



UTM

UNIVERSITI TEKNOLOGI MALAYSIA



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1ST INTERNATIONAL
CONFERENCE (VIRTUAL) ON
SUSTAINABLE ENERGY AND
CATALYSIS (ICSEC 2021)

16-17th February 2021

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Chemical Reaction Engineering Group (CREG), School of Chemical & Energy Engineering, Faculty of Engineering, University Teknologi Malaysia (UTM), Malaysia

US-Pakistan Center for Advanced Studies in Energy (USPCAS-E), National University of Sciences & Technology, Pakistan



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16-17th FEBRUARY 2021

Chemical Reaction Engineering Group (CREG), School of Chemical
and Energy Engineering, Faculty of Engineering, Universiti Teknologi
Malaysia, Malaysia

&

US-Pakistan Center for Advanced Studies in Energy (USPCAS-E),
National University of Sciences & Technology, Pakistan

ICSEC 2021

1st International Conference (Virtual) on Sustainable Energy and Catalysis

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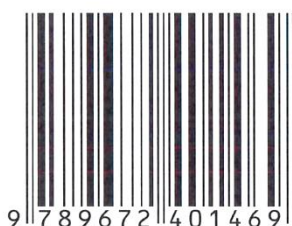
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Foreword

Advisor

Prof. Dr Mohd Ghazali Mohd Nawawi

Chair

School of Chemical and Energy Engineering

Faculty of Engineering

Universiti Teknologi Malaysia (UTM)

Assalamualaikum Warahmatullahi Wabarakatuh Salam Sejahtera

First and foremost, I would like to take this opportunity to congratulate the Chemical Reaction Engineering Group, School of Chemical and Energy Engineering, Faculty of Engineering, Universiti Teknologi Malaysia and School of Chemical and Materials Engineering & US-Pak Center for Advanced Studies in Energy, National University of Sciences & Technology, Pakistan for organizing 1st International Conference (Virtual) on Sustainable Energy & Catalyst (ICSEC 2021).

The ICSEC 2021 started as an idea by the Universiti Teknologi Malaysia, Malaysia and National University of Sciences & Technology, Pakistan to provide a platform to bring together researchers, scientists, and engineers from academia, research institutions and industry to exchange information, experiences and expertise in the field of chemical reaction engineering, catalysis and energy conversion & waste management, hence to foster research relations between the universities and the industries. The theme of ICSEC 2021 is 'Advancement in Sustainable Energy & Catalysis for Green Future'. In order to make this 1st International Conference a success, the ICSEC 2021 needs a lot of hard work and commitment from the organizing committees. Thus, I would like to take this opportunity to thank and congratulate the ICSEC 2021 organizing committee for their efforts in planning and executing the tasks to make this event a reality. I wish all the best for all the participants.

I would also like to take this opportunity to thank our distinguished plenary and keynote speakers, international committee members, organizing committees, participants, and guests to the 1st International Conference (Virtual) on Sustainable Energy & Catalyst (ICSEC 2021). I believe that this conference will benefit the participants.

Thank you and best wishes.



Prof. Dr Mohd Ghazali Mohd Nawawi

Universiti Teknologi Malaysia



Foreword

Chairman

Prof. Ir Dr Nor Aishah Saidina Amin

**International Conference (Virtual) on
Sustainable Energy & Catalysis (ICSEC 2021)**

Assalamualaikum Warahmatullahi Wabarakatuh and Good Day

The 1st International Conference (Virtual) of Sustainable Energy and Catalysis 2021 was held on February 16-17th, 2021. This is a joint conference between UTM and NUST in which the Chemical Reaction Engineering Group and School of Chemical & Energy Engineering, UTM together with the US-Pakistan Center for Advanced Studies in Energy, NUST took parts due to an established MoU.

The idea of having the 1st International Conference of Sustainable Energy and Catalysis 2021 was initially mooted in the fourth quarter of 2020 to enhance the collaboration between UTM and NUST. During the pandemic era of COVID-19 knowledge and networking should abide to the new norm and we decided to conduct the conference virtually using platforms such as StreamYard and YouTube channel. The organization of the conference was not without problems but we are so thankful that the challenges were overcome due to the dedication, cooperation and diligence among the committee members.

