptible to coke deposition and sintering developed via Boudouard, C_2H_4 polymerization, and CH_4 breakdown. Hence, it is conceivable to counter these constraints by altering the catalyst features via several recommendation strategies, including support selection, promoters' addition, and appropriate synthesis technique. As a result, this study assessed all of these efforts in detail and their impact on the performance of Ni-based catalysts in C_2H_5OH-CO_2 reforming.

CATALYST DEACTIVATION

In C_2H_5OH-CO_2 reforming over Ni-based catalyst, the catalyst deactivation may be triggered by (1) the enlargement of crystallite size (sintering), generally noted for Ni-based catalysts due to calcination and reaction phases or (2) coke/carbon deposition (fouling) typically arose via side reactions, disintegrating catalyst particles, loss of adsorption sites for reactants, and plugging of the reactor voids. Although the deactivation of catalysts is unavoidable, deactivation could be decelerated. Several strategies discussed in this review might have avoided the potential of deactivation occurrence, such as incorporating alkaline support or promoters, which may help in carbon suppression or by selecting an appropriate parameter condition for avoiding sintering.

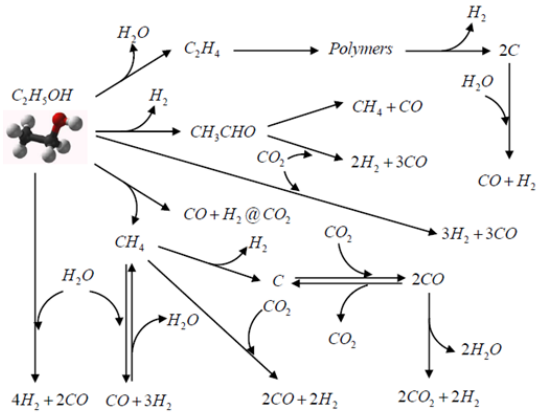

Fig. 1. Typical reaction mechanism involved in CO_2 reforming of ethanol.

In conclusion, the effort in modification of Ni-based catalysts, including support selection, promoter addition or synthesis strategies, effectively improved the physicochemical features of Ni-based catalysts. Consequently, this improvement resulted in more significant catalytic activity, stability and decreased coke formation.

Keywords: Hydrogen; CO_2 reforming; Ethanol; Nickel; Renewable.

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HE6-140

EMERGING SURFACE PHYSICOCHEMISTRY MODIFICATION AND STRUCTURAL DESIGN OF GRAPHITIC CARBON NITRIDE FOR ENHANCED PHOTOCATALYTIC SOLAR FUEL GENERATION AND WASTEWATER TREATMENTS

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Extended Abstract

Graphitic carbon nitride (g-C_3N_4) has been extensively studied in a variety of photocatalytic applications [1–3]. The performance of g-C_3N_4 influences its design and manufacture, with optical and electrical features dictating its performance. To improve photocatalytic activity of g-C_3N_4, surface and chemical structure enhancements are studied in depth [4–6]. On a molecular level, the straightforward production of g-C_3N_4 simplifies structural engineering [7]. This paper summarizes and discusses current developments on surface functionalization and grafting, defect production, elemental doping, covalent bonding with nonmetals, and heterojunction interfacial formation as ways to improve both structural and chemical aspects of the g-C_3N_4 structure. The use of g-C_3N_4 as a photocatalyst in a variety of processes is explored [8,9]. The relevance of g-C_3N_4-based photocatalyst in numerous photocatalytic processes indicates that frontier technologies are rapidly approaching as shown in Fig. 1. As a result, overcoming hidden hurdles and developing superactive photocatalytic activity at the molecular level for long-term environmental and energy-related applications is critical.

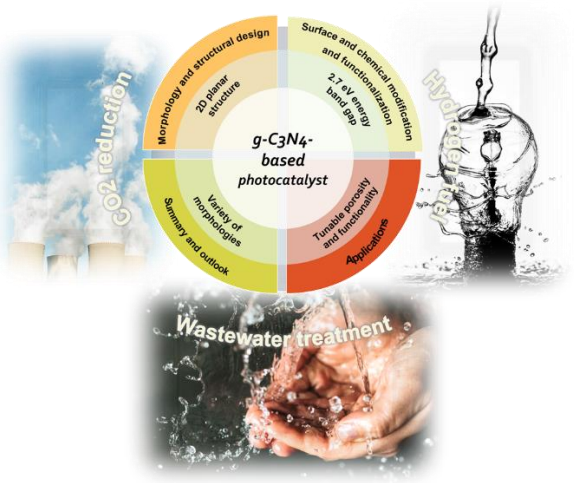

Figure 1: An illustration of g-C_3N_4 as a new class of photocatalytic material with fascinating physicochemical features for a variety of promising photocatalytic applications

Keywords: Defect; hierarchical; g-C_3N_4; solar fuel; emerging pollutants.

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HE7-126

Determining Most Effective on Dry Reforming of Methane Over Fibrous Silica Alumina via Nickel and Cobalt

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***Keywords**: Dry reforming; Silica-Alumina; Fibrous; Syngas*

ABSTRACT. Presently, the production of syngas through the dry reforming of methane is a widely employed approach for reducing vast amounts of greenhouse gas emissions. Multiple metals have been evaluated as potential active sites for the DRM reactions, particularly with transition metals having been active with different supports. However, the first investigation for comparing Cobalt with Nickel through fibrous silica-alumina support in DRM reaction was the FSA fabrication by the hydrothermal method and then the impregnation method for loading Ni and Co. The specimens were characterized via FESEM mapping, TEM, XRD, H_2-TPR, BET, FTIR, TGA/DTA, and Raman spectra. The Ni/FSA displayed a higher surface area with fine dispersion and fewer agglomeration than Co/FSA. Tests were done on the specimens to see how well they could dry reform methane at temperatures between 650 and 800 ºC. The mixture of 25:25:50 CH_4:CO_2:N_2 was fed through a 30,000 mL g^{-1} h^{-1} system. In the whole temperature range of 650 to 800 degrees Celsius, the Ni/FSA demonstrated more conversion of CH_4 (97%) than the (56%) of Co/FSA with long-life stability of 30h at 800ºC with low coke formation and sintering, which was confirmed by TEM, Raman, and TGA/DTA results.

Introduction

In recent years, there has been a great deal of interest in the carbon dioxide reforming of methane. This process turns inexpensive carbon-containing gases (CH_4 and CO_2) into synthesis gas with an H_2/CO ratio of one, which is used to produce synthetic fuel [1–3]. This procedure is incredibly significant in terms of the environment when utilized in gas sources with elevated amounts of methane and carbon dioxide, all of which are detrimental greenhouse gases. In the Fischer-Tropsch synthesis, a feedstock gas combination containing a low H_2/CO ratio is preferred for the creation of hydrocarbon fuels [4–6]. To achieve appropriate conversion levels, the endothermic aspect of this reaction necessitates a high reaction temperature. Because of the considerable operational temperature, adequate catalysts are required. The creation and build-up of carbonaceous deposits typically lead to the sintering of metal particles and the catalyst's inactivation as a consequence of the excessive temperature [7–11].

Recently is proven that noble metals including platinum, rhodium, and ruthenium, as well as non-noble metals as transaction metals (Ni, Co, and Fe), are either employed as catalysts in dry reforming processes[7,8]. According to reports, noble metals possess excellent catalytic activity and cause negligible carbon formation. However, due to their restricted variety and expensive cost, they are not widely used in the industrial sector. Because of their cheaper cost and equivalent catalytic efficiency, non-noble metals such as nickel and cobalt have piqued the curiosity of researchers [12–15]. Despite the great catalytic performance demonstrated by nickel-based catalysts, the significant carbon accumulation and swift inactivation prevent them from being used in industrial applications. Cobalt catalysts possess a considerable soot oxidation ability which could be employed to increase the resistance of a catalytic process to carbon production by reducing the creation of carbon. Nonetheless, cobalt catalysts exhibit a high proclivity for re-oxidation, resulting in low performance [16–19].

The recent investigation is primarily focused on reducing carbon creation in a variety of methods, including; i) using supports that have high oxygen ion mobility which may interact

with adsorbed carbon species, such as SiO_2, CeO_2, and ZrO_2 solid solutions, as opposed to conventional supports[20–24]; ii) involve the employment of additives such as potassium or sodium, which provide basic aspects to the surface characteristics, despite the reality that they reduce the catalytic activity[25,26]. iii) by modification the morphologies of support specifically bimodal, mesoporous, nanorods, core-shell, nano-fibrate, and dendritic fibrous [27–33]. The fabrication of incredibly multifunctional supported metal catalysts by wide metal dispersion of nanoparticles is one of the crucial options for heterogeneous catalytic systems that require research. Our prior research on the successful growth of fibrous silica-alumina (FSA) via exceptional surface area and thermal stability was the inspiration for this study [34]. In the present study, the FSA was investigated for DRM and compared to the performance of the metals Ni and Co via FSA with the ambition of getting a greater understanding of the metal's impact on catalytic efficiency and carbon formation.

METHODOLOGY

The microwave-assisted hydrothermal approach will be applied for the fibrous silica-alumina (FSA) support preparation in a typical procedure, as shown in figure 3.2. An aqueous mixture solution of hexadecyltrimethylammonium bromide (CTAB, 23.8 g) and urea (CH_4N_2O, 14.72 g) will be mixed with 732 mL of distilled water. The resulting mixture will undergo stirring at room temperature for 5 min to ensure complete dissolution. A 5.9g Aluminum nitrate oxide will be dissolved in an aqueous mixture solution of 31.2 mL of 1-butanol ($CH_3(CH_2)_3OH$) and 623.57 mL of toluene (C_7H_8), and the subsequent mixture will be added into the first solution, followed by a mixing process for 30 min at ambient temperature. Thereafter, (55.623 ml) of tetraethyl orthosilicate (TEOS) will be dropwise added into the solution with stirring for 2h. This resultant solution is poured into a Teflon bottle and subjected to an oven for exposure to intermittence MW radiation at 400 W at 120 ^oC for 6 h. The obtained milky solution is allowable to cool down to room temperature before undergoing the drying process at 110 ^oC overnight. The obtained white solid powder is further being calcined in a furnace at 550 ^oC with the ramping rate of 3 ^oC min^{-1} for 6 h to yield the fibrous FSA support.

RESULTS AND DISCUSSION

Figure .1A. display the crystalline structures through the X-ray diffraction (XRD) for the specimens FSA, Ni/FSA, Co/FSA. All the samples demonstrated the intense band of 2Θ within a range of 20-30º, this is often attributed to the amorphous phase of SiO_2 (JCPDS card No. 29-0085)[35,36]. Because of the existence of silica species during the fabrication of dendrimeric silica fibres, the XRD pattern intensity diminished. In comparison, the Ni with Co via FSA exhibited nine prominent peaks at 2Θ of 25.7°, 35.3°, 37.9°, 43.4°, 52.7°, 57.6°, 66.6°, 68.3°, and 77.1° corresponding to the (0 1 2), (1 0 4), (1 1 0), (1 1 3), (0 2 4), (1 1 6), (2 1 4), (3 00), and (1 1 9) alumina crystalline planes via structures of rhombohedral (JCPDSICDD File No 46-1212) for FSA sample [34,37].

The constructional heterogeneity of the FSA-supported Ni and Co catalysts was evaluated by employing FTIR spectroscopy in the wavelength range of 400–4000 cm^{-1}, as shown in Fig. 1B. The most distinct peaks were spotted in the 400–1300 cm^{-1} range, showing siliceous frames as Si interacted via various atoms (e.g., Si-OH, Si-O-Si, Al-O-Al, Si-O-Al, and Si-O) [38]. The five peaks at wavenumbers 1240, 1090, 960, 790, and 460 cm^{-1} were demonstrated in all specimens, which indicative Si-O-Si element peaks within a domain of 1000-1300 cm $^{-1}$were readily discernible via all samples. Simultaneously, the peak at 3400 cm^{-1} was remarked for all catalysts in Fig.1B. Furthermore, Si-O-Si transverse-optical (TO) and longitudinal-optical (LO) band asymmetric stretching were attributed to the dominant transmittance peak at approximately 1240 cm^{-1} and 1090 cm^{-1}, respectively [39]. The weak bands at 960 and 1640 cm1 were assigned external Si-OH groups, whilst symmetric and asymmetric Al-O and Si-O stretch vibrations were detected at 800 cm^{-1} and 462 cm^{-1}, respectively. Moreover, asymmetrical and symmetrical stretched vibrations, in addition to stretching vibrations of Si-O-A, were ascribed to the bands at 1090 cm^{-1}, 790 cm^{-1}, and approximately 460 cm^{-1}. The strength of these peaks diminished when Ni and Co were introduced to FSA, implying that the Si–O–Si and Si-OH were partially replaced by Ni–O–Si, Co–O–Si, Ni-O, and Co–O. In particular, in the Co/FSA spectra,

one special peak at 666 cm^{-1} attributable to Co–O vibrations occurred, indicating to the Co had been successfully incorporated into the catalyst [17,41].

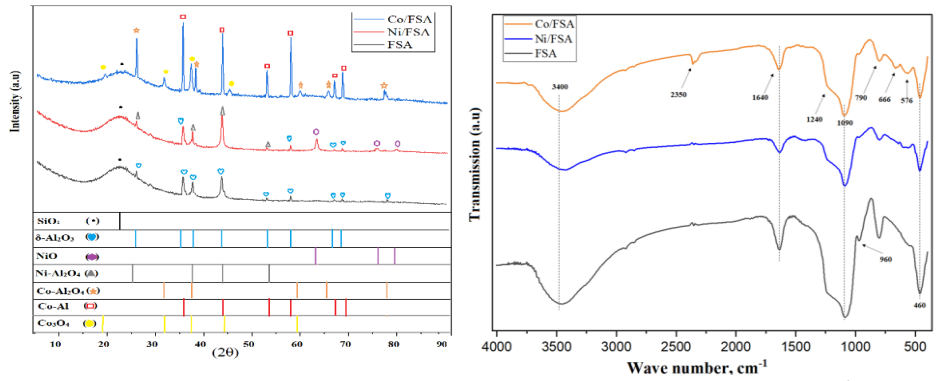

Fig 1. (A) XRD patterns (B) FTIR (KBr) spectra for FSA, Ni/FSA, Co/FSA.

ACKNOWLEDGMENT

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HE8-171

BIOHYDROGEN PRODUCTION FROM PINEAPPLE PEELS USING IMMOBILISED CO-CULTURED BACTERIA ONTO ACTIVATED CARBON SPONGE

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Extended Abstract

Pineapple peels is one of potential agriculture waste that can be valorised for biohydrogen (bioH_2) production through fermentation process. Pineapple peels contains significant concentrations of sugar and organic acid that can be exploited as lignocellulosic substrate in the fermentation process using suitable H_2-producing type bacteria. However, the process of using lignocellulosic substrate is often challenging to achieve high production of bioH_2 that make the process is unfeasible for industrial sclae. A combined method of co-culturing and immobilizing the bacteria can be used as one of strategy to maximize bioH2 production in the fermentation process of lignocellulosic substrate. In this study, three different bacteria culture namely *Escherichia coli*, *Enterobacter aerogenes* and *Clostridium sporogenes* was co-culture each other and immobilized onto activated carbon (AC) sponge. *E. aerogenes* and *E. coli* have been selected because they are facultative anaerobes that can be survived if the oxygen present and then utilize the oxygen which simultaneously provide anaerobic condition to the strict anaeorobes, *C. sporonges*. The AC sponges was used to retain bacteria for the attachment on the surface of the materials through the adsorption technique of immobilization. The schematic diagram of the experimental setup is shown in Fig. 1. The fermentation process using the heat pre-treated pineapple peels in a 500 mL Dreschel bottle with a working volume of 300 mL. The pineapple peel solution (210 mL) was first added to a Dreschel bottle, and 30% v/v inoculum was then added to the substrate. The initial substrate pH of 4.4 was adjusted using 0.5 M sodium hydroxide (NaOH) to the targeted pH of 7. Nitrogen sparging was applied to provide an anaerobic condition for the fermentation process. The bottles were sealed and placed in a water bath to maintain the culture medium at the desired temperature (Fig. 1) for 48 hours fermentation time. BioH_2 contents in the biogas collected in PDVD bag were analysed by a gas chromatograph (Agilent Technologies, 6890N, Network GC System) equipped with a thermal conductivity detector. The bacterial concentration of the inoculum was checked every 12 hour via optical densities (OD600) measurement using a spectrophotometry method. For the kinetics study, the results of cumulative bioH_2 values were used to fit the modified Gompertz model to evaluate the effect or performance of the different bacterial combinations in the co-culture.

To conclude, this work has successfully produced bioH_2 from pineapple peels substrate fermentation process using all the selected bacteria either as (i) a single culture or co-culture or (ii) free cell or

immobilised cell. All the experimental result is shown in Figure 2. The co-culture of *E.coli* and *C.sporogenes* was determined as the best combination of co-culture bacteria from the three single

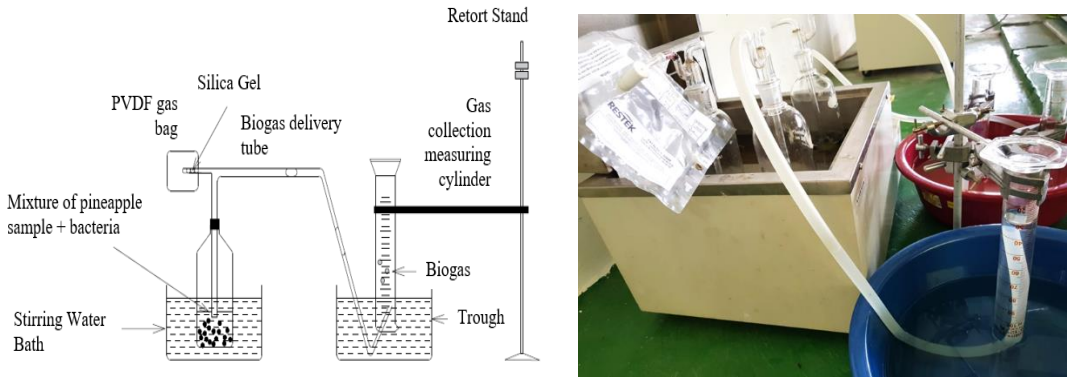

Fig. 1: a**)** The schematic diagram of experimental setup. b) Picture of experimental set up

cultures to produce a cumulative bioH_2 production of 15.42 L after 48 hr fermentation time with pH condition of 6.65. This work has also provided the evidence that the immobilisation method increased the production rate by one fold within 24 to 36 h fermentation time compared to free cell fermentation of the same co-culture. From the kinetic study, it is revealed that the process can be described by Modified Gomperts model where the accumulative bioH_2 production of all fermentation showed a goodness of fit with the model. The strategy of using co-culture instead of a single culture increased the production of biohydrogen by an average of 40%–60% compared to every single culture alone after immobilization. All co-culture bacteria shown a good survival rate in the immobilization form, which evidenced by OD measurement readings and SEM images. This study proven that the combination of activated carbon sponge and co-culture able to enhance the bioH_2 production in pineapple residues fermentation.

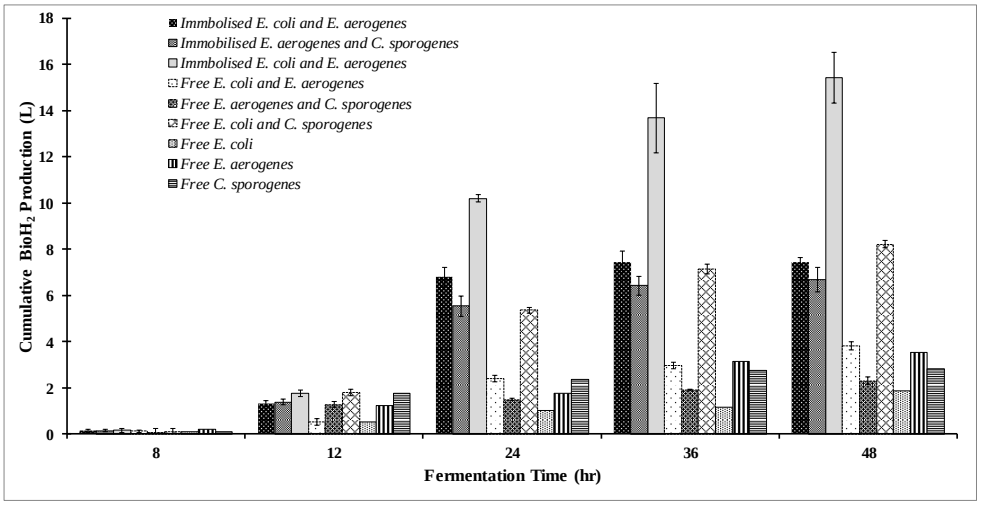

Fig. 2 Cumulative bioH_2 production of free and immobilised co-cultured bacteria

Keywords: Biohydrogen production; co-cultured bacteria; immobilisation; activated carbon sponge; Modified Gompertz

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HE9-196

RISK EVALUATION OF HYDROGEN DISPERSION FROM COMPRESSED HYDROGEN (H2) STORAGE VESSELS.

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Extended Abstract

Hydrogen is a promising energy carrier. However, hydrogen has a wide flammable range of 4–75 vol.% (in air) and a very low ignition energy of 0.019 mJ. The primary issue of hydrogen utilization is safety in various scenarios for the coming hydrogen economy. This work focuses on hydrogen leakage, which is typically induced by structural failure in refueling stations and transit vehicles, with attention to eliminate public concern and provide references for design, legislation, and standards. Rodionov et al. [1] presented a risk assessment of the hydrogen explosion related to a hydrogen-driven engine car, indicating that. that hydrogen explosion in open and semi-confined environments has a high level of risk with potential injuries to people and damage to cars and area of the hydrogen explosion. Hydrogen explosions in a confined environment have a low probability, but, the aftermath is catastrophic. For the safe design of retail facilities, it is essential to understand all the hazards that could arise following the accidental release of hydrogen and to have data to allow the appropriate standards to be developed. These data can be also used to develop and validate models used in quantitative risk assessment tools [2-3] and tools based on computational fluid dynamics (CFD) [4] or tool based on integral models e.g. DEGADIS,SLAB, PHAST, HGSYSTEM, and ALOHA. The present study was formulated in order to determine the consequences caused by hydrogen dispersion, adopting ALOHA software, which has been built upon the Gaussian dispersion model of continuous, buoyant air pollution flumes that capable to simulate the accidental release of hazardous substances and the dispersion of chemical vapor. Variables such as wind speed and the leak hole diameter were selected as the factors to simulate the consequences of hydrogen storage leakage accidents. The impacts of each variable on accident consequences were analyzed for obtaining the reasonable and effective reference in actual accidents and conducting fire risk assessment. For this work, hydrogen refueling station (HRS) facilities with storage involving compressed gas hydrogen have been chosen as the subjects of simulation. Suppose leakage occurred at Pasir Gudang highway with coordinate of 1.4825°N, 103.8811°E. The initial condition of the simulation and for the potential incidence of release, two hypothetical scenarios (I and II) have been created with environmental configurations as shown in Table 1.

Table 1 Initial condition and Potential incidence of release

Potential release	**Scenario I: Rupture in tank at a refueling station (HRS)**	**Scenario II: Rupture of storage hydrogen tank in a car**
Simulation scenarios	**a) Pipeline** • Diameter = 0.15, 0.20 and 0.30 m • Pipe length = 200 m • Pressure in pipe = 70 bar • Wind speed: 2 and 8 m/s from North • Ambient temperature = 33°C • Humidity = 46 % **For storage tank** • Direct source of hydrogen (worst case scenario) • Leak hole diameter of 15 cm • Volume: 300 litre • Uncongested area of hydrogen refueling station • Vessel pressure = 500 bar	Use Toyota Mirai as model for the simulation • Moving car – possible being hit at back (25-L hydrogen storage tank) • Possible rupture of all connected storage tanks (Total volume is 141 litre) • Storage pressure = 700 bar • Car moving in semi-confined area, e.g., tunnel • Car parked in a confined area and congested area, e.g., multilevel parking

The main consequences of hydrogen leakage in this work are jet fire (radiation intensity) , flammable cloud and blast overpressure of vapor cloud explosion at different wind speeds i.e. 2 and 8 m/s. It can be depicted that the effect of the wind speeds on from the hydrogen leakage sources is minimum at the stable climate condition. However, when the leak hole diameter pipe increases in case of Scenario Ia, the maximum distance from flammable vapor cloud and maximum radiation level increase with a higher leakage diameter due to an increased release rate and an increased amount of hydrogen. For Scenario II, it can be said that the congested condition gave higher maximum distance of blast overpressure (0.55 bar) and 60% LEL flammable cloud i.e. 24 m and 97 m , respectively as shown in Fig.1. It can be explained as; the multilevel parking and available cars can represent congestion and if engulfed by a vapour cloud, can lead to significant flame acceleration. The turbulent energy created by the congestion has a greater effect on explosiveness than does the total amount of leakage or premixed volume [5]. Hence the implication is that it is not necessary to release large quantities of hydrogen to obtain high overpressures on ignition. A release of relatively small quantities with rapid ignition may give a severe event.

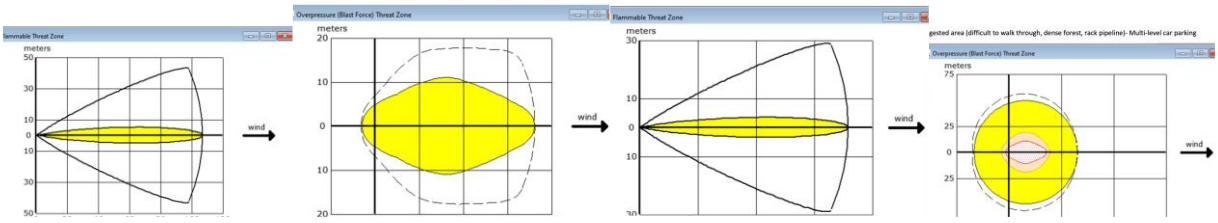

Fig. 1 Threat zones of hydrogen release from the vehicle storage leakage at total rupture for uncongested scenario (two from left) and congested area (two from right)

Keywords: ALOHA; climatic factor; consequences; hydrogen dispersion;

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HE10-239

CATALYTIC DECOMPOSITION OF METHANE INTO HYDROGEN AND CARBON NANOTUBES : EFFECT OF Ni LOADING

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Extended Abstract

Hydrogen is an alternative source of renewable energy that can be produced by methane decomposition without any Co_x formation [1]. In this work, an impregnation method was used to prepare a set of Ni-based catalysts (5% to 50%) supported on mesostructured silica nanoparticles (MSNs) for its application in methane decomposition. The physical, chemical and structural properties of the catalysts was studied and the results indicated that NiO was the active species in the fresh catalyst that were effectively distributed on the mesoporous surface of MSN. The results indicated that NiO was the active species in the fresh catalyst that were effectively distributed in the mesopores and surface of the MSN support. The crystallinity of NiO was found to be increased with an increase in the loading of nickel whereas the specific surface area of MSN extremely decreased after Ni loading and with its incremental amount, as seen in Figure 1. The peaks were located at 37.2°, 43.2°, 62.7°, 75.4° and 79.1° which belong to the face-centred, cubic-phase crystalline structure of NiO [2].

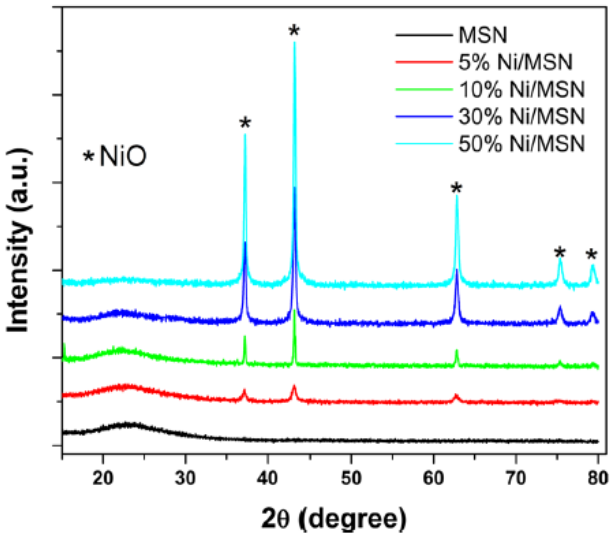

Fig. 1 XRD patterns of the prepared samples: wideangle diffraction patterns

The hydrogen yield increased with the increment of Ni amount in the catalysts. The catalytic activity of the 50% Ni/MSN catalyst showed that this catalyst was highly efficient and stable compared with other catalysts (figure 2).

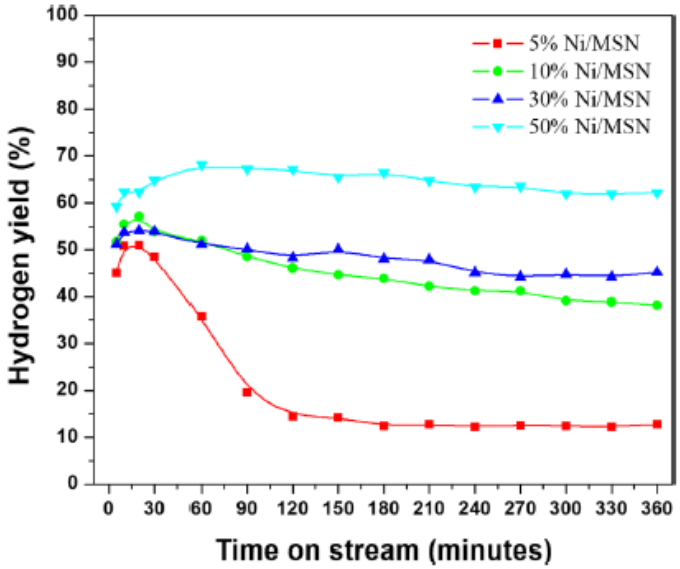

Fig. 2 Catalytic activity of the Ni/MSN catalysts for methane decomposition at 700 °C

The catalyst showed the highest hydrogen yield of 68% and remained more or less the same during 360 min of reaction. Approximately 62% of hydrogen yield was observed at the end of reaction. Further analysis on the spent catalysts confirmed that carbon nanotubes was formed over Ni/MSN catalyst with high graphitization degree. The physicochemical properties of MSN play a crucial role in the improved activity and stability of Ni-based catalyst in methane decomposition. The homogeneous dispersion of metallic species on the MSN support with high surface area and a proper metal support interaction. As conclusion, the characterization results demonstrated that the porous structure of MSN is well preserved in the prepared catalysts even after the incorporation of high Ni amounts. The active phase of nickel was found to be NiO in the fresh samples that were well dispersed on the surface of the MSN support with proper metal support interaction. The pore blocking of MSN by NiO species on the surface of MSN decreased the surface area of Ni/MSN catalysts, with increased Ni loading. The pronounced catalytic performance of the catalyst could be assigned to the improved synergistic effects of nickel species with MSN support. The contributions of high surface area, dispersion of metal species on the support, an appropriate metal support interaction and the presence of metallic Ni nanoparticles are responsible for the high catalytic efficiency of the Ni/MSN catalysts. The characterization studies of the deposited carbon showed that multiwalled carbon nanotubes with high crystallinity and graphitization degree were formed over Ni/MSN catalysts after decomposition reaction.

Keywords: Hydrogen production; Mesostructured silica nanoparticles; Carbon nanotubes; Surface Catalysis

Acknowledgement

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HE11-244

EVALUATION OF COMMERCIALIZED AIR COMPRESSOR FOR HYDROGEN COMPRESSION

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Extended Abstract

Hydrogen energy is one of the new green energies that emerge recently. Hydrogen energy is one of the alternative energies for road vehicles is hydrogen energy. Recently, studies have been done about hydrogen fuel cells. The hydrogen fuel cell generates electrical energy via electrochemical process [1]. During the process, hydrogen is combined with oxygen and produces water and energy. A large amount of hydrogen gas is needed in producing enough energy to drive the car. Therefore, the storage of hydrogen in moderate quantities is a must to operate a hydrogen fuel cells-driven car [2]. There are several methods used to store hydrogen. The hydrogen storage methods are classified into 2 categories which is chemical based and physical based [3], [4]. One of the physical method of hydrogen storage is compressed hydrogen gas [5]. The compression of hydrogen gas is done by a compressor or a series of compressors. However, the hydrogen compressors are expensive and uncommon in the market. Since there are many commercialized air compressors that are cheap and available in market, this study is to determine the possibility replacing the hydrogen compressor with commercialized air compressor.

In literature, the energy consumption varies with the type of compressor, range of compression, and type of compression. Most of the data from the literature are incomparable as the type of compressor and compression pressure range are different. According to [6], the energy requirement and power consumption for single stage compression is higher than multiple stage compression. The power consumption for single stage compression up to 98MPa is 25.06MJ. While [7] stated that the theoretical energy requirement to compress hydrogen gas at 300K isothermally, from 20bar to 350bar is 1.05 kWh per kg of hydrogen gas, while to 700bar is 1.36kWh per kg of hydrogen gas. If to compress the hydrogen gas from ambient condition (1.013 bar and 300K) to respective pressure an additional theoretical value of 1.02kW per kg of hydrogen is needed. In [8], the experimental energy consumption for hydrogen compression using hydrogen booster from 4.6 bar to 200 bar is 15kWh/kgH2 (without consideration of electrical power consumption) or 65kWh/kgH2 (include the electrical power). The author also indicates that power absorbed by the air-driven hydrogen booster is higher. In [9] stated that the energy consumption for compression of hydrogen from range between 120 bar to 200 bar to 450 bar is range between 4.4 to 9.3kWh/kg. In [10], the energy consumption to compress hydrogen gas to 70MPa is 6.0kWh/kg

This study is aims to determine the possibility of using the current commercialized air compressor to compress hydrogen gas and to evaluate the air compressor used. The objectives of this study are to measure the actual energy consumption of selected commercialized air compressor – YONG HENG; to calculate the theoretical energy consumption of the process and evaluate the compressor by comparing both experimental and theoretical results.

The YONG HENG air compressor is able to compress hydrogen up to 1000psi. However, the efficiency is low. The experimental energy consumption for compressing hydrogen gas up to 1000 psi is 37.241kWh/kg. While the theoretical energy consumption for compressing hydrogen gas up to 1000 psi for 10 various equation of state range between 2.6036 to 3.1059kWh/kg. The percentage errors between experimental energy consumption and theoretical energy consumption are all more than 90%.

Keywords: Hydrogen Compression, Air compressor

Acknowledgement
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BIOMASS AND BIOFUEL (BB)

BB1-130

PRODUCTION OF BIOKEROSENE HYDROCARBONS USING COCONUT OIL AND PALM KERNEL OIL WITH COO-NIO/KAOLIN CATALYST VIA SOLVENT-FREE AND INERT ATMOSPHERE CATALYTIC DEOXYGENATION

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Abstract

Concerns on the depletion of fossil fuel and emissions of harmful gases lead to the search for alternative aviation fuel. The present study demonstrates the production of biokerosene hydrocarbons from coconut oil and palm kernel oil via solvent-free catalytic deoxygenation under inert N_2 atmosphere. The deoxygenated product is examined through Gas Chromatography-Mass Spectrometry (GC-MS) analysis to determine its chemical composition and hydrocarbons distribution. CoO-NiO/Kaolin catalyst was used along with several other catalysts to study the reactivity of different catalysts in catalytic deoxygenation. Coconut oil and palm kernel oil are composed of middle-chain saturated fatty acids (capric acid, lauric acid, and myristic acid) which are favorable for the conversion into biokerosene hydrocarbons due to their carbon chain length as shown in Table 1. Both feedstocks display comparable performance with coconut oil being a slightly better feedstock. In terms of the types of catalyst, CoO-NiO/Kaolin proves to be the best catalyst with optimum selectivity of biokerosene hydrocarbons at 83.4% as shown in Figure 1. A parametric study was executed on coconut oil using CoO-NiO/Kaolin, and the result indicated that the optimum reaction conditions are 330°C, 2 hours reaction time, and 5 wt.% of catalyst. The biokerosene hydrocarbons produced have the likelihood to be the drop-in substitutes for aviation fuel.

Keywords: Aviation fuel; biokerosene; catalytic deoxygenation; coconut oil; palm kernel oil

Table 1. Fatty acid compositions of coconut oil and palm kernel oil

Components (%)	Coconut oil [1]	Palm kernel oil [2]
Caproic acid (C6:0)	0.52	0.298
Caprylic acid (C8:0)	7.6	4.683
Capric acid (C10:0)	5.5	4.281
Lauric acid (C12:0)	47.7	52.465
Myristic acid (C14:0)	19.9	15.645
Palmitic acid (C16:0)	-	7.536
Stearic acid (C18:0)	2.7	2.098
Oleic acid (C18:1)	6.2	11.284
Linoleic acid (C18:2)	1.6	1.545
Arachidic acid (C20:0)	-	0.097
Eikosenoic acid (C20:1)	-	0.068

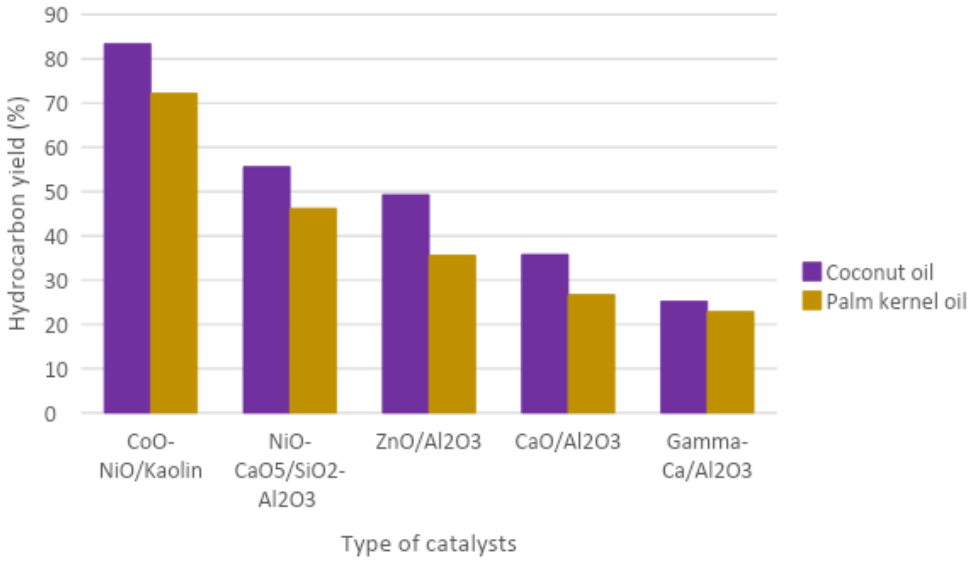

Fig. 1: Biokerosene hydrocarbon yield for different types of catalysts and feedstock

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BB2-155

Biopesticide Production from Pineapple Peel

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Extended Abstract

Malaysia is known as one of the pineapple exporters in Southeast Asia [1]. Around 42,129 metric tons of pineapple had been exported from a cultivation area of 16,653.55 hectares with Johor, Sarawak and Selangor as the primary producer of Malaysia's pineapple. However, pineapple wastes such as pineapple peels also increase with the increase of pineapple consumption. Alternatively, pineapple peels can be further processed to produce biopesticide through a fast pyrolysis process. Pyrolysis is a process to produce charcoal, bio-oil and fuel gas through the thermal degradation of biomass by heat in the absence of oxygen [2]. The pyrolysis bio-oil can be used as biopesticide if it contains phenol and methyl ester [3]. Much research investigates the biopesticide properties of pyrolysis bio-oil produced from biomass, but the biopesticide characteristic of pyrolysis bio-oil produced from pineapple peels is not being justified until today. Thus, this thesis was focused on justifying the biopesticide properties of pyrolysis bio-oil produced by analysing its phenolic and methyl ester composition using GC-MS analysis. Besides, the operating parameters of pyrolysis temperature and reaction time were manipulated to determine the optimum conditions of parameters that can produce the highest pyrolysis bio-oil yield. Finally, the efficacy of pyrolysis bio-oil as biopesticide was studied by observing the condition of green worm caterpillars after being served by the pyrolysis bio-oil. At the beginning of the research, proximate analysis was done to investigate the moisture content, volatile matter, ash content and fixed carbon of the feed sample, and the result was shown in Table 1. From the research, the highest percentage yield of pyrolysis bio-oil (41.05%) was obtained when the fast pyrolysis reaction was carried out at 500℃ for 60minutes. Besides, the result of the GC-MS analysis shown in Figure 1 indicated the presence of phenol and methyl ester in the pyrolytic bio-oil produced from pineapple peel. This indicates that the bio-oil can be used as a biopesticide to control or kill the green worm caterpillars. In addition, all the green worm caterpillars were dead after being served by the pyrolysis bio-oil. Therefore, in this research, the pyrolytic bio-oil produced from pineapple peel was proven to have biopesticide properties.