The Chemical Reaction Engineering Group is a single discipline research group at the School of Engineering, Faculty of Engineering, Universiti Teknologi Malaysia. It has 7 members with expertise in the areas of catalysis, photocatalysis, biofuels and reaction engineering. As the head of CREG, I am proud to announce that our research group is one of the most productive groups in securing research grants, publications and awards. All our members are principal investigator. For this conference, two other research groups the Advanced Materials and Separation Technologies (AMSET) and Solid Waste and Management Group (SWAM) also contributed to organize it.

The theme of the conference is Advancement in Sustainable Energy and Catalysis for Green Future, which aptly fits in the aspiration of both universities and the current global situation. ICSEC 2021 is aimed to provide a platform to bring together researchers, scientists, and engineers from academia, research institutions and industry to exchange information, experiences and expertise in the field of chemical reaction engineering, catalysis and energy conversion & waste management, hence, to foster research relations between the universities and the industry. The concern about fossil fuels and its effects on climate change has brought researchers from various

backgrounds working on solving the issue. Renewable energy is an alternative energy source for a sustainable future. Green technology has paved new and innovative ways of using catalysis to produce chemicals and fuels. Chemistry, chemical reaction & reactor engineering, physics and other science and technology fields are often integrated to provide solutions to the pressing problems concerning our planet.

The scientific plenary and keynote lectures by international and national speakers and oral presentations support the United Nation Sustainable Development Goals (UN SDGs) to impart incisive impact to our participants. All peer-reviewed accepted papers will be published in the conference proceeding while top quality papers will be selected to be published in *Bulletin of Chemical Reaction Engineering & Catalysis* (Scopus indexed & WOS master journal list).

I would like to take this opportunity to thank the organizing committee for working very hard to make the conference become a reality. I would also like to thank all the plenary and keynote speakers for their insightful talks. Even faced with the pandemic, ICSEC 2021 has managed to attract about 30 presenters and 232 registrations in total for both presenters/participants from 18 countries (Malaysia, Pakistan, Indonesia, Mexico, India, Thailand, Vietnam, Iraq, Saudi Arabia, Nigeria, Brazil, Egypt, Russia, United Arab Emirates, Spain, Norway, United States and South Korea) despite the challenging times by utilizing the online technology and social media to the fullest.



Professor Ir Dr Nor Aishah Saidina Amin

Chairman

International Conference (Virtual) on Sustainable Energy & Catalysis (ICSEC 2021)

Universiti Teknologi Malaysia

Plenary Speaker 1



Mark Crocker

Professor of Chemistry & Associate Director, University of Kentucky Center for Applied Energy Research

PROFILE

Mark Crocker received BSc. and Ph.D. degrees in chemistry from the University of Bristol in the United Kingdom and spent two years as a NATO Research Fellow at the University of Wisconsin-Madison. Thereafter he spent 15 years working in industry, first for Shell Research in Amsterdam and then for Degussa's automotive catalyst division in Michigan, USA. In 2003 he moved to the University of Kentucky (UK) where he is currently a Professor in the Department of Chemistry and an Associate Director of the Center for Applied Energy Research. At UK he leads a research group focusing on CO₂ recycling using microalgae, biofuels and environmental catalysis.

ABSTRACT

BENEFICIAL RE-USE OF INDUSTRIAL CO₂ EMISSIONS USING MICROALGAE

Carbon dioxide utilization through algal biomass production has undergone extensive research, mainly focusing on the replacement of traditional petroleum fuels. However, achieving economic viability for algae-based fuels has proven difficult due to their low value and comparatively high production costs. Consequently, the algae industry has experienced a shift in focus away from fuels towards more valuable products, examples including nutraceuticals, specialty chemicals and human food additives. Unfortunately, these higher value products tend to have very limited markets, which have the potential to saturate when scaling algae production facilities to large scales. In principle, bioplastics derived from algal biomass offer a pathway to solve these problems. Algae-based bioplastics represent a drop-in replacement for many everyday products ranging from flexible foams to synthetic fibers, food packaging films and even 3-D printing filament. As proteins are the most desirable component of the algal biomass in bioplastic production, fuel production techniques based on lipid extraction can potentially be employed to improve the bioplastic quality (and thus value) while producing a useful fuel co-product. This seminar will summarize our work aimed at algae cultivation using flue gas from a coal-fired power plant as the CO₂ source. The results of techno-economic and life cycle analyses will also be presented, conducted to assess the economic viability and environmental impact of an algae biorefinery that integrates the complementary functions of bioplastic feedstock and fuel production.