Table 1. Proximate Analysis of Pineapple Peel

Type of content	Wt%
Moisture	5
Volatile matter	80
Ash content	4
Fixed carbon	11
Total	100

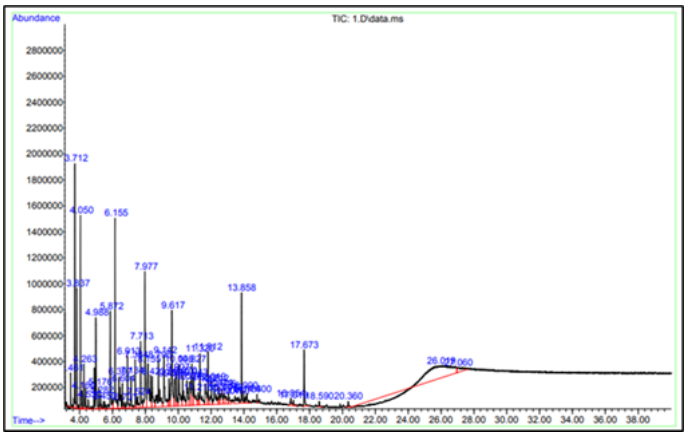

Fig. 1: Result of GC-MS Analysis

Keywords: Pineapple peel; pyrolytic bio-oil; biopesticide; phenol; methyl ester

Acknowledgement
The research team wishes to acknowledge the cooperation given by the industry and their workers while conducting the survey. Gratitude for Vot No: R.J130000.7809.5F323 (FRGS) for the funding of the study.

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BB3-148

PRODUCTION OF BIO-OIL BY COCONUT SHELL PYROLYSIS AS BIOPESTICIDE

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Extended Abstract

Coconut shell is a common and abundant biomass found in vast quantities throughout the tropical climates of Asia, Latin America and Africa [1]. Despite the huge amounts of residues produced, by-products of thermochemical conversion, such as bio-oil, have the potential to create a valuable product for the industry. Bio-oil is a liquid derived from the pyrolysis of coconut shells via a steam condensation process. The bio-oil contains a high concentration of phenolic compounds due to its main components, such as lignin, cellulose and hemicellulose [2]. The phenolic compound is corrosive and can damage the engine, but it has economic value that can be used as pesticides, resins, explosives and disinfectants [3]. Phenolic compounds are active ingredients in the formulation of bio-pesticides. Hence, this study investigated the factors affecting the maximum yield of bio-oil derived from coconut shell, to analyse the phenolic content in the bio-oil and further testing its effectiveness as biopesticide with the bio-assay of caterpillar pest method. The parameters used in this experiment was varied. The experiment was conducted at a temperature of 400℃, 450℃, 500℃, 550℃ and 600℃ with reaction time between 20 minutes and 100 minutes and particle size in a range of 0.09mm and 2mm. Nitrogen gas was served as a substitute of air in the reactor. The Gas Chromatography-Mass Spectroscopy (GC-MS) and Fourier-Transform Infrared Spectroscopy (FTIR) were used to analyse the bio-oil components. The maximum liquid yield (42.06%) was observed to be at a temperature of 550℃ in a range of feed size between 1mm and 2mm for 60 minutes. The main compositions of the bio-oil contain alcohol (phenol), ketone, ether and aromatic compound as in Figure 1. Lastly, the bio-oil of coconut shell pyrolysis was an effective biopesticide against caterpillar pest with a diluted bio-oil at 550℃ due to the presence of phenol in the bio-oil as presented in Figure 2.

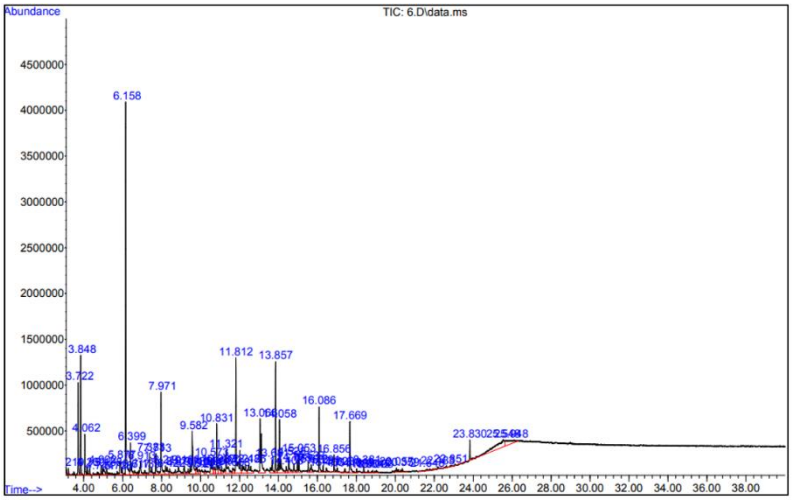

Fig. 1: GC-MS of components produced from the bio-oil of coconut shell pyrolysis

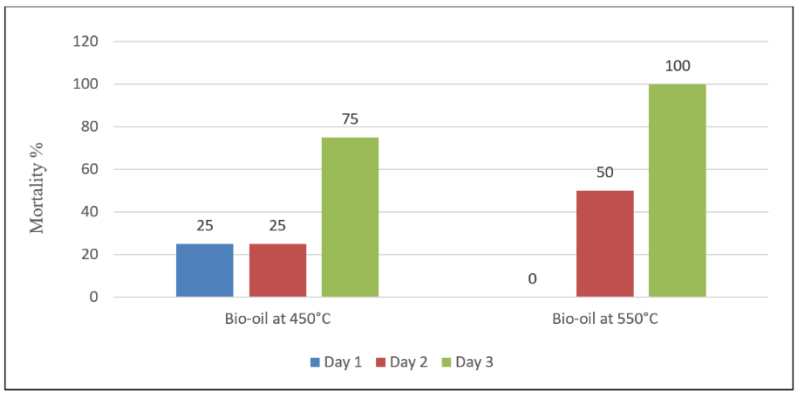

Fig. 2: Graph of mortality percentage vs days for diluted bio-oil at 450°C and 550°C

Keywords: Coconut shell; pyrolysis; bio-oil; phenol; biopesticide.

Acknowledgement
The research team wishes to acknowledge the cooperation given by the industry and their workers while conducting the survey. Gratitude for Vot No: R.J130000.7809.5F323 (FRGS) for the funding of the study.

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BB4-149

PYROLYSIS TREATMENT OF SUGARCANE BAGASSE AS BIOMASS WASTE TO PRODUCE BIO-PESTICIDE

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Extended Abstract

Sugarcane bagasse (SB) is a type of lignocellulosic biomass which is the by-product after extracting the sugarcane juices from the sugarcane plant. Improper management of this biomass waste can lead to many problems such as soil and water pollution. This SB, however, can be converted into biomass energy and chemical via thermal conversion pyrolysis, aiding in minimising the disposal problem that arises with biomass waste. The pyrolysis products consist of liquid bio-oil, solid biochar, and pyrolytic gas [2]. The bio-oil can potentially be an alternative to the chemically synthetic pesticide. This is said that the bio-oil contain high aromatic compounds such as phenols, which are active ingredients in formulating bio-pesticides [1]. Hence, the purpose of this study is to generate and analyse the bio-oils from SB via pyrolysis at different temperatures through pH analysis (litmus paper), analytical analysis: Fourier Transform Infrared (FTIR) and Gas Chromatogram-Mass Spectrometry (GC-MS) and bio-assay analysis on garden snails. Fast pyrolysis was done using a fixed bed reactor operating at 450 ℃, 550 ℃ and 650 ℃ with a constant flow rate of nitrogen gas at 100 cm^3/min, the residence time of 30 minutes and feedstock of particles size of less than 0.5 mm. Such controlled operating parameters are selected to produce the maximum bio-oil [3]. Bio-assay analysis of the bio-oils produced was conducted to test the pesticidal activity on garden snails based on the consumption and mortality rate on green salad leaves and tomato slices for five days. The highest bio-oil obtained was at 550 ℃, the optimum temperature to produce the maximum bio-oil yield. All the bio-oils produced showed acidic results with a pH reading of less than two, which might be due to organic acids and phenolic compounds. The analytical analysis showed that all the bio-oils indicate the presence of alcohols (phenolic compound), ketones, esters, ethers, carboxylic acid, and aldehydes, as depicted in Figure 1. After five days of the bio-assay analysis, Table 1 shows that the garden snails remained alive as there was no food consumption. In conclusion, the bio-oils could be used as a repellent towards garden snails which might be due to the acidic property of the bio-oils and the presence of phenolic compounds.

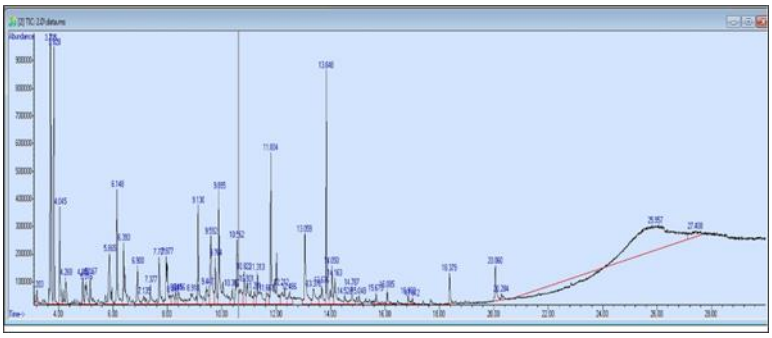

Fig. 1: GC-MS spectrogram of bio-oil produced at 550 ℃

Table 1. Observation on the garden snails after five days

Parameters	Observations
Control	The snails consumed food. The snails were still alive after five days.
450 °C	The snails did not consume food. However, the snails were still alive after five days.
550 °C	The snails did not consume food. However, the snails were still alive after five days.
650 °C	The snails did not consume food. However, the snails were still alive after five days.

Keywords: Garden snails; sugarcane bagasse (SB); bio-oil; bio-pesticide; phenol.

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The authors fully acknowledged Ministry of Higher Education (MOHE) and Universiti Teknologi Malaysia for the approved fund which makes this important research viable and effective.

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BB5-150

PRODUCTION OF BIO-OIL AS BIO-PESTICIDES FROM PYROLYSIS SPENT COFFEE GROUNDS

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Extended Abstract

Spent coffee grounds (SCG) are waste products obtained during the coffee brewing process. SCG are considered to be a promising biomass resource due to the growth of coffee consumption and source of valuable products. Pyrolysis is one of the alternative methods to reduce SCG waste. Pyrolysis is the most widely used thermo-chemical process for biomass conversion, in which the biomass is decomposed at high temperatures in an oxygen-free environment, producing biochar, bio-oil and gases [1]. Several studies have investigated the pyrolysis oil from several biomasses including SCG to be used as alternative pesticides as the biomasses have bio-pesticides properties. The purpose of this study is to produce and characterize pyrolysis bio-oil from SCG for the purpose of identifying natural chemical pesticides properties in the bio-oil by chromatography analysis. Caffeine is known as a chemical with natural pesticides properties that are contained in SCG [2,3]. Besides, the effectiveness of bio-oil from pyrolysis SCG as bio-pesticides is investigated based on the mortality of grasshoppers and the leaves consumption by them. Pyrolysis was carried out with a fixed bed reactor at different temperatures of 400℃, 450℃, 500℃, 550℃ and 600℃ with varying feed particle sizes of 300 µm, 500 µm and 700 µm. The optimum temperature and feed particle size for the highest yield of bio-oil (35.31%) were at 550℃ and 300 µm respectively. The bio-oil was analyzed by GC-MS had identified the presence of caffeine (18.05%), 2-Furanmethanol (8.54%) and phenol (2.29%) as the major compounds. Other acids, alcohols and ketone compounds were also found in the bio-oil. Bio-oil produced at optimum conditions was tested for insecticidal activities against the grasshoppers. Control treatment of 100% concentration showed only a small amount of leaf consumed by grasshoppers and the highest adjusted percent mortality of grasshoppers which was 20% after 48 hours. Therefore, it showed that the SCG bio-oil can act as a repellent and is capable to kill grasshoppers. Since caffeine has been found to have the highest composition in the bio-oil, caffeine likely had a significant role in insecticidal activity.

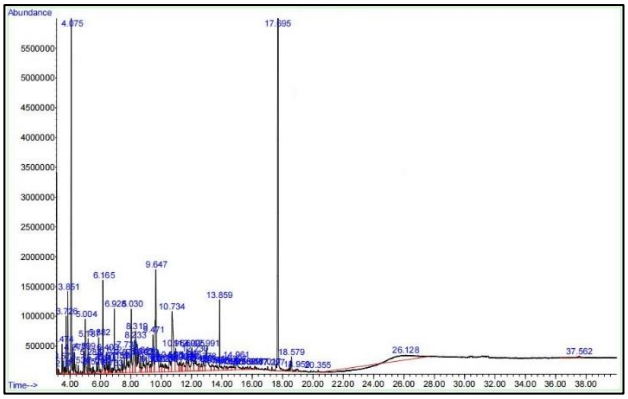

Fig. 1: Total ion chromatogram of bio-oil from pyrolysis of SCG on optimum conditions

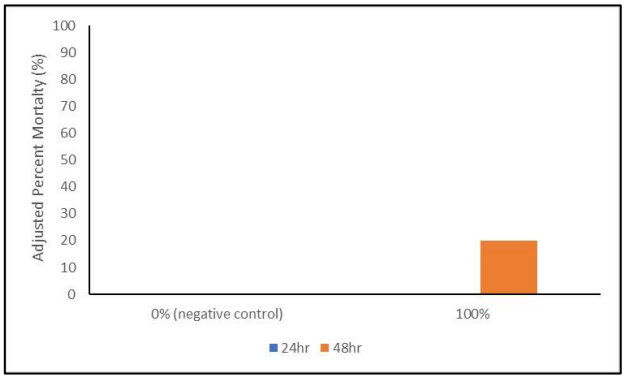

Fig. 2: Adjusted percent mortality of grasshoppers with different concentration after 24 hours and 48 hours

Keywords: Spent coffee grounds; pyrolysis; bio-oil; caffeine; grasshoppers.

Acknowledgement
The authors fully acknowledged Ministry of Higher Education (MOHE) and Universiti Teknologi Malaysia for the approved fund which makes this important research viable and effective.

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BB6-152

Assessment of Polycyclic Aromatic Hydrocarbons (PAHs) in Microwaved-Biochar as a Requirement for Soil Amendment Application

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Biochar is a carbon-rich material produced by the pyrolysis process of biomass. The product is commercially used as a soil conditioner in sustaining soil fertility and conserving plant nutrients for a prolonged period. However, the production of biochar can be contaminated with the presence of polycyclic aromatic hydrocarbons (PAHs) compounds. The evaluated PAHs must satisfy the International Biochar Initiative (IBI) guideline in the range of 6-20 mg/kg to assure sustainability and quality of biochar production. The study on PAHs compound in biochar from conventional pyrolysis had been extensively conducted using various type of lignocellulosic biomass materials. Only a few specific research activities on PAHs contamination of biochar via microwave method focusing on sewage sludge feedstock [1]. Accordingly, the aim of this study is to produce biochar from empty fruit bunch (EFB) through microwave pyrolysis and quantitative determination of PAHs compounds in microwaved-biochar were also focused.

Biochar samples were prepared from EFB material at the desired power of 450 W and various irradiation times (5-20 min) under N_2 flow (1 L/min). The surface area of biochar was characterized using multiple-point nitrogen (N_2) adsorption-desorption isotherm at 77K. The FESEM analysis was conducted to analyze the morphology of the biochar surface at the optimum pyrolysis condition. The extraction of PAHs compound from the surface of biochar was performed using the Soxhlet extraction method (1 g biochar, 160 mL of toluene, 6 h, 160 °C). Then, the extraction solvents were rotary evaporated until concentrated. Prior to analysis, 2 mL of internal standard's solution (p-dibromobenzene in acetone) were added to the concentrated sample extract and further quantitively measured by GC-FID.

As a result, the biochar yield decreased from 29.6 to 19.2 % when the pyrolysis time was increased as more materials is devolatilized. The biochar product at 10 min period showed the highest BET surface area of 337.49 m^2/g. Total pore volume also increased from 0.1066 to 0.1590 cm^3/g when the pyrolysis time was increased from 5 to 10 min. The pyrolyzed biochar at 10 min exhibit clean, well-developed pores and a honeycomb-like shape. The high porosity of biochar may improve nutrient and water retention in agricultural soil. Figure 1 shows the concentrations of individual PAHs compounds were identified at different pyrolysis time. Approximately 7 PAHs compounds were detected as dominant PAHs in the surface of biochar which is categorized as Low Molecular Weight (LMW) namely naphthalene, anthracene, phenanthrene, acenaphthene, and fluorene while the High Molecular

Weight (HMW) PAHs comprise of fluoranthene and pyrene. Generally, the yield of PAHs was reduced with increased pyrolysis time. Pyrene compound contributed the highest individual PAHs yield during microwave pyrolysis of EFB-derived biochar. The total PAHs concentration ranged between 7.51-15.19 mg/kg. The highest yield of PAHs content in biochar was synthesized at 5 min of pyrolysis time. This may be due to the highest occurrence of LMW PAHs formation simultaneously with the biochar during the primary decomposition of EFB. After 20 minutes, the PAHs content was decreased due to the release of LMW PAHs from the solid char into the gas phase. Overall, the optimum residence time was selected at 10 min with the highest BET surface area in compliance with IBI standards for PAHs quantification. Comparatively, the total PAHs concentration was analyzed between microwave and conventional pyrolysis processes. The extracted PAHs in biochar from conventional pyrolysis are between 0.58-0.77 mg/kg. Although PAHs have been identified at high concentrations in microwaved-biochar, all the individual PAHs compounds still satisfy the Department of Environment (DOE), Malaysia, and IBI guidelines. Therefore, microwaved-biochar is safe for soil amendment applications.

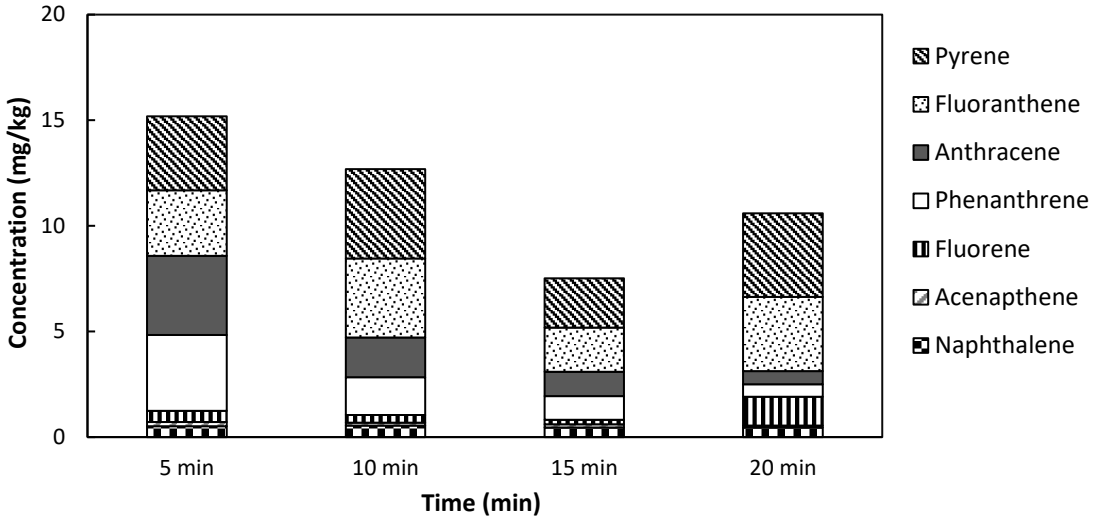

Fig. 1: Total PAHs compound in microwaved-biochar at varied pyrolysis times.

Keywords: Microwave pyrolysis; biochar; polycyclic aromatic hydrocarbons, soil remediation

Acknowledgement

Financial supports are acknowledged by the Ministry if Higher Education (MOHE), Malaysia and Universiti Teknologi Malaysia via UTM Fundamental Research Grant (Q.J130000.2551.21H55). This research also partly sponsored by Collaborative Research Grant National (R.J130000.7341.4B489) and JASTIP-Net 2019.

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BB7-166

Kinetics Modelling of Green Solvents Delignified Oil Palm Empty Fruit Bunch Pyrolysis via Thermogravimetric Analysis

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Extended Abstract

The urge to seek for green alternatives in replacement of conventional pretreatment methods has led to the disclosure of a new class of designer solvents termed Low-Transition-Temperature-Mixtures (LTTMs) as a prospective green pretreatment method [1]. The lack of researches makes it difficult to gain a clear insight on how actually the pyrolytic behaviour of pretreated biomass will be affected. Correspondingly, a kinetic study on the pyrolysis process of sucrose-based LTTMs pretreated oil palm empty fruit bunch (EFB) was carried out by using thermogravimetric analysis (TGA) equipment at various heating rates of 10, 30, 50 and 70 ℃/min. The present research project focused on the thermal degradation and determination of kinetic parameters such as the activation energy and frequency factor by means of three model-free methods namely Kissinger model, Kissinger-Akahira-Sunose (KAS) model and Flynn-Wall-Ozawa (FWO) model [2]. The results derived from TGA showed that three stages of thermal decomposition of oil palm EFB were identified such as dehydration, devolatilisation and degradation. In addition, the weight loss curves indicated that the pyrolysis of untreated and delignified EFB took place mainly in the range of 200 to 400 ℃. Moreover, the peaks of the differential thermogravimetry (DTG) curves which represent maximum degradation tended to shift slightly towards the right at higher temperature when the heating rates were being increased. The results showed that the values of kinetic parameters evaluated from model-free methods were compatible with each other whether it be untreated EFB or the delignified EFB. Furthermore, there was an increase in the activation energies after the process of pretreatment. Specifically, the activation energies increased from 129.40 kJ/mol to 188.83 kJ/mol for Kissinger model; 167.87 kJ/mol to 194.93 kJ/mol for KAS model; 167.22 kJ/mol to 190.09 kJ/mol for FWO model as shown in Table 1. The values evaluated from the three models were deemed to be in quite a good agreement. Similar results were also reported by Khan et al. (2015) in which the activation energies obtained from Kissinger, KAS, FWO as well as Starink model-free methods with reference to the untreated cellulose were compatible with each other [3]. Consequently, fundamental study on the kinetics modelling of LCBs pyrolysis associated with the current engineering advancements would definitely bring about the growth in certain industries.

Table 1. Kinetics parameters for the delignified EFB via Kissinger, KAS and FWO model

	Activation energy, E_a (kJ/mol)	Frequency factor, A $(min.^{-1})$	R^2 value	Activation energy, E_a (kJ/mol)	Frequency factor, A $(min.^{-1})$	R^2 value
0.1	111.48	5.773×10^{7}	0.3083	114.69	1.448×10^{14}	0.3431
0.2	197.52	2.390×10^{15}	0.9573	196.79	2.120×10^{21}	0.961
0.3	228.67	5.291×10^{17}	0.9663	226.67	3.735×10^{23}	0.9689
0.4	262.12	1.626×10^{20}	0.9788	258.71	9.230×10^{25}	0.9802
0.5	243.67	2.009×10^{18}	0.9963	241.34	1.362×10^{24}	0.9966
0.6	225.03	3.361×10^{16}	0.9892	223.74	2.732×10^{22}	0.9901
0.7	241.49	6.430×10^{17}	0.9955	239.53	4.668×10^{23}	0.9959
0.8	186.67	9.227×10^{20}	0.8214	166.88	1.284×10^{14}	0.8027
0.9	57.73	9.063×10^{9}	0.9121	42.51	1.154×10^{4}	0.8694
Average	**194.93**	$\mathbf{1.209\times10^{20}}$	-	**190.09**	$\mathbf{1.050\times10^{25}}$	-
Kissinger Model	$\boldsymbol{E_a = 188.83}$			$\boldsymbol{A = 1.037 \times 10^{13}}$		

Keywords: Biomass pyrolysis; kinetic parameters; model-free methods; thermal decomposition; thermogravimetric analysis.

Acknowledgement
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BB8-188

DEOXYGENATION OF PALM FATTY ACID DISTILLATE INTO GREEN DIESEL: OPTIMIZATION OF PROCESS PARAMETERS USING RSM HISTORICAL DATA DESIGN

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Extended Abstract

Palm fatty acid distillate (PFAD) from the palm oil refining industry serves as a low-cost feedstock to produce green diesel. It also has the potential to replace fossil fuels in the future, especially in tropical countries like Malaysia. In this study, PFAD was catalytically deoxygenated to produce hydrocarbon biofuel over a Ni-Co/SBA-15-NH_2 catalyst with the targets of high hydrocarbon (H/C) yield and diesel selectivity. The influence of two procedure parameters – temperature and time, as well as their interactions on the said targets was tentatively investigated in this paper. The dimensions of information constraints were (a) temperature of 270, 300, and 330 °C and (b) reaction time of 60 – 360 mins used to direct the trial. This study used historical data, and a second-order polynomial relapse equation model was constructed before being optimized using Response Surface Methodology (RSM). The optimal strategy parameters were at 270 °C and 360 mins. Table 1 shows the summary of the design, while the 3D response surface is represented graphically in Fig. 1. This study proved that authentic plan information with RSM is a well-organized statistical technique for forecasting the optimum operating conditions for catalytic deoxygenation, which plays a vital role in green diesel performance.

Table 1. Summary of design

Process parameters	Symbol	Range	Lower code	Higher code
Temperature (°C)	A	270 – 330	–1	+1
Reaction time (mins)	B	60 – 360	–1	+1
Response				
Hydrocarbon yield (%)	R1	Analysis polynomial	75.97	89.45
Diesel selectivity (%)	R2	Analysis polynomial	90.01	97.92

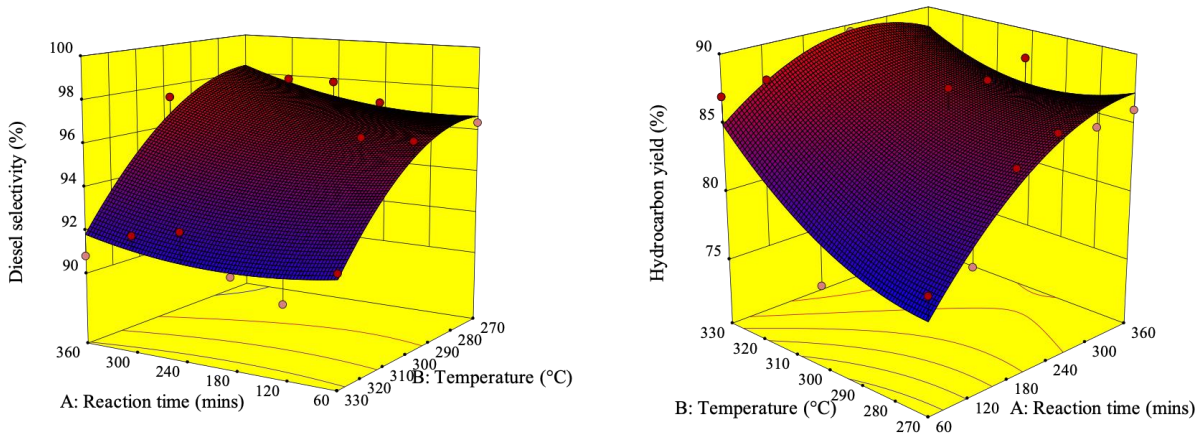

Fig. 1: 3D response surface plots

Keywords: palm fatty acid distillate; green diesel; response surface methodology; historical data; catalysts.

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BB9-208

DEVELOPMENT AND CHARACTERIZATION OF LOW-COST ALUMINA-KAOLIN MEMBRANE FOR REMOVAL OF GLYCEROL FROM BIODIESEL

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Extended Abstract

Biodiesel is commonly produced through a transesterification reaction of vegetable oil with alcohol in the presence of a catalyst [1]. This reaction also produces glycerol that must be separated from the biodiesel to meet the international standard of biodiesel product [2,3]. In most biodiesel industries, the separation of glycerol from biodiesel is usually conducted using water washing method [3,4]. However, this conventional method requires a vast amount of water and consumes a lot of energy for heating. As a result, a vast amount of wastewater is produced by using the conventional method and the wastewater treatment is costly [5]. In this work, a ceramic membrane to separate glycerol from biodiesel was developed using a mixture of alumina and kaolin as the membrane material. The use of membrane technology for the separation process is advantageous since it does not require any heating energy and no wastewater is produced [6,7,8]. Moreover, the use of kaolin as the membrane material opens the possibility for the fabrication of a cheap ceramic membrane since kaolin is an abundant natural resource and cheap. In this work, a tubular ceramic membrane was prepared from a mixture of alumina-kaolin suspension through a slip casting method. The membrane was dried at room temperature for 12 h, then it was dried in an oven at 60°C for 24 h and finally sintered at 1100°C at a controlled heating rate. The tubular alumina-kaolin membrane had an outer diameter of 10 mm with an inner diameter of 5 mm. The characterization of the membrane using scanning electron microscopy (SEM) showed a membrane microstructure that had a characteristic of a microfiltration membrane. The membrane was then tested through a microfiltration experiment using pure biodiesel as the feed solution. The membrane showed a permeate flux of pure biodiesel that was relatively stable against the permeation time as shown in Figure 1. The microfiltration experiment using biodiesel containing 1000 ppm glycerol showed a slight decline of the permeate flux with time due to the concentration polarization on the membrane, and then a stable permeate flux of about 40 $Lm^{-2}h^{-1}$ was obtained after 120 min as shown in Figure 1. From the analysis of the glycerol concentration in the permeate, the rejection of glycerol by the membrane was found to be 91%. The result of this work showed that a low-cost ceramic membrane for the biodiesel purification process was obtained using alumina-kaolin as the membrane material. The membrane showed a high permeate flux and a high selectivity for the separation of glycerol from biodiesel, thus it has great potential to be applied as an effective purification method in biodiesel industries.

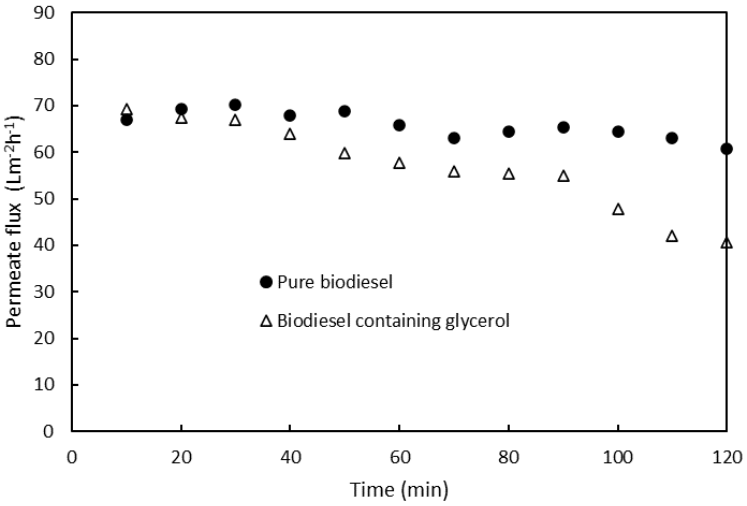

Fig. 1 Permeate flux of alumina-kaolin microfiltration membrane as a function of permeation time

Keywords: Ceramic membrane, microfiltration, alumina, kaolin, biodiesel, glycerol

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BB10-209

Green diesel production from waste cooking oil by Ni-Co/SBA-15 catalyst via deoxygenation reaction

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Extended Abstract

ABSTRACT

The 5Ni5Co/SBA-15 catalyst was successfully synthesized in this study. The hexagonal structure of SBA-15 and crystalline structure of 5Ni5Co/SBA-15 catalyst was confirmed by XRD (low and wide angle). In catalytic deoxygenation of the 5Ni5Co/SBA-15 catalyst at 300ºC for 6 h (1 h intervals)., it was found that the catalyst exhibit excellent performance in converting waste cooking oil into green diesel.

1. INTRODUCTION

In order to achieve one of the sustainable development goal as outlined by the United Nation, it is important to produce low-cost biomass into a valuable green fuel. Biomass-derived biofuel has appeared as a potential alternative towards a greener and sustainable for energy production [7]. By utilizing biomass such as waste cooking oil (WCO), two major issues could be solved which are lowering the production cost and a solution for proper waste oil management [5]. Generally, WCO could be converted into green diesel via deoxygenation reaction, by removing the carboxyl group from fatty acid of WCO to produce hydrocarbons (green diesel) by releasing CO_2, CO and H_2O [3]. The application of catalyst could promote the efficiency of the deoxygenation reaction and SBA-15 catalyst appeared as a good choice for catalyst support because of its 2D hexagonal structure, highly ordered mesopore channel, large surface area and pore volume and thick pore walls [6]. In addition, the presence of metal promoter such as nickel and cobalt could enhance the catalyst's properties due to their magnetic properties and inexpensive metal [10]. Therefore, in this study, 5Ni5Co/SBA-15 catalyst was synthesized and its performance was observed in deoxygenation reaction of WCO at 300ºC of 6 h reaction.

2. METHODOLOGY

2.1 Synthesis of catalyst

The synthesis of SBA-15 support was done by following a combination method developed by [8, 4]. 10.12g Pluronic P123 was dissolved with 308ml deionized water at 40°C by continuous stirring. Then, 57mL of 2M HCl was added and stirred for 2h, followed by 23mL TEOS and continued stirred for 24h. The solution was transferred into a Teflon bottle and heated at 80ºC for aging process (24 h). Lastly, the solution was washed with ethanol repeatedly and dried overnight at 80°C, followed by calcination at 500°C for 5h. The synthesized SBA-15 was doped with 5% of nickel ($Ni(NO_3)_2.6H_2O$) and 5% of cobalt ($Co(NO_3)_2.6H_2O$) by the wet impregnation method [2]. The metal salt was dissolved with 40ml of ethanolic solution (1:1, ethanol: water) by stirring at room temperature for 3 h. Then, the mixture was heated slowly at 80°C and stirred continuously until a pinkish green milky suspension formed. The solution was then dried for 18h at 80°C, followed by calcination at 550°C for 5h and labelled as 5Ni5Co/SBA-15.

2.2 Catalytic deoxygenation of WCO

The catalytic deoxygenation of WCO by 5Ni5Co/SBA-15 was done in a semi-batch reactor equipped with a cooling system in a H_2-free reaction condition. The reaction was carried out at 300ºC for 6 h (1 h intervals) with 5% of catalyst loading. Initially, the reactor was flushed with nitrogen gas for several minutes to ensure the reaction occurred in an inert atmosphere. Then, temperature was increased to 300ºC with nitrogen flow (20 cc/min) and maintained for 6 h under constant stirring. The biofuel products were collected at 1 h intervals and were analyzed using GC-FID.

3. RESULTS AND DISCUSSION

3.1 Characterization of catalyst

Figure 1a displayed the low angle XRD of synthesized support SBA-15 and 5Ni5Co/SBA-15 catalyst, where an intense peak appeared at 0.8°~1.1°, representing for the (100) peaks of the hexagonal mesostructure [9]. Albeit the intensity for (100) peak in 5Ni5Co/SBA-15 showed reduction owing to the successfully metal doping onto the support, it is still maintaining the (100) peak which prove that the metal doping does not interfere with the ordered hexagonal mesoporous structure of SBA-15 (Jin et al., 2019). The synthesized catalyst was further analyzed by wide angle XRD (figure 1b) to determine the crystalline structure and phase purity of the catalyst. A broad peak appeared at 15-30°, represent for amorphous silica in the framework [6]. For 5Ni5Co/SBA-15 catalyst, the presence of NiO (43.3º) (JCPDS-ICDD=78-0429), Co_3O_4 (31.2º, 36.9º) (JCPDS-ICDD=15-0806) and $NiCo_2O_4$ (36.9º, 44.6º, 59.4º) were clearly observed which proved that the metals are successfully impregnated onto the catalyst support.

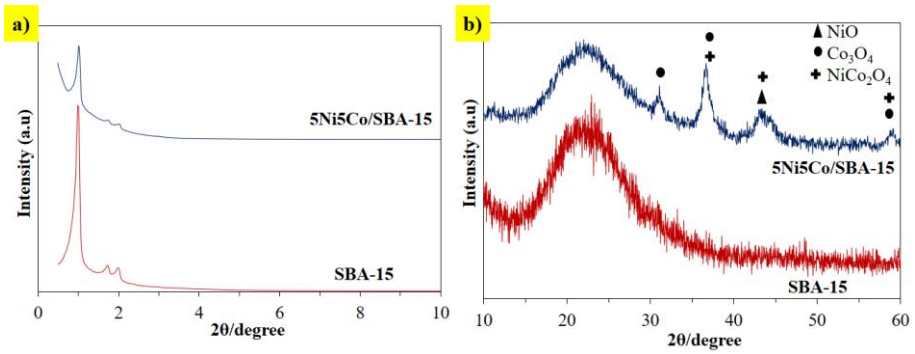

Figure 1 XRD; low angle (a) and wide angle (b)

3.2 Green diesel production

The catalytic activity of 5Ni5Co/SBA-15 was tested in a semi-batch deoxygenation reaction at 300ºC and was continuously observed within 6 h/360 min (60 min intervals) of reaction to determine the capability of the catalyst to convert WCO into green diesel fuel. From the GC-FID analysis of the green diesel produced from the reaction (figure 2), it was found that the hydrocarbon yield obtained was increasing from 30 min (44%) to 180 min (83%) and starting to decrease at 240 min (80%) to 360 min (71%). It is believed that the reactivity of the catalyst was increased over time but decreasing at some reaction time due to the coke formation on the catalyst that cause pores blockage which reducing the catalyst efficiency [1]. The same pattern was observed for diesel selectivity (C_{14}-C_{18}), where it was increasing from 30 min (80%) to 300 min (93%) and drop at 360 min (89%). Overall, it can be concluded that the synthesized 5Ni5Co/SBA-15 catalyst showed excellent performance in converting WCO into valuable green diesel fuel as it is able to produce high hydrocarbon yield (>80%) with high selectivity towards diesel-range hydrocarbon (>90%).

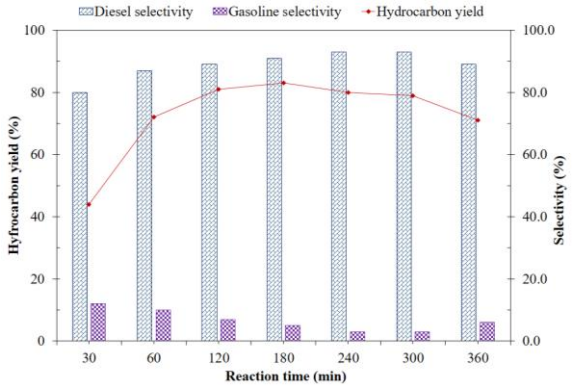

Figure 2 GC-FID analysis; hydrocarbon yield and selectivity

4. CONCLUSION

The synthesized 5Ni5Co/SBA-15 catalyst showed excellent performance in converting WCO into green diesel as it produced high hydrocarbon yield (>80%) and high diesel selectivity(>90%).

Keywords: SBA-15, nickel, cobalt, waste cooking oil, deoxygenation

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BB11-224

COMPARATIVE STUDY OF YIELD, COMPOSITION, REPRODUCIBILITY AND TOXICITY OF EXTRACT QUERCUS INFACTORIA GALL WITH CONVENTIONAL EXTRACTION AND Co-SOLVENT ASISTENT IN SUPERCRITICAL CO2 EXTRACTION

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Extended Abstract

Comparative studies of phenolic acid extracts from *Quercus Infectoria Gall* (*QIG*) using conventional solvent (water or methanol) extraction methods and with SFE-CO_2 and SFE-CO_2 extraction with co-solvents (water or methanol) can result in yielding, phenolic acid composition and differences in toxicity of the resulting extract. Conventional solvent extraction is carried out by inserting 10 grams of QIG (diameter 0.1-1 mm) inserted in solvent (water or methanol) with a volume ratio of 1:10 heated 50 and stirred for 8 hours, and the filtrate is evaluated Supercritical extraction of CO_2 (SFE-CO_2) is carried out with the same weight of *QIG* material and performs at a temperature of 60 ^oC and a pressure of 200 bar extraction time of 30 minutes, Further extraction of SFE-CO_2 with co-solvent (water or methanol) is done in the same way in a way without co solvent. The extract results from the extraction process are identified with phenolic acids (gallic acid, ellagic acid and tannic acid) by using HPLC as a composition of tannin acid, gallic acid and ellagic acid, and the total phenolic acid is higher than the extraction method of SFE-CO_2 and SFE-CO_2 with Co-Solvent compared to conventional extraction methods. The toxicity of SFE-CO2 extract is smaller than in the usual way of equilibrium. Reproducibility of phenolic composition in the SFE-CO_2 way is higher than the conventional extraction method.