Plenary Speaker 2



Sibudjing Kawi

Professor, Department of Chemical and Biomolecular Engineering, National University of Singapore

PROFILE

Prof. Kawi joined the Department of Chemical and Biomolecular Engineering, National University of Singapore in 1994. He has published > 300 journal papers (citations > 15,000, h index = 67), 4 patents, 1 book, 4 book chapters, edited > 10 special issues (as a Guest Editor of J. CO₂ Utilization, ChemCatChem, Catalysis Today, Ind. & Eng. Chem. Research, Reaction Chemistry & Engineering, Environ. Sci. & Pollution Research, Topics in Catalysis, Catalysts, Reactions, Processes, Membranes). He serves on the Editorial Board of ChemCatChem, Reactions, Waste & Biomass Valorization, Associate Editor of Frontiers in Energy Research (Carbon Capture, Storage and Utilization) and Associate Editor of Frontiers in Chemical Engineering (Catalytic Engineering).

ABSTRACT

INNOVATING SUSTAINABLE CATALYST AND MEMBRANE SYSTEMS FOR TACKLING CO₂ AND H₂ CHALLENGES

Anthropogenic carbon dioxide production is widely accepted as a major reason for accelerated climate change and global warming. In recent years, there has been wide amount of global interest in finding sustainable ways to reverse the increasing CO₂ levels in the atmosphere. Globally, treaties such as the Kyoto Protocol and the Paris Agreement identify reduction in carbon emissions as vital in preventing the potentially disastrous effects of further global warming. Carbon Capture and Utilization (CCU) is one of the key areas that can achieve CO₂ emission targets while at the same time contributing to the production of energy, fuels and chemicals to support the increasing demands. In CCU, carbon dioxide is captured and separated from emission gases and then converted into valuable products. This presentation shall cover our current catalyst and membrane technologies for tackling CO₂ and H₂ challenges, with the focus on 3 main technologies; 1) direct CO₂ conversion processes, 2) simultaneous CO₂ capture/separation and utilization and 3) CO₂-neutral H₂ production processes. Specifically, this presentation shall cover the strategies that our research group has been developing to design and prepare stable catalysts and membrane systems for various CO₂ conversion processes such as CO₂ reforming of methane, CO₂ hydrogenation, r-WGS, and CO₂-neutral H₂ production reactions such as steam reforming of biomass tar, propane dehydrogenation, water gas shift and CH₄ decomposition.

Plenary Speaker 3



Haiping Yang

Professor, State Key Laboratory of Coal Combustion,
Huazhong University of Science and Technology

PROFILE

Haiping Yang is a professor at Huazhong University of Science and Technology. Prof Yang's research is focused on Biomass pyrolysis/gasification for H₂ enriched gas fuel, liquid bio oil and carbon contained materials and chemicals, and she is also working on the fundamental mechanism exploration of biomass thermochemical conversion process. So far, she has published over 100 SCI papers, 6 of which were cited in ESI, while the highest SCI citation for 1 paper is over 3000. Her many achievements and involvements include Newton Advanced Fellowships (2018) and the Most Cited Chinese Researchers (Elsevier, 2014-2019) and the National Science Fund for Excellent Young Scholars program in 2016 (China). She is the associate editor of Fuel Processing Technology, and board member of Fuel, Journal of Analytical and Applied Pyrolysis, also guest editor of Fuel, Bioresources Technology, and Energy Fuels, etc.