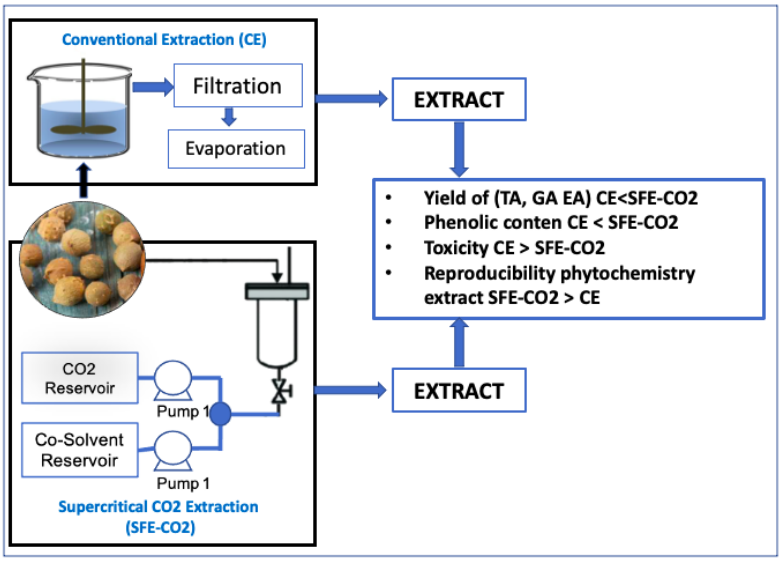

Fig. 1: Graphical abstract of *Quercus Infectoria Gal* extraction with Conventional Extraction and Supercritical Fluid extraction

Keywords: Quercus_infectoria, Extraction_Solvent, Supercritical-CO_2_extraction, Yield_extract, phenol_content_Reproducibility, Toxicity

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BB12-082

THE IMPACT OF TiO_2 ON THE COMBUSTION CHARACTERISTIC, KINETIC AND THERMODYNAMIC PARAMETERS OF MICROALGAE *Spirulina platensis*-SYNTHETIC WASTE BLEND

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Extended Abstract

This paper evaluates the catalytic impact of TiO_2 addition on the combustion behavior of the microalgae *Spirulina platensis* (SP) and synthetic waste (SW) blend using a thermogravimetric analyzer. The blend ratio of 30SP/70SW, 50SP/50SW, and 70SP/30SW (wt,%) with 5% of TiO_2 were used for each experiment. Around 10 mg of the sample was decanted on a ceramic crucible and heated in a furnace a with a rate of 10 ^oC/min from room temperature until 1000 ^oC. A 100 ml/min air atmosphere was continuously flowed to ensure sufficient oxidizing agent during the combustion process.

The results show that the blended fuels with and without 5%TiO_2 both decomposed in three stages, as shown in Figure 1. The main combustion reaction took place in the second stage. Depending on the type of the sample, temperatures in this stage started at around 166-191 ^oC and ended at around 490-507 ^oC, as presented in Table 1. Assessment of the second stage revealed that the decomposition could be divided into two zones. Zone I started at 166-191 ^oC and finished at around 360-395 ^oC. Zone II started at the end temperature of Zone I and finished at around 490-507 ^oC. The presence of 5% of TiO_2 forced the mass loss rate of the samples in Zone II toward a higher rate, except for the 30SP/70SW.

The kinetic evaluation performed by using the Coats-Redfern method was implemented on the six selected models, i.e., three diffusion model (parabolic law (D1), valensi equation (D2), Ginstling-Broushtein equation (D3)), two-phase interfacial reaction model (shrinkage geometrical column (S1) and shrinkage geometrical spherical (S2)) and power-law model (P). The results showed that the presence of 5% of TiO_2 in the samples significantly reduced the activation energies.

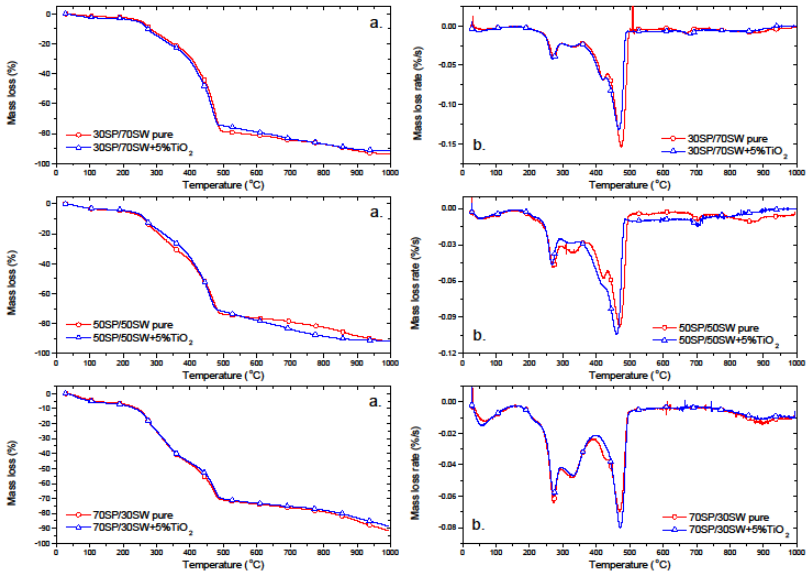

Fig. 1: The TG (a) and the DTG (b) curves of the samples

Table 1. Catalytic performance of the catalysts

Samples	Zone I				Zone II			
	Ti (°C)	Tmax (°C)	Tf (°C)	Mmax (%/s)	Ti (°C)	Tmax (°C)	Tf (°C)	Mmax (%/s)
30SP/70SW	191,044	272.596	363.823	-0.0396	363.823	475.19	501.115	-0.1539
30SP/70SW+5%TiO_2	190.101	268.122	362.022	-0.0425	362.022	467.933	496.784	-0.1318
50SP/50SW	172.93	269.322	366.511	-0.0483	366.511	470.718	506.874	-0.0977
50SP/50SW+5%TiO_2	173.554	266.28	360.106	-0.0463	360.106	461.162	490.504	-0.104
70SP/30SW	167.396	271.663	396.12	-0.0644	396.12	469.603	504.708	-0.0698
70SP/30SW+5%TiO_2	166.838	271.592	395.533	-0.0590	395.533	470.809	500.28	-0.0798

Keywords: Combustion; *Spirulina platensis*; synthetic waste; kinetics; thermodynamics

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Support received from Universitas Negeri Malang and the Government of Indonesia are acknowledged.

BB13-136

SAGO STARCH INDUSTRY IN MALAYSIA: OPPORTUNITIES FOR CLEANER PRODUCTION

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Extended Abstract

Sago is an important commodity crop to the state of Sarawak in Malaysia. Its starch is unique in character which is not possessed by any other starch producing crops thus making its highly in demand by specific food industries in Malaysia and Japan. However, water and energy conservation, coupled with concerns over the management of wastes cast a doubt on the long-term sustainability of the sago industry. This study elucidates the opportunities for cleaner sago starch production to increase its productivity level while at the same time addresses the current environmental problems faced by the industry and proposed solution the issues. Major input and output material flow were measured and assessed to identify the underlying issues in sago starch production. An overview of the production process, its mass flow, energy consumptions, production cost and opportunities of cleaner production were discussed. Among the proposed measures for cleaner sago starch production are housekeeping improvements, water conservation and recycling, modification to production process and treatment of wastes for value-added products generation. The large volume of wastes generated warrants effective and innovative measures to be adopted to ensure sustainability of the industry in all the three aspects being economy, social and environment. Among the available green technologies, sago wastewater treatment system coupled with biogas capturing is the most promising to address these issues of pollution that is facing the industry. An overview on the development of an integrated demonstration pilot plant to recover, treat and utilize the sago wastes were highlighted. These measures are capable to chart the Sarawak sago industry on the right path towards a sustainable future.

Table 1. Mass flow in sago starch production

Input/Output[1,2]	**Quantity**
Inputs	
Sago logs (number of sections)	70 ± 5.80
Water (m3)	68 ± 39.52
Electricity (kwh)	405 ± 97.24
Fuel oil (litre)	16.53 ± 15.36
Agriculture waste as burner fuel (ton)	0.12 ± 0.03
Outputs	
Starch (ton)	1
Repos/*Hampas* (ton bone dry)	0.45 ± 0.09
Bark (ton)	0.78 ± 0.19
Wastewater generation (ton)	77.8 ± 39.4
COD loading (kg)	8.03 ± 3.80

[1] Input and output units are based on 1 ton of dry starch at 12% moisture content

[2] All data are averaged based on n= 2 to 5 (based on availability of data)

Fig. 1: Development of an integrated sago waste recovery, treatment and utilization demonstration plant in Mukah, Sarawak

Keywords: Sago starch industry; cleaner production; sago wastes; biofuel.

Acknowledgement
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BB14-235

PERFORMANCE OF BIOCHAR-BASED GRAPHITIC CARBON NITRIDE: EFFECT OF PRECURSORS

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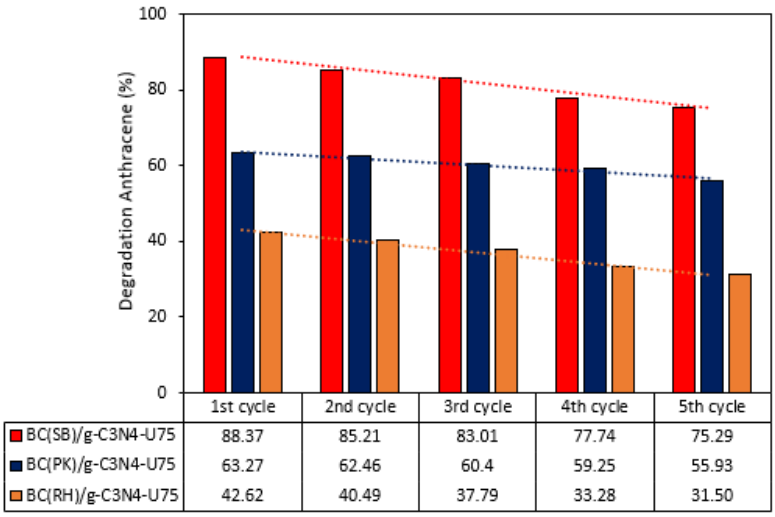
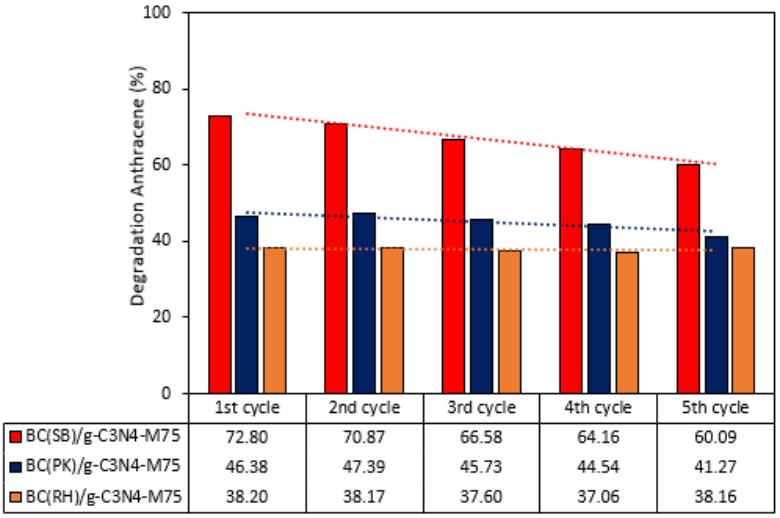
Extended Abstract

In this study, biochar-based graphitic carbon nitride (BC/g-C_3N_4) photocatalyst derived from different biomasses (sugarcane bagasse, rice husk and palm kernel) were synthesized via a facile thermal polycondensation method. The role of precursors was investigated by synthesizing the photocatalyst using different types of precursors (i.e., urea and melamine). The prepared photocatalyst were characterized by FTIR, N_2 sorption isotherm and XRD. Investigations on the effect of pH, initial concentration of pollutants and catalyst dosage to the performance of the photocatalyst was presented. Experimental results revealed that BC/g-C_3N_4 prepared from urea and derived from sugarcane bagasse demonstrated the highest percentage degradation of anthracene (88%) as compared to BC/g-C_3N_4 prepared from melamine (72%) under visible light irradiation, as shown in Fig. 1 and 2. Experimental results also suggested that several factors during photocatalysis influenced the overall performance of the photocatalyst. It is important to note that the new and green photocatalyst prepared from biomass waste holds great potential in green and sustainable wastewater remediation.



	1st cycle	2nd cycle	3rd cycle	4th cycle	5th cycle
BC(SB)/g-C3N4-U75	88.37	85.21	83.01	77.74	75.29
BC(PK)/g-C3N4-U75	63.27	62.46	60.4	59.25	55.93
BC(RH)/g-C3N4-U75	42.62	40.49	37.79	33.28	31.50

Fig. 1: Catalytic performance of BC/g-C_3N_4 prepared from urea



	1st cycle	2nd cycle	3rd cycle	4th cycle	5th cycle
BC(SB)/g-C3N4-M75	72.80	70.87	66.58	64.16	60.09
BC(PK)/g-C3N4-M75	46.38	47.39	45.73	44.54	41.27
BC(RH)/g-C3N4-M75	38.20	38.17	37.60	37.06	38.16

Fig. 2: Catalytic performance of BC/g-C_3N_4 prepared from melamine

Keywords: Biochar; Graphitic Carbon Nitride; Photocatalytic, Anthracene

Acknowledgement

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OCEAN THERMAL ENERGY SYSTEM (OTES)

OTES1-177

An Assessment on Technical Challenges of Heat Exchangers in Hybrid Ocean Thermal Energy Conversion

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Extended Abstract

The ocean is an unlimited source of energy covering about 70% of earth's surface. Ocean thermal energy conversion (OTEC) is the application of thermal gradient which is clean and renewable, continuously available, and able to contribute to base-load power supply compared to solar and wind [1]. Based on the location such as at the equator, temperature difference between surface seawater and deep seawater from 700 m depth experience negligible changes throughout the year [2]. Numerous simulations were also reported to show the potential in theoretical OTEC to produce annual power production up to 30 TW from 1000 m depth [3]. However, OTEC technology has not reached commercial stage attributed to several challenges.

It is crucial to identify the present technical challenges of heat exchangers in OTEC which is one of the main components. In OTEC, plate type heat exchanger is often selected because of the compact design. Currently, Makai Ocean Engineering, Institute of Ocean Energy Saga University (IOES), Kumejima OTEC and Korea Research Institute of Ships and Ocean (KRISO) floating OTEC have plate type as the heat exchangers. Theoretical thermal efficiency in OTEC is low due to the limited temperature difference in heat sources, which is up to 30 °C, thus it is important to improve the heat transfer performance of the system. In OTEC, some degradation factors were identified to hinder this objective such as corrosion, erosion, fatigue, and biofouling. Except for biofouling, these degradation factors can be prevented by selecting suitable material. Biofouling consists in the deposition of microorganisms on material surface, that could prevent the maximum heat transfer efficiency in the heat exchangers and increase maintenance cost [4]. It was reported that the built up of thick biofilm ranging 25 to 50 μm decreased the heat transfer performance of the heat exchanger by 40 to 50% [5]. Thus, scholars are investigating physical and chemical methods to contain biofouling as much as possible. Besides, researchers are recently developing the hybrid cycle which uses an evaporator-condenser, referred to as "eva-con", that is not subject to biofouling. This short review aims at finding the present biofouling prevention method and **identifying the** difficulty in assessing eva-con heat transfer coefficient in hybrid OTEC.

The proposed chemical and physical methods include heat treatment using high temperature surface seawater, chlorination, and mechanical cleaning [6-8]. For chemical method, the number of microorganisms in seawater needs to be assessed before deciding the chemical dosage. For physical method, in the hybrid cycle developed by Universiti Teknologi Malaysia (UTM) and IOES, surface seawater steam is generated by a flash chamber. The use of distillation process in flash chamber will completely prevent the salt and other impurities from entering the eva-con thus preventing biofouling [9]. The condensation of this steam in eva-con releases substantial amount of latent heat. This heat will be transferred to working fluid side such as ammonia which vaporized to run a turbine for power generation. This also allows the eva-con to be manufactured in a low-grade material such as stainless steel or aluminum instead of titanium as corrosion can be prevented. Besides, material like aluminum could offer better heat transfer performance because of the higher thermal conductivity compared to titanium.

The issue with this cycle is the difficulty to assess the eva-con heat transfer coefficient because of the different approach on the performance evaluation method compared to conventional evaporator. Previous researcher investigated on the conventional evaporator, for instance, Koyama et al [10] developed an empirical correlations for ammonia boiling to predict convective evaporation heat transfer coefficient by using Lockhart-Martinelli parameter based on known single phase convective heat transfer coefficient of seawater side. However, this method could not be assigned to the eva-con because of the phase changes on both heat source side (vaporized surface seawater) and working fluid side. Therefore, a different method to evaluate the heat transfer coefficient is required. The closest reference with phase change in both sides was done by Kafi et al [11], who proposed the heat transfer coefficient for evaporation and condensation of seawater in their multi-effect distillation (MED).

In conclusion, the developing method of hybrid OTEC is more promising for biofouling prevention compared to chemical and physical method. This use of such a cycle does not require pre assessment of the seawater and mechanical cleaning as no biofouling phenomenon occurs in the eva-con. Finally, at present, adequate references do not exist in the literature for the applicable empirical formulas to assess the heat transfer coefficient for the design of eva-con in hybrid OTEC, and more investigation are therefore required.

Keywords: OTEC; plate heat exchanger; biofouling; eva-con; heat transfer coefficient

Acknowledgement
Authors are grateful to acknowledge the Science and Technology Research Partnership for Sustainable Development (SATREPS) and the Japan International Cooperation Agency (JICA). Also, to the IOES and Ocean Thermal Energy Centre UTM.

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OTES2-207

Climate Change, Water Resources, & Renewable Energy in The Bahamas

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*"**A measurable scientific well condition, of the effectiveness of liquid waste dispersion in a deep well, is the temperature profile of the static well water. At depth throughout the Commonwealth of the Bahamas, due to the massive amounts of seawater that move in and out of the carbonate banks in response to tidal currents, the temperature of the water decreases with depth. This inverted geothermal gradient in the subsurface of the Bahamas, is indicative of a high degree of exchange with the surrounding ocean and responsible for very high hydraulic conductivities on a regional scale. This alone differentiates us to the continental areas" (Cant, 2004).***

There is presently no formal definition of a 'water-energy nexus' for The Bahamas, but the concept involves the effective use of ocean water for the provision | production of energy. Both freshwater supply and energy demand are constraints of achieving sustained economic growth throughout the islands of The Bahamas. Ocean Thermal Energy Conversion (OTEC) is being researched for implementation to effectively address the water-energy nexus, using the natural conditions of the groundwater resources. Due to the inverted geothermal conditions of the water resources, groundwater wells versus direct abstraction from the marine environment (or, return to) is possible for the application to the proven principals of OTEC. The OTEC technology is based on a local renewable source [saltwater], occupies a small land area, is not affected by tropical weather, and has no Green House Gas (GHG) emissions/waste. The United Nations Conference on Sustainable Development (RIO+20) – "the future we want"; recognized the linkages of the Sustainable Development Goals (SDGs) with a particular concentration on 'people'. These SDGs are universal for all countries; independent of their level of development, and are rather simple development goals. The lessons learned from the Millennium Development Goals (MDGs) were transferred to the SDGs; for instance, the synergy of access to both water and energy.Climate Change is expected to have overarching effects due to rising sea levels, variation of rainfall distribution, the frequency of related tropical cyclones, and storm surges associated with tropical storms. The Bahamas is an archipelagic state challenged with water resources, climate variation effects, and effective renewable energy options. Sustainable use of all the natural resources must be a key consideration built within all of the development plans. Thru the integration of OTEC with the Seawater Reverse Osmosis (SWRO) technologies, it is hoped to possibly address two key climate resilience goals of The Bahamas – SDG#6, Clean Water & Sanitation, and SDG#7 provision of affordable and clean energy [Renewable Energy]. Small Island Developing States (SID's) remain the most vulnerable areas to climate change. Compounded with the foreseen energy crises, climate change and renewable energy remain at the forefront of many of the Caribbean Region activities. In The Bahamas, the water resources comprise of the freshwater lenses that float on seawater at depth, with a brackish water interface. All freshwater in The Bahamas is as a result of rainwater that penetrates the ground surface and generally encountered at 0.9 to 1.5-meter (3 to 5-Ft) below ground level (see Figure 1). What is specifically unique of the water resources of the Bahamas is the existence of the subsurface inverted geothermal conditions. The conditions of the groundwater are indicative of the high degree of exchange with the surrounding ocean. The geography is a marine environment with limited freshwater resources, like many other SIDs. SWRO is utilized to address concerns of availability of freshwater resources throughout the islands, but the cost of the water is grid and/or generator specific (all presently tied to fossil fuels). SWRO presently utilizes groundwater wells temperature profiles of 24°C to 25°C (75°F to 78°F). The minimum temperature differential required for OTEC is 20°C (36°F) between the water sources. The average surface water temperature from shallow wells is 27°C (81°F). For the OTEC Proof Of Concept and using existing groundwater wells, it is proposed to adjust the high temperature source water for the OTEC by Solar Photovoltaic Cells to 50°C (122°F). As with the temperature differential of the marine waters: the inverted

geothermal conditions of the groundwater in The Bahamas must be further explored for combined SWRO + OTEC [a source of renewable energy for the reverse osmosis process]. Seawater District Cooling (SDC) and Seawater Air Conditioning (SWAC) are presently being utilized throughout the islands of The Bahamas. Borehole data is available from a pilot well drilled down to 304.8-meter (1,000-Ft) in the Cable Beach Area on the Island of New Providence. At a depth of 304.8-meters (1,000-Ft.) the water has a temperature of 20.3°C (68.5°F); which supports the contention that the reverse geothermal gradient extends further into the subsurface (see Fig 2 from Ardaman & Associates, 2013). In The Bahamas, using the natural conditions of the groundwater resources, OTEC can efficiently be used to address the water-energy nexus.

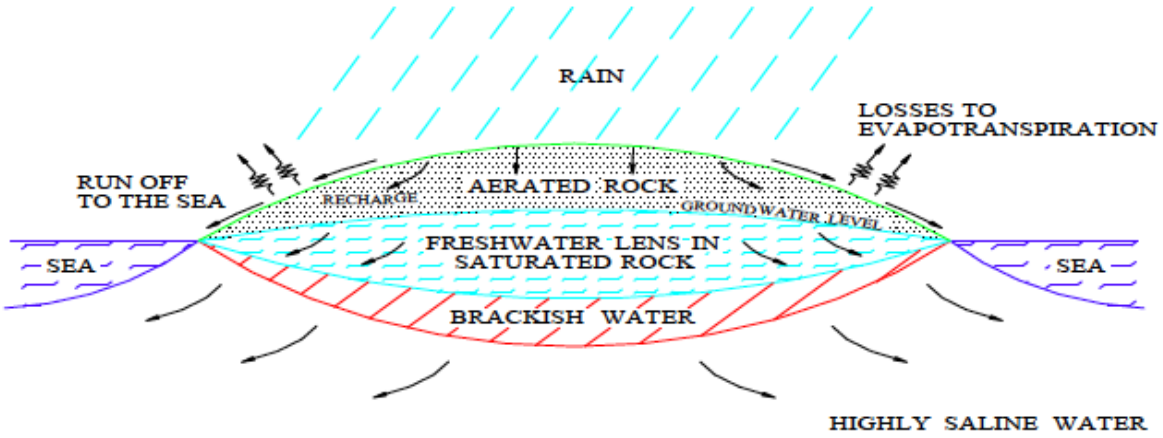

Fig. 1: Groundwater Resources of The Bahamas

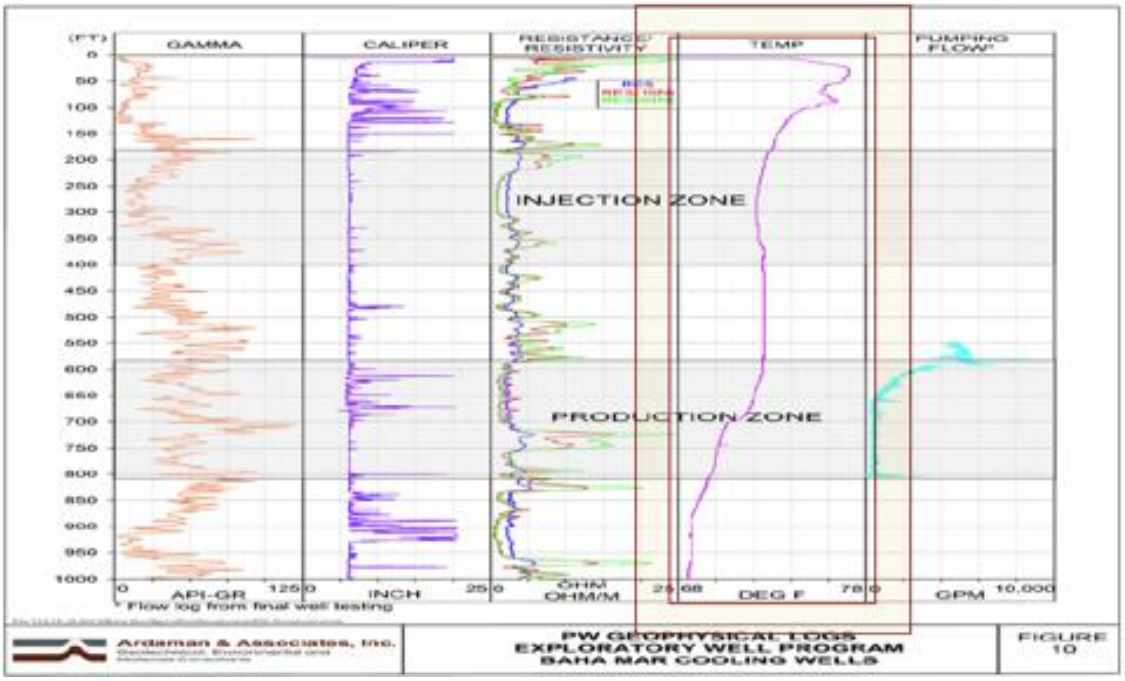

Fig. 2: Hydrogeological Data from an SDC Supply Well in The Bahamas

Keywords: Climate Change; OTEC; SDGs; SIDs; SWRO

Acknowledgement
Water Resources Management Unit related works by Dr. Richard V. Cant | Philip S. Weech | Michael Swann.

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OTES3-127

EVALUATION OF MAJOR COMPONENTS IN CLOSED CYCLE OTEC SYSTEM: A REVIEW

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Abstract

Ocean Thermal Energy Conversion has the potential to develop low-carbon societies and sustainable energy systems. There are over 1863 publications on OTEC related studies that can be found in Scopus, from the year 1972 to 2022. However, there are least number of review papers published on comprehensive study of OTEC components. In this review paper, the major components of closed cycle OTEC system that been studied are turbine, evaporator, condenser, working fluid circulation pump, and ocean water pipe. The main objective of this review paper is to conduct a systematic study on the contributing parameters and performance optimization of major components in closed cycle OTEC system.

Keywords: Ocean Thermal Energy Conversion, Closed-Cycle, Major Components, Contributing Parameters, Performance Optimization

1. Introduction

Ocean Thermal Energy Conversion (OTEC) has tremendous potential in tropical regions to be an alternative source of energy which is renewable and green. There are various usage and products from an OTEC plant, such as desalinated water, refrigerated soil agriculture, aquaculture, and many more [1]. Many researchers from different parts of the world have studied the feasibilities and developed new innovative ideas on OTEC system. However, review papers were not able to focus on all aspects of the OTEC components. Therefore, in this review paper, a systematic study on the contributing parameters and performance optimization of major components of closed cycle OTEC system was carried out based on previous studies. This review could give a wide-range view on the status of OTEC research and identify the suitable research gap which can be covered in upcoming studies.

2. Bibliographic Analysis

A comprehensive bibliography analysis on OTEC related studies as of February 2022 was carried out by utilizing the Scopus analysis tool. The data on the number of publications by year, primary contributors, publication sources, actively involved countries, authors' and indexed keywords are some of the data collected from Scopus. Based on the analysis, there were a total of 1863 publications which consist of conference papers, articles, review papers and others, published from the year 1972 to 2022.

3. Discussion

As shown in fig 1, the principle of closed-cycle OTEC system starts with warm, surface seawater entering the evaporator and vaporize a working fluid, ammonia with a low-boiling point, which then turns a turbine to generate electricity. The vapor ammonia is then condensed to liquid ammonia by exchange of heat with the cold, deep seawater in the condenser. The process continues by the working fluid circulation pump which returns the condensed ammonia to the evaporator to be vaporized again [2]. The major components in OTEC system are evaporator, condenser, turbine, working fluid circulation pump, and ocean water pipe. A review of these components based on their contributing

parameters and performance optimization are compiled and discussed. As for turbine, the radial-inflow turbine shows better stability without obvious backflow and eddy current [3], and the performance is influenced by the number of stator blades [4]. While for evaporator and condenser, plate-type heat exchangers are shown better performance and the optimization of evaporator [5] and condenser [6] were conducted in previous studies.

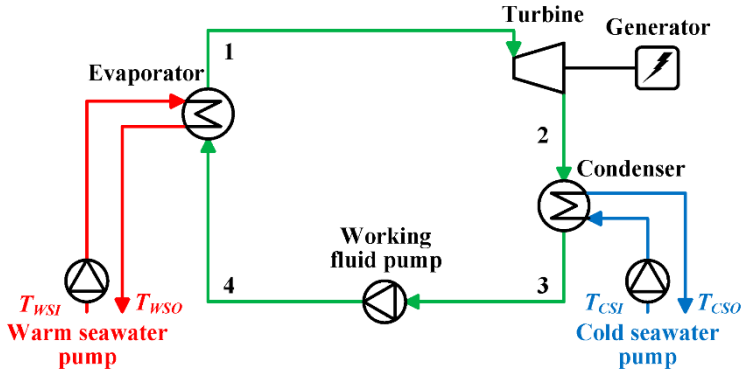

Figure 1: Schematic diagram of closed cycle OTEC system [2]

4. Conclusion

OTEC has huge potential in the production of desalinated water together with power generation. In this review paper, the major components in OTEC system have been thoroughly discussed on various aspects of the components such as the contributing parameters and performance optimization.

Acknowledgement

Authors are grateful to acknowledge Ocean Thermal Energy Centre – Universiti Teknologi Malaysia (UTM), Institute of Ocean Energy – Saga University (Japan), Ministry of Education (MoE) of Malaysia for this Long-Term Research Grant Scheme (LRGS), MyPAIR grant R.K130000.7856.4L894, and Science and Technology Research Partnership for Sustainable Development (SATREPS) project members from both Malaysian and Japanese team.

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OTES4-134

Structural Analysis of Radial Turbine Impeller for OTEC

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Extended Abstract

The radial turbine impeller in the OTEC turbine unit experiences fluid pressure and spins at a high rotational speed. The objective of this paper is to give a detailed insight about the structural behaviour of a radial turbine impeller under fluid forces, centrifugal forces, and vibration. Finite element analyses were first conducted on the impeller blade for different blade thicknesses and materials at start-up conditions under the maximum fluid loading pressure of 800 kPa. Suitable blade thickness and material were chosen and the whole impeller was then analysed under running conditions of 630 kPa fluid pressure and the maximum centrifugal load at 50,000 rpm. For the startup condition, blades from aluminium alloy would not fail if the thickness is 1 mm or more. Stainless steel and titanium alloy give better results. Also, from the modal analyses done on the impeller, aluminum alloy impeller gives lowest natural frequency, followed by stainless steel and titanium alloy. Finally, frequency response analyses were done on the impeller with 1 mm thickness stainless steel blades to obtain the resonance frequency, which gives the highest deflection at 10,000 Hz and highest stress at 12,000 Hz.

Keywords: OTEC; Radial Turbine; Stress Analysis; High RPM.

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OTES5-192

Development of Advanced Hybrid Ocean Thermal Energy Conversion (OTEC) Intake Piping Filtrations System: First Experimental OTEC Plant of Malaysia

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Abstract – OTEC utilises temperature differences between ocean surface water and cooler deep water to produce electricity. The concept of using temperature differentials between surface and subsurface waters in tropical ocean areas as an energy source is not new, although the process has only recently become practical. One of OTEC's most significant advantages is that it allows the co-production of drinkable water, in addition to electric power through desalination. For each megawatt of generated electricity, it can produce up to 2 million litres per day. The electricity produced by OTEC has a fixed cost; therefore, it is not susceptible to the volatility of costs that affects other energy sources such as coal, natural gas, and petroleum. Also, no products of combustion are generated during the process since OTEC has less environmental impact than other sources of energy. Input obtained from OTEC experts in Malaysia and Japan, the need to obtain good seawater quality is very important, it is proposed that an up-to-date design for water intake with filtering appropriate to the conditions in the waters of Port Dickson, N. Sembilan. Based on the latest data collections, there is a need to develop an additional seawater filter and piping system to support the overall development of the SATREPS OTEC project. The need for this additional contingency scope is identified once the exact location for the intake and quality of seawater is obtained. An additional 183- meter piping system is required to ensure that H-OTEC operations can be carried out as originally planned based on the lowest low tide height data obtained. Special cone-shaped weights will be designed to be placed on the seabed. In addition, advanced seawater filters are required to minimize the rate of foreign particles and sludge entering the H-OTEC system that could potentially interfere with future operations and research activities.

Keywords: H-OTEC, sea water intake, filtration system, piping

OTES6-212

PRELIMINARY STUDY OF BIOFOULING GROWTH AND ADHESION PROFILE AT VARIOUS TEMPERATURE SETUP– A CASE STUDY FOR OCEAN THERMAL ENERGY CONVERSION (OTEC) FACILITY

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Extended Abstract

Ocean Thermal Energy Conversion (OTEC) is renewable source of energy that harnesses potential energy from sea water temperature difference between warm sea water surface and cold deep sea water. Apart from its consistent energy generation, it could be diversified into other side industries, making OTEC as attractive and sustainable source of renewable energy [1, 2]. As the system utilizes sea water as its main fluid, this may cause unwanted biofouling growth and accumulation in pipelines and processing equipment, causing hindrance of optimum flow inside pipelines, reducing OTEC performance or in a worst-case condition causing severe blockage and damage to the processing equipment [3]. Considering that biofouling is an inevitable condition which may not be completely eliminated, a comprehensive study for assessing potential biofouling growth and deposition mechanism is a crucial step for strategizing effective biofouling management in a commercial and large-scale OTEC power plant facility.

Temperature variation is the main focus for this study due to its requirement for utilizing sea water at warm surface seawater and cold deep seawater. Previous studies on temperature variation reported various outcome of bacterial growth profile and adhesion in either higher or lower temperature range [4-6], in which the applicability of these outcomes with respect to OTEC limited on factors such as sea water sample, characteristic of surface (substrate) for biofouling adhesion, design and operability of biofouling assessment, environmental factors and other factors. Based on this outcome, a laboratory setup with temperature controlled environment is the best and practical for replicating biofouling assessment under OTEC setup. However, simulating such setup close to realistic OTEC conditions is a challenging task due to the absence of any comprehensive biofouling assessment study concerning on temperature evaluation. Therefore, a preliminary study for determining suitable parameters in setting up condition under laboratory protocols is necessary prior to a complete biofouling assessment.

In this study, a bench-scale flow setup was constructed in which it simulates coastal condition where the potential OTEC to be constructed, in this case, a proposed site of an OTEC laboratory facility in Port Dickson was considered in this study. For setting up a realistic biofouling environment, samples of sea water and soil obtained from the proposed site. The samples were later used in the laboratory setup where a circulated sea water flow system was set up along with a temperature-controlled heated plate

for heating up sea water sample. The acquired sand sample was added into a small water aquarium tank to replicate seabed environment. A plastic board consists of a set of short high density polyethylene (HDPE) pipes acting as substrates for biofouling adhesion surface was place inside a tank and subjected to circulated sea water flow within a period of assessment. Two different temperature setups were specified in this assessment (40°C and 60°C) along with one setup at room temperature. Assessment of biofouling was done by measuring weight of dry and wet sample of HDPE pipe sample obtained in four interval days (2nd, 4th, 7th and 21st day) within 21 days of experiment was conducted.

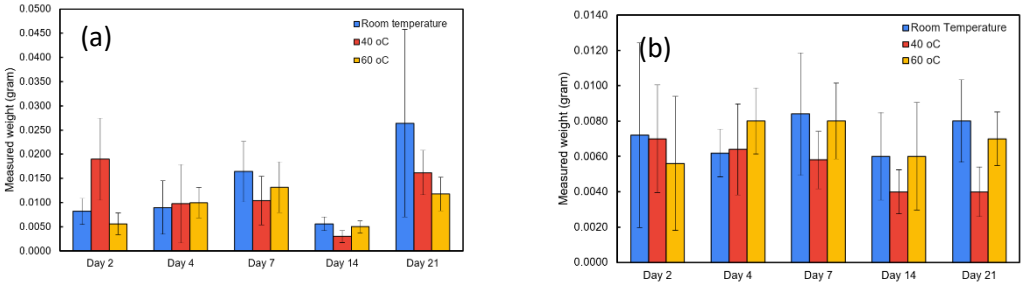

Fig. 1: Measurement of biofouling weight for wet (a) and dry (b) samples

Data presented in Fig. 1(a) indicates no significant variation of data showed in the wet sample within the range of maximum 0.025 gram to the lowest at 0.05 gram. However, potential increment of biofouling was recorded at the 21st day for the samples obtained in room temperature, where similar trend was also recorded for setup at 60°C with the period of the 2nd day to the 7th day. Assessment conducted in the wet sample (Fig.1(b) indicated similar observation with inconsistence data trend within 0.01 gram to 0.004 gram sample.

Increasing trend of biofouling growth and adhesion conducted at room temperature indicated a few possibilities, either there is potential accumulation of dead biofouling on the surface of sample or continuous biofouling growth with respect to time. Under the scope of biofilm accumulation process, the absence of clear biofouling accumulation within three different temperature range shows that it is sufficient to conduct an improved experimental within room temperature. For assessing any potential impact of high temperature range, the results show a need to improve further this experiment by conducting longer period of observation with further improvement on analytical assessment of biofilm formed on the substrates.

Keywords: Ocean thermal energy conversion (OTEC); biofouling; temperature variation

Acknowledgement

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OTES7-228

ASSESSMENT OF POTENTIAL SITE FOR OCEAN THERMAL ENERGY CONVERSION (OTEC) IN SABAH, MALAYSIA

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Extended Abstract

Renewable energy (RE), often know as clean energy, such as solar, wind, geothermal energy plays a significant role in energy security and the reduction of greenhouse gas emissions. Considering that the RE benefits the environment, the Malaysian government has set an aim on achieving 20% penetration of the renewable energy spectrum by 2025. Ocean Thermal Energy Conversion (OTEC) which involves the harnessing of temperature differences between the ocean surface waters and deep ocean waters, is a technology to produce renewable energy. Sabah, being located in the tropical region, has a surface water that is generally much warmer than its deep water and this difference in temperature is suitable for the OTEC to produce electricity and to desalinate ocean water. Given the potential of OTEC in Sabah, the potential site for OTEC must be analyzed and comprehended in terms of energy sources. As a result, this study is being carried out to evaluate the potential site for OTEC based on temperature, salinity, and dissolved oxygen derived from a few selected databases, which include ocean model and field observational data, namely the World Ocean Database (WOD) and numerical ocean model. The assessment has been conducted on three selected locations off the coast of Sabah, namely Pulau Mengalum, Pulau Kalumpang, and Pulau Bum Bum. The temperature-depth profile derived from WOD at Pulau Mengalum indicated that the surface temperature was between 26 – 31.5 °C and decreasing to approximately 6 °C at 700 m, whereas the surface temperature was between 26 – 31°C and decreasing to around 6 °C at 800 m at Pulau Kalumpang and Pulau Bum Bum (Figure 2). According to Thirugnana et al. [1], the temperature difference between the surface and deeper layers must be greater than 20 °C in order to operate a viable hybrid OTEC; thus, the cold seawater pipes must reach at least 700 m at Pulau Mengalum and 800 m at Pulau Kalumpang and Pulau Bum Bum in order to obtain a temperature difference of 20 °C between the surface and deeper layers.

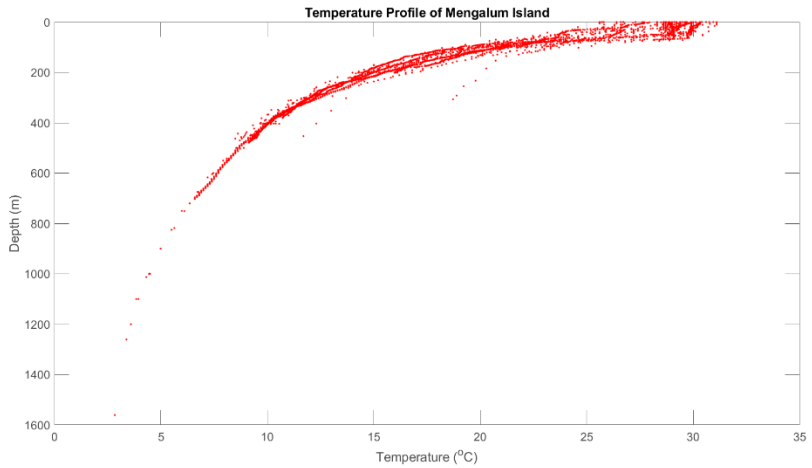

Fig.1: Temperature-depth profile at Pulau Mengalum derived from WOD.

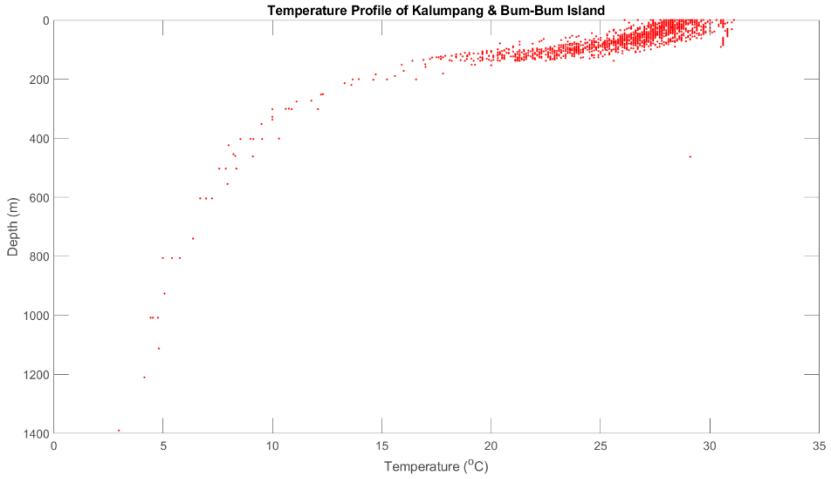

Fig.2: Temperature-depth profile at Pulau Kalumpang and Pulau Bum Bum derived from WOD.

Keywords: renewable energy; OTEC; Sabah; temperature-depth profile

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OTES8-241

Novel Strategies for Data Centre Waste Heat Use

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Abstract. Data centres – warehouses where thousands of computers drive our online activities as well as an increasing amount of data computation and storage – are heavy electricity users. This paper proposes reusing the energy after the computers have transformed the electricity into waste heat. Two novel strategies are presented, commodity dehydration (for human consumption and for heat storage solutions) and increased work efficiency for ocean thermal energy conversion (OTEC) technology. We argue that data centre waste heat use is possible both in cold and warm nations, but that strategies to use the heat efficiently must be case-dependent. It is concluded that few, if any, other energy savings can be so easily made for the data centre industry – saving billions of dollars in the process – and bring societal gains globally, as data centre waste heat use.

INTRODUCTION

"Data centres" are warehouses with thousands of computers and owned by the likes of Amazon and Google, smaller enterprises, authorities and individual, "co-location" providers. Consuming about 1% of world electricity [1], these heavy electricity users come with high carbon footprints and with severe strains on national energy grids. Their high power need is due to processor intense computations and the cooling of the servers. Supplied electricity ultimately transforms into waste heat, which is typically vented out. The filtered and often dehumidified airflow of a data centre is only in the range of 30-45°C. Apart from heating and cooling under favourable conditions, how can the waste heat be used? Our recommendations fall into two categories: commodity dehydration and increasing work efficiency of renewable energy technologies based on thermal principles.

METHOD

Finding new use cases for energy reuse calls for cross-disciplinary thinking, and paving new ground makes validation challenging. To verify our findings, we use "triangulation", which gives a multi-faceted perspective on one specific issue. In this case, the research problem has been approached through an extensive and cross-disciplinary literature review, ethnographic research in Sweden and Malaysia, interviews, and participation in data centre industry hearings.

COMMODITY DEHYDRATION

A theme we currently explore, and first presented to the research community in 2020 [2], involves commodity dehydration. This previously uncharted territory would not decrease energy use, but give an ability to repurpose heat to the benefit of high-, mid- and low-income countries around the Globe. Furthermore, using the heat as-is avoids the need for heat exchangers and their associated energy conversion losses.

Large-scale commodity dehydration One commodity used today for large-scale commodity dehydration is wooden pellets. Many other commodities can potentially be dehydrated using data centre waste heat, such as fruit, fish or tea leaves for human consumption, fodder for cattle, and seaweed for biofuel production. In so doing, data centres would substitute massive amounts of electricity and fossil fuel used for dehydration today. The strategy bears merit also in the tropics: industrial dehydration in warehouses increases food security due to the enclosure.

Small-scale commodity dehydration In addition to addressing the world's electricity use, data access and commodity dehydration are enablers for building local sustainable communities. One particularly

suitable commodity for dehydration is coffee, the world's most traded commodity after oil. For an agricultural community away from major cities, the prospects of using data centre waste heat to dry commodities are appealing. Bridging political ecology and engineering, this strategy can be used in many countries.

Energy storage solutions There are ways to store waste heat energy economically, safely and reliably. The wooden pellets drying example above is one such technique. Another idea worth further investigation is dehydration of salt hydrates. The idea has several benefits: salt hydrates are inexpensive, can be stored for a long time, and are non-toxic. Importantly, some of them work at the low-temperate heat provided by data centres.

OCEAN THERMAL ENERGY CONVERSION (OTEC) INTEGRATION

One option we put forward in 2021 [3] is running a working fluid such as ammonia, air or water between a data centre and a dedicated heat exchanger in an ocean thermal energy conversion (OTEC) plant. In OTEC, warm surface water and cold deep ocean water interplay to either evaporate and condense a working fluid or evaporate the incoming surface water, which produces drinking water as a by-product. In both cases, the evaporated fluid drives a turbine and generates electricity. In our proposition, heat energy is transferred via heat exchangers from used server cooling fluid to the OTEC plant. The working fluid or a separate intake of seawater or river water would cool the multi-megawatt data centre. The data centre's electricity would thus be reused as heat in the OTEC process, and the retrieved heat energy would help to power the data centre as electricity in a circular fashion.

Much of the world's population and financial growth in the coming three decades will take place in Africa and Southeast Asia. Hence, this is where new data centres are needed, and the areas coincide with OTEC's most favourable locations.

CHALLENGES

For both main strategies, some challenges remain. C*ommodity dehydration* has been proven to work. Still, this highly site-dependent strategy needs research on factors such as temperature, humidity, available commodities, commodity drying season length, political stability, road infrastructure, ICT needs and country financials.

The combination of *OTEC* and data centres is appetising, not least as it may provide a financial injection to the still small OTEC industry. However, there is the question of the OTEC industry itself. The technology has been proven, but needs scaling up. In addition, more research is needed find the appropriate working fluid and discovering where in the OTEC process to inject it to achieve optimal results.

CONCLUSION

The triangulation-based methodology points towards one single conclusion: data centre waste heat use is possible in both cold and warm climates and regardless of social structures and local financial situation. Evidently, there are several exciting uses for data centre waste heat. The many possibilities that the two strategies offer also pave the way for future work regarding engineering design solutions and geography-based case studies. We claim that for the data centre industry, few, if any, other energy savings can be so easily achieved, and bring the societal gains that data centre waste heat use can. Our further work will shed more light on this issue.

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SOLAR THERMAL ENERGY (STE)

STE1-112

Evaluation of Contemporary Renewable Energy Schemes in Malaysia and its Relevancy for Photovoltaic Thermal Roof Tile Application

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Extended Abstract

Solar energy technology has evolved rapidly these days as it is forecasted as a future energy which promotes sustainability and inherently a non-polluting source. The typical solar energy technology that are being applied in Malaysia is either photovoltaic solar or thermal solar. In a most recent finding, solar photovoltaic and solar thermal are being integrated and design as a roof tile. In order to sustain the solar energy application in Malaysia, the government has implemented numbers of mechanism in term of framework (i.e. policy, scheme and action plan) to encourage various sectors to apply the prior technology. However, the relevancy of the existing framework towards the latest photovoltaic thermal (PVT) roof tile technology is still uncertain and debatable. Hence, this study aims to review related policies available in Malaysia and analyse it readiness and relevancy for the PVT roof tile technology. The evaluation was done by expert interviews with related agencies in Malaysia such as Sustainable Energy Development Authority (SEDA) and Malaysian Green Technology and Climate Change (MGTC). It is suggested that the 1-InnoCERT certification programme is the most suitable as it provide financial assistance of a new product. By applying this certificate, applicant will be given a fast-track access for government incentives and it will undoubtedly ease the burden and open up more business or collaboration opportunities for the applicant. A preliminary finding obtained from this study will be beneficial for future implementation of the PVT roof tile in Malaysia.

1.0 Introduction

Malaysia has targeted to achieve 20% renewable energy by 2025 which includes the energy from biogas, biomass, hydropower system and solar. According to the statistic published by the Sustainable Energy Development Authority (SEDA), solar photovoltaic (PV) is the highest renewable energy system implemented in Malaysia from year 2015 until 2018 (SEDA, 2021). This trend contributed from the strong support from Malaysian government in term of incentives and grants in order to accelerate the growth of the renewable energy industry particularly in solar energy. Among the incentives that have been introduced by the government, Net Energy Metering (NEM) and Large Solar Scale (LSS) are the pertinent incentives which have been critically discussed and reviewed academically [4][5]. There are also reports on the readiness of the existing policies towards the implementation of solar PV technologies [1][3], which exhibited positive social acceptance in the Malaysian context.

Recently, innovation on the hybrid solar PV and thermal roof tile (PVT integrated system) has emerged as a modern and future renewable energy due to its significant contribution in term of efficient and flexible (multipurpose) energy system [2]. Nevertheless, scarce study has been done pertaining to the evaluation of policy relevance and action plan consequently provide vital challenge on the large-scale commercialization of PVT roof tile technology. Hence, this study aims to review solar energy policies available in Malaysia and analyse its suitability to be applied for the PVT roof tile technology.

2.0 Methods

The evaluation of solar energy policy and its relevancy towards PVT roof tile technology was conducted via two steps. Firstly, is by reviewing and evaluating the contemporary policies available in Malaysia followed by the interview session with the experts. In this regard, two agencies have been chosen which are the Sustainable Energy Development Authority (SEDA) and Malaysian Green Technology and Climate Change (MGTC). The personnel from both agencies were selected based on their managerial position in which they are capable and have experience in decision making, policy and project advising as well as ability to consult on the applicable policies and incentives. Open-ended questions were conducted during interview sessions with the main objectives are to evaluate the relevancy of contemporary renewable energy framework (i.e. policy, incentive, action plan, program) for PVT roof tile application.

3.0 Results

Four incentive/schemes have been suggested and proposed by the experts (SEDA and MGTC personnel) based on the outcome from the interview sessions. Each individual schemes are conceptually explained and its relevance towards the PVT roof tile technology is structurally extracted from the opinion and advise/perception by the experts.

Net Energy Metering Scheme (NEM)

The NEM scheme shows significant relevant to the application of PVT roof tile technology since it gives good initiative to encourage consumers to convert to renewable energy since it is a fair initiative for TNB and affordable to the consumers. Moreover, this PVT technology is highly suitable for individual consumers (self-consumption). Where, the consumers can utilize solar PVT for personal use and at the same time they are able to benefit from the excess energy generated from the PV.

Green Technology Financial Scheme 2.0

The existing certified solar rooftop projects under the GTFS 2.0 are mainly focus on the solar PV and it create competition among the existing and register project. However, the application of PVT roof tile project may create huge opportunity to apply and to be relevant to this scheme due to its feasible and sustainable technology

Green Investment Tax Allowance (GITA) and Green Investment Tax Exemption (GITE)

These schemes are seeming to be relevant to the PVT roof tile technology based on the conceptual services stated above. Nevertheless, for a new invented technology such as PVT roof tile, this scheme may not be suitable for new inventor but rather more suitable for the high-end technology which have proven technology with years of reputation.

3.4 1-InnoCERT

By applying this certificate, a fast-track access for government incentives will be granted and open up more business/collaboration opportunities in developing and implementing PVT technology. This scheme is highly relevant to new invented technology with huge potential to be implemented in large scale set up.

Keywords: Solar thermal roof tile, policy, solar energy, future energy.

Acknowledgement
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PHOTOVOLTAIC (PV)

PV1-147

IMPACT OF PV IN DISTRIBUTION SYSTEM USING TIME-VARYING LOAD DATA

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Extended Abstract

The integration of distributed renewable energy generation (DREG) into the distribution system has recently gained attention due to rising fossil fuel prices in the global market. As a result, many utilities have started to integrate RE resources into the distribution networks [1]. Among all available RE technologies, extensive studies on photovoltaic (PV) DREG integration have been conducted by many researchers [2-4]. However, most researchers assumed that PV power is dispatchable and did not consider the uncertainties of power, which are highly dependent on solar irradiance and weather conditions. In addition, constant load models are normally considered for PV planning in the distribution system. Such consideration may lead to inaccurate conclusions; power loss reduction and voltage improvement are not optimal. Moreover, the optimal PV sizing is important to avoid further losses in the distribution system. Therefore, the aim of this work is to study the impact of integrating renewable PV using time-varying weather and load data to reduce power losses and improve the voltage profile of the distribution system.

In this study, a historical data of 13-year irradiance in Malaysia from 2007 to 2020 based on daily data from Global Solar Radiation Tracking System [5] is used. A beta distribution function is used to calculate the hourly expected PV power. PV sizing is optimized to reduce power losses and improve the voltage of the distribution system, considering different time-varying load demands. Three indices are used to describe the impact of PV on system performance: Active Losses Index (PLI), Reactive Losses Index (QLI) and Voltage Deviation Index (VDI). The simulation is performed in a MATLAB environment, and IEEE 33-bus is used as a bus test system with different load demands: Industrial, Residential, Commercial and Mixed load. The results are evaluated based on the comparative analysis of total active and reactive power losses, PV size, PV penetration level and various impact indices for different load demands, and the results are summarized in Table 1.

Findings show that different load models have different effects on the performance indices. The optimal PV sizes for industrial, residential, commercial, and mixed loads are 1.81 MW, 2.08 MW, 2.85 MW, and 2.04 MW. The peak hour voltage profile has significantly improved for all load types compared to the values without PV. The commercial load model shows the most significant improvement, followed by residential, mixed, and industrial load demand, as shown in Figure 1. Thus, the voltage deviation index, VDI is lowest with commercial load and highest with industrial. The VDI of ideal improved system performance should be zero or as small as possible so that the present voltage does not deviate too much from its nominal value. PLI and QLI are calculated using active and reactive power losses with and without PV integration for the power loss index. The results are shown in Figure 2. The results show that a high PLI and QLI indicate that PV has a small impact on reducing power losses,

while a low value indicates significant losses. It can be observed that both indices are relatively low for commercial load, but relatively high for industrial load demand. Overall, the total system losses were reduced by 13.84% - 32.71% and the minimum bus voltage improved significantly after PV integration for all load models.

Table 1. Simulation results of IEEE-33 bus system

Parameters/Load Model	**Base Case**	**Industrial**	**Residential**	**Commercial**	**Mixed**
PV Location (Bus)	-	6	6	6	6
PV Size (MW)	-	1.81	2.08	2.85	2.04
P_{loss} reduction, %	-	13.84	20.70	32.71	19.41
Q_{loss} reduction, %	-	12.41	18.63	29.54	17.06
V_{min} (p.u)	0.9038	0.9224	0.9663	0.9719	0.9462
PV Penetration, %	-	26.47	33.10	40.15	30.40

Findings show that different load models have different effects on the performance indices. The optimal PV sizes for industrial, residential, commercial, and mixed loads are 1.81 MW, 2.08 MW, 2.85 MW, and 2.04 MW. The peak hour voltage profile has significantly improved for all load types compared to the values without PV. The commercial load model shows the most significant improvement, followed by residential, mixed, and industrial load demand, as shown in Figure 1. Thus, the voltage deviation index, VDI is lowest with commercial load and highest with industrial. The VDI of ideal improved system performance should be zero or as small as possible so that the present voltage does not deviate too much from its nominal value. PLI and QLI are calculated using active and reactive power losses with and without PV integration for the power loss index. The results are shown in Figure 2. The results show that a high PLI and QLI indicate that PV has a small impact on reducing power losses, while a low value indicates significant losses. It can be observed that both indices are relatively low for commercial load, but relatively high for industrial load demand. Overall, the total system losses were reduced by 13.84% - 32.71% and the minimum bus voltage improved significantly after PV integration for all load models.

This study shows that the PV integration has a different impact on reducing power losses and improving the voltage profile on load demands. The reduction is highest in the case of PV are integrated with the commercial load and lowest with industrial load. The optimal PV size is also largest for commercial demand and lowest for industrial demand. In addition, the peak hour voltage profile at IEEE-33 bus has significantly improved for all load types compared to the base values.

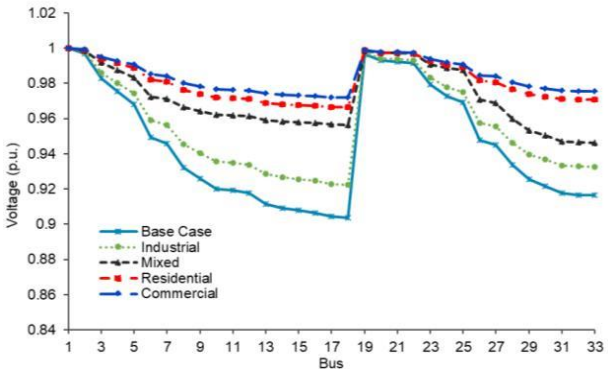

Fig. 1: Voltage profile magnitude of IEEE-33 bus system at peak hour load

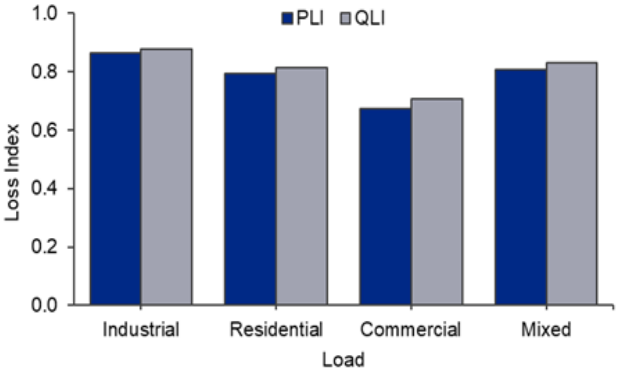

Fig. 2: Active and reactive power losses index of IEEE-33 bus system

Keywords: Photovoltaic; solar irradiance; time-varying load data; power loss; voltage deviation.

Acknowledgement

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PV3-210

ARTIFICIAL INTELLIGENCE BASED FIRE DETECTION IN PV SYSTEMS

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Abstract

Aging cables, loose contacts can cause DC series arc failure, which generate high temperature that discharge of molten metal, arc failure will eventually lead to electricity fire. Every year, such a fire causes great loss and damage that is established. The conventional protection techniques cannot do this in the situation where a short arc flash occurs, the circuit is cut off and arc current below thermal or instantaneous trip level. In this paper, an intelligent method of fire detection in PV system is designed based on object detection method. It is computationally intensive due to their low parameters and are suitable for embedded microprocessor-based edge applications. The object detection method relays on a digital camera that will monitor the photovoltaic system and continuously analyzing the captured images to detect any fire that could happen in the PV system. The proposed method can be used for its ease of design, use and low material cost.

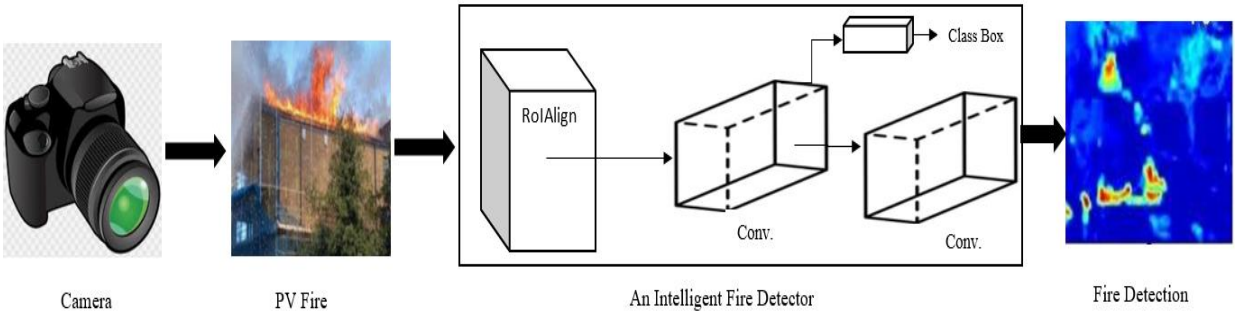

Fig. 1: Proposed System Block Diagram

Keywords: Fire Detection, Fire Localization, Fire Disaster, Image Classification, Surveillance Network

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PV4-215

DESIGN, INSTALLATION AND PHYSICAL EVALUATION OF 102.15KWP FLOATING SOLAR PHOTOVOLTAIC (FSPV) SYSTEM AT NEAR SHORE AREA IN MALAYSIA

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Extended Abstract

The needs to achieve Net Zero by 2050 is high. Human activities have fundamentally increased the concentration of greenhouse gases in Earth's atmosphere, warming the planet. The effect of global warming has shrunk glaciers, loss of sea ice and accelerated sea level rise and more intense heat waves. The Intergovernmental Panel on Climate Change (IPCC) forecasts a temperature rise to 2.0 degrees Celsius over the next century if there are no intervention in managing CO_2 emission to the atmosphere [1]. Renewable Energy sources is unlimited energy source, it is also considered sustainable for the environment because the energy production generated from Renewable Energy emits zero emission. Solar energy is one of the sources that is abundant and available anywhere in the world. Malaysia's position around the Earth's equator makes it suitable in utilizing Sun's energy in a form of light waves for Solar Photovoltaic (PV) systems to perform with high efficiency. Malaysia received approximately 1,575 to 1,812 kWh/m^2 of energy from the Sun with average value of 1,726 kWh/m^2 [2]. Typical Solar PV installations such as Ground Mounted PV Systems and Retrofit PV Systems require large spaces of land and building's roof respectively. Installing Ground Mounted Solar PV Systems create competition on land utilization where the same land location can be used for other economic activities such as agricultural and industrial activities [3]. Large Scale Solar Photovoltaic (LSS) introduced by The Government of Malaysia specifically to increase the RE penetration to the national grid in Malaysia. The Government of Malaysia targeted to increase National's RE penetration to the Grid to 31% and 40% by 2025 and 2035 respectively [2]. Floating Solar PV (FSPV) can be an alternative in installing Solar PV, where the installation of Solar PV can be done on water surface, inland, near shore and offshore. A 105.12kWp of FSPV system has been installed at Sultan Azlan Shah Power Plant in Manjung, Perak, Malaysia.

Floating Solar PV (FSPV) system in general, a Solar PV that floats on water surface using floating devices [4]. It is said to have advantages over PV installations on land where while FSPV utilizing unutilized water surface, it can avoid land competition with other economic activities as well as avoiding high cost of land acquisition to develop Solar PV systems. FSPV system components comprises of similar component as land-based Solar PV system except the mounting structure to hold the Solar PV module on water surface and passage floaters for operation and maintenance purposes.

This paper aims to evaluate the physical conditions of FSPV system installed at Sultan Azlan Shah Power Plant in Manjung, Perak, Malaysia after one year of operation. The detail components of the FSPV system are as shown in Table 1.

Figure 1. FSPV Installation at Sultan Azlan Shah Power Plant

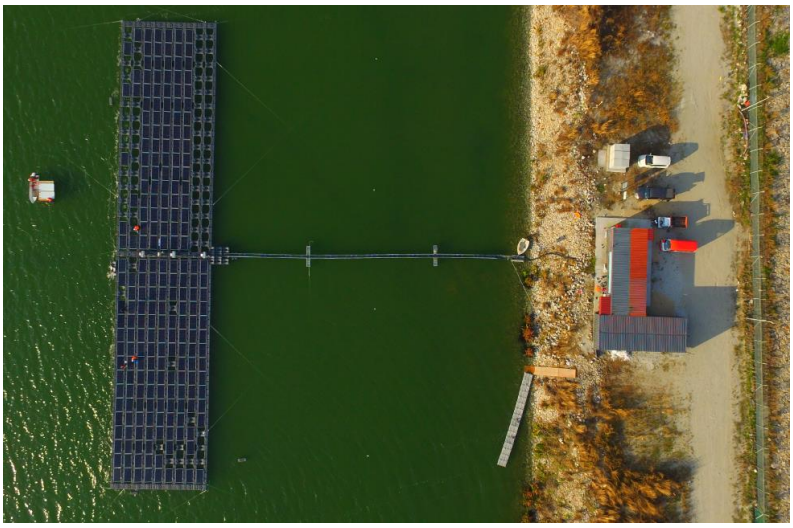

Table 1. FSPV Installation System Components at Sultan Azlan Shah Power Plant

Item	Specifications
Solar PV Module	Make: JinKO Solar
	Model: JKM465M
	Origin: China
	Type: Mono-Crystalline, Full Cell, PERC Technology
	Rated Power: 365 Wp
	Quantity: 288 Units
	Total Power: 105.12 kWp
	Series-Parallel Arrangement: (16 X 6) X 3 Units of PV Inverter
Floating Device	Make: JNTECH
	Origin: China
	Main Floaters: 288 Units
	Connecting Floaters: 244 Units
	Passage Floaters: 252 Units

	Structure Floaters: 9 Units
Anchoring & Mooring System	Make: Weight: 40 Units X 100kg Bottom Anchors with combination of Fiber Rope and Steel Wire Cable
PV Inverter	Make: Huawei Model: SUN2000-36KTL Origin: China Rated Power: 36kWac (Max) Total Output Power: 108kWac Quantity: 3 Units

Keywords: Solar; Floating Solar PV System; Large-Scale Solar; Renewable Energy; Malaysia

Acknowledgement
The FSPV project are parts of research activities funded by TNB Research through Seeding Fund. The authors would like to express sincere gratitude to the Management of TNB and TNB Research which have provided continuous support to this project especially in funding the project, also in terms of site, data and permits as well as personnel involvement in this project, directly or indirectly.

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PV5-227

A DETERMINISTIC APPROACH TO MAXIMIZE ACCOMMODATION OF PLUG - IN ELECTRIC VEHICLES AND IMPROVE DISTRIBUTION NETWORK PERFORMANCE

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Extended Abstract

The Plug-in Electric Vehicles (PEVs), with zero tail pipe emissions and reduced road carbonization compared to Internal Combustions Engines (ICEs) motivates the researchers and policy makers for their swift adoption. However, a paradigm shift from ICEs to PEVs imposes accommodation and technical challenges in current Radial Distribution Networks (RDNs). Alternatively, appropriate planning of Distributed Generators (DGs) provides a promising solution to improve the system performance while planning for accommodation of PEVs [1,2]. In this context, the proposed study develops a framework to maximize accommodation of PEVs and percent Power Loss Reduction (%PLR). Initially, the PEVs are accommodated on optimal bus location which is selected based on Loading Capability to Power Loss Index (LCPLI). The accommodation profile is developed based on uncertainty parameters of PEVs which include Battery capacity (BC) and current State of Charge (SoC). Then, the DG units are allocated to improve %PLR using standard Arithmetic Optimization Algorithm(AOA). The results demonstrate that the optimal bus can accommodate PEVs in the range of 1297 to 31,988 units depending on BC and current SoC as shown in Fig.1. Furthermore, in presence of maximum PEV loading on optimal bus location, the highest %PLR of 47.4% can be achieved with optimal allocation of DG unit using AOA. It is also found that the standard AOA is superior to standard Salp Swarm Algorithm (SSA) and Particle Swarm Optimization (PSO) in terms of %PLR and statistical characteristics as shown in Table 1. Furthermore, the convergence characteristics of AOA are also superior to the contending algorithms. The proposed study helps local power distribution companies to plan smooth and enhanced accommodation of PEVs in the current RDN.

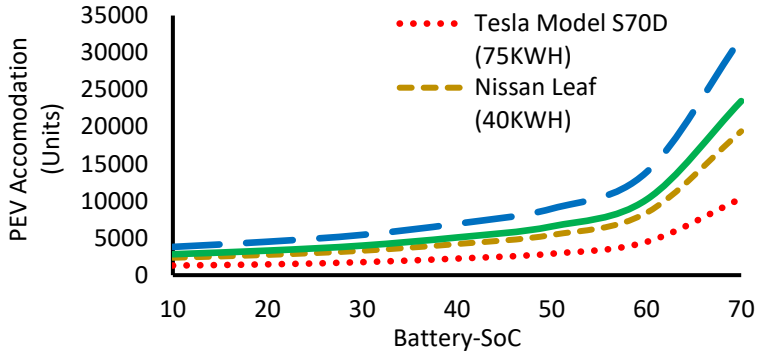

Fig. 1: Accommodation profiles of PEVs

Table 1. %PLR and statistical characteristics obtained with DG allocation using different algorithms

Case	Optimization Technique	DG Size, kW (@Bus location)	Power loss (kW)	%PLR	Mean Power Loss(kW)	Standard Deviation	Variance
Base Case (No DG allocation)	-	-	224.43kW				
Allocation of 1 DG unit	AOA	2425(6)	118.05	47.4%	124.71 (44.4%)	4.31	18.55
	SSA	2528.3(26)	119.5	46.7%	126.01 (43.85%)	5.18	26.85
	PSO	2551.2(26)	120.7	46.21%	127.42 (43.3%)	5.30	28.08

Keywords: Plug-in Electric Vehicles (PEVs); Distributed Generation (DG) Allocation; Arithmetic Optimization Algorithm (AOA); Power Loss Reduction (PLR); Radial Distribution Networks (RDNs).

Acknowledgement

The authors would like to acknowledge the Centre of Electrical Energy Systems (CEES), Institute of Future Energy (IFE) Universiti Teknologi Malaysia (UTM), Malaysia, Mehran University of Engineering & Technology (MUET), Pakistan, and the Higher Education Commission (HEC), Pakistan, for their unlimited support.

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PV6-233

Study on Inrush Current in PV System

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Abstract. In a stand-alone solar power generation system, battery can be functioning as an energy supplier, and also can be used as a backup storage when needed. Due to these functions, it could cause the occurrence of an inrush current. Inrush current is a surge in current that occurs in the range of µs to ms with an amplitude that can reach several times of the normal current. Therefore, this study presents the in-rush condition of a battery in stand-alone PV system by comparing inrush current situations in 12V/14Ah and 12V/7Ah batteries. The analysis has been carried out on different loads in a household, and also in different testing time. In this experiment, 50A/75mV shunt resistor was used as a battery output current sensor. From the experimental study, it has been observed that inrush current may spikes up to 172A in 520µs when 14Ah battery is connected to the inverter with an inductive load RL. From the comparison study, it has been found that 14Ah battery with internal resistance of 14 milliohms presents higher current spike compared to 7Ah battery with 28 milliohm resistance. By setting a test time lag of 10 minutes, it has been shown that the signals from the battery and inverter devices, were able to return to the normal condition whereby the inrush current can be measured finally at around165A.

Keywords: battery, inrush current, shunt resistor, stand alone, PV system.

WTE1-204

A REVIEW OF DARRIEUS HYDROKINETIC TURBINE PERFORMANCE ENHANCEMENT STRATEGIES

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Extended Abstract

The Darrieus turbine employ a vertical axis to convert the kinetic energy of the fluid. The flexibility of the installation location and the simple design have made the Darrieus turbine widely developed for water turbines and wind turbines. However, hydrokinetic Darrieus turbine has several drawbacks that need to be improved, such as blade wake interactions, dynamic stall, sinusoidal torque pattern and poor self-start capability. In this article, the strategies to enhance the performance of hydrokinetic Darrieus turbine will be categorized into parameter design, augmentation technique, blade modification and flow control approaches, as shown in Fig. 1.

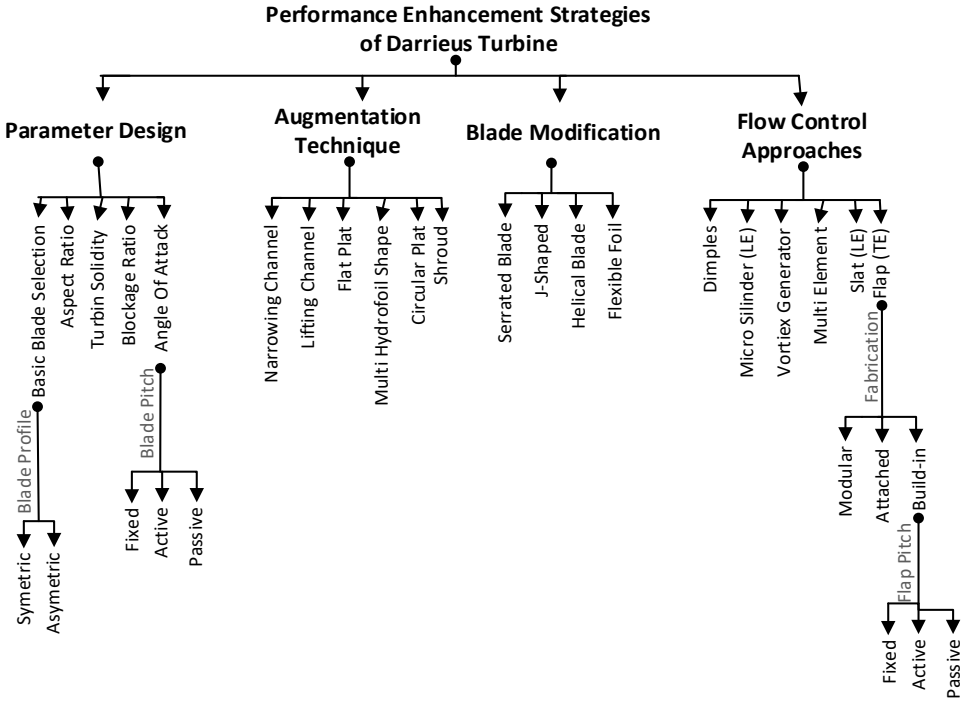

Fig. 1: Performance enhancement strategies classification

Keywords: Hydrokinetic turbine; darrieus turbine; vertical axis turbine; hydrokinetic development

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WTE2-020

Prediction of Solar Irradiation and Wind Speed in the Philippines using Artificial Neural Network

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A Shallow Neural Network (SNN) model is employed to predict the yearly solar irradiance and wind speed potential in San Jose, Western Visayas, Philippines. The data is collected from RET Screen software for two data sets; Data set A consists of 5 years of data from 2013 to 2017, while the Data set B consists of 20 years of data from 1998 to 2017. A multi-layered feed forward SNN model having 10 hidden layers, delay factor of 2 and the input variables according to the data sets that is solar irradiance and wind speed to predict their yearly values. The input and the target data sets have been divided into three sets, which are as follows: 80% of the total data set will be used for training which is around 291 target time steps, while the validation and testing are divided equally each with 10 %, comprising of 37 target time steps from a total of 365. This technique will avoid overfitting and also provide improved SNN generalization. Moreover, these predictions will also highlight the locations where we can place solar panels and wind turbines as per the amount of solar irradiance and wind speed experienced in a particular area to harvest the energy in much efficient way. According to the experimentation, the predicted data shows quite similar results to the observed data and provide adequate information regarding the feasibility of many solar and wind power plants.

WTE3-206

STUDY ON LOW-SPEED WIND ENERGY POTENTIAL AND ENERGY YIELD ANALYSIS FOR HIGHWAY APPLICATION IN MALAYSIA

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Extended Abstract

By 2025, Malaysia aims to increase the renewable energy generation capacity from 20% to 31% [1]. As an alternative energy resource, renewable energy provides a greener solution in replacing fossil fuel to meet the energy demand. Wind energy is one of the energy sources that should not be put aside. Even though Malaysia's wind condition is considered low speed [2], some studies have shown that energy can still be generated from low-speed wind resources such as traffic, islands, and hills. Traffic is one of the potential sources for low-speed wind energy generation due to the turbulences generated from moving vehicles [3]. This paper aims to investigate the possibility of harvesting wind energy from traffic by identifying the traffic wind pattern.

Two Malaysian highways have been selected in this project for wind data collection: Jambatan Sultan Abdul Halim Muadzam Shah (Penang Second Bridge) and Lebuhraya Shah Alam (KESAS). The locations of these sites are illustrated in Fig. 4. The wind speed data was measured through wind sensor systems that have been installed on the sites. It was found that the annual average wind speed at Penang Second Bridge is 6.48 m/s, whereas KESAS measured at 3.72 m/s. Further statistical results are shown in

Table *1*.

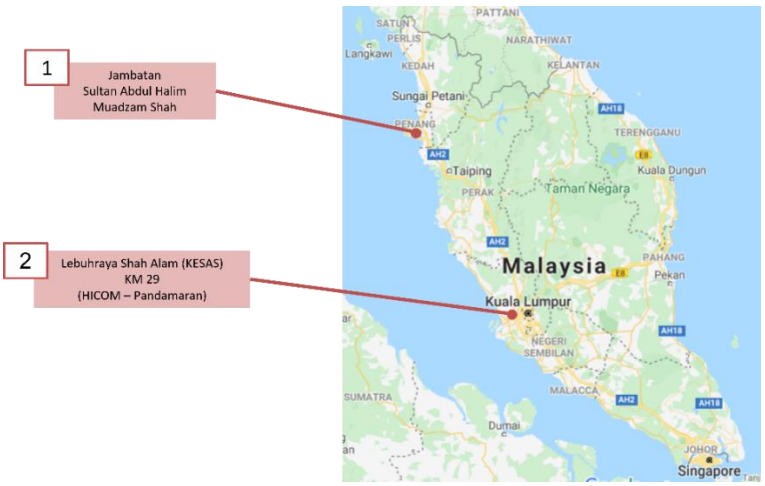

Fig. 4: Location of Wind Measurement Site

Table 1: Statistical Results of Wind Speed at Penang Second Bridge and KESAS

Site Location	Min (m/s)	Max (m/s)	Median (m/s)	Average (m/s)
Penang Second Bridge	1.45	24.03	5.95	6.48
KESAS	0.70	10.20	3.60	3.72

The research project was performed to determine the possibility of harvesting wind energy from traffic. This study has also identified suitable low-speed wind turbine technology for feasible traffic-induced wind power generation. It is evident through the findings in this project, that Penang Second Bridge site has a higher wind speed with average 6.48 m/s. Various designs of wind turbine models that are suitable for the considered site's wind conditions were proposed, including its energy yield analysis and its forecasted techno-economic analysis. 13 of the wind turbines are found to have capacity factor more than 20%. Other potential bridges in Malaysia are among the areas than can be further explored for future development of harvesting low-speed wind energy.

Keywords: Wind Energy, Low Wind Speed, Traffic Wind, Vertical Axis Wind Turbine, Renewable Energy

Acknowledgement

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WTE4-117

CRITICAL FACTORS INFLUENCING THE IMPLEMENTATION OF WIND TURBINE AT THE EXISTING BUILDING SITE

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Abstract

Fossil fuels consumption such as oil and gas as the source of power caused irreparable damage to humanity such as environmental pollution, greenhouse gas emission, acid rain and climate change. Thus, the importance of the environment's preservation and the concern on the nature of fossil fuels have drawn human attention to have energy generation by renewable sources. The implementation of wind turbines has shown a competitive advantage over other energy sources such as solar and thermal because it is known as a sustainable, environmentally friendly and reliable source of energy generation. However, implementing wind turbines potentially creates certain challenges in cost, services and others. This paper establishes a critical factor in implementing wind turbines at the existing building site as part of retrofitting method to minimize the risk and ensure the project's success. This paper adopts the questionnaire survey distributed to the green certified facilitators and organizations experts in renewable energy implementation. Factor Analysis with Principal Component Analysis Varimax Rotation was applied as an analysis method. The priority factors were summarized based on the significant threshold factor loading 0.50 and above. The results revealed that the factor of Management, Environmental, Economic, Design And Site Assessment achieved the significant factor loading value. This paper contributes to providing information about the factors that require assessment during the decision to implement renewable energy options specifically for the wind turbine to maximize the benefits and achieve an optimal strategy.

Keywords: Critical Factors, Renewable Energy, Wind Turbine, Retrofitting, Building

WTE5-175

OPTIMIZATION OF SAVONIUS TURBINE FOR LOW-VELOCITY WATER STREAMS USING CFD-TAGUCHI APPROACH

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Abstract

One of the sea and river renewable energy producers is the Savonius turbine, which generates electricity from moving water. This research will conduct several CFD simulations to optimize the Savoinus turbine to reach its highest performance at low inlet speeds, using the mixed-level Taguchi method. The influences of the number of blades, deflectors, the overlap between the paddles, the diameter of the paddles, and the gap ratio have been studied. The study started with creating the quality function, and the levels and factors were identified. Then, the orthogonal array was constructed, and the CFD simulation was conducted for all runs after examining the mesh and the boundary conditions. The Taguchi analysis showed the best combination of the parameters in low-speed streams and found that the most significant parameter affecting the hydrodynamic performance is the diameter and the aspect ratio. The result showed the power of coefficient (Cp) for the optimized Savonius turbine is improved by approximately 10% compared to the initial design.