ABSTRACT

DEVELOPMENT OF BIOMASS PYROLYSIS POLYGENERATION AND THE HIGH VALUE UTILIZATION

As the only carbon contained renewable energy resources, the utilization of biomass is the key for the problem between energy and environment. Pyrolysis can convert biomass to gas fuel, liquid oil and solid char efficiently, it can convert biomass to high quality fuel, and is one of the main route for biomass utilization. Technology of polygeneration based on biomass pyrolysis was put forward with target product controlling theory, and the operation experiment on the pilot and commercial size had also finished. The volume content of combustible composition in bio-gas would be above 70 vol %, especially, the volume content of CH₄ would be above 22 vol %, while the LHV of gas would up to 15 MJ/Nm³. It is a good quality gaseous fuel for user. At the same time, a higher performance on the adsorption and combustion was obtained for the solid char product while the liquid oil was enriched more light weight composition such as phenols and acetic acid. The technology economic and environmental analysis shown that this technology has a good economy and environment performance compared with other biomass conversion technology. A further upgrading of the pyrolytic products for H₂ rich gas fuel, liquid chemicals and solid carbon contained materials were carried out. For example, after nitrogen doping, the char product was converted to a good electrode material with the specific capacitance ~300 F/g. It will be expected as a better biomass conversion technology to enhance the utilization level of abundant biomass resources in China.

Plenary Speaker 4



Kevin M. Van Geem

Professor, Faculty of Engineering and Architecture at Ghent University (UGent)

PROFILE

Kevin Van Geem is a professor in the Faculty of Engineering and Architecture at Ghent University (UGent). He is the director of the Center of Sustainable Chemistry and the director of the board of the Laboratory for Chemical Technology of Ghent University. His main research interest is thermochemical reaction engineering in general, with a particular focus in the transition from fossil fuel to alternative resources such as biomass fuel, CO/CO₂ and plastic waste. He is a former Fulbright Research Scholar of MIT, and a visiting professor at Stanford. He is in charge of pilot plants for steam cracking, chemical recycling, biomass pyrolysis and super dry reforming. He is the author of more than two hundred scientific publications, owner of 3 patents and he is the managing director of his own spin-off company on modeling steam cracking. He is involved in electrification, process intensification, machine learning & data mining, product formulation, drug discovery, scale-up and process modelling.

ABSTRACT

SOLVING THE PLASTIC WASTE PROBLEM BY CHEMICAL RECYCLING

The complexities of recycling of plastic waste are many. First of all, the complexity of the feedstock and the fact that many reactions are occurring simultaneously makes it very challenging for chemical engineers. Also, on the reactor level no consensus exist on what is the optimal design for each feed type, not even on what is the best "chemical recycling" option because of the varying economics and different government incentives Worldwide. If we could predict how the product distribution and conversion depends on the feedstock composition, reaction conditions and assess process operation issues, we could rationally design and optimize the system on the computer. The first step is to identify all the important species and reactions; this can be done using automatically or by hand with different levels of complexity. Unfortunately, we seldom have enough experimental data to determine the rate parameters for all the important reactions. Moreover, the data that is typically available does not allow to determine intrinsic kinetics, not even to close to mass balances. With novel experimental and computational techniques we currently try to improve our understanding of chemical recycling, but still a huge step for mankind is needed to come to truly fundamental understanding of chemical recycling. Information from 4 bench scale units and 3 pilot units is used to take chemical recycling to a new level at Ghent University.

Keynote Speaker 1



Tetsuya Shishido

Professor, Tokyo Metropolitan University

PROFILE

Tetsuya Shishido received his PhD at Hokkaido University in 1997 for fundamental research on acid-base catalysis. He began his career as an Assistant Professor at the Department of Applied Chemistry, Hiroshima University in 1997, carrying out research on supported metal catalysts for energy innovation, for example from methane to hydrogen, and then moved to the Department of Molecular Engineering, Kyoto University in 2005. In 2013, he was promoted to full Professor at Tokyo Metropolitan University. His research focuses on heterogeneous catalysis, catalysis by metallic nanoparticles or metal oxides on supports, and by solid acid-base. He also works on in situ spectroscopic methods to elucidate the reaction mechanism on heterogeneous catalysts at the molecular level.

ABSTRACT

SUPPORTED GOLD-PALLADIUM ALLOY CATALYSTS FOR HIGHLY EFFICIENT HYDROGEN STORAGE SYSTEM

Hydrogen (H_2) is an attractive candidate as a chemical energy carrier for a sustainable energy technology, because the only byproduct of its reaction with oxygen is water, and efficient energy conversion can be realized by combining with fuel cell technology. However, the advancement of sustainable H_2 economy is hindered by the lack of the successful integration of H_2 generation from renewable materials and its storage/transportation. A considerable amount of challenge is currently devoted to exploring new storage methods, including the use of metal hydrides, carbon nanostructures, and metal-organic frameworks. Ammonia borane ($NH_3-BH_3:AB$) has attracted attention as a promising hydrogen carriers due to its high hydrogen content (19.6 %) and H_2 release at ambient conditions. In this study, the correlation between the catalytic activity toward methanolysis of AB and the state of supported PdAu alloy was investigated in detail. We proposed that methanolysis of AB included i) cleavage of B-H bond in AB, ii) cleavage of B-N bond, iii) coordination of oxygen atom in methanol to unoccupied orbitals of boron atom and H_2 formation, and iv) recombination of B-N bond. Kinetic analysis indicates that electron-deficient Pd atom surrounded by Au atoms in random PdAu alloy NPs promotes cleavage of methanol to form proton (step iii), in other word, stabilize conjugate base of methanol, resulting in acceleration of H_2 formation. Based on structural characterization and kinetic analysis of methanolysis of amine boranes, we conclude that electron-deficient Pd atom surrounded by Au atoms in random PdAu alloy NPs work as active sites.

Keynote Speaker 2



Lee Keat Teong

Professor, Director (Research Creativity & Management Office), Universiti Sains Malaysia

PROFILE

Lee Keat Teong obtained his PhD in Chemical Engineering from Universiti Sains Malaysia (USM) in 2004. He is currently holding the position of Professor at the School of Chemical Engineering and he is also the Director of Research Creativity & Management Office, Universiti Sains Malaysia. Prof. Lee has co-authored 2 books, 10 book chapters, 35 review papers and more than 110 research papers in peer reviewed international journals. Dr. Lee is currently the Co-Editor for Energy Conversion and Management (Elsevier) and Editorial Board Member for Bioresource Technology (Elsevier) and Energy Science & Engineering (Wiley).

ABSTRACT

THE ROLE OF RENEWABLE ENERGY IN GLOBAL TRANSFORMATION FOR A SUSTAINABLE ENERGY FUTURE

Renewable energy has a very crucial role in meeting the sustainability of energy demands in the future. It was reported that renewable energy, primarily biomass, solar PV and wind can meet at least two-thirds of the global energy demand. Although the cost of renewables have considerably been on the decline due to intensive research and development activities, but it is still relatively expensive for many developing and less developed countries. In this regard, enabling policy and regulatory framework has a very crucial role and especially support from developed countries can further mobilize and accelerate the utilization of renewable energy. Nevertheless, the recent decision by European Union to gradually ban the use of biofuels derived from palm oil may be seen by many as a step backward in the development of renewable energy. Although having access to affordable and sustainable energy is one of The Sustainable Development Goals (SDGs), one has to remember that another equally important goal is to end extreme global poverty. The palm oil industries primarily in Malaysia and Indonesia has lifted millions of people out from the poverty bracket and this fact should not be ignored for future decisions on the fate of oil palm utilization as feedstock for biofuels. On the other hand, a truly sustainable energy future can only be achieved with a shift in societal mind-set and life-style change to go hand-in-hand with technological and economical advancement in renewable energy development.