Keywords: CFD; Savonius; Taguchi method

Acknowledgement

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WTE6-226

SYMMETRICAL FAULT ASSESSMENT OF GRID INTEGRATED DOUBLY FED INDUCTION GENERATOR USING MODIFIED SUPER-TWISTING FRACTIONAL ORDER TERMINAL SLIDING MODE CONTROLLER

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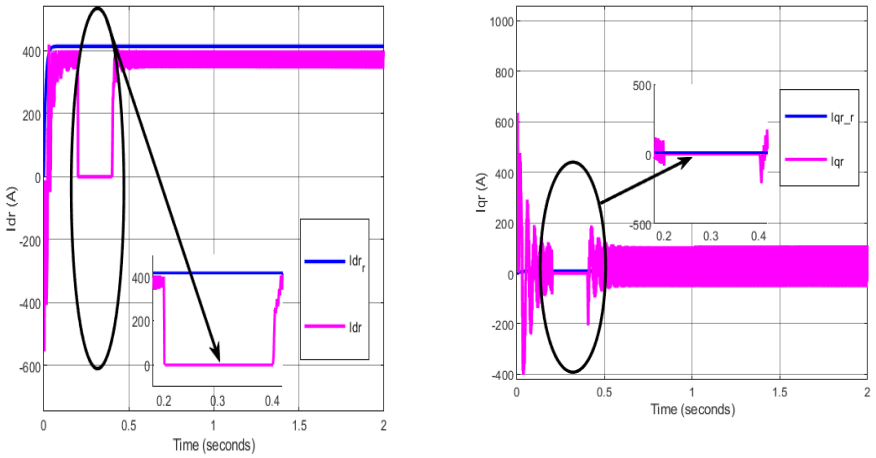
Extended Abstract

The demand for cutting-edge wind energy conversion systems (WECS) has grown to provide a viable alternative to the power grid. Increased wind energy penetration enhances power output, but grid fluctuations can degrade it. As a result, symmetrical faults in the electricity system must be investigated to test the low voltage ride through capability of wind turbine generators and meet grid code requirements. For the current control at the rotor side converter (RSC) side of a doubly fed induction generator (DFIG), modified super-twisting fractional order terminal sliding mode control (MSTFOTSMC) has been used in conjunction with a three-level neutral point clamped (3L-NPC) power converter coupled with a battery energy storage system (BESS). In this research, the response of a WECS based on a DFIG has been tested under symmetrical faults. The suggested technique, according to MATLAB simulation results, preserves the reference tracking of direct and quadrature components of rotor current within safe limits, as shown in Fig. 1 with quick convergence and minimal chattering soon after the symmetrical fault terminates. The MATLAB simulation parameters for grid integrated DFIG are shown in Table.1



(a) (b)

Fig. 1 Direct and Quadrature components of rotor of DFIG during symmetrical fault

Table. 1 Simulation parameters of grid integrated DFIG

Parameters	Symbol	Value	Parameters	Symbol	Value
Stator voltage	V_s	690 V	Magnetizing Inductance	M	2.5e-3 H
Blade length	R	35 m	DC link capacitor	C_{DC}	6.6 mF
No of pole pairs	Pp	03	DC Link voltage	V_{DC}	1150 V
Inertia Constant	J	765.6 H	Transformer Voltage at PCC	V_N	690 V/33 kV
Frequency	F	50 Hz	Mode of Connection	D_{11}/ Yg	
Stator resistance	Rs	0.012 Ω	Grid Transformer Voltage	V_N	33kV/132kV
Stator inductance	Ls	5.86e-3 H	Ground Power	P_g	47 MVA
Rotor resistance	Rr	0.014 Ω	Mode of Connection	V_g/ D_{11}	
Rotor inductance	Lr	5.86e-3 H			

Keywords: Wind Energy Conversion System, Symmetrical Faults, Low voltage Ride Through, DFIG, Fractional order Sliding Mode Controller.

Acknowledgement
The authors are extremely thankful to the joint support extended by Mehran University of Engineering and Technology, Jamshoro, Sindh, Pakistan, and Centre of Electrical Energy Systems (CEES), Institute of Future Energy (IFE), School of Electrical Engineering (SKE) Universiti Teknologi Malaysia for the financial support and other necessary facilities to carry out research work.

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WASTE TO ENERGY (WE)

WE1-200

PRODUCTION OF GREEN DIESEL VIA HYDROGEN-FREE AND SOLVENTLESS DEOXYGENATION REACTION OF WASTE COOKING OIL

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Extended Abstract

ABTRACT

This study has successfully developed a modified 5Ni5Co/SBA-15-SH catalyst and has been applied in the production of green diesel via deoxygenation reaction from waste cooking oil. It has been observed that the modified 5Ni5Co/SBA-15-SH catalyst has large surface area and pore size (509.26 m^2/g, 4.6 nm) and also has influenced the acidity of the catalyst. This improved properties of catalyst has positively affect the deoxygenation reaction as this catalyst is able to produce high hydrocarbon yield (77%) with highly selective towards diesel-range hydrocarbon fuel (70%).

1. INTRODUCTION

Advanced biofuel has appeared as a promising alternative for replacing current fuel due to its similar structural compound and potentially leading towards green and sustainable fuel. Second generation biofuel generated from inedible feedstocks such as waste from animal, plant and industrial wastes have gained attention due to low cost production [1]. Waste cooking oil (WCO) is one of the most abundant wastes and has high potential to be used as fuel feedstock. Transforming WCO into biofuel via deoxygenation reaction could be a more economical reaction pathway without the H_2 consumption and safer reaction as it uses lower reaction temperature that other catalytic reaction [3]. The efficiency of deoxygenation reaction could be increased by consuming a good catalyst such as SBA-15 which is a highly ordered mesoporous silica catalyst with 2D hexagonal structure, large surface area and pore-volume, and thick pore walls [7]. Surface modification by orgnosilane materials has been reported in the literature that is able to improve the properties of SBA-15 by increasing the acidity strength of the catalyst [9]. The objective of this study is to modify the porous properties of SBA-15 by organosilane materials that is could enlarge the porous structure of SBA-15 and influence the catalyst's acidity and applied in biofuel production.

2. METHODOLOGY

2.1 Synthesis of Catalyst

Synthesis of catalyst involved two steps, which are synthesis of catalyst support by following method proposed by former studies [10, 5, 4] and addition of Nickel and Cobalt via wet-impregnation method. During the synthesis of catalyst support, 10.12g of Pluronic P123 was dissolved with deionized water

followed by the addition of 57mL of 2M HCl and continually to stir for 2h at 40ºC. Then, 23mL of TEOS was added into the mixture and stirred for 24h. For the modified SBA-15-SH support, the silane materials, MPTMS (3-Mercaptopropyl trimethoxysilane) was added after TEOS addition (1M TEOS:0.1M MPTMS) and H_2O_2 was added dropwise to promote the oxidation of propyl-SH from MPTMS to propyl-SO_3H. Then, both mixture (SBA-15 and SBA-15-SH) were transferred into a Teflon bottle and left in the oven for aging at 80°C for 24h. The SBA-15 was washed with ethanol before it was dried overnight at 80°C, followed by calcination at 500°C for 5h and denoted as SBA-15. Meanwhile, the SBA-15-SH was filtered and washed with ethanol under 24h reflux for template removal. After that, the mixture was filtered, washed with ethanol, and allowed to dry overnight at 80°C.

Both support, SBA-15 and SBA-15-SH were added with 5% of $Ni(NO_3)_2.6H_2O$ and 5% of $Co(NO_3)_2.6H_2O$ via wet impregnation method (Baharudin et al., 2019). Initially, the metal salt was dissolved with 40ml of ethanolic solution (1:1, ethanol: water), followed by the addition of 1g of support into the solution and was stirred for 3 h at room temperature. The solution was continuously stirred and was heated slowly at 80°C until a pinkish green milky suspension appeared, and the solution was almost dry. The solution was then dried for 18h at 80°C, followed by calcination at 550°C for 5h and labelled as 5Ni5Co/SBA-15 and 5Ni5Co/SBA-15-SH.

2.2 Deoxygenation reaction of WCO

In deoxygenation reaction, WCO was converted into green diesel by consuming the synthesized catalysts (5Ni5Co/SBA-15 and 5Ni5Co/SBA-15-SH) without the presence of H_2 in a semi-batch reactor. 10g of WCO and 5% of metal loading were used with the reaction parameter of 350ºC, 2 h of reaction under constant stirring and nitrogen flow rate of approximately 20 cc/min. Finally, the deoxygenated product/green diesel was collected and further analyzed using GC-FID.

3. RESULTS AND DISCUSSION

3.1 Physicochemical properties of the catalysts

The synthesized catalysts (5Ni5Co/SBA-15 and 5Ni5Co/SBA-15-SH) were analyzed by N_2 adsorption-desorption isotherm analysis (Table 1). From the analysis, it can be observed that the addition of MPTMS has successfully increased the surface area and enlarged the porous support's pore sizes support due to the interaction between silane material and TEOS [8]. The presence of sulfonic acid from MPTMS has enhanced the acidity of the surface of SBA-15, which then promoting the micelles formation into silica walls and subsequently increase the pore sizes [6]. Indeed, the acidity of the catalysts for 5Ni5Co/SBA-15-SH was found to have 1932.89 µmol/g compared to 5Ni5Co/SBA-15 that has 700.24 µmol/g (Table 1), owing to the presence of rich sulfur species upon the addition of MPTMS.

Catalyst	Surface area (m^2/g)[a]	Pore size (nm)[b]	Pore volume (cm^3/g)[c]	Amount of NH_3 adsorbed (µmol/g)[d]
5Ni5Co/SBA-15	335.35	4.4	0.43	700.24
5Ni5Co/SBA-15-SH 0.1	509.26	4.6	0.62	1932.89

[a,b] determination of surface area by BET
[c] determination of pore volume by BJH
[d] determination of acidity by TPD-NH_3

3.2 Green diesel production

The liquid product collected from deoxygenation reaction of WCO using the synthesized catalysts were analyzed by GC-FID analysis (figure 1). From the analysis, the hydrocarbon yield for blank was 18.1%, while catalyzed deoxygenation obtained hydrocarbon yield of 67% (5Ni5Co/SBA-15) and 77% (5Ni5Co/SBA-15-SH), suggesting the importance of catalyst in promoting the deoxygenation reaction. In addition, the 5Ni5Co/SBA-15-SH catalyst showed higher hydrocarbon yield compared to 5Ni5Co/SBA-15 catalyst, indicated that the MPTMS modification has significantly affect the deoxygenation activity due to its large surface area and high acidic properties, as discussed previously. Moreover, the 5Ni5Co/SBA-15-SH catalyst also favour the formation of diesel-range hydrocarbon compared to gasoline-range due to high acidity that promoting C-C cleavage during deoxygenation reaction [2].

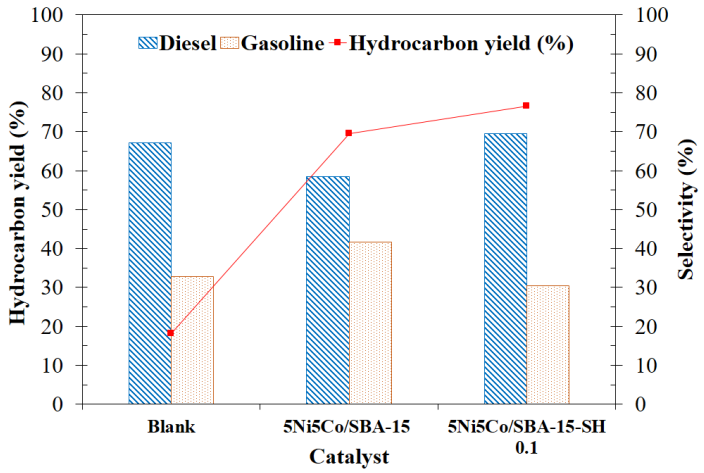

Figure 1 Hydrocarbon yield of deoxygenated liquid product and selectivity

4. CONCLUSION

Green diesel has been successfully produced via deoxygenation reaction of waste cooking oil by utilizing the synthesized catalyst. It was found that more active sites due to the increase of surface area and pore sizes has promoted the catalytic activity. In addition, the presence of sulfonic acid from the MPTMS addition has greatly increased the acidity of the catalyst, which result in a more efficient deoxygenation reaction.

Keywords: Biofuel, SBA-15, organosilane, waste cooking oil

Acknowledgement

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WE2-203

FUNCTIONALIZATION OF PALM WASTE USING IONIC LIQUID FOR THE RECOVERY OF GOLD: FIXED-BED COLUMN STUDY

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Extended Abstract

Agricultural industry produce a wide variety of biomass from crop stalks, leaves, roots, peels, and shells, etc [1]. In 2020, Indonesia produce nearly 140 million tons of biomass. Indonesia aimed to use biomass as alternative energy source for electric generator [2]. However, this raise an environmental concern over a long period of practice due to increase greenhouse gas emission. Palm oil industry has been one of the main economic driver in some Southeast Asian countries. A fresh palm fruit produce 21% palm oil, 6-7% palm seed, 14-15% palm fiber, 6-7% palm kernel, and 23% empty bunch [3]. Palm oil industry has been one of the main economic driver in some Southeast Asian countries. A fresh palm fruit produce 21% palm oil, 6-7% palm seed, 14-15% palm fiber, 6-7% palm kernel, and 23% empty bunch. Indonesia is one of the biggest agricultural country. However, biomass-based adsorbents need to be researched and a sufficient number of comprehensive review papers are required because of their being ecofriendly, cost-effective, and widely available. As stated in the principle of circular chemistry: “waste is a resource”, recycling from end-of-life products is essential for achieving sustainable mineral resources. The produced biomass has a lot potential to turn into various useful component. One of the target for utilization is activated carbon. Activated carbon is one of the most popular adsorbent for various component. Activated carbon has a strong mechanical and chemical strength which is desirable properties as adsorbent. Functionalization of activated carbon is one of the way to improved their adsorption capacity and selectivity. Ionic liquid has been one of the popular functionalization agent to improve the adsorption capacity. A wide variety of organic cations and organic/inorganic anions can be used to synthesize a huge number of ionic liquids (IL). IL can provide any required criteria for effective metal extraction owing to their tunable properties. Due to the similar nature of precious metals, some of the metals are difficult to be removed selectively. However, the tunability of IL could potentially enhance the solid adsorbent selectivity towards particular pollutant [4]. However, in the real application the IL composite should be able to operate over a long period. Thus, the investigation of the dynamic behavior of IL composite is crucial to the study [5].

In this study, activated carbon originated from the waste of palm industry was functionalized by using an imidazolium-based ionic liquid, denoted as AC-IL. The adsorbent was then characterized by using X-ray diffraction, Fourier transform infrared spectroscopy, and nuclear magnetic resonance. The functionalized activated carbon was then used as adsorbent for gold (Au) from a mobile phone leachate simulated solution. The dynamic behavior of the recovery was assessed in a fixed-bed column. The adsorption results was then fitted with Adam-Bohart, Thomas, and Yoon-Nelson model to predict their dynamic behavior. Following the Langmuir model, P8Cl_MSN showed a high capacity of 170.3 mg g^{-1} . Following the fixed-bed adsorption results, the optimal condition was achieved with extended bed depth (9 cm), moderate flow rate (5 mL min^{-1}), and high initial concentration (100 mg L^{-1}), leading to a

continuous adsorption capacity of 131.7 mg g^{-1}. The experimental data is better suited with the Thomas and Yoon-Nelson models.

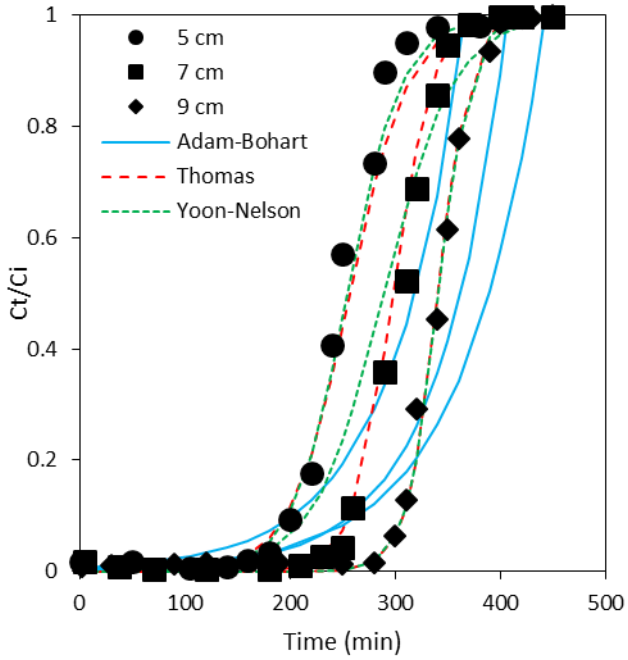

Fig. 1: Effect of bed depth on the adsorption of Au by AC-IL and modelling fit

Keywords: Waste recycling, Adsorption, Gold, Activated Carbon, Ionic Liquid

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MODELLING AND STIMULATION STUDIES (MSS)

MSS1-139

SIMULATION OF AN OFF-BOARD DC FAST CHARGING STATION FOR ELECTRIC VEHICLE BATTERY

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Extended Abstract

Conventional fossil fuel-driven vehicles have caused acute environmental pollution. This demands the obligation of developing automotive industries that manufacture vehicles with lower carbon footprint impact on the environment. In the light of this need, electric vehicles (EVs) appear to be the best-suited alternatives to the conventional internal combustion (IC) engine [1]. Despite having environmental benefit, electric vehicles charging creates a negative impact on the power grid. Hence, this study focuses to achieve these two specific objectives; (a) To design and simulate an Off-board EV charging station with two control strategies; Voltage Control (VC) and Constant Current-Constant Voltage (CCCV) charging approach. (b) To ensure constant DC bus voltage is achieved while maintaining standard grid voltage during charging the EV battery.

To achieve the mentioned objectives, the unidirectional off-board level-3 EV charger was designed and simulated in Matlab/Simulink environment. This off-board charger has been divided into two parts. The first part is AC-DC converter where this part is controlled using voltage control approach to ensure standard grid voltage can be smoothly maintained, and to maintain the DC-link voltage at the constant level. The second part comprises the DC-DC converter, which functioning to ensure the battery can be charged within a specified limit using a constant current/constant voltage approach.

From the simulation results, in terms of current signals, pure AC signal from the grid cab be attained. The signals of the AC grid current signals are depicted when DC station charges the single unit of EV to 4 EV units, respectively. The grid current before connecting the EV, which shows 5kA 3-phase peak grid current with a proper waveshape. During 1 EV charging, 2kA 3-phase peak current were observed. For the current case, when 2 EV batteries are charged, the pure sinus signals can be generated. While charging the 3 EVs, the current waveforms seem balanced. While when 4 EVs were changing at the same time, current waveforms were smooth. It is characterized that, upon load grid current also increases and reaches up to 5kA on full load.

For the current THD level, the THDi of grid before connecting the EV is 6.39% which has already violated the standard. In the meantime, upon charging the 1-EV the THDi were increased to 7.30%. During the charging of the 2-EV batteries, the current THD was 8.32% which has violated the IEEE standard 519-2014 for current distortion. When charging the 3 EVs batteries, the THD of the grid current, THDi were overserved 9.21%, in which this indicates the standard guideline set by IEEE 519-2014 is no longer adhered. In case of charging the 4-EV batteries, the current THD was 9.95% which has also violated the

standard of the IEEE 519-2014. It can be said that, as the number of EV increases the current THD also rises. For the current THD level, the requirement is available in [2].

In terms of battery voltage charging performance, for the DC-link output voltage before connecting the batteries, it can be observed that the steady state condition at 800V DC level is achieved after 0.3 seconds, even though at the early simulation time, there was a transient signal before reaching the steady state condition. When charging 1 EV, the voltage starts with an 14% overshoot and comes to a steady state after 0.4s. Upon connecting the 2 EVs batteries, the same phenomenon was observed. During connecting 3 EVs, the voltage starts with an overshoot of 12% and after 0.4s it came to a steady state. In case of 4 EVs are charged, the signal demonstrates same pattern as 3EVs. However, it can be observed that the transient overshoot for the 4th EV unit presents a slight smaller envelope than the 1, 2 and 3 EVs. As a whole picture on the other hand, it can be summarized that when the number of EV charged is increased at the same time, the transient envelop will become bigger. It is noticed however, steady state condition at 800V can be achieved at the same time, which is around 0.4 seconds. Therefore, this represents the situation of stable and normal operational system during the charging activities.

Fig. 1 shows the batteries state of charge, charging current, and charging voltage. The initial SoC were set for EV1, EV2, EV3, and EV4 are 0%, 20%, 40%, and 60% respectively. Here all the batteries are set at same ratings. The batteries are getting charged with 400A constant current until the battery reaches the pre-set value 400V. From the battery specification, the fully charged battery voltage is 419V. The maximum charging voltage set here as 400V so that the battery does not get overheated. While reaching the battery pre-set value, the charging current starts decreasing while maintaining constant voltage of 400V. From the presented results in Fig. 1 as well, it can be depicted that when the SoC of the battery is too low, i.e. at 0 SoC level as represented by EV1, it will take some times to enable the current and voltage to reach at the required steady state level. For zero SoC, current will start to change after 0.6 minutes, while for the voltage, it took 0.6 minutes to reach at the maximum voltage. For others, the maximum voltage of 400V can be reached very fast since the SoC of the voltage are already in the best region to charge and discharge the battery. Meanwhile for the current signals, they depict the relevant tracking signals where higher the SoC condition, faster the current will track the steady state level.

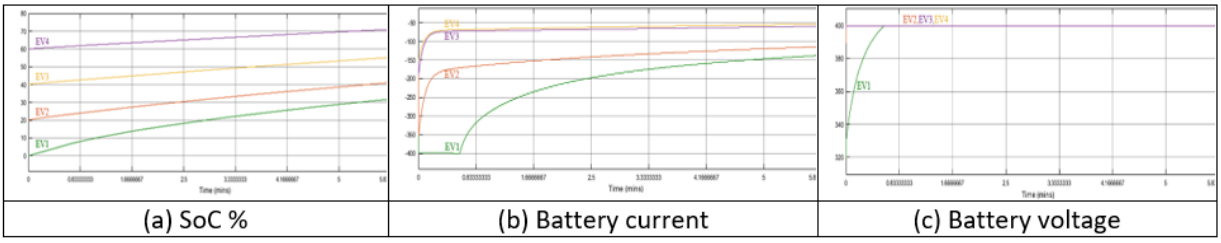

Fig. 1: Battery charging performance

From the presented results, it can be concluded that the proposed off-board EV charging station for 4 EVs units has been successfully designed and developed. As outcomes, the AC grid voltage has been successfully maintained its smooth sinusoidal waveforms even at full-load conditions. So does with the AC grid current and voltage where the THD levels for both signals are within the permissible limit under the IEEE Standard 519-2014 requirements. When the number of EV unit charged is increases, current total harmonic distortion also increases. However, the AC grid voltage can be still maintained. The DC-link voltage has been also successfully managed to maintain at the 800V level. For the battery safety condition, charging can be executed as required without overheating the battery.

Keywords: DC fast charger, off-board charger, electric vehicle, electric battery, matlab/simulink.

Acknowledgement
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MSS2-198

ENHANCED CONTROL OF STORAGE TANK, VAPORIZER, AND HEATER IN LNG REGASIFICATION PROCESS USING MULTI-LOOP PI CONTROLLERS BASED ON DISTURBANCE MODEL

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Extended Abstract

One effective way to transport natural gas is through the LNG regasification process. For optimization, the control system is continuously being studied, yet it is still possible for the system to comply with disturbances that scale down the performance. To overcome this, an approach using a multi-loop PI controller with the biggest log modulus tuning (BLT) offers a control system that reduces disturbance through developing a model. This study identifies and verifies the disturbance model to obtain the best first order plus dead time (FOPDT) by using Smith, LILJA, Wade methods, solver, and statistical methods, with the verification method using the sum of square error (SSE). The controller performance was analyzed against multivariable model predictive control (MMPC) developed by Wahid and Phenica (2020) in a linear and nonlinear system. The disturbance model of inlet temperature and feed flow rate was designed for a set point model of four controlled variables, namely LNG storage tank pressure which is maintained at 16.5 psia, vaporizer outlet pressure at 444 psia, vaporizer outlet temperature at 6˚C, and heater gas outlet temperature at 30˚C. The results showed the best value of the disturbance model obtained by Solver method. Muti-loop PI BLT provides the best control performance compared to multi-loop PI Ziegler Nichols when applied to linear and nonlinear processes. Furthermore, multi-loop PI-BLT in the linear process achieved better performance compared to MMPC. However, when multi-loop PI-BLT and MMPC are applied to nonlinear processes, MMPC is still exceptional.

Keywords: Disturbance Model; FOPDT; LNG Regasification; Multi-Loop; PI Controller.

MSS3-069

CONTRIBUTING FACTORS OF FALLING FROM HEIGHT ACCIDENTS IN CONSTRUCTION SITE

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Extended Abstract

Construction industry has been known as one of the prime industries, with composite, hazardous environment and has high number of injuries in comparison of other industries. Workers in construction site that work at high level has tendency to involve in fall accident. Falling from working at height accident is leading cause of fatalities and injuries in the construction industry. Statistic 2018 from Department of Occupational Safety and Health (DOSH) has shown that the number of fatalities in construction industry is contributed 81 fatalities compared to another sector. The main purpose of this study is to determine level awareness on existing safety practice among workers and management in selected construction site. This research shall have analyzed the causes contributing to falling from working at height accident in construction site. From there, recommendation will be proposed to improving safety practice in eliminating or reducing fall accident in the future. In this research, quantitative approach was chosen with survey method. From October 2019 until November 2019, survey for this research was conducted through questionnaires and distributed to one of construction site in RAPID Pengerang Project. Total of 105 respondents from different age and designation that exposed to working at height level were participated in this survey and all completed questionnaires were returned, indicating a response rate of 100%. Data was analysed using the Statistical Packages for Social Sciences (SPSS) version 20.0 software. Statistically, found that that respondent in this study have high safety practices awareness on the current construction site they work. Worker with competency certificate level and young generation of workers have high level awareness on safety practices. Unsafe act which is failure to wear personal protective equipment (PPE), unsafe working condition which is poor site housekeeping, poor management commitment which is failure of management to provide sufficient personal protective equipment have the majority response that cause the falling accident. Our finding suggests that safety recommendation plan should be establish and strengthen to reducing the number of falling from working at height accident at construction site in future. Future research on this topic should be encouraged and developed to all small contractor, designer or developer as well other industry besides construction as it could potentially help reduce the likelihood of fall accident during working at height.

Keywords: Falling; working at height; awareness; unsafe act; unsafe working condition; poor management commitment.

Acknowledgement

All the praised and glory to Almighty Allah (SWT), who provided me with strength, direction and showered me with blessings throughout the completion of this thesis. My sincerest gratitude to my supervisor Associate Professor Dr. Anwar bin Johari for his continuous guidance and support. I am also indebted to Universiti Teknologi Malaysia (UTM) for giving me this opportunity to enhance my knowledge and skills in this field of study. I also wish to acknowledge the industry leaders and workers who gave their time, effort and support to collect the data that is the basis of this research. Their

contribution makes this all possible. Finally, my deepest appreciation to all those who support and assist me in various occasions with valuable views and tips to complete this thesis.

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MSS4-061

FATIGUE AMONG WORKERS IN THE CONSTRUCTION SECTOR FOR OIL AND GAS INDUSTRY FACILITIES

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Extended Abstract

Work-related fatigue has been identified as an important issue for workplaces in some of the countries such as Australia, United State of America, Japan, and etc. Fatigue can have a profound effect on an individual's wellbeing, work performance and safety. The main purpose of this research is aimed to measure awareness regarding fatigue among workers in the construction sector for oil and gas industry facilities. This research shall have assessed the fatigue level of workers and their perception towards fatigue. Alternatively, the factors in association with workers' fatigue can be determined. The interest of this research is to provide comprehensive information about fatigue in the construction sector for oil and gas industry facilities. The methodology used was a survey. Survey for this research was conducted through self-administered questionnaires, which were distributed at the research location with the involvement of various category of workers. From October, 2019 to November, 2019, the questionnaire was administered throughout the selected research location in Pasir Gudang to a total of 500 construction workers. 440 completed questionnaires were returned, indicating a response rate of 88%. Descriptive and inferential statistical analyses were conducted and results are provided. Overall, most of the workers were having a good understanding and awareness on fatigue. Higher qualification level and young generation of workers have high level of awareness on fatigue. Older employees and employees with longer working hours reported a higher level of fatigue. Employees who reported a higher level of fatigue, also reported more physical health symptom. Fatigue was not facilitated by sleep factor. Hence, ensuring the concepts of fatigue is properly understood has the potential to improve health, safety, and sustainability in the industry. Future research on this topic should be encouraged and developed because it could potentially lead to new facilitations against this issue and how fatigue-factors should be measured and managed in the construction sector for oil and gas industry facilities. It is hoped for that the findings of this research will provide a groundwork for improving the capability of construction employers in Malaysia to manage factors that impact on fatigue and the health outcomes related to fatigue.

Keywords: Fatigue; awareness; perception; sleep factor; health factor; work factor.

Acknowledgement

First and foremost, I thank Allah, God the Almighty for being my pillar and my foundation, providing me the strength, direction and blessings throughout the completion of this thesis. I would like to express my sincerest gratitude to my supervisor, Associate Professor Dr. Anwar bin Johari for his direction, assistance, support and guidance. I also wish to acknowledge the industry leaders and workers who gave their time, effort and support to collect the data that is the basis of this research. Their contribution makes this all possible. Finally, I wish to express my deepest gratitude to all those who helped me in one way or another to complete this thesis.

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MSS5-202

ADSORPTIVE OPTIMIZATION OF ANTIBIOTICS OVER CO-ZIF-67-DERIVED CO_XO_Y@C: A CHEMOMETRIC APPROACH USING TAGUCHI ORTHOGONAL ARRAY DESIGN

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Extended Abstract

The ciprofloxacin (CFX) is a second-generation fluoroquinolone antibiotic used as a treatment for infections caused by gram-negative and gram-positive bacteria [1]. However, a large amount of its unmetabolized residue (in ng/L-µg/L concentration) via animal feces and urine pathways has slow degradation, resulting in durable retention in the environment [2]. In addition, the penetration of CFX antibiotic into soil and groundwater is highly likely to contaminate water resources for human and animals [2]. Such pollution can be found in hospital effluents (up to 150 µg/L) or drug production facilities (31 mg/L) [3]. Due to adverse effects, especially bacterial resistance against drugs, the adsorptive removal of residual CFX molecules from water to remediate their exposure and accumulation has received great attention.

The development of conventional technologies in antibiotics remediation has recently been employed; however, their effectiveness and performance are a de facto challenge, intercepting their applications in water treatment [4–6]. For example, advanced oxidation processes (AOPs) can regenerate a series of potentially carcinogenic byproducts and fragments in treated water and utilization of membrane separation tends to be restrained because of their cost-effectiveness and complexity barriers. Meanwhile, adsorption is considered a promising method relating to its huge advantages, e.g. performance, recyclability, and safety. Therefore, adsorption can reach a “greener” approach by the use of effective adsorbents synthesized from carbonaceous sources, such as porous carbon.

Herein, we describe the synthesis of Co-ZIF-67 and Co-ZIF-67-derived Co_xO_y@C for removal of CFX antibiotics. The characterization results (XRD, FT-IR, SEM, TEM) revealed that the Co-ZIF-67-derived Co_xO_y@C obtained a highly mesoporous structure, high surface area (~100 m^2/g), large pore along with important amino functional groups. To design the experiments for the removal of CFX from water, we used the response surface methodology (RSM) by Design Expert 10.0 program, which the effect of three variables including initial concentration (10–60 mg/L), dosage (0.1–0.4 g/L) and pH (2–10) were investigated. With the deep analysis of ANOVA table (R^2 ~ 1.0, AP ratio > 4.0, and P values < 0.0001) and confirmation tests (error below ±5%), we asserted the high fitness of proposed RSM model, deserving to diagnose the optimal conditions for the removal of CFX (~100%). Moreover, the kinetic, and isotherm were studied, which pseudo-second order model and isothermal data were best fitted with the experimental data. The effect of contact time (0–120 min), Co_xO_y@C dosage (0.1–1.0 g/L), ionic strength (0–500 mg/L Na^+), CFX concentration (10–100 mg/L) were systematically investigated.

The thermodynamic results showed that the adsorption is a spontaneous and endothermic process. The adsorption capacity of Co_xO_y@C was ~90 mg/g which is the highest compared to most of the materials for the antibiotics. The high adsorption capacity is attributed mainly to π-π stacking, hydrogen bonding and electrostatic interactions. Finally, the recyclability, and leaching test studies revealed the high chemical stability along with several recycles (up to 4), suggesting the high adsorption performance of Co_xO_y@C in the elimination of CFX.

Keywords: CFX pollutant, Co_xO_y@C, metal-organic frameworks, adsorption models.

Acknowledgment

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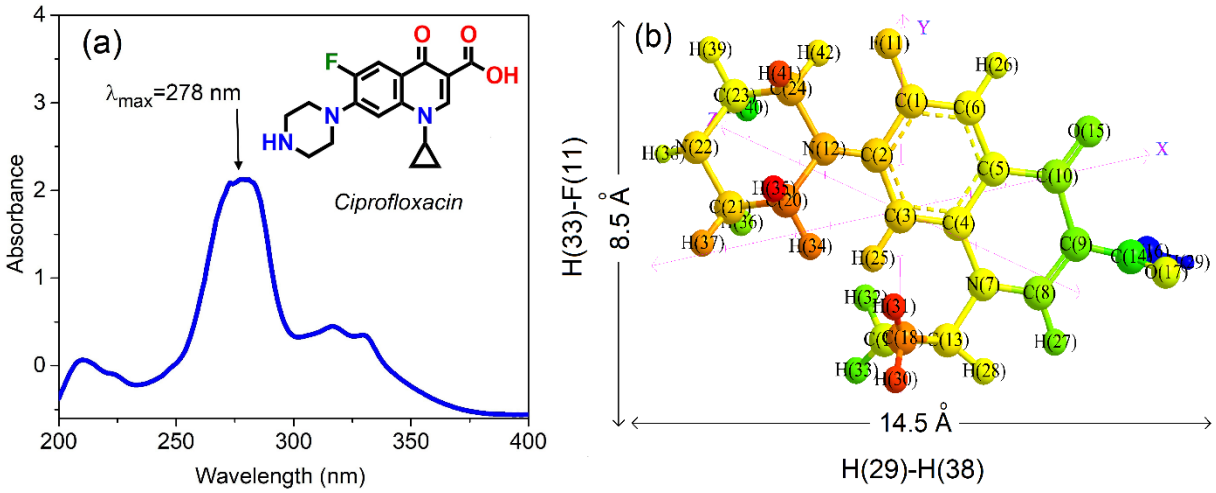

Fig. 1. UV-Vis spectrum and schematic simulation of CFX molecule

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MSS6-201

MAGNETIC POROUS CARBON NANOCOMPOSITES DERIVED FROM *OPUNTIA STRICTA* CACTUS FOR THE REMOVAL OF TOXIC DYES: OPTIMIZATION OF SYNTHESIS CONDITIONS USING RESPONSE SURFACE METHODOLOGY

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Extended Abstract

Industrial textile wastewater can contain almost toxic dyes such as Rhodamine B, methyl orange, methylene blue, crystal violet, Congo red, and methyl red. These dyes are known as a major source causing adverse impacts on aquatic ecosystems. Therefore, treatment of dye pollutants gained much attention from scientists.

Prickly pear (scientific name: *Opuntia stricta*) belongs to the cactus family Cactaceae. This plant prevalently grows in arid and semi-arid climate regions like South Africa. In Vietnam, it was detected in national parks such as Cat Ba, Hai Phong City (Tan et al. 2012). While many cactuses comprise of some benefits such as foods, medicines, and shields against desertification, prickly pear is considered as an invasive alien plant (Hoffmann et al. 2020). Their most influential effect is to pose a major threat to the integrity and biodiversity of the park, and to agroecosystems more widely. Thus, conversion of prickly pear into useful materials for environmental remediation is recommended.

In this study, we use prickly pear as a locally available, zero-cost, and eco-friendly bioresource to fabricate magnetic activated carbon $ZnFe_2O_4$@AC. The materials were structurally characterized such as X-ray diffraction, Fourier-transform infrared, Raman spectroscopy, and transmission electron microscopy. Several parameters influencing the treatment efficiency were investigated, including $ZnFe_2O_4$@AC dosage, dye concentration, pH index, reusability, kinetic, and isotherm. This work not only expects high performance of magnetic bioadsorbent derived from prickly pear for the treatment of toxic dyes but also contributes to abating invasive alien plants to biodiversity.

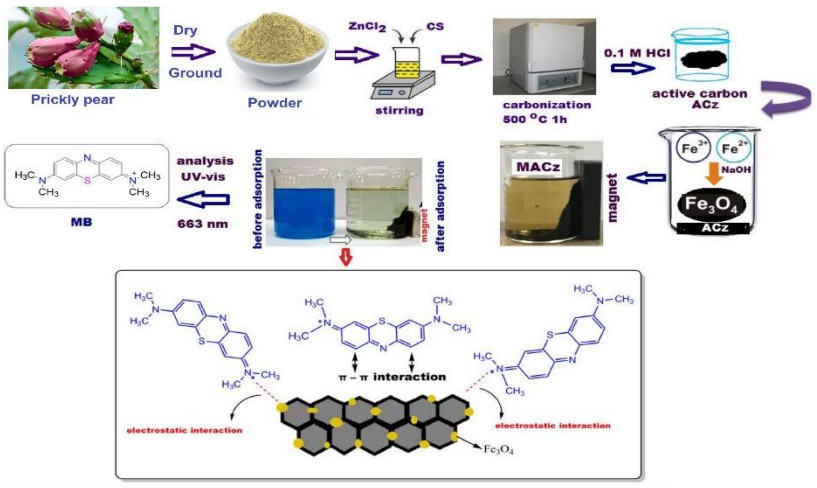

Fig. 1: Illustrative synthesis process of the magnetic porous carbons from prickly pear and their application for the removal of methylene blue from aqueous solution (Yağmur and Kaya 2021).

Keywords: Magnetic porous carbons; prickly pear; dye pollutants; adsorption mechanism; kinetic modelling; nanocomposites.

Acknowledgment

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MSS7-214

NUMERICAL ANALYSIS AND COMPARISON OF PTAA AND PEDOT: PSS EMITTER FOR SIGE SOLAR PHOTOVOLTAIC

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Extended Abstract

Application of infrared band absorption prone transparent solar cell is very attractive for building integrated photovoltaic. For that purpose, p-type organic material as an emitter and thin nSiGe as active absorption layer has been used in an organic-inorganic hybrid solar cell. The electrical properties for the design PTAA/nSiGe and PEDOT: PSS/nSiGe cells are investigated by using SCAPS simulator. The electrical property of greater conductive PTAA emitter in comparison to facile and solution processed PEDOT: PSS is studied. Effect of SiO_2 nanomaterial on nSiGe and eventual p-PTAA/SiO_2/nSiGe and p-PEDOT: PSS/SiO_2/nSiGe solar PV models efficiency parameters have also been studied. Greater efficiency, open-circuit voltage, short circuit current density and fill factor of PTAA/nSiGe solar cell in contrast to PEDOT: PSS/nSiGe is realized. For PTAA emitter 5.62% efficiency in comparison to 2.88% for PEDOT: PSS for 10 µm SiGe active layer is exhibited. The highest 48.8 mA/cm^2 current density of 3 µm SiGe while for PEDOT: PSS emitter it is shown 48.3 mA/cm^2.

Table 1: Comparison between PEDOT:PSS and PTAA without SiO^2 layer.

Material	**PEDOT:PSS/nSiGe**				**PTAA/n-SiGe**			
Thickness (µm)	**Efficiency (%)**	**Voc (V)**	**Jsc (mA/cm^2)**	**FF (%)**	**Efficiency (%)**	**Voc (V)**	**Jsc (mA/cm^2)**	**FF (%)**
0.5	2.74E+00	4.17E-01	4.38E+01	1.50E+01	5.5	0.453	4.56E+01	26.61
1	2.85E+00	5.86E-01	4.58E+01	1.06E+01	5.71	0.453	4.77E+01	26.43
3	2.88E+00	7.55E-01	4.64E+01	8.23E+00	5.74	0.453	4.79E+01	26.47
5	2.88E+00	7.55E-01	4.63E+01	8.24E+00	5.71	0.4531	4.74E+01	26.59
10	2.88E+00	7.55E-01	4.61E+01	8.26E+00	5.62	0.4531	4.62E+01	26.87

Table 2: Comparison between PEDOT:PSS and PTAA with SiO_2 layer

Material	PEDOT:PSS/SiO2/n-SiGe				ptaa/SiO2/n-SiGe			
Thickness (µm)	Efficiency (%)	Voc (V)	Jsc (mA/cm2)	FF (%)	Efficiency (%)	Voc (V)	Jsc (mA/cm2)	FF (%)
0.5	3.32E+00	4.15E-01	4.56E+01	1.75E+01	6.59E+00	6.93E-01	4.60E+01	2.07E+01
1	3.43E+00	5.83E-01	4.78E+01	1.23E+01	6.82E+00	7.52E-01	4.82E+01	1.88E+01
3	3.36E+00	7.50E-01	4.83E+01	9.28E+00	6.75E+00	7.50E-01	4.88E+01	1.84E+01
5	3.25E+00	7.47E-01	4.81E+01	9.05E+00	6.61E+00	7.47E-01	4.87E+01	1.82E+01
10	3.02E+00	7.42E-01	4.76E+01	8.57E+00	6.32E+00	7.42E-01	4.83E+01	1.76E+01

This numerical analysis was calculated by using SCAPS simulator by Marc Burgelman from University of Gent, Belgium [1].

Keywords: PTAA; PEDOT: PSS; SiGe; nano-structure materials; emerging solar cell; open circuit voltage; efficiency

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MSS8-216

THERMODYNAMIC PHASE EQUILIBRIUM COMPOSITION DETERMINATION OF ETHANOL STEAM REFORMING BY DIRECT MINIMIZATION OF GIBBS FREE ENERGY USING PENG-ROBINSON PROPERTY METHOD

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Extended Abstract.

Determination of appropriate process parameters for ethanol conversion to obtain maximum hydrogen yield and zero net carbon deposition via ethanol steam reforming was studied. Thermodynamic equilibrium analysis of ethanol steam reforming was carried out by direct minimization of Gibbs free energy method using Aspen Plus (V8.8). Equilibrium compositions of each species were analysed for temperatures ranging from 873 to 1173K, steam-ethanol molar ratio of 2:1 -6:1 and pressure at 1atm.The performance of the reformer is expressed in terms of conversion and yield[1][2]. The highest ethanol conversion was observed to be 66.7% with respect to feed ratio of 2 for the considered temperatures (see Figure1), due to thermodynamic limitation and preference of CO and H_2 production at low input [4]. The maximum hydrogen yield(84.8%) was observed at temperature of 1073K relating to feed molar ratio 2:1 and at pressure of 1atm (shown in Figure 2), which implies that CO and H_2 are mainly produced at low input [3]. The reforming reactions operated at high temperature enhance the formation of hydrogen, being an endothermic reaction and the reduction of carbon (IV) oxide shifted the equilibrium in favour of hydrogen. The prediction of the simulation is significant, since the considered process parameters lead to maximum hydrogen yield and carbon formation minimization, which is yardstick for the commercialization of hydrogen production from ethanol steam reforming. for fuel cells application.

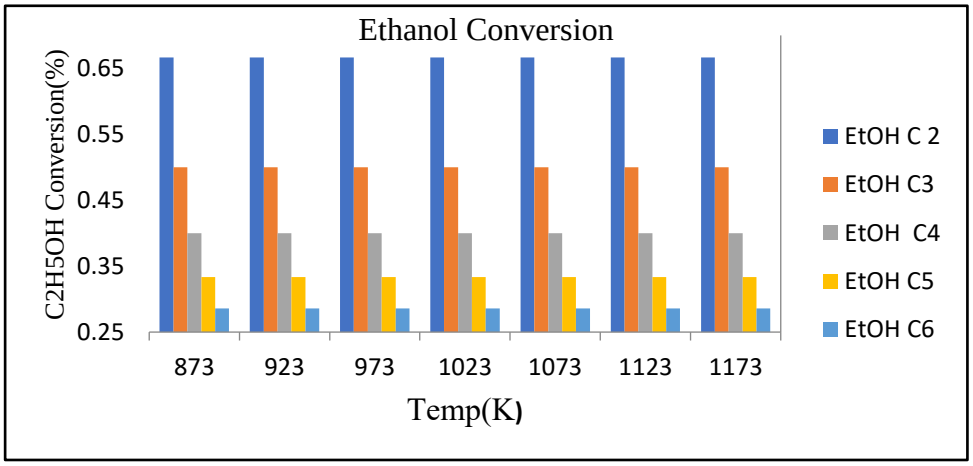

Fig. 1: Ethanol conversion over temperature range of 600-900℃ and feed molar ratios (2:1 - 6:1mol/mol

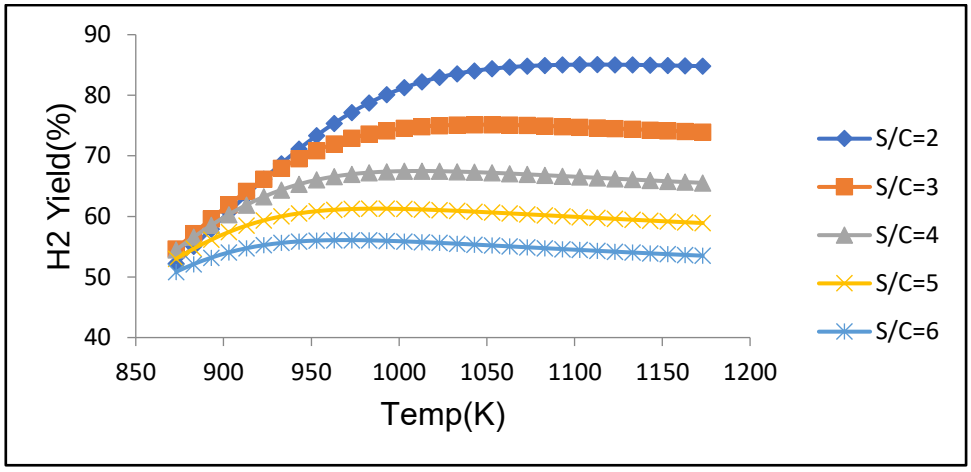

Fig. 2**:** Hydrogen yield over temperature range of 600-900℃ and feed molar ratios (2:1 -6:1mol/mol)

Keywords: Equilibrium composition; hydrogen production; carbon deposition; solid oxide fuel cell; ethanol steam reforming.

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MSS9-163

DRYING MODEL OF STINGLESS BEE POT-POLLEN USING A SWIRLING FLUIDIZED BED DRYER

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Extended Abstract

Pot-pollen is a product from stingless bee (Malay: kelulut) comprising of pollen, mixed with nectar and bee secretions, and stored in cerumen pots [1]. Pot-pollen has high moisture content, making it susceptible to microbes and fungi growth [2]. This will lead to spoilage and toxins which is harmful for consumption [3]. Thus, a suitable preservation method is required to enable storage and transport of pot-pollen. Conventional methods used include sun drying, and oven drying. However, these methods can be unhygienic, inefficient, and hard to control the temperature which leads to nutrient loss. Hence, a swirling fluidized bed dryer (SFBD) is proposed as it has rapid drying performance at relatively low temperature. Currently, drying models of various materials in fluidized bed dryer has been studied such as coconut residue, olive pomace, broccoli florets, and mangoes [4]–[7]. However, studies on drying model of stingless bee pot-pollen using a swirling fluidized bed dryer are still lacking. Therefore, the objective of this paper is to determine the most suitable drying model from literature for drying of stingless bee pot-pollen using a SFBD. A lab scale swirling fluidized bed dryer (SFBD) with a 67° swirling distributor is used to dry 25 g of stingless bee pot-pollen at superficial air velocities of 4, 5, and 6 m/s. From previous studies, 7 drying models obtained from literatures are compared to determine the most suitable model for drying of pot-pollen in SFBD.

Table *2* shows the mathematical models used in the current study. It was found that, the Midilli-Kucuk model was the most suitable drying model compared to other drying models tested. Fig. 5 shows the drying curve as predicted by the Midilli-Kucuk model compared to the actual experimental values. It can be seen that the model closely predict the experimental values for all superficial air velocities tested. The experimental results also shown that increasing the superficial air velocities will lead to increase in drying

rate. Thus, it can be concluded that Midilli-Kucuk model can be used to describe the drying of stinglesss bee pot-pollen in SFBD.

Table 2.Mathematical models fitted to pot-pollen drying in a swirling fluidized bed dryer

No.	Model name	Equation	Reference
1	Lewis/Newton	$MR = \exp(-kt)$	[8]
2	Page	$MR = \exp(-kt^n)$	[9]
3	Henderson and Pabis	$MR = a\exp(-kt)$	[10]
4	Logarithmic/ Yagcioglu et al.	$MR = a\exp(-kt) + c$	[11]
5	Two-term exponential	$MR = a\exp(-kt) + (1-a)\exp(-kat)$	[12]
6	Wang and Singh	$MR = 1 + at + bt^2$	[13]
7	Midilli-Kucuk	$MR = a\exp(-kt^n) + bt$	[14]

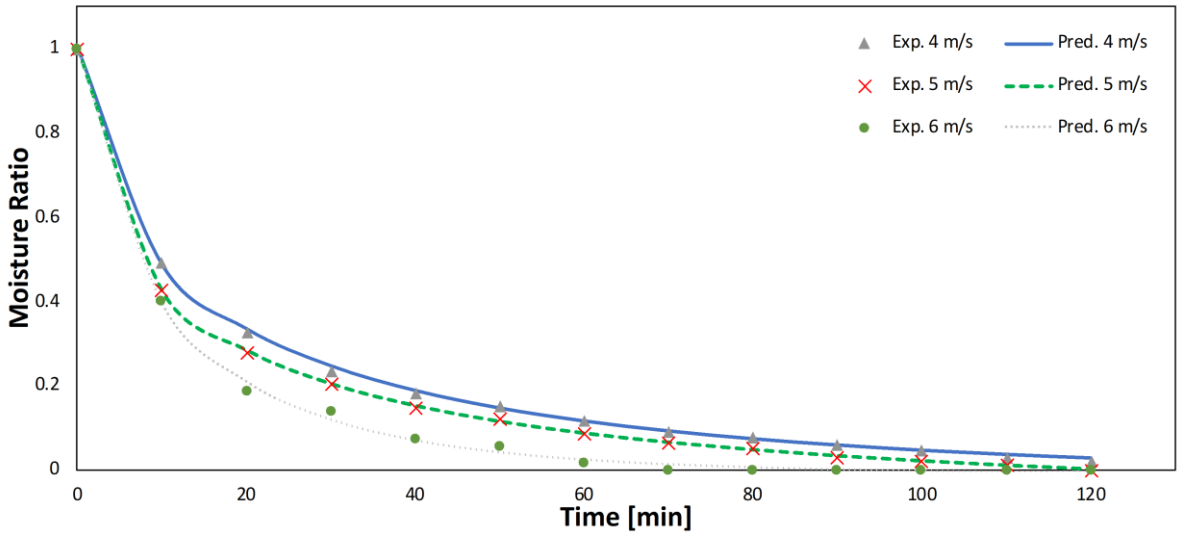

Fig. 5: Experimental and predicted drying curve for SFBD drying pot-pollen at 38 °C and velocities of 4 m/s, 5 m/s, and 6 m/s

Keywords: stingless bee; pot-pollen; swirling fluidized bed dryer; drying model

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MSS10-246

HYDROGEN-ENRICHED SYNGAS PRODUCTION FROM GASIFICATION OF OIL PALM BIOMASS: PROCESS SIMULATION AND OPTIMIZATION USING ASPEN PLUS

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In this study, ASPEN Plus software was used to perform a simulation model to investigate the performance of oil palm biomass gasification process. The developed model includes three major processes: oil palm biomass drying, pyrolysis, and gasification. The predicted results are aligned with those reported in the literature. The effect of different operating parameters, like the gasification temperature, gasification pressure, and the equivalence ratio (ER), on the syngas composition and H2/CO ratio were investigated using sensitivity analysis. The findings revealed a set of parameters that will potentially maximize the H2 gas generation. The generated H2 gas can be further separated and purified to be used as fuel or energy.

MSS11-118

OPTIMIZATION OF COLD FLOW PROPERTIES OF DIESEL BLENDED BIODIESEL

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Abstract

Biodiesel is becoming as an alternative way for usage of diesel fuel for its equivalent good properties. However, there are some limitations in the cold flow properties of biodiesel that must be overcome. Thickening of biodiesel in low temperature can lead to clogging of fuel pipes. In this research, pour point is the main focus. Pour point means the lowest temperature at which the fuel loses its flow characteristics that being influenced by parameters such as density and viscosity. There are a lot of methods on overcoming the poor pour point of biodiesel. In this research, the method used is by blending the biodiesel with cold flow improver. Diesel has chosen to be the cold flow improver. Properties such as density and viscosity of pure diesel and pure biodiesel has been determined from the software called Aspen Plus. Method of blending diesel and biodiesel is based on compositions of diesel added, ranging from 0 to 1.0, with a step size (h) of 0.1 at a set range temperature from -5°C to 30°C, with a step size (h) of 5°C. The blended density, blended viscosity and pour point is calculated under different compositions of ethanol added at a set range of temperature using Kay Mixing Rule, Grunberg-Nissan equation, and Riazi-Daubert equation respectively. Optimum pour point temperature for the various combinations of blended density and blended viscosity with smallest errors has been determined.

Keywords: biodiesel; cold flow; pour point; blending

FINANCING ENERGY PROJECTS (FEP)

FEP1-229

An assessment of the Financial Feasibility of an OTEC Ecopark: a Case Study at Cozumel Island

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Extended Abstract

Ocean Thermal Energy Conversion (OTEC) is a marine energy that converts heat into mechanical energy through a thermodynamic cycle, which uses the temperature difference (20 °C or more) between the warm surface water of the ocean and cold ocean water from ~1000 m depth. Base load power is produced, as well as valuable by-products, such as desalinated water [1] and deep ocean water (DOW) that can be utilized in various sustainable activities such as aquaculture, cold agriculture, and sea water air conditioning (SWAC) [2]. In order to promote OTEC development, some researchers have focused on improving the technical aspects of OTEC, performing thermodynamic and mechanical analyses and creating multipurpose OTEC plant designs in order to improve its efficiency and decrease costs. OTEC would become more attractive as a multi-purpose integrated system, called OTEC Ecopark.

The aim of this two-page abstract is to describe how an OTEC Ecopark could provide comprehensive, sustainable, and quality products that satisfy the diverse needs of coastal communities in Mexico, that could help to satisfy the present and projected demands for water, energy, and food (WEF) supporting sustainable development, crucial to the UN's SDGs.

An offshore 60 MW hybrid OTEC plant (60 MW-H-OTEC), is proposed in the Cozumel Island. The Ecopark would: (1) produce energy, permitting wider access to high-quality electricity, and consequently satisfying present and projected energy demands, as well as diversifying the national energy matrix; (2) supply desalinated water; and (3) provide the necessary conditions to enable Offshore Seaweed Aquaculture (OSA) of Ulva spp. both for food production and carbon capture (Figure 1).

An assessment of the financial feasibility of the plant as well as a comparative analysis against other forms of energy generation was carried out. The methodology includes a market description, literature review for the technical design, methods for mitigating socio-environmental risks, and an analysis of operational risks. To determine financial feasibility, the Capital Costs (CAPEX), Operation, Maintenance, Repair, Replacement and Administrative Expenses (OPEX) and annual revenue, including the sale of

Clean Energy Certificates (CELs) and carbon credits, were evaluated. The Internal Rate of Return (IRR) suggests that the system would pay for itself in year 5 of the system's 30-year life. The methodology used for this case study, with site-specific adaptations, can be applied to other coastal communities across the globe [3].

Although OTEC is a promising renewable energy source, further research is still required. Particularly in the development of large-scale plant installation technologies and the evaluation of the benefits of by-products. It is hoped that this work will serve as motivation to drive the deployment of OTEC Ecoparks and facilitate comprehensive sustainable solutions that help foster more resilient coastal communities around the world.

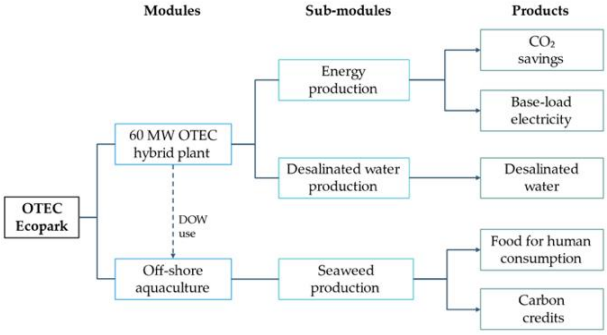

Fig. 1: Components of the OTEC Ecopark.

Keywords: OTEC Ecopark; financial feasibility; offshore aquaculture; Levelized Cost of Energy; capacity factor.

Acknowledgement
The authors are grateful to NREL and the MECC for providing us with an opportunity to be part of the competition. Thanks to the Centro Mexicano de Innovación en Energía-Océano (CEMIE-Océano) for supporting this research. Thank you to the following experts: Luis Vega, Colin R. Meyer, Benjamin Martin and Ted Jagusztyn, for engaging in personal communications and advising us throughout our research.

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SAFETY (SF)

SF1-213

BIBLIOMETRIC ANALYSIS OF GLOBAL RESEARCH TRENDS ON HYDROGEN RISK USING SCOPUS DATABASE

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Extended Abstract

In recent years, the potential of hydrogen as renewable clean energy has been explored extensively. In ASEAN countries three major national oil companies Petronas (Malaysia), Pertamina (Indonesia) and PTT (Thailand) leading the initiatives in developing the facilities of this renewable energy [1]. However, the accidents that happened in the past evoked safety concern in the process. The statistics from HIAD 2.0 database show that seventy percent of the total two hundred seventy-two events were initiated by the hydrogen system [2]. Therefore, the safety issue related to the hydrogen system is very crucial where it should reach a certain acceptable level to fulfill societal and regulatory requirements and to maintain a positive image and economic viability.

The objective of the bibliometric study in this paper is to evaluate the global research trends on hydrogen risk based on temporal distribution patterns of hydrogen risk articles; the most impactful papers in the field and common terminology and research topics. The bibliometric analysis in this study was conducted using Scopus database and the bibliometric map was created using VOSviewer (version 1.6.18), developed by Centre for Science and Technology Studies, Leiden University, The Netherlands [3], a software tool for constructing and visualizing bibliometric maps.

Using the Scopus database, a total of 368 journal articles published between 1970–2022 were retrieved. Results have shown that the number of publications increased publications recorded in the year 2020, resulting in a steady increase in the cumulative total publications until present. Most publications were contributed by researchers from China and USA, leading the other 44 countries. The bibliometric maps created in this study based on keywords shown in Figure 1. The density of the maps shows that current research interest focusing on hydrogen risk. Further investigation on hydrogen risk topic includes the following (but not limited to) (i) hydrogen storage system, and (ii) regulatory requirements.

Keywords: hydrogen risk; hydrogen storage; hydrogen safety

Acknowledgement
The authors would like to acknowledge the support from Universiti Teknologi PETRONAS for providing the related research facilities and sponsoring the training on bibliometric analysis under the STIRF grant.

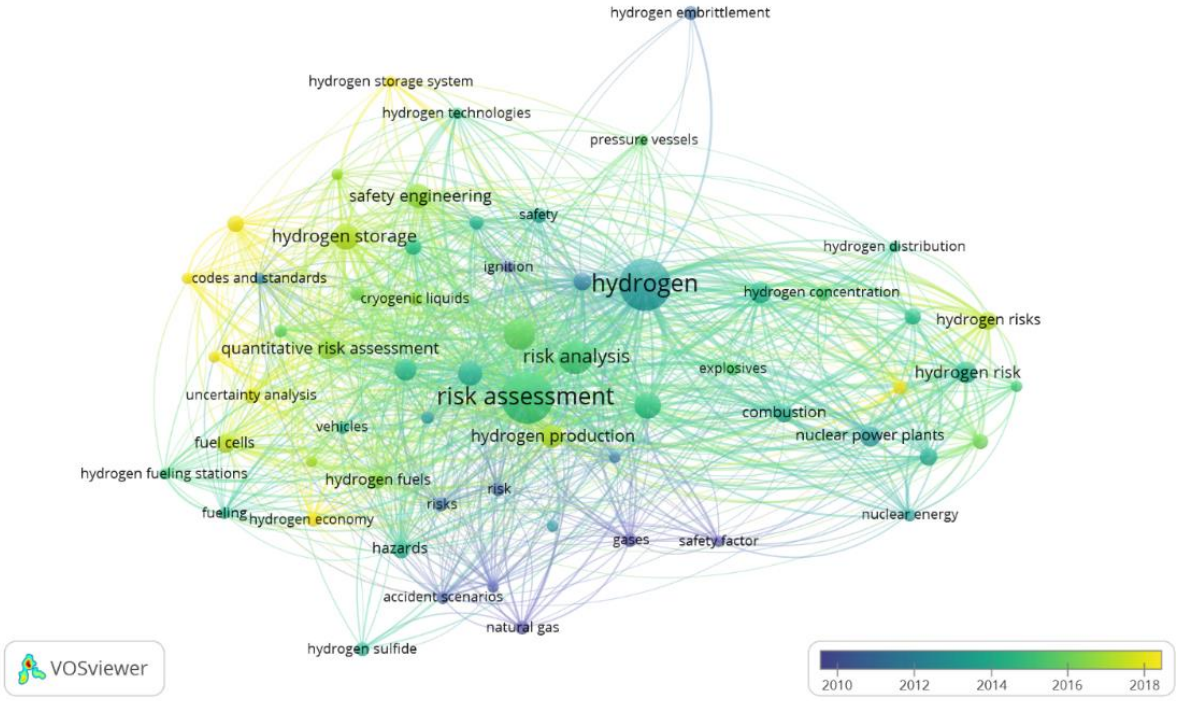

Fig. 1 : Bibliometric maps for hydrogen risk

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SF2-132

DEVELOPMENT OF RISK ASSESSMENT MODEL FOR FTJ BIOPOWER PLANT BOILER USING BAYESIAN NETWORK

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Extended Abstract

The growing popularity of biomass power generation is linked to its reputation as a green and low-cost renewable energy source. Since it has been utilised for power production, biomass has improved; nonetheless, assessment of possible occupational health and safety (OH&S) concerns connected with biomass fuels in combustion-based generation remains limited [1]. As of 2016, Malaysia's biopower industry had matured, resulting in the construction of large-scale biomass, biogas, and small hydro plants. Nonetheless, there are challenges in terms of feedstock availability and pre-treatment for large-scale power generation, as the expense of treatment would result in a higher feedstock cost than coal [2].

The boiler in a biomass power plant is one of the most important pieces of equipment in a burned fuel power plant. A risk-based inspection is a type of unified system management theory and technique that may efficiently assess equipment risk while also lowering operational costs [2][3]. However, there are a number of major risks and health and safety concerns associated with the EFB biopower boiler that must be addressed. Because EFB contains roughly 67 percent moisture, it requires a lot of drying before it can be used as a boiler fuel. Furthermore, the high alkali content of EFB play an important role for organic fertilizers or bioethanol production but not suitable for combustion as it will cause slagging and fouling in the boiler [4]. Thus, the objective of this study is to develop a condition and safety relationship framework of biomass power generation boiler using Bayesian network.

Bayesian Network (BN) is an inexorably famous technique for demonstrating unsure and complex systems, for example, biological communities and ecological administration [5]. The information was collected through from FTJ biomass plant by using interview session and questionnaire. Once the risks has been identified, the relationships were expressed into a BN. In constructing the BN, the graphical representation, indicating the relevant variables (nodes) and dependencies (arcs) were established. The software used for constructing the network is HUGIN [6]. The next step was to specify the states and to input values for a CPT (Conditional Probability Table) of each node. In this work, a case study from local biopower plant in Jengka was applied. The predictive, diagnosis and sensitivity analysis of Bayesian network were performed to identify the casual links which cause the failure in the system based on time.

Referring to the data gathered, the main risks areas are categorized into fuel preparation, water cooling system, deaerator, and economizer as depicted in Figure 1. The results obtained from the proposed Bayesian Networks model could be a solution in establishing effective error management and provide information about the essential factors that need to be controlled. Thus, this framework may support the decision maker to decide when and where to take preventive or mitigate measures in the risk management process for biomass power plant.

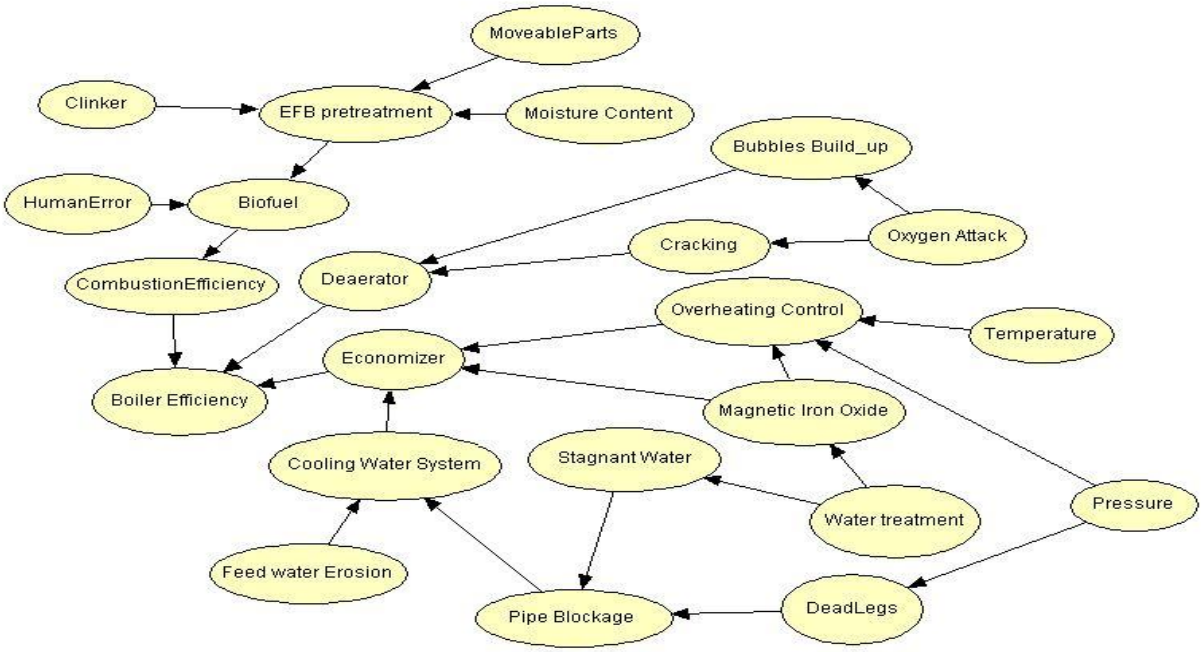

Fig. 1: Bayesian Network model for biomass boiler

Keywords: Biomass Boiler, Bayesian Network, Risk Analysis, Risk assessment, Biomass plant

Acknowledgment

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SF3-123

GREEN E-WASTE PROCESSING: IDENTIFICATION OF INHERENT SAFETY AND HEALTH PROPERTIES

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Extended Abstract

E-waste or also knowns as electronic waste refers to electric or electronic equipment that reached their end of lifecycle and cannot be utilized by users anymore [1]. There are various types of e-waste for example small and large household appliances, computers and laptops, televisions and radios, communication devices such as mobile phones, lighting equipment as well as electrical and electronic tools such as drills and electric saws [2].

E-waste is consisting of both hazardous and non-hazardous chemicals for example the volatile organic compounds as well as heavy metals. 44.7 million metric tonnes of e-waste were produced globally in 2016 [3], a staggering rise from 20 million tonnes per year in 2006 [4], the global production of e-waste is estimated to be around 20 to 25 million tonnes per year and is expected to rise through the decade. E-waste is associated with large range of toxic chemicals [5]. It was proven by previous researchers that e-waste releases toxic metals as well as polyhalogenated organics for example polychlorinated biphenyls (PCBs) as well as polybrominated diphenyl ethers (PBDEs). According to Puckett and Smith [6], there are more than 1000 toxic substances that can be found in e-waste divided into toxic metals for example barium, cadmium and lead as well as persistent organic pollutants for example brominated flame retardants (PBR) and polycylic aromatic hydrocarbons (PAHs). These substances cause serious harm to human health through food chain in which the toxic substances end up entering the food chain and direct impact to workers who work in the e-waste pre-treatment plant. In light to the various safety and health impacts of e-waste processing activities to human health and the environment, implementation of the green industry concept in e-waste processing is highly needed.

The objective of this research is to identify the associated inherent safety and health properties on the existing e-waste processing technologies. This work will act as the preliminary step in identifying the significant safety and health aspects for green e-waste processing.

In this work, relevant e-waste processes will be identified. Noted examples of e-waste processing methods are pyrometallurgical and hydrometallurgical methods. Next, associated inherent safety and health parameters for example flammability, explosiveness and toxic release will be identified for every e-waste processing method recognized earlier.

The results presented in this work will be in the form of preliminary green checklist that integrates the green e-waste processing methods and the associated safety and health properties. The green checklist to be developed is called the Green E-Waste Processing Checklist (GEPC) and is intended to work as a guideline in determining the level of green practices compliance in e-waste processing activities.

Keywords: e-waste processing; inherent safety; inherent health; green processing; properties identification.

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ENVIRONMENTALLY CATALYTIC TECHNOLOGY (ECT)

ECT1-194

EFFECT OF pH ON SIMULTANEOUS PHOTOREDOX OF CONGO RED AND CHROMIUM (VI) OVER ZINC OXIDE LOADED FIBROUS SILICA-ZIRCONIA

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Extended Abstract

In recent years, dyes and heavy metals have been identified as significant source of water contamination, resulting in environmental complications [1]. Researches have attempted to eradicate congo red (CR) and hexavalent chromium (Cr (VI)) via various techniques such as nanofiltration and adsorption [2-3]. However, these methods have some weaknesses such as the production of large amounts of sludge, the persistence of residual toxicity, and the long time periods required to complete the processes. The semiconductor-mediated photocatalysis has been acknowledged as a potential wastewater treatment method that capable to remove the heavy metal and dyes simultaneously [4]. Zirconium dioxide (ZrO_2) has recently been recognized as a potential photocatalyst due to its chemical stability and suitable redox potential. However, limited light-harvesting capabilities, charge recombination, and wide bandgap restrict the ZrO_2 to be applied under visible light irradiation [5]. Thus, many methods have been incorporated to address these restrictions such as doping with another semiconductors [6]. In addition, the photocatalytic abilities are also dependent on reaction parameters such as the pH of the aqueous solution. The pH influences the adsorption abilities of the composite, the surface charge, and the radical interaction [7].

In this study, the effect of pH was studied using zinc oxide loaded on fibrous silica-zirconia (ZnO/FSZr) as semiconductor catalysts to determine the influence on surface-charge properties of the catalysts for simultaneous photoredox of CR and Cr (VI). The catalysts properties were characterized further by X-ray Diffraction, and Fourier Transform Infrared spectroscopy. The effect of pH on the simultaneous photoredox n of CR and Cr (VI) was explored by varying the pH from 1 to 9 as illustrated in Fig. 1A. The results demonstrated that greatest photo-oxidation for CR was obtained at pH 3 with 73%, while photooxidation at pH 1, 5, 7 and 9 were 37.5%, 25%, 15%, and 4%, respectively. As for Cr (VI), the photoreduction was also highest at pH 3 with a value of 27% followed by 9%, 0.7%, 1% and 0% at pH 1, 5, 7 and 9, respectively. This result can be explained by the amphoteric behavior of the catalyst, as the point zero charge (pHzpc) of ZnO/FSZr was found to be at pH 5 (Fig. 1B). Hence, the catalyst surface would be positively charged below this pH value and electrostatically attracted to the negatively charged of both CR and Cr (VI), and vice versa.

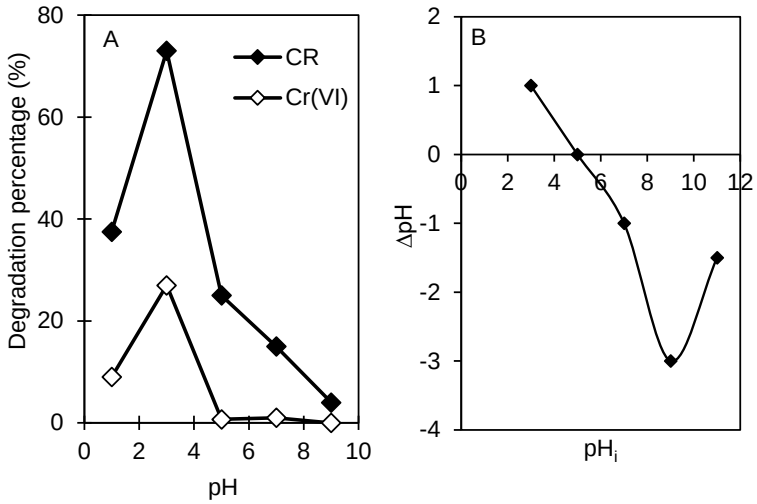

Fig. 1: (A) Effect of pH on photoredox of CR and Cr (VI) for ZnO/FSZR, (B) pH_{ZPC}.

Keywords: pH; point zero charge; ZnO/FSZr; degradation; Congo Red; Chromium (VI)

Acknowledgement
The authors are very grateful to the financial support from Universiti Teknologi Malaysia for the award o UTM research grant (08G52).

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ECT2-129

EFFECT OF CALCINATION TEMPERATURE ON FIBROUS SILICA ZIRCONIA TOWARD ENHANCED REMOVAL OF Cr(VI) AND *P*-CRESOL

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.

Extended Abstract

Fibrous silica zirconia (FZ) with different calcination temperature, 450, 550 and 650 °C (450FZ, 550FZ and 650FZ) were synthesized by microemulsion method and the physicochemical properties of catalysts were characterized by XRD and FTIR. The calcination temperature controlled the crystallinity and the presence of Si-O-Zr bonds. All the catalysts were utilized for photocatalytic removal of Cr(VI) and p-cresol under visible light irradiation. The 550FZ exhibited the highest photocatalytic reduction of Cr(VI) (95.5%) and oxidation of p-cresol (50.7%) using 0.5 g/L of catalyst. The result could be due to its high crystallinity and the presence of adequate amount of Si-O-Zr bonds. This work offers new material strategy for photocatalyst exploration especially in coexistence of binary pollutants.

INTRODUCTION

Nowadays, wastewater is facing severe contamination from organic compounds and heavy metal ions owing to growth of population and high demand in industries [1,2]. Cr(VI) and *p*-cresol commonly coexist in wastewater from industries, posing a serious threat to human health because they have the effect of mutagenesis, genotoxicity and carcinogenesis [3]. Hence, the efficient elimination of Cr(VI) and *p*-cresol has earned further attention in the wastewater treatment operation. Among the water treatment technique, photocatalysis is the most efficient method due to its high performance and environmentally friendly [4]. Lately, ZrO_2 has been investigated as good photocatalyst for reduction of heavy metals as well as oxidation of organic compounds due to its nontoxicity, chemical inertness and environmentally friendly [5,6]. However, the major limitation of this semiconductor in photocatalysis is its wide band gap (4-5 eV) and low surface area.

METHODOLOGY

In this research, fibrous silica zirconia (FZ) with different calcination temperature, 450°C, 550°C and 650 °C (450FZ, 550FZ and 650FZ) were synthesized by microemulsion method and the physicochemical properties of catalysts were characterized by XRD and FTIR. Photocatalytic reaction was conducted for removal of Cr(VI) and p-cresol simultaneously.

RESULTS AND DISCUSSION

The calcination temperature controlled the crystallinity and the interaction between zirconia and silica framework of the catalysts. It is observed that the intensities of diffraction peaks were increased at high calcination temperature, showing the highly crystallinity due to the growth of ZrO_2 crystallite

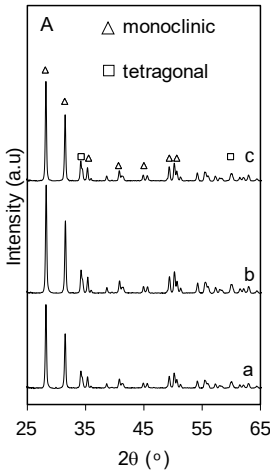

Fig. 1 XRD patterns of (a) 450FZ (b) 550FZ and (c) 650FZ

The 550FZ exhibited the highest photocatalytic reduction of Cr(VI) (95.5%) and oxidation of *p*-cresol (50.7%) using 0.5 g/L of catalyst (Fig. 2). The result could be due to its high crystallinity and Si-O-Zr bonds. This work offers new material strategy for photocatalyst exploration especially in coexistence of binary pollutants.

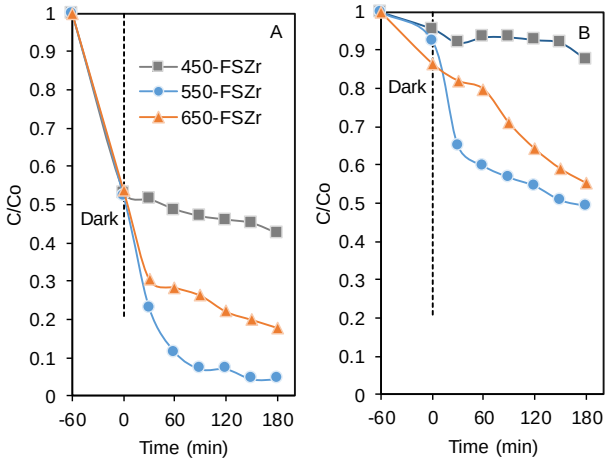

Fig. 2 Simultaneous photoredox of Cr(VI) and *p*-cresol in visible light by different catalysts [W= 0.5g L^{-1}, pH=1, initial concentration of Cr(VI) and *p*-cresol = 10 mg L^{-1} and H_2O_2= 5 mmol L^{-1}]

Keywords: Cr(VI); fibrous silica zirconia; *p*-cresol; photooxidation; photoreduction

Acknowledgement

As author, we are thankful to Ministry of Education for the financial support by Fundamental Research Grant Scheme FRGS/1/2020/STG05/UTM/02/13 (Grant No. 5F342) and Universiti Teknologi Malaysia for High Impact Research Grant (Grant No. 08G92).

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ECT3-128

SYNTHESIS OF FIBROUS SILICA CERIA FOR ENHANCED VISIBLE-LIGHT DRIVEN PHOTODEGRADATION OF CIPROFLOXACIN COUPLING WITH SULFATE RADICAL

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Extended Abstract

In a rapid urbanization, the removal of antibiotics in water surface has become a serious matter due to the massive consumption of it that has resulted in the wide occurrence of water pollution. Recently, sulfate radical ($SO_4^{\bullet-}$)-based advanced oxidation processes (SR-AOPs) have aroused enormous attention to decontaminate wastewaters containing antibiotics with provides $SO_4^{\bullet-}$ as active species. In this work, fibrous silica-ceria (FSC) was synthesized using hydrothermal method characterized using XRD. The results revealed that despite the FSC reduced the crystallinity, but the surface area was increase which altered their behavior toward enhanced photodegradation of ciprofloxacin (CIP) under visible light in the presence of peroxydisulfate (PDS). The performance on photodegradation of CIP using catalyst are in the following order: FSC, PDS (92%) > FSC (61%) > commercial CeO_2, PDS (37%) > commercial CeO_2 (17%) for 240 min. Overall, FSC demonstrated the best performance on CIP degradation due to well-defined fibrous morphology, higher surface area and appropriate crystallinity. This work believes that the FSC coupled with PDS displayed promising applications for the various pharmaceuticals

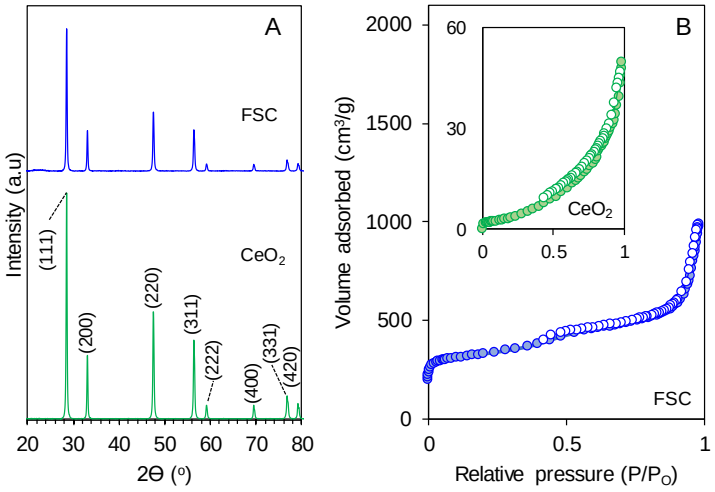

Fig. 1: (A) XRD and (B) N_2 adsorption desorption isotherms of commercial CeO_2 and FSC catalysts

Fig. 1A illustrates a XRD diffractogram for the fibrous silica ceria (FSC) and CeO_2 catalysts. A series the diffraction peaks of pristine CeO_2 were noticed at (111), (200), (220), (311), (222), (400), (331), and (420) planes, which was indexed to the fluorite cubic phase of CeO_2 (JCPDS 34-03494) [1]. Similar peaks belong to cubic phase were observed for the FSC but the intensity were decreased due to the silica can

inhibit the growth of CeO_2 [1,2]. According to the N_2 adsorption-desorption as shown in Fig. 1B, All the catalysts exhibited type IV isotherms with an H1 hysteresis loop, confirming the characteristics of highly uniform mesoporous materials [3,4]. FSC shows higher mesoporous amount compared to CeO_2 signifying that higher surface area was obtained by FSC.

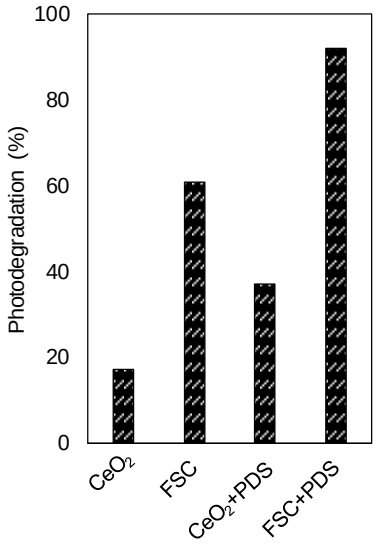

Fig. 2: Photodegradation of CIP using different types of synthesized catalysts in the present of PDS [condition: Visible light, Time (240 min), catalyst dosage (0.375 g L^{-1}), PDS loading (1.0 g L^{-1}), $[Pollutant]_o$ 10 ppm, pH 7]

The photocatalytic activities of FSC and CeO_2 were studied by CIP photodegradation at room temperature and neutral pH as shown in Fig. 2. Noticeably, a relatively high CIP photodegradation efficiency around 60% was achieved over FSC compared to CeO_2 with 17% of degradation with the absence of PDS. Then, a distintive synergetic effect was noticed when using the catalysts combined with PDS during photodegradation. The performances were increased to 36% and 92% of degradation for the CeO_2 and FSC, respectively. This occurrence signifying the catalyst was able to generate $SO_4^{\bullet-}$ [5]. This study provides a new insight in accelerating photocatalytic degradation using FSC coupled with PDS. As a future prospect, this study can be futher investigated by comparing with various types of oxidants to generate active species.

Keywords: Fibrous silica Ceria; Photodegradation; Ciprofloxacin; Sulfate radical

Acknowledgment

This study was supported by Research Student Grant Scholarship and Fundamental Research Grant Scheme FRGS/1/2019/STG07/UTM/01/1 (Grant No. 5F192) and Collaborative research grant (Grant no. 07G62).

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ECT4-187

CONTEMPORARY ASSESSMENT OF SILVER OXO-SALTS AS PHOTOCATALYST FOR REMEDIATION OF DYE WASTEWATER

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Extended Abstract

The growing demand for clean water has becoming the major problem around the world as the declining its resources with the expansion of industry and human populations [1]. An article by the World Health Organization (WHO) found that only one-quarter of the world's population had access to hygienic drinking [2]. In order to minimize the water demand in a water-scarce environment, strategic approach to recycling the wastewater effluent has been considered. The wastewater disposal come from synthetic chemicals will be discharged organic compounds into water body without any treatment through industrial activities such as agriculture, pharmaceuticals, textiles and domestic [3]. These practices greatly increase the ecological toxicological problem that can cause serious environmental and living organisms' problems. Currently, many industrial like textile, paper, cosmetic and plastic used dyes and pigments for coloring of their products [4]. Excessive usage of dyes will turn it to the dye product waste which difficult to decolorize since most of dyes contain highly carcinogenic aromatic amine [5]. Most of these dyes escape from the conventional wastewater treatment processes and persist in the environment. In the textile manufacturing, they were used anti-microbial agent resistant to biological degrade using natural fiber such as cotton [5]. However, the complex aromatic structures of these agents make them more intractable to biodegradation. Hence, the effective environmental method to remove wastewater of dyes requires further consideration.

Advanced oxidation processes (AOPs) have been considered as an effective technique in order to treat organic chemical dyes [6]. AOPs are based on generating the hydroxyl radical which is highly oxidizing agents. The heterogeneous photocatalysis has become an extremely promising technology by producing a strong oxidizing agent that can oxidize the organic pollutant into harmless product [7]. Among of the photocatalyst, silver oxo-salts based photocatalyst such as Ag_2SO_4, Ag_3PO_4, Ag_2CO_3 and Ag_2MoO_4 have

attracted intense in the current research works due to the excellent oxidation photocatalyst [8]. Moreover, most of the silver oxo-salts could be applied in heterojunction system due to the excellent electron transfer and electron reservoir properties [9].

The all-encompassing objective of this work is to give a critical review of current progress and approaches on the utilizations of the silver oxo-salts photocatalysts on the photocatalytic degradation of organic dyes in the environment. Herein, it will first provide overview of dyes and its derivative structure and various types of silver oxo-salts. Furthermore, the photocatalytic degradation pathways and intermediate product of organic dyes over these photocatalyst are then discussed with an aim to explore the reaction process. Finally, prospects and challenges are also summarized and discussed at the end of this critical review. Lately, research and development of new photocatalysts has expanded by introduce metal halides and metal oxo-salts. The fact that silver oxo-salts such as Ag_3PO_4, Ag_2SO_4, and Ag_2CO_3 exhibit potential photocatalyst activity under light irradiation is crucial. The different oxo-salt groups include XOy (X = C, P, S, As, and other P-block elements; y = 3, 4) which may be binding to create semiconductor networks with various metal ions, therefore provide opportunity to construct a novel, effective photocatalysts. Among of the oxo-salt group, the silver oxo-salt has been shown to be a potential photocatalyst for water splitting and organic pollutant degradation using visible light irradiation [10]. Furthermore, because of their distinct crystal and electronic structures, which impact the energy band structure and charge carrier transfer efficiency, these photocatalysts display exceptional photophysical performance and photocatalytic activity. Table 1. summarises current work on silver oxo-based composite photocatalysts, with the goal of providing direction for the creation of better photocatalysts for potential real-world applications.

Table 1. Several study on silver oxo-salts composite photocatalyst for photodegradation of organic pollutants

Photocatalysts	Dye / conc.	Performance (%)	Ref.
$Ag_3PO_4/CoFe2_4$	MB (20 mg L^{-1}) RhB (20 mg L^{-1})	98% MB and RhB removal after 90 min	[11]
$Ag_3PO_4/N\text{-}TiO_2$	RhB (10 mg L^{-1})	91% RhB removal after 120 min	[12]
$Ag@Ag_2SO_4$	MO (10 mg L^{-1}) RhB (10 mg L^{-1})	98% MO and RhB removal after 20 min	[13]
$Ag_2CO_3/g\text{-}C_3N_4$ core shell	RhB (10 mg L^{-1}) MB (10 mg L^{-1})	95% RhB, 95% MB, removal after 54 min	[14]

Keywords: Silver oxo-salts, photocatalyst, wastewater, dyes

Acknowledgement

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ECT5-144

FABRICATION OF VISIBLE-LIGHT-MEDIATED MFE@FST PHOTOCATALYST FOR EFFICIENT SIMULTANEOUS PHOTOCATALYTIC REMEDIATION OF PHARMACEUTICAL PRODUCTS

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Extended Abstract

The immense production and consumption of pharmaceutical products such as antibiotics, anti-inflammatory drugs, and hormones nowadays have detrimentally affected our environment. The pharmaceutical compounds particularly tetracycline (TC) and 4-nitrophenol (4-NP) exhibit low biodegradable ability and thus, have been classified as among the emerging pollutants. Moreover, these pollutants also can bring numerous illnesses to humans upon contact or consumption exceeding the prescribed dosage [1,2]. This situation has urged humans, especially researchers worldwide to formulate effective strategies to eliminate these hazardous compounds of pharmaceuticals from the environment. After years of extensive research on wastewater purification areas, solar-light-driven photocatalysis has emerged and been regarded as among the effective methods to purify these contaminants from the hydrosphere [3]. Moreover, the photo-oxidation and photo-reduction processes can be performed simultaneously by the photocatalysis method which results in better photocatalytic activity than conventional photocatalysis. Notably, nowadays, the study on simultaneous photocatalysis mostly is focusing on removing heavy metal and organic pollutants simultaneously [4]. On the other hand, the study on simultaneous photocatalytic degradation of organic pollutants is still in the immature stage. Herein, we developed a novel iron-based metal-organic framework [MIL-53(Fe)] supported on fibrous silica-titania (FST) by effortless microemulsion and incipient wetness impregnation methods for simultaneous photocatalytic removal of oxidative tetracycline and reductive 4-nitrophenol compounds.

The prepared iron-based metal-organic framework supported on fibrous silica-titania (MFe@FST) demonstrated high photocatalytic activity towards simultaneous photocatalytic removal of tetracycline and 4-nitrophenol which can be assigned to the significant enhancement on the optical property and effective charges transportation. As shown in Tauc Plot (Fig. 1a), the incorporation of MIL-53(Fe) with FST demonstrated a negative shift in the bandgap energy, signified the improvement in visible light response range and better light absorption. In addition, the intensity of the photoluminescence spectrum (Fig. 1b) for MFe@FST is much lower than that of FST and commercial

MIL-53(Fe), signifying the low recombination rate of photogenerated charges due to effective utilization and transportation of charge carriers.

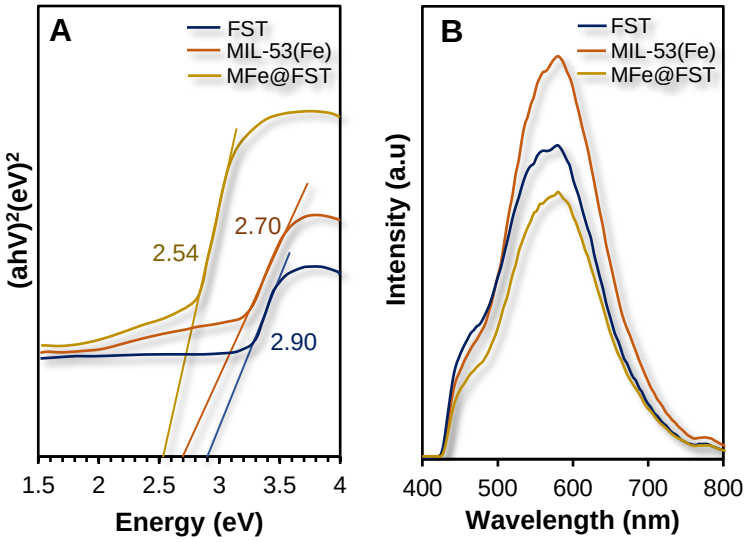

Fig. 1: (a) Tauc plot and (b) Photoluminescence spectra of MIL-53(Fe), FST, and MFe@FST catalysts.

The photocatalytic experiment was conducted under visible light illumination. Interestingly, the simultaneous photocatalysis method (Fig. 2) shows superior photocatalytic activity compared to conventional photocatalysis with degradation efficiency for TC and 4-NP (77% and 66%) in the simultaneous system and (64% and 56%) in a single system, respectively. This might be due to the synergistic effect formed from the oxidation of tetracycline and reduction of 4-nitrophenol which result in the efficient utilization of photoexcited charges. This finding is similar to the study reported by Xu et. al, (2022) in which the synergistic effect in simultaneous photocatalytic reactions boosted the photocatalytic activity significantly [5].

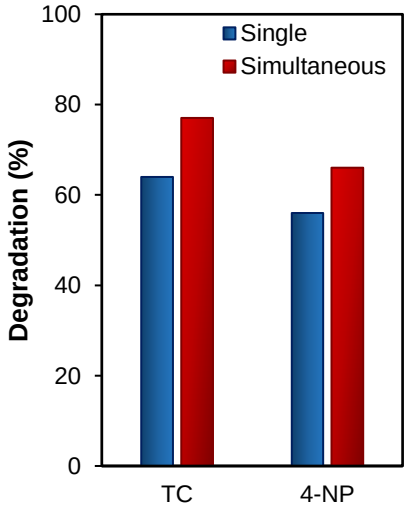

Fig. 2: Photocatalytic activity of MFe@FST catalyst toward degradation of tetracycline and 4-nitrophenol in single and simultaneous system. (W = 0.375 g L-1, tetracycline = 10 mg L^{-1}, 4-nitrophenol = 10 mg L^{-1}, pH = 7, t = 3h)

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ECT6-161

FIBROUS SILICA-FeOOH PHOTOCATALYST FOR SIMULTANEOUS REMOVAL OF HEXAVALENT CHROMIUM ION AND METHYL ORANGE UNDER VISIBLE LIGHT IRRADIATION

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Extended Abstract

As a result of rapid urbanization and industrialization, different inorganic and organic contaminants including highly hazardous ions have been improperly handled and discharged into water supplies[1]. Chromium hexavalent (Cr(VI)) and methyl orange (MO) are common pollutants found in the metalworking, leather, textiles industries and other sectors [2]. A mixture of this pollutants are hazardous and impose great danger to aquatic environment and human beings for a long period of time [3]. Various approach have been applied to treat Cr(VI) and MO individually. However, it is not practical to be applied in real wastewater treatment since both of this pollutant usually coexist in the same system that could exhibit different physicochemical properties compared with single system [4], [5]. Various approach has been studied on the removal of Cr(VI) and MO simultaneously in one system. Advanced oxidation processes (AOPs) have been identified as a viable alternative to traditional treatment methods for eliminating heavy metal and organic contaminants from aqueous systems in this condition [4]. Among AOPs, photo-Fenton technique has been widely used due to its high removal rate of organic contaminants in water [6]. FeOOH catalyst not only exists vastly in nature, inexpensive and adaptable, but it also has moderate band gap range (2.0-2.6 eV) for photocatalysis under visible light [7]. However, it limits the photocatalytic activity due to low electron-hole rate transfer [6]. Recent discovery from Polshettiwar and colleges in dendrimitic fibrous nanosilica catalyst known as KCC-1 have shown promising performance in various activities including photocatalysis [10].

To our knowledge, there is no study reported on incorporation of silica with FeOOH in simultaneous photodegradation of Cr(VI) and MO. Thus, in this study, fibrous silica iron oxide (III)-hydroxide (FSFeOOH) was prepared by microemulsion method. The physicochemical properties of the FSFeOOH was studied using FTIR and UV-Vis DRS spectroscopy to determine functional group present and the band gap of the catalyst respectively and the results were compared with the pristine FeOOH. Figure 1.a shows the band gap of FeOOH was tuned from 2.1 eV to 1.95 eV due to the addition of fibrous silica. The photocatalytic activity on removal of Cr(VI)/MO were studied in simultaneous system compare to the single system. From figure 1.b, it was found that the photocatalytic reduction of Cr (VI) and oxidation of MO of the FSFeOOH for the simultaneous and single system were 64.17/98.94 % and 61.42/61.42 % respectively. The efficient photocatalytic activity of Cr(VI) and MO could be due to the decrease band gap of FeOOH after incorporation with silica which facilitate the movement of electron process. Hence, the modification of FeOOH catalyst with fibrous silica morphology offers an ideal strategy for simultaneous photocatalytic reaction removal of heavy metals and organic pollutants.

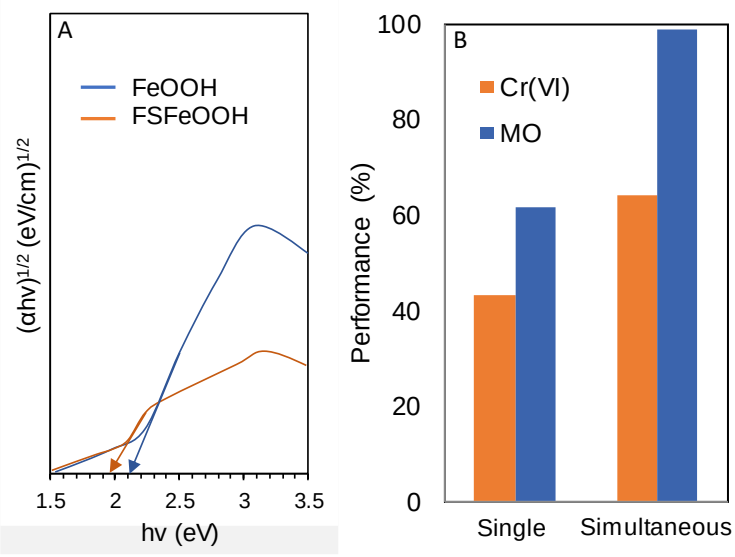

Fig. 1: (A) Kubelka-Munk spectra and (B) Catalytic performance of FSFeOOH in simultaneous and single system [W = 0.375 g L^{-1}, pH=1, t=180 min, initial concentration of Cr(VI) and methyl orange =10 mg L^{-1} and [H_2O_2]= 10 wt%]

Keywords: photo-fenton; Cr(VI); methyl orange; fibrous silica iron; simultaneous degradation

Acknowledgement

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ECT7-191

SIMULTANEOUS PHOTOCATALYTIC DEGRADATION OF DYES USING ZINC OXIDE MODIFIED CARBON NITRIDE CATALYST

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Extended Abstract

There have been numerous water remediation techniques developed to treat pollutants in wastewater due to an increasing demand for clean water. Photocatalysis is one of the potential techniques in water purification due to its environmentally friendly and has an ability to destruct the pollutant. Through photocatalysis, pollutants, especially dyes in wastewater are converted into water and carbon dioxide. Herein, the different weight percentages of Zinc Oxide modified graphitic Carbon Nitride (2, 5 and 8 wt% ZnO/g-C_3N_4) catalysts were synthesized and used in the photocatalytic degradation of simulated dyes in an aqueous solution. The simulated dye used consisted of a mixture of Methylene Blue (MB), Methyl Red (MR), Methyl Orange (MO) and Rhodamine B (RhB) solutions and was set at pH 6 and an initial concentration of 10 mg/L. Figure 1 shows the performance of the synthesized catalyst for degradation of simulated dyes.

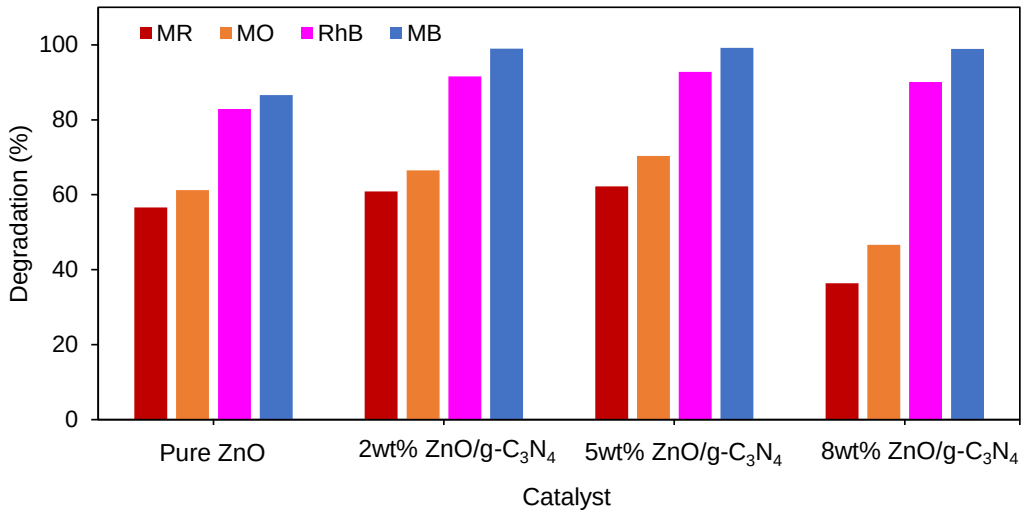

Figure 1: The performance of synthesized catalysts [w=1.0g/L catalyst; pH6; Dyes Conc.=10 mg/L]

As shown, after the loading of g-C_3N_4, the percentage photocatalytic degradation of simulated dyes for 2wt% ZnO/g-C_3N_4 and 5wt% ZnO/g-C_3N_4 catalysts are better than pure ZnO after 30 minutes of UV light irradiation. The highest degradation percentage was obtained by 5wt% ZnO/g-C_3N_4 catalyst, which at 62, 70%, 93% and 99% for the removal of MR, MO, RhB and MB, respectively. The enhanced performance of photocatalyst is due to the synergistic effect between ZnO and g-C_3N_4 that creates a

good combination at the interface of the catalyst [1]. Moreover, the addition of g-C_3N_4 has also improved the performance of ZnO by overcoming the high rate of photoinduced electron-hole pairs recombination in ZnO [2]. However, increasing the loading up to 8wt% in ZnO/g-C_3N_4 showed the lower percentage degradation due to the agglomeration effect between g-C_3N_4 and ZnO which ruined the surface morphology and structures in ZnO/g-C_3N_4 catalyst [3]. Thus, it proves that 5wt% is a suitable ratio between ZnO and g-C_3N_4 which lead to an to optimize photocatalytic activity of hybrid ZnO/ g-C_3N_4 catalyst.

Keywords: Dyes, Photocatalytic, Zinc Oxide, Carbon Nitride.

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ECT8-193

EFFECT OF pH ON SIMULTANEOUS PHOTOREDOX OF CHROMIUM (VI) AND METHYLENE BLUE USING FIBROUS TITANIA SILICA

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Extended Abstract

Cr (VI) and methylene blue (MB) often coexist in wastewaters such as tannery effluents. Coexistence of these pollutants further devastate the proliferation of aquatic organisms and the ecosystem [1]. Hence, effective simultaneous removal of both pollutants is needed. Among many techniques, simultaneous photocatalysis is one of the most promising technique due to its safely, simple and high efficiency [2]. Recently, Azami et al. synthesized fibrous silica titania (FST) by using a combination of the microemulsion and crystallization of the crystal-seed method [3]. FST features excellent physical properties, including high surface area, unprecedented fibrous surface morphology and high accessibility of active site that can enhanced the photocatalytic activity [4]. In view of these attractive attributes, the sequence of metal and silica precursors during the synthesis was changed for the first time to produce fibrous titania silica (FTS). In this study, FTS was prepared via a modified FST synthesis method as reported [4]. The morphological properties and band gap energy of the catalyst were investigated using FESEM and UV–vis/DRS spectrophotometer, respectively. Among several factors that affects the photocatalytic activity, pH of the pollutants plays an important role in adsorption and dissociation of substrate, catalyst surface charge, and other physiochemical properties [5]. The significant effect of pH was studied toward FTS to determine the influence on surface-charge properties of the catalyst for simultaneous photo -oxidation of MB and -reduction of Cr (VI). The pH_{PZC} of the catalyst was performed using powder addition method as reported in the literature [6]. The effect of pH on the photo -oxidation of MB and -reduction of Cr (VI) using FTS was investigated by varying the pH from 1 to 7 as shown in Figure 1A and B, respectively. The best performance was obtained at pH 3 with 98% for MB oxidation and 61% for Cr (VI) reduction. Theoretically, the highest reduction of Cr (VI) could be achieved at $pH<pH_{pcz}$ (5.1) and vice versa for MB. However, Fig. 1B shows that the total degradation of MB is almost similar at every pH. According to Xie et. al., the attraction between the negatively charged Cr (VI) and positively charged MB formed complex of Cr-MB on catalyst surface at $pH<pH_{PZC}$ (5.1) and make the photooxidation of MB possible to happened [7]. In addition, pH 3 was chosen to be the best pH due to higher photocatalytic activity compared to other pH. In conclusion, this finding shows the important role of pH solution in the simultaneous removal of heavy metal and organic pollutant.

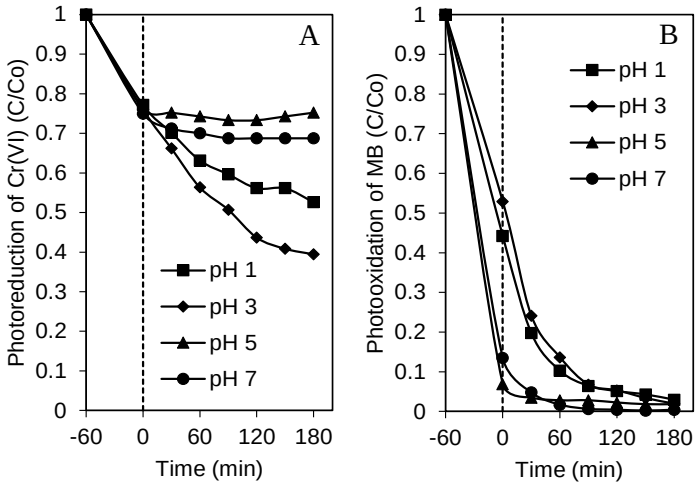

Fig. 1: Simultaneous (A) photoreduction of Cr (VI) and (B) photooxidation of MB [catalyst dosage = 0.375 g L^{-1}, initial concentration of both pollutants = 10 mg L^{-1}]

Keywords: pH; point zero charge; fibrous silica titania; methylene blue; chromium (VI).

Acknowledgement

We are thankful to the Malaysian Ministry of Higher Education for the financial support by Fundamental Research Grant Scheme (Grant No. FRGS/1/2020/STG05/UTM/02/13-5F342) and also Universiti Teknologi Malaysia for High Impact Research Grant (Grant No. 08G92).

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ECT9-154

VANADIUM OXIDE LOADED ON FIBROUS SILICA TITANIA FOR ENHANCED PHOTODEGRADATION OF CIPROFLOXACIN

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Extended Abstract

Abstract. The release of pharmaceutical compounds effluent in wastewater has risen and is one of the major environmental matters due to its toxicity and negative impact on human beings and aquatic life. For instance, ciprofloxacin (CIP) was extensively used to treat human and animal bacterial infections, which its complex chemical structure leads to the significant hazard to antibiotic activity. Herein, vanadium oxide loaded onto fibrous silica titania (V/FST) photocatalyst for photodegradation of ciprofloxacin (CIP) was reported in this study. X-ray diffraction, Fourier transform infrared spectroscopy and ultraviolet-visible diffuse reflectance spectroscopy were used to analyse the physicochemical properties of the catalysts. The results showed that the addition of vanadium on FST narrowed the band gap of the catalyst could enhance the photocatalytic activity. The V/FST demonstrated higher performance (83%) compared to FST (76%) for photodegradation of CIP within 3 hours due to its lowest band gap. This study demonstrated that the V/FST has a potential to be used in photocatalytic degradation of various organic pollutants.

Contamination of the environment by pharmaceutical compounds (PCs) in wastewater is a severe issue worldwide [1]. Conventional wastewater treatment plants have recently been shown to be ineffective at removing persistent organic pollutants that remain in treated water [2-4]. Antibiotics are one of the most essential PCs categories because of their widespread usage and ubiquitous behaviour as environmental pollutants. Apart from many other negative consequences, the presence and unregulated disposal of antibiotics in the environment may hasten the emergence of antibiotic resistance genes in bacteria, posing health hazards to humans and animals [5]. Ciprofloxacin (CIP) is a widely used fluoroquinolone antibiotic found in the aquatic environment, causing harm to the aquatic ecology and, by extension, humans [6]. As a result, CIP degradation has gotten more attention in the wastewater treatment process. Advanced oxidation processes (AOPs) such as ozonation, photolysis, photocatalysis, and coagulation, chemical precipitation, and chlorination are used to address these issues. Heterogeneous photocatalysis, one of the AOPs, is an effective degrading strategy due to its high oxidation ability, non-toxic nature, and long-term photochemical corrosion resistance. TiO_2 is one of the most studied materials in the photocatalysis field [7-8]. However, this semiconductor's large bandgap (3.2 eV) and low surface area make it impractical for photocatalysis.

Fibrous silica titania (FST) was synthesised by using microemulsion method followed by silica seed-crystal crystallisation method. Then, the preparation of vanadium oxide loaded on FST (V/FST) was done

through impregnation method. The physicochemical properties of catalysts were characterised by XRD, FTIR and UV-Vis DRS. V/FST exhibited the highest photocatalytic degradation of CIP (83%) compared to FST (76%). This is attributed to decreased electron-hole recombination rate due to the smaller bandgap energy and most excellent contact. Overall, this work could lead to the development of high-efficiency photocatalysts for various degradation processes.

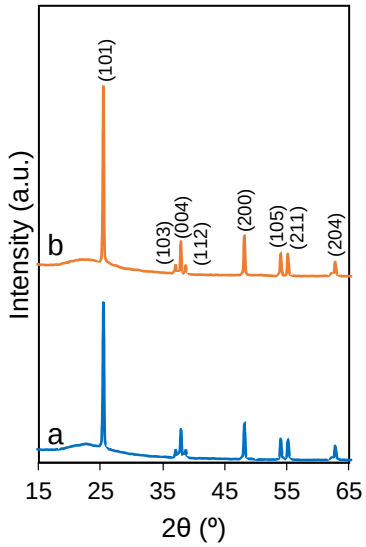

Fig. 1. XRD patterns of (a) FST and (b) V/FST.

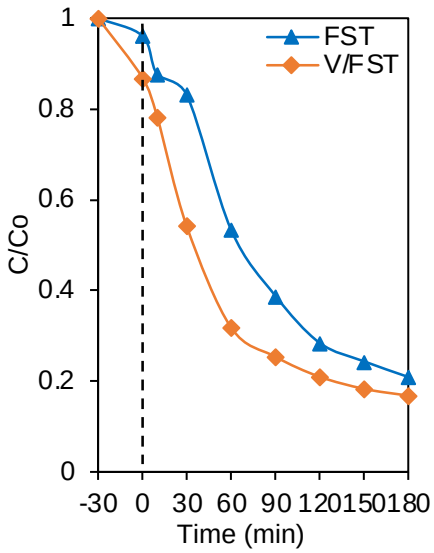

Fig. 2. Photodegradation of CIP in visible light by different catalysts [W= 0.375 g L^{-1}, pH 3, $[CIP]_0$=10 mg L^{-1}].

Keywords: Fibrous silica titania; Ciprofloxacin; photodegradation; vanadium

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ECT10-142

PHOTOCONVERSION OF GLUCOSE USING ZINC OXIDE SUPPORTED ON FIBROUS ZSM5 (CHE-Z5) CATALYST

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Keywords: Glucose; high-valued product; photoconversion; biomass transformation; fibrous ZSM5.

Abstract

Recently, conversion of glucose by oxidation has been extensively studied by many researchers to obtain high valued products. Photocatalysis is one of the promising processes that can produce those products in one step. In this study, zinc oxide supported on fibrous ZSM-5 (Zn/CHE-Z5) zeolite photocatalyst was synthesized using the impregnation method for photoconversion of glucose. From N_2 adsorption-desorption analysis, it was found that the specific surface area of Zn/CHE-Z5was 1345 m^2g^{-1}, which was higher than that of pristine ZnO (3 m^2g^{-1}) and CHE-Z5 (501 m^2g^{-1}). The good properties of ZnO/CHE-Z5 photocatalyst, including having an appropriate bandgap (2.34eV) and high surface area, could achieve superior photocatalytic glucose conversion (98%) compared to both pristine ZnO (88%) and CHE-Z5 (30%) using 0.375 g/L catalyst loading at pH5.

Introduction

Glucose is the most diffuse and cheapest carbohydrate as it can be directly obtained from cellulose, the most abundant and renewable biomass on Earth [1]. The conversion of renewable biomass can be utilized for the sustainable production of high-value chemicals [2]. Recently, many studies on glucose conversion are extensively reported oxidation reactions to obtain high-value products. Photocatalysis is one of the ways to produce those products in one step under an ambient temperature and pressure. The use of metal-semiconductor supported on ZSM5 zeolite has been proven to increase photoactivity due to their unique structure of zeolite, large surface area and having uniform pores. Recently, the fibrous morphology of photocatalyst has attracted much interest among researchers in photocatalysis [3, 4]. To the best of our knowledge, there is the first time using ZnO supported of fibrous ZSM5 catalyst for photocatalytic oxidation of glucose. It is believed this photocatalyst can achieve high photoconversion of glucose and able produce high value-added chemical products.

Experimental

Fibrous silica ZSM-5 (FZSM-5) was prepared by microemulsion technique coupled with zeolite seed-assisted crystallization. Then Zn/CHE-Z5 was synthesized using the impregnation method. The photoactivity of the catalysts was tested for the conversion of glucose. The photocatalytic experiments were performed in a batch reactor fixed with a cooling system.

Results and Discussion

The crystallinities of the photocatalysts were characterized by XRD, and their diffractograms in the range of 2θ = 20°–90° are shown in Fig.1 A. All peaks in the ZnO sample showed a characteristic peak of pure wurtzite structure of ZnO (JCPDS No. 36-1451) [5]. Two main peaks were observed for the bare CHE-Z5 indicating the characteristic pattern of a zeolite structure similar to results reported in the literature [6]. No significant changes were observed after the introduction of ZnO. Moreover, there was an absence of diffraction peaks of ZnO in Zn/CHE-Z5. This was probably due to the poor crystallinity of the zinc species or an amount of ZnO below the detection limit of the instrument. The surface areas, pore volume, and pore size of the catalysts were tabulated in Table 1. From the results, Zn/CHE-Z5 catalyst possessed the highest surface area, pore volume and smaller pore size, indicating that ZnO nanoparticles were dispersed on the surface of CHE-Z5.

The photoactivity of the catalysts for the degradation of glucose is shown in Fig. 2. It could be observed that photoconversion of CHE-Z5 resulted in only 30% degradation, while the pure ZnO was able to improve the degradation up to 88%. However, a significant enhancement was seen for the Zn/CHE-Z5 catalyst with 98% degradation achieved. Indeed, the higher surface area, as well as larger pore volume and smaller pore size of the Zn/CHE-Z5, were contributed to its higher activity.

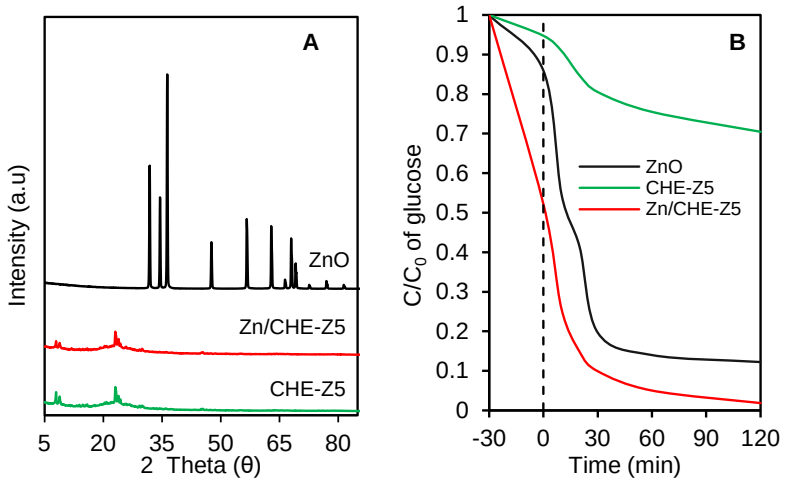

Fig. 1: A) XRD pattern and B) Performance of all photocatalyst

Table 1. Textural properties of all photocatalysts.

Catalyst	BET Surface Area (m^2/g)	Pore Volume (cm^3/g)	Pore Size (nm)	Band Gap (eV)	Photoconversion (%)
ZnO	3	0.0073	9.707	2.48	88
CHE-Z5	501	0.7992	6.379	1.82	30
Zn/CHE-Z5	1345	2.095	6.229	2.34	98

Conclusion

In summary, Zn/CHE-Z5 was successfully prepared by combining the microemulsion and impregnation methods. The excellent activity of Zn/CHE-Z5 in photoconversion (98%) of glucose could be attributed to the high accessibility of active sites and also the high dispersion of metal particles due to the large surface area of the Zn/CHE-Z5 catalyst. This study demonstrated that the incorporation of ZnO nanoparticles into CHE-Z5 can provide superior structural properties and can enhance photocatalytic activity.

Acknowledgment

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ECT11-197

MESOPOROUS SILICA ZIRCONIA IN CALCINED AND UNCALCINED STATES FOR PHOTODEGRADATION OF 2-CHLOROPHENOL

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Extended Abstract

2-Chlorophenol (2-CP) and its derivatives are extremely hazardous compounds that are commonly used in several industries such as paper, biocides, agriculture, cosmetics, etc. [1]. Generally listed by Environmental Protection Agency as key pollutants, they may cause carcinogenic and teratogenic effects to humans and the environment if not treated properly before being discharged into water bodies [2]. Consequently, the treatment of these industrial wastewater is of great importance to reduce the concentrations of such compounds as required under environmental regulation acts. Numerous methods such as ozonation, chemical oxidation, electrochemical degradation, adsorption, ion exchange, and membrane separation have been explored [3]. Such techniques, however, encounter a few drawbacks including time-consuming, creating secondary products, and processing large amounts of sludge. Photocatalysis is an effective approach for the removal of organic contaminants from the environment [4]. Zirconia (ZrO_2), one of the most suitable semiconductor photocatalysts, was widely used to degrade organic pollutants [5]. However, the photocatalytic efficiency of ZrO_2 is constrained by several drawbacks including high electron-hole recombination, narrow bandgap, and limited light-harvesting capabilities [6]. Therefore, several efforts have been done to improve the photocatalytic efficiency of ZrO_2 such as coupling with another semiconductor and optimizing the photoreaction parameters [7]. In addition, altering the catalyst's physicochemical properties also enhanced the photocatalytic activity, mainly via the calcination process.

In this study, the silica-doped ZrO_2 was successfully synthesized through a microwave method and calcined at 850 °C, which is denoted as $SZ_{calcined}$. Subsequently, the SZ also was synthesized without a calcination process for comparison and denoted as $SZ_{uncalcined}$. The synthesized catalysts were characterized by X-ray diffraction, Fourier transform infrared spectroscopy, and electron spin resonance spectroscopy. The photoactivity of the catalysts was investigated under visible light for 2-CP degradation. $SZ_{calcined}$ showed a higher degradation of 10 mg/L of 2-CP (95%) compared to $SZ_{uncalcined}$ after 3 h degradation at pH=5 as shown in Fig. 1. Most possibly, the efficacy of $SZ_{calcined}$ is due to the higher number of defect sites such as oxygen vacancy (OV) and metal defect site (Zr^{3+}), which

suppressed the recombination of photogenerated carriers by acting as an electron trapper. In conclusion, it can deduce that the calcination process induced the formation of Zr-O-Zr, Zr^{3+}, and OV.

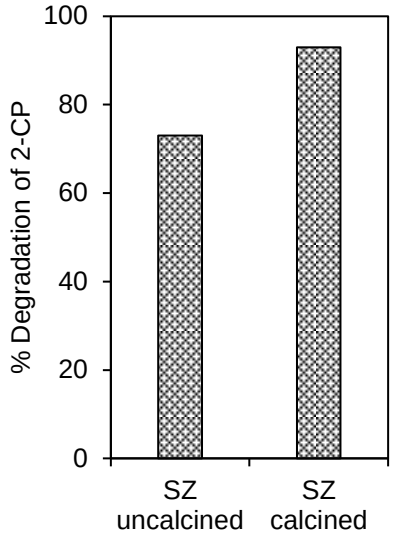

Fig. 1: Catalytic performance of the catalyst under visible light irradiation toward photodegradation of 2-CP

Keywords: Mesoporous silica zirconia; calcined; uncalcined; photodegradation; 2-chlorophenol

Acknowledgement

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ECT12-218

VISIBLE LIGHT PHOTOCATALYTIC ACTIVITY OF TiO_2 INFLUENCED BY V_2O_5 NANOCATALYST FOR METHYLENE BLUE DEGRADATION

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Abstract

Water is the essential pre-requisite of every organism on the earth. In this way, the major anxiety grew upon environment to seize the harmful pollutants so as to provide clean environment. This approves the way for degrading various textile organic dye effluents that pollute the major eco-system. Moreover, the non-biodegradable azo dyes are of aromatic nature which has the stability and higher strength of carcinogenic agents. Therefore, the researchers have focused to destroy the harmful waste water effluents. After Fujishima and Honda's experimental analysis over the generation of hydrogen, photocatalysis shows an increasing attention because of the ability of titanium di-oxide (TiO_2) to bring degradation among the various industrial textile dyes [1]. For this, UV light is initially utilized for the occurrence of photocatalytic reactions. But the researches are currently focusing towards sunlight reactions which are low-cost consuming process.

In this report, a high band gap (3.2 eV) TiO_2 semiconductor is used with low band gap V_2O_5 to degrade from sun's natural visible radiation. Inspite of having good properties and applications, TiO_2 wishes to be improved via doping or coupling with other materials such as metals, non-metals and polymers [2]. Moreover, TiO_2 occurs in three forms namely anatase, rutile and brookite in which the anatase is the most essential and widely applicable phase. Further, TiO_2 offers successful results for environmental purification, solar cells and antibacterial activities. In this scenario, synthesis of V_2O_5/TiO_2 composite metal oxides have carried out by newly integrated sol-gel and thermal decomposition methods. Since the above methods does not involve with other superior equipment, the process is simpler and economically friendly. Meanwhile, V_2O_5 has high visible light absorption, chemical stability and non-toxicity. Also, V_2O_5 has its great nanostructure because of size and morphological properties. Hence, V_2O_5 and TiO_2 semiconductors were focused for this study since these have great applications favoring photocatalytic reactions [3, 4].

The main aim of the present study is as follows: The combined V_2O_5 and TiO_2 metal oxides will be synthesized by integrated sol-gel and thermal decomposition methods. The prepared catalysts will be characterized by various instrumental techniques such as X-ray diffraction (XRD), High resolution-Transmission electron microscopy (HR-TEM), X-ray photoelectron spectroscope (XPS), Energy dispersive x-ray spectrum (EDXS), Photoluminescence (PL) spectrum and UV-visible spectrum to confirm the structure, morphology, chemical composition, thermal stability, bandgap analysis and excitation energy. The synthesized V_2O_5-TiO_2 composite is applied for photocatalytic degradation of methylene blue (MB) dye.

The result shows that the composite system has deep-rooted the presence of binary structures namely orthorhombic V_2O_5 and anatase phase tetragonal structure of TiO_2 from the XRD analysis. Further, the internal surface morphology such as size, phase, and interfaces of the V_2O_5-TiO_2 composite system was

long-established by TEM observation. The elemental presence was detected by EDXS instrument. The nanocomposite exhibits the high surface area. The PL emission analysis confirms the excitation wavelength occur in the visible region. Moreover, the UV-vis spectra confirm the low band gap of the composite. The absorption wavelength of V_2O_5 assisted TiO_2 photocatalytic reactions was in the visible light range.

Here, the V_2O_5 supported TiO_2 nanocomposite probably hinders the charge recombination process on comparing with pure TiO_2 phase. Since V_2O_5 has small band gap of 2.3 eV, it can easily trap the electrons to reduce the charge recombination and finally shows effective degradation under irradiating visible light. Further, the composite photocatalytic suspension has been analyzed with UV-vis spectrum involving methylene blue (MB) dye degradation under visible light irradiation. Since V_2O_5 having lower band gap stimulates TiO_2 to weaken the band gap due to the presence of vanadium pentoxide and also the combined effect of TiO_2 and V_2O_5 system [4]. The outcome of this analysis tends to increase the photoactivity of the nanocomposite system under visible light. The result exhibits that V_2O_5 assisted TiO_2 material influences a promising way for degrading the organic dyes.

Keywords: Water pollution; photocatalysis; binary structures; absorption wavelength; dye degradation.

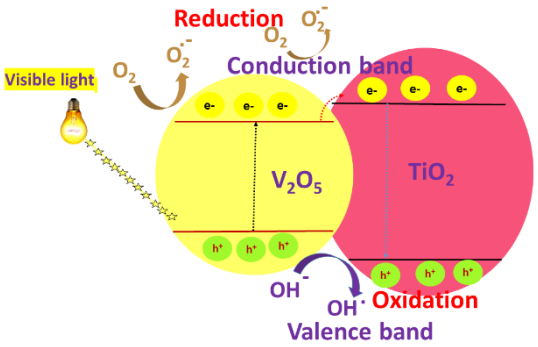

Fig. 1: Visible light photocatalytic mechanism of TiO_2 influenced with V_2O_5 for MB degradation

Acknowledgement

The authors acknowledge the support of ANID through the project ANID/FONDAP/15110019.

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ECT13-219

COBALT OXIDE INCORPORATED ON NICKEL OXIDE SURFACE FOR THE DEGRADATION OF METHYL ORANGE DYE UNDER VISIBLE LIGHT CONDITION

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Abstract

Water is the most vital resource among the natural resources, essential to human survival, food production, and economic development. Today, worldwide people suffer from acute shortages of water, and nearly 40 percent of the world's population lives in states without access to adequate water [1]. All of these factors are affected by water, its regional and seasonal availability, as well as its quality. Water quality is being affected by human activities, including urbanization, population growth, industrial production, climate change, and pollution [2]. This produces water pollution that threatens the well-being of the earth as well as its population.

Nickel oxide (NiO) semiconductor nanoparticle has a large bandgap of 3.5eV and itplays a vital role in catalysts, gas sensors, dye-sensitized solar cells, and batteries [3]. But, NiO drawback is effective under visible light illumination. For the above problem, challenging task were tried to rectify various approaches like doping, polymer, semiconductor, graphene and Mxene based composites [4] [5]. Recent days, the NiO coupled with various small bandgap materials(CuO, Fe_3O_4 and V_2O_5) expressed the favored catalytic degradation under visible light condition. On the other hand, Cobalt oxide semiconductor has direct band gap energy of 1.48-2.19 eV. This possesses extraordinary electronic, optical, mechanical and magnetic properties.Apart from this, the spinel $Co_3O_4$is used for several applications [6]. These nanoparticles were synthesized using any of the following methods; sol-gel, surfactant-mediated synthesis, polymer-matrix assisted synthesis, sprays pyrolysis and thermal decomposition.

For the above reason, in this study, the NiO semiconductor was mixed with Co_3O_4 for the photocatalytic degradationreaction of methyl orange under visible light condition[7]. In this study, NiO coupled with cobalt oxide nanoparticle was synthesized using a thermal decomposition method. The sample was characterized by X-ray diffraction method to find the structural property of the NiO/Co_3O_4 material. The obtained results were clearly expressed the hybrid structure and the nano sized particles were obtained without any other impurities. The Fourier transform infrared (FTIR) spectra confirm the dual structures with their accurate functional groups. Furthermore, the UV-Visible spectra result has established that the NiO/Co_3O_4materialhas extended its absorption towards higher wavelength, when compared with pure NiO which is in UV region. Hence, the characterization results confirmed that the nanocomposite NiO/Co_3O_4 has the capability to absorb the visible light and able to degrade the pollution under visible light.

Finally, the target of the current NiO/Co_3O_4 composite was effectively utilized for the degradation of methyl orange under visible light condition. The photocatalyst were prepared by 1 g of catalyst along

with 1 L of methyl orange (concentration 5 x 10^{-3} m/L) dye solution. The solar stimulator is used for the visible light source. Then, the mixed reaction solutions were irradiated with uniform interval of time. Finally the irradiated solution concentrationswere monitored by UV-Visible spectrophotometer. Hence, the obtained results analyzed that the prepared composite hasthe capability to destroy the methyl orange solution with 58% efficiency. Further, the developed novel catalyst NiO/Co_3O_4has explored the photocatalyst degradation for waste effluent from the textile industries.

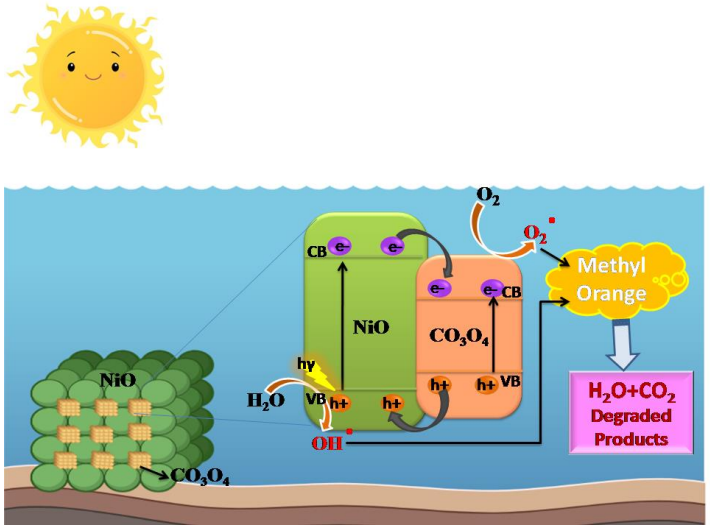

Fig .1: Photocatalyic schematic represent of NiO/Co_3O_4nanocomposite materials

Keywords: Thermal decomposition; Methyl Orange; degradation;Photocatalytic Performance.

Acknowledgement
The author (S.R) acknowledges the support of ANID through the project ANID/FONDAP/15110019.

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ECT14-223

SURFACE MODIFICATION OF COPPER OXIDE OVER COBALT OXIDE USEFUL FOR THE DEGRADATION OF METHYL ORANGE UNDER VISIBLE LIGHT CONDITION

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Abstract

All over the world, water is essential for life. Water quality and its contaminants issue are a major challenge we are facing in this twenty-first century. Domestic sewage, industrialization, population growth, pesticides and fertilizers, plastics and polythene bags, urbanization, weak management system are the major sources of water pollution. For water purification process, there is an urgent need for innovative and simple technologies to engineer materials [1]. Photocatalysis is a new and exciting technology that is bringing clean, green, and long-term innovation to environmental remediation. The use of semiconducting materials as photocatalysts is becoming increasingly relevant in terms of offering alternative energy sources and solving environmental pollution issues. To tackle this problem, numerous new kinds of semiconductors have been created as photocatalysts [2]. Copper oxide (CuO) is a transition metal oxide semiconductor material, which has a bandgap of 1.2 eV to 1.4 eV which makes it an appealing choice for light-harvesting applications [3,4]. It has monoclinic structure. CuO compounds are technologically well-known materials with applications in solar energy materials, electronic materials, gas sensors, magnetic media, optical devices, batteries, and catalysts, among others [5]. On the other hand, it has a few drawbacks as a photocatalyst. The key issues are its relatively low visible light absorption, limited accessibility to its reaction sites, and a high recombination rate of light-induced electron–hole pairs due to its small bandgap [6]. Recent days, cobalt oxide (Co_3O_4) is a viable p – type semiconductor material for numerous applications. It is cubic in structure. It may also be used in a variety of photocatalytic processes since it is non-toxic, eco-friendly, and cost-effective. Cobalt oxide is appealing due to its optical energy band of 2.00 eV, within the range of possible band gaps for optical absorption. In the recent years, the nanocomposite system helped to achieve good stability under visible light degradation. For this beneficial of both semiconductors in the current work, Cobalt oxide is incorporated with the copper oxide. In this research, CuO coupled with cobalt oxide nanocatalysts were synthesized using a thermal decomposition method. When compared to other techniques of preparation, this process is simple, quick, and cost-effective. The structural property of the CuO/Co_3O_4 material was determined using the X-ray diffraction technique. The hybrid structure was clearly expressed in the acquired data, and nanosized particles were produced without the presence of any extraneous contaminants. The dual structures and their functional groups can be validated using the Fourier transform infrared (FTIR) spectrum. Furthermore, optical absorption region was examined by UV Visible spectrum. As an outcome of the characterization results, the nanocomposite CuO/Co_3O_4 has the tendency to accumulate visible light and reduce pollution on exposing it.

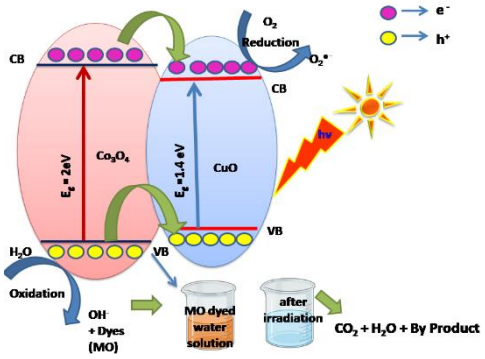

Fig.1: Photocatalytic mechanism of Co_3O_4/CuO nanocomposite

The CuO/Co_3O_4 combination successfully decomposed methyl orange under visible light. To make photocatalysts, 1 g of methyl orange dye solution was mixed with 1 L of catalyst. The light source used was an ultra - violet light source. The irradiation reaction solutions were exposed to light for a consistent amount of time. Finally, the concentrations of irradiation solution were measured using UV-Visible spectrophotometer. Based on the findings, the composite material is capable of destroying methyl orange solution with an 37 % efficiency. The created new catalyst has also been performed to evaluate the photocatalytic degradation of textile industry waste effluent upon utilising CuO/Co_3O_4.

Keywords: Thermal decomposition; Photocatalyst; Methyl orange; Dye degradation.

Acknowledgement:
The author (S.R) acknowledges the support of ANID through the project ANID/FONDAP/15110019.

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ECT15-225

ENHANCED ELECTROCHEMICAL PERFORMANCE OF ZEOLITE/POLYETHERSULFONE (PES) COMPOSITE SEPARATOR FOR LITHIUM-ION BATTERIES

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Extended Abstract

The battery separator is a critical component of batteries that strongly affects their performance. The control of their properties being particularly important for obtaining lithium-ion batteries with high performance. Separators are placed between both electrodes, should show high mechanical, thermal stability and ionic conductivity. Considering the relevance of battery separators in the performance of lithium-ion batteries, this work to obtain ZSM-5 (hierarchical)/PES composite membrane with phase inversion technique. Composite membranes were fabricated with concentration variation; 10%, 20%; 30% H-ZSM-5 as filler. The morphology of the HZSM-5/PES membrane resulted in an asymmetric membrane structure with finger-like pores. Addition of filler material to the membrane has been proven to increase wettability, thermal stability and ion conductivity. The optimal composite membrane results in the composition of 30% H-ZSM-5/PES with porosity and liquid uptake of 82.1%, 356.3% respectively, the meltdown temperature (MD) reaches 223 ℃ with relative expansion 3.38% at 90 ℃ and conductivity ion reached 4.74 x10^{-5} (S/cm).

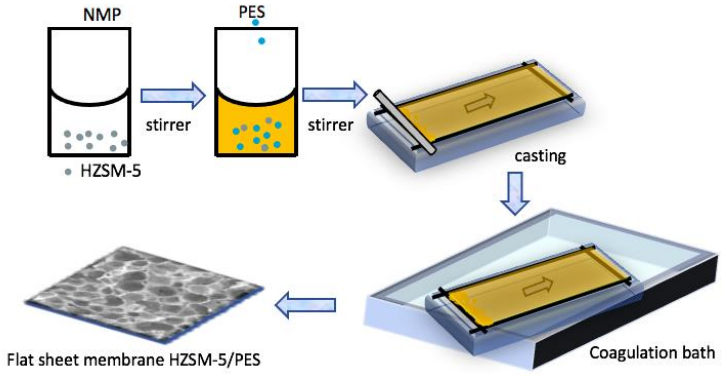

Fig. 1: Schematic of flat sheet HZSM-5/PES membrane preparation by phase inversion technique

Table 1. Physical properties of HZSM-5/PES composite membrane

Parameters	PES	10%HZSM-5/PES	20%HZSM-5/PES	30%HZSM-5/PES
Porosity (%)	49.82	66.87	77.78	82.10
Uptake (%)	260.81	358.82	342.03	356.25
Ion conductivity 10^{-5}(S/cm)	0.71	2.95	3.45	4.74

Keywords: Separator; lithium-ion battery; HZSM-5/PES; phase inversion.

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ECT16-231

CATALYTIC PERFORMANCE EVALUATION ON COMBUSTION OF MICROALGAE *Arthrospira platensis*-ACTIVATED CARBON MIXTURE AT MASS RATIO OF 10:1

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Extended Abstract

This paper presented the combustion characteristics of *Arthrospira platensis*-activated carbon (AP/AC) mixture at a mass ratio of 10:1 using the thermogravimetric analysis apparatus. The experiment was carried out at a heating rate of 10°C/min with an oxygen flow rate of 100 ml/min and a temperature range of 25-1000 °C. The results were compared to the parent material of AP. The results showed that thermal degradation of the sample has occurred in three stages, with the main degradation and combustion taking place in the second stage, which was divided into two-phase processes. At the stage of removing water and releasing light volatile (Stage I), the AP completed the process at 160 °C, whereas AP/AC shifted toward a higher temperature around 162 °C; therefore, AC inhibits the water evaporation and light volatile release at this stage. At Stage II, AC acts as the inhibitor to the carbohydrate and protein degradation and combustion, and conversely, it behaves as the accelerator for the decomposition and combustion of lipids. Finally, Stage III showed residual ash of AP/AC less than the individual sample of AP.

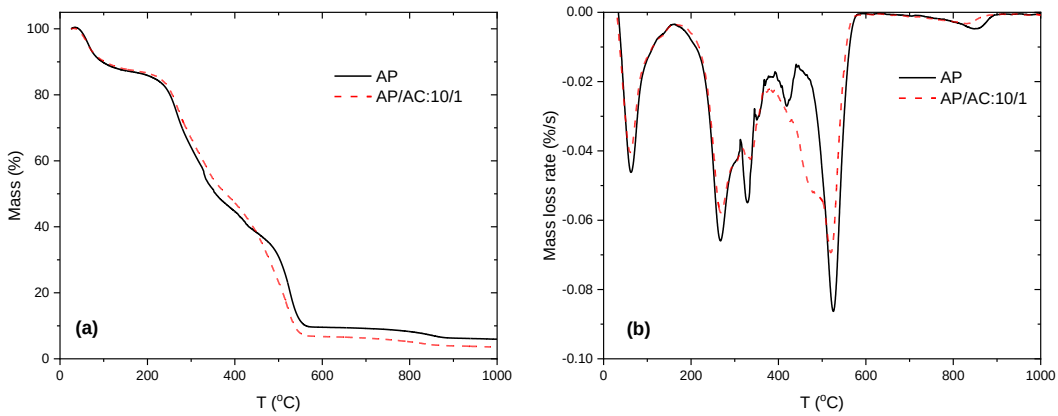

Fig. 1: TG (a) and DTG (b) graphs of the samples with and without activated carbon at 10 °C/min

Table 1. Thermal characteristics of the sample at the main combustion stage

Sampes	Phase	T_i (°C)	T_f (°C)	T_{max} (°C)	DTG_{max} (%/s)	Mass loss (%)
AP	I	160.00	440.67	267.50	-0.06062	47.92
	II	440.83	585.67	525.67	-0.07777	29.57
AP/AC:10/1	I	162.50	379.33	268.50	-0.05422	37.41
	II	379.50	579.83	519.83	-0.06322	43.27

Ti: the initial temperature at the phase studied, Tf: temperature of the final process at the phase studied, Tmax: temperature of maximum mass loss rate at the phase studied, DTGmax: maximum mass loss rate at the phase studied

Keywords: Combustion; *Arthrospira platensis*; activated carbon; catalytic performance; kinetics

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ECT17-242

SYNERGISTIC DEGRADATION OF RHODAMINE B AND REDUCTION OF Cr^{6+} OVER SILVER (II) OXIDE/FIBROUS SiO_2/ZrO_2 PHOTOCATALYST

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Extended Abstract

Rhodamine B dye is widely used in dyeing, printing, textile and many other industries. Its discharge in wastewater has produced great pollution to the aquatic environment [1]. Meanwhile, Cr^{6+} heavy metal ion is largely disposed by leather tanning, printing as well as textile industries is considered highly toxic and causing a serious threat to human health [2]. The existence of both pollutants in the same industries, generate a complex compound due to the possible interaction and make the removal process become more complicated. Therefore, the effective disposal and safe for the remediation of RhB and Cr^{6+} ions from contaminated wastewater has triggered greater concern nowadays. Lately, photocatalysis method has been established to be an effective and efficient technique to remediate those pollutants consisting in the water due to easy to operate, environmentally friendly and high decontamination rate [3]. Hence, it is indispensable and important to fabricate effective photocatalyst with high visible light harvesting and photo-induced electrons and holes separation to achieve high simultaneous photocatalytic degradation of RhB and Cr^{6+}.

Recently, silver (II) oxide (AgO) has drawn huge interest, due to its optical and photochemical properties as well as its narrow band gap [4]. Nevertheless, the activity of AgO in photocatalysis is not satisfactory owing to its low surface area, agglomeration and low efficiency of separation between electrons and holes. Thus, improving the efficiency still remains a challenge and a crucial for application in wastewater treatment. Unique morphology of FSi/Zr catalyst was successful synthesized and has received a great deal of attention [5]. Currently, developing heterostructures between semiconductors and FSi-based catalyst can induce the probability of photogenerated electrons-holes recombination for improvement of photocatalytic reaction rate. The presence of electronic interactions between the two component catalysts have potential for migration of charge carriers from one to another. Additionally, FSi/Zr plays role as the site for AgO to has better dispersion of active site and lead to the high photocatalytic performance.

In this work, the incorporation of AgO and FSi/Zr to produce AgO-FSi/Zr was reported. The characterization and photocatalytic activity of the composite catalyst was compared with bare AgO and FSi/Zr. Their photocatalytic performance was investigated toward the simultaneous photo-degradation of RhB and -reduction of Cr^{6+} under the visible light irradiation. For a betterunderstanding the control

experiments to explore the roles of each pollutant in the simultaneous photocatalytic process Were performed. The composite AgO-FSi/Zr catalyst was prepared by two step methods. The physicochemical properties of AgO-FSi/Zr was studied and compared with the bare AgO and FSi/Zr. The AgO-FSi/Zr catalyst exhibited an efficient catalytic activity which are 99% of RhB degradation and 87% of Cr^{6+} reduction due to the highly dispersion of AgO on FSi/Zr and possible perturbation of FSi/Zr framework after addition of AgO to form Si-O-Ag bonds. The addition of AgO improved the separation of photogenerated charge carrier in the AgO-FSi/Zr composite. Notably, AgO-FSi/Zr exhibited better performance in coexist pollutants rather than isolated pollutant, indicating the synergistic effect of both degradation and reduction activity of RhB and Cr^{6+}, respectively to scavenge the charge carriers.

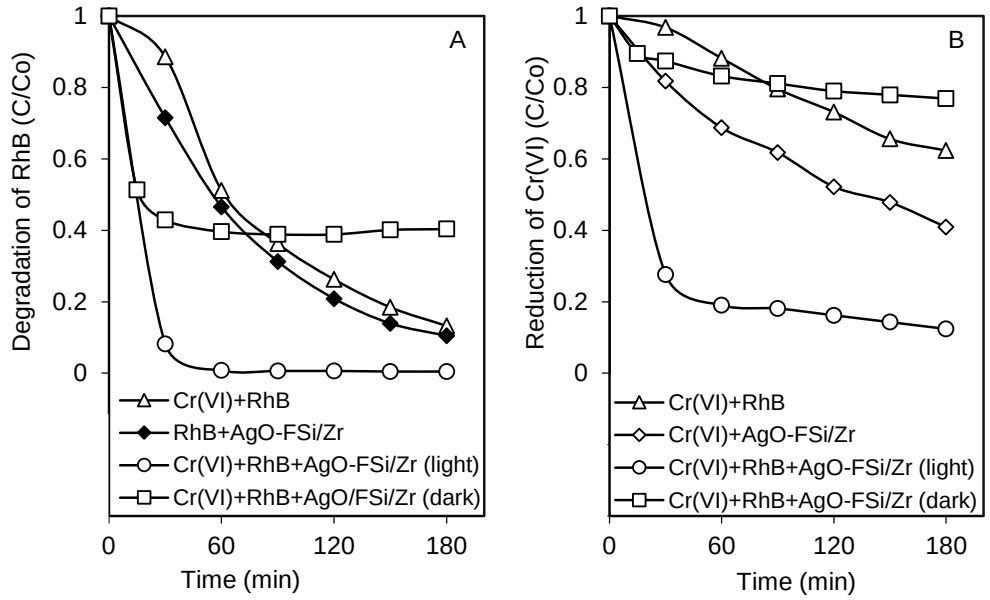

Fig. 1: Photocatalytic activity of AgO-FSi/Zr photocatalyst in various conditions [Initial concentration of RhB and Cr^{6+} = 10 mg L^{-1}, pH=1 and catalyst dosage= 0.4 g L^{-1}]

Keywords: AgO, Cr^{6+}, fibrous SiO_2/ZrO_2, rhodamine B, simultaneous photocatalytic

Acknowledgement

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ECT18-243

EFFECT OF DIFFERENT PRECURSORS OF GRAPHITIC CARBON NITRIDE TOWARDS PHOTOCATALYTIC CONVERSION OF CARBON DIOXIDE TO METHANOL

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Extended Abstract

Graphitic carbon nitride (g-C_3N_4) is a versatile polymeric, organic semiconducting material and have the band gap of 2.7 eV [1]. g-C_3N_4 material is consists of graphitic, two dimensional (2D), π-conjugated polymeric structures with tri-s-triazine repeating unit and hold weak Vander Waal forces between the layers [2]. g-C_3N_4 have promising properties such as excellent optical property, good stability, tunable electronic band structure and photocatalytic and mechanical property [3]. In addition to this, it is abundant, low cost and environmentally friendly material. Hence, it is widely used in photoelectrochemical water splitting, hydrogen generation, pollutant degradation, supercapacitors, solar cell, lithium-ion batteries and chemical sensors etc.

As a new semiconductor material with excellent properties in mechanics, optics and other fields, g-C_3N_4 had broad applications in many fields. The g-C_3N_4 was commonly prepared by the methods of thermal polymerization, solvent hot method, template-directed solid-state, soft-templating synthesis, sonochemical [4] and so on. However, g-C_3N_4 had disadvantages as photocatalyst due to its low surface area and (10 m^2 g^{-1}) and low photocatalytic efficiency. There were some strategies to improve its photocatalytic efficiency, such as doping with noble metals or prepared by co-catalysts [5]. Some technologies such as preparation of mesoporous g-C_3N_4 were utilized to enhance its surface area. The enhanced photocatalytic activity might be related to the favorable structure resulted from different heat-treatment temperatures, and also related to the content of g-C_3N_4, wide range optical absorption, separation and transportation of electronic-holes, as well as the morphology of composite. There have been numerous studies done to date on the synthesis of co-catalysts linked to g-C_3N_4, but few have compared the synthesis of these materials. Urea was the normal materials utilized to produce C_3N_4 and it was an organic nitrogen heterocyclic triazine compound. Similarly, melamine is a trimer of cyanamide, with a 1,3,5-triazine skeleton. Meanwhile, dicyandiamide was a dimer of cyanamide and also the derivatives containing cyano guanidine.

In this study, we chose the structurally distinct nitrogenous precursors urea, dicyandiamide, and melamine to create the graphite phase C_3N_4(g-C_3N_4) using fractional thermal polymerization. The objective was to thoroughly examine the various structures and characteristics of g-C_3N_4 made from various basic materials. The synthesized catalysts were characterized using X-ray Diffraction (XRD), Fourier Transform Infrared Spectrometer (FTIR) and UV-Vis Diffuse Reflectance Spectroscopy (UVVis/DRS).

The result showed that the use of different g-C_3N_4 precursors have profound effect on the physicochemical

properties of the g-C_3N_4 catalysts. M-gC_3N_4 displays the great photoactivity performance as it produced the highest concentration of methanol followed by U-gC_3N_4 and D-gC_3N_4 (Fig. 1). This is due to the melamine structure contained a greater number of nitrogen which improved the adsorption and chemisorption ability of CO_2, in which high electrostatic potential of N-doped carbons enhances the CO_2 adsorption energy, leading to selective and higher CO_2 adsorption to be converted into methanol.

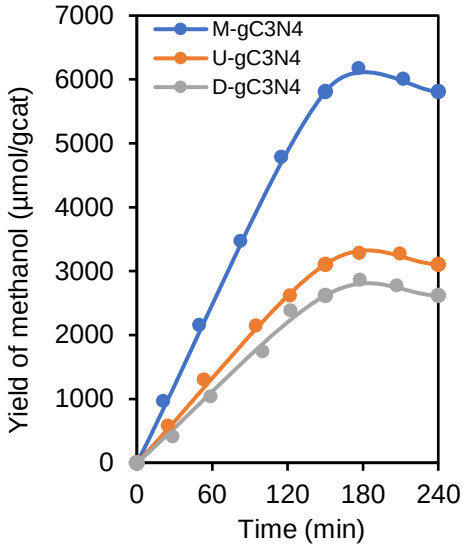

Fig. 1: Catalytic performance of the catalyst towards conversion of CO_2 to methanol

Keywords: Graphitic carbon nitride, precursors, photocatalytic conversion, carbon dioxide, methanol

Acknowledgement
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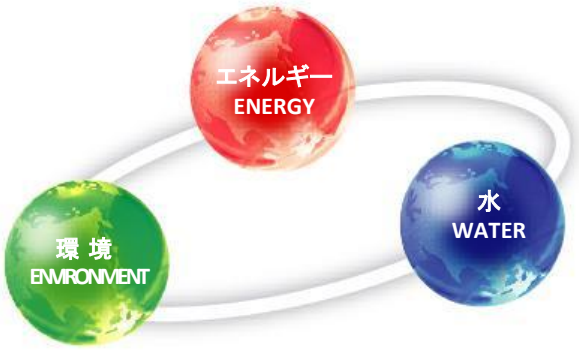

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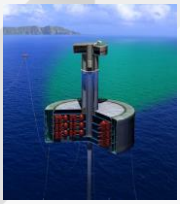

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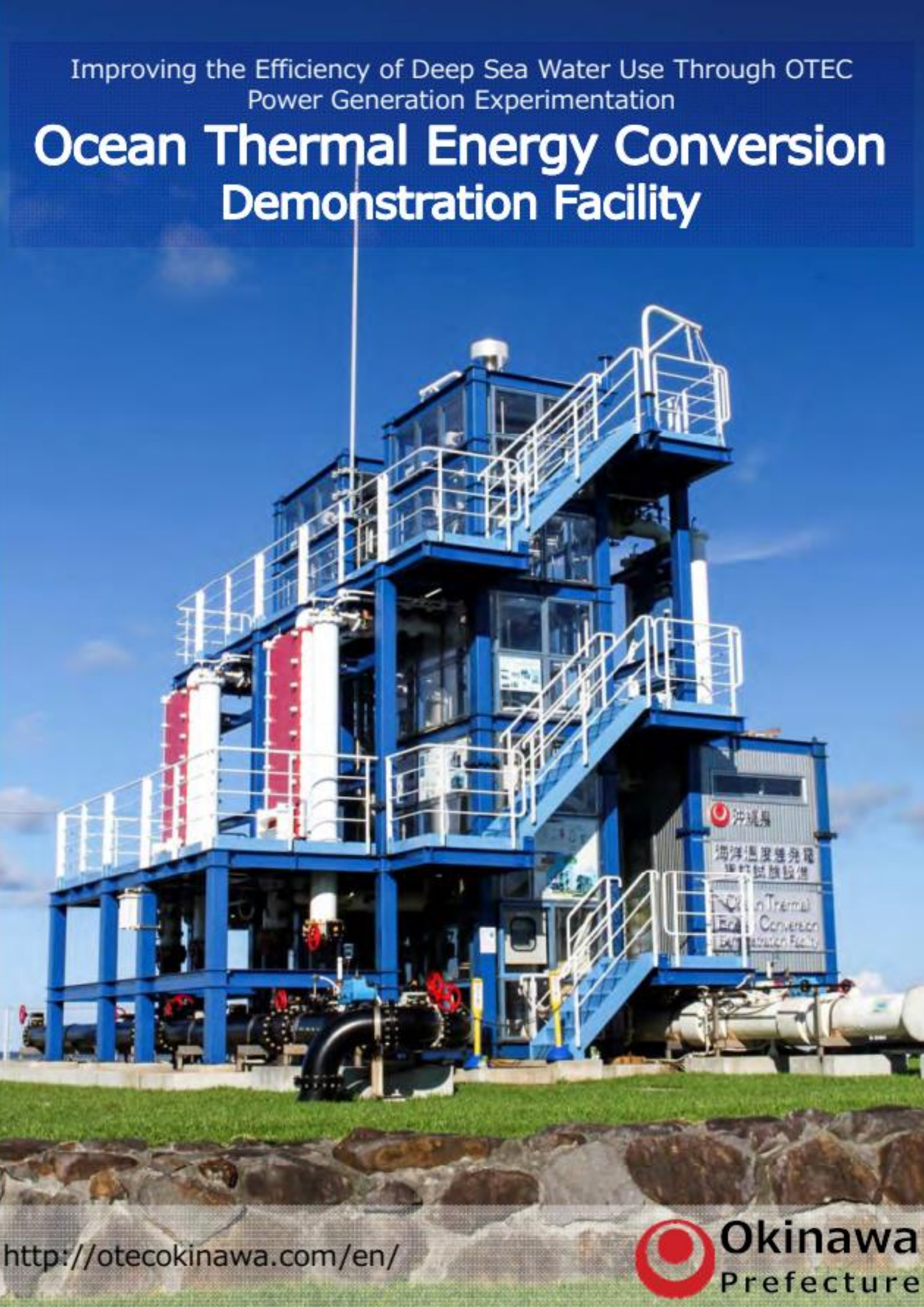

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*Data as of 30 June 2022

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1. MANAGEMENT	2. ORGANIZATION	3. PROCESS	4. INFORMATION	5. FINANCIAL	7. ACHIEVEMENT
4 CRITERIA	5 CRITERIA	5 CRITERIA	4 CRITERIA	2 CRITERIA	4 CRITERIA
ENERGY POLICY	APPOINTMENT OF AEMAS CEM	ANALYSIS OF ENERGY USE	DOCUMENT CONTROL	BUDGET MANAGEMENT	ENERGY EFFICIENCY MONITORING
EXECUTIVE MANAGEMENT REVIEW	EM STRUCTURE & RESPONSIBILITIES	PURCHASING & PROCUREMENT	ENERGY RECORDS	INVESTMENT	SEMS INTERNAL AUDIT
ENERGY TARGET & PLAN	STAFF COMPETENCY	OPERATION CONTROL	STAFF COMMUNICATION	**6. CORPORATE RESPOSIBILITY**	MANAGEMENT REVIEW
PLANNING & ALLOCATION OF RESOURCES	ORGANIZATION AWARENESS & ACCOUNTABILITY	MAINTENANCE	REPORT STRUCTURE	1 CRITERIA	ENERGY PERFORMANCE ACHIEVEMENT
	RECOGNITION OF EM	CORRECTIVE & PREVENTIVE ACTIONS		REGULATION COMPLIANCE	

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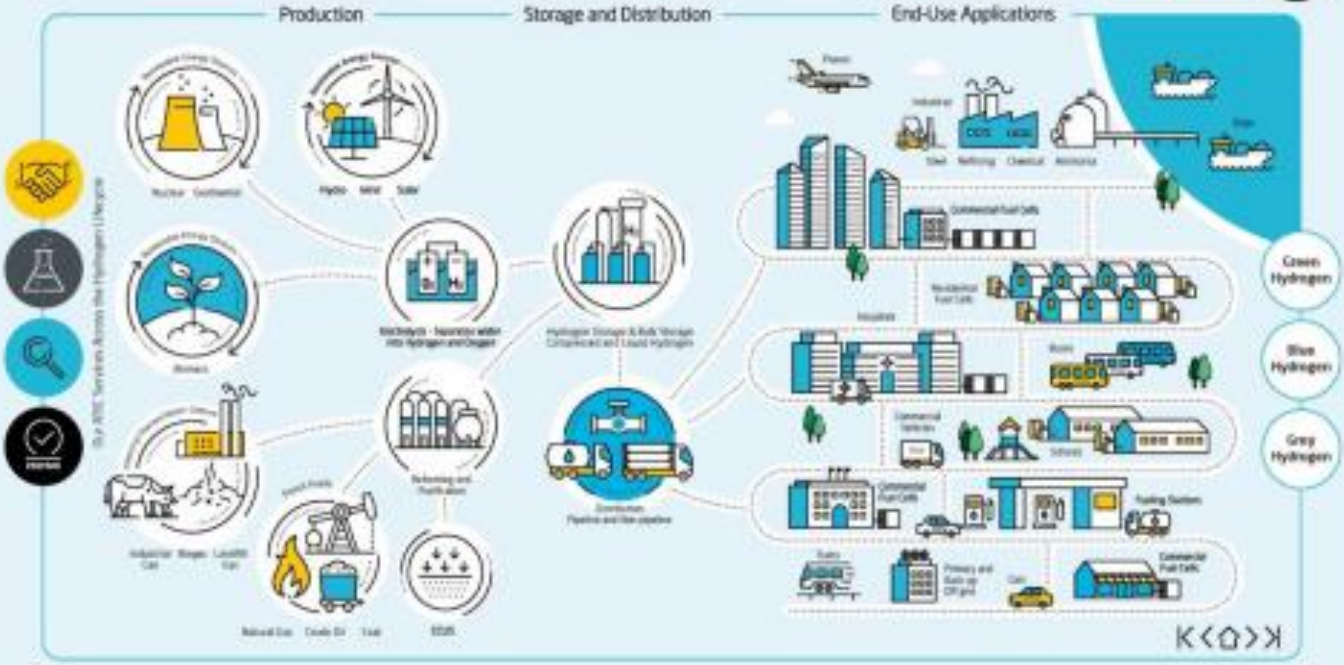

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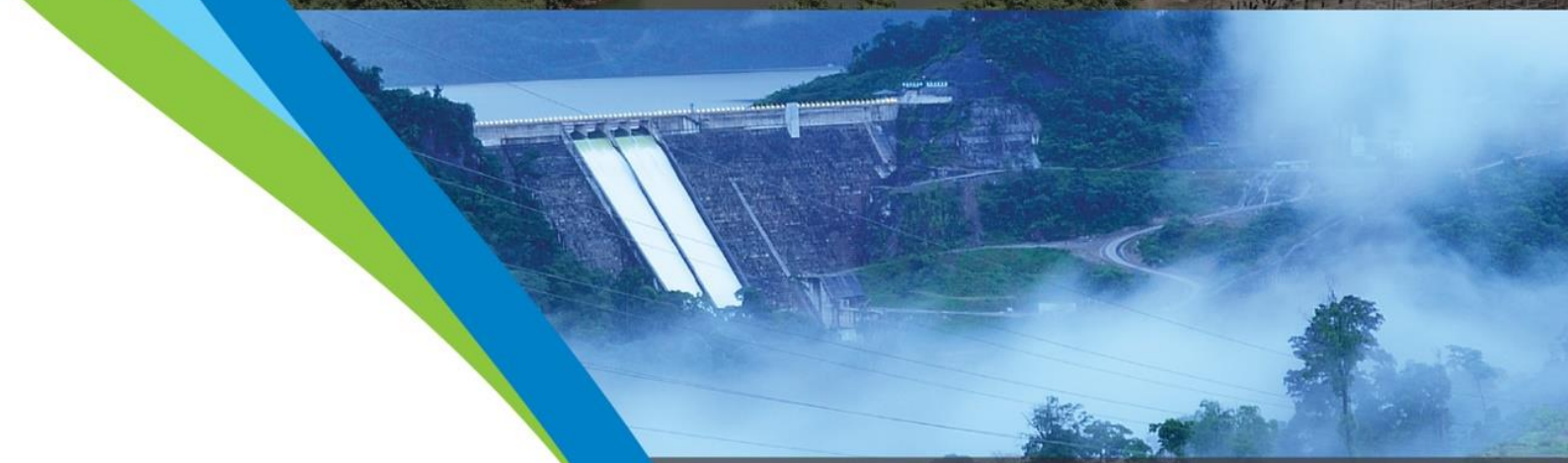

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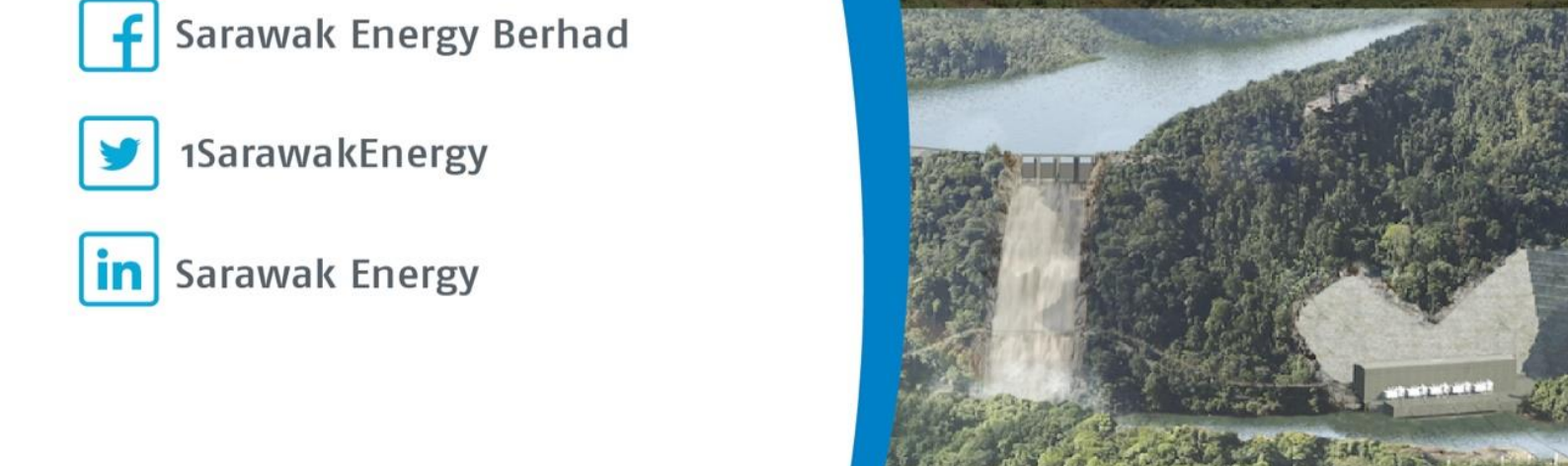

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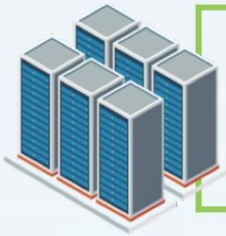

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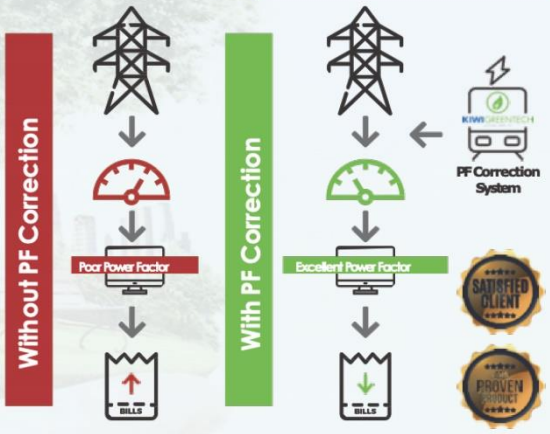

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