Keynote Speaker 3



Haslenda Hashim

Professor, Resource Sustainability Research Alliance, Universiti Teknologi Malaysia

PROFILE

Haslenda Hashim is the Chair/Dean of Resource Sustainability Research Alliance Universiti Teknologi Malaysia. She specializes in supply demand energy modeling and optimization and climate-resilient energy systems. She is the recipient of 1Belt-1Road Young Scientist from Shanghai Municipality (2019), 2018/2019 Asean S&T Fellow specialise in Energy theme, Korean Women Inventors Special Award 2013, Young Scientist Network - Akademi Sains Malaysia, 2013 and Renewable Energy Research Program Award from the National Science Council of Taiwan, 2009, 2014. She has also published more than 100 technical papers in national and high-impact international journals. She holds 10 patent filings and more than 20 copyrights. She is the Associate Editor for Energy Report (Elsevier) and guest editor for Journal of Cleaner Production (Elsevier) and Clean Technology and Environmental Policy for Low Carbon Asia special issue.

ABSTRACT

HAS SUSTAINABLE BIOENERGY SYSTEMS BEEN EFFECTIVE TO MEET NATIONAL EMISSION REDUCTION TARGET?

Malaysia has committed to reducing her emissions by 45 percent however efforts are happening independently of each other. If COVID-19 has taught us anything, it is that with synergy, better outcomes can be reached. In order to reach the 45% target, multisectoral optimisation is the way to go. We can tap into the abundance of biomass resources we have; such as palm oil biomass and agricultural waste; to generate power, fuel for transportation and other sectors within the economy. Moreover, techno-economic models that can capture the dependencies of bioenergy supply chain variables among end-use sectors still need to be explored. This work examined a spatio-temporal techno-economic approach for cross-sectoral policy evaluations under high spatial and long-term temporal resolution. The spatio-temporal model demonstrates the urgency for synergetic strategies between cross-sectoral policies to satisfy CO₂ reduction at the national-level without resource conflicting. The finding indicate that the substantial synergies between sectoral can be realised by substitution up to 30%, 27%, and 12% of power, heat, and transport energy demand with bioenergy which lead to 58 Mt/year of CO₂ emission as compared to CO₂ reduction target, 49 Mt/year. Although less in CO₂ reduction, the policy prioritizing CO₂ reduction can provide up to 37% of cost savings while delivering less ambitious renewable electricity mix in the near term. The model highlighted the bioenergy and decarbonisation policy in tandem could realise Malaysia's palm oil industry inspiration to contribute towards national emission reduction target.

PROGRAMME AND PRESENTATION SESSION SCHEDULES



1st ICSEC 2021
1st International Conference (Virtual) on Sustainable Energy and Catalysis 2021
"Advancement in Sustainable Energy & Catalysis for Green Future"

Organized by:





U.S.-Pakistan Center for Advanced Studies in Energy

CONFERENCE PROGRAM
DAY 1: TUESDAY, FEBRUARY 16TH, 2021

TIME (GMT +8) EVENT	PROGRAM SCHEDULE		
8:00 - 9:00 AM Registration	Registration of Conference Participants & Presenters		
9:00 - 9:30 AM Opening ceremony	Registration of Guest and VVIPs Welcoming speech by VVIP of the 1st ICSEC 2021:		
	Chairman : Prof. Ir. Dr. Nor Aishah Saidina Amin (UTM, Malaysia) School of Chemical and Energy Engineering (SCEE) and Chemical Reaction Engineering Group (CREG), Universiti Teknologi Malaysia		
	Advisor : Assoc. Prof. Dr. Adeel Waqas (USPCAS-E, NUST, Pakistan) Principal, US-Pakistan Centres for Advanced Studies in Energy (USPCAS-E), National University of Sciences and Technology (NUST)		
	Officiant : Profesor Dato' Ir. Dr. Mohammed Rafiq Bin Abdul Kadir (UTM, Malaysia) Dean, Faculty of Engineering (FE), Universiti Teknologi Malaysia		
	Conference Launching ceremony of 1st ICSEC 2021 (Multimedia Presentation)		
Topic 1: Catalysis for Future Energy Sustainability			
9:30 - 10:30 AM Plenary session by Plenary Speaker 1	"Beneficial Re-use of Industrial CO ₂ Emissions using Microalgae"		Professor Mark Crocker Centre for Applied Energy Research, Department of Chemistry, University of Kentucky.
10:30 - 1:00 PM Oral presentation	Day 1 - First Session		
1:00 - 2:00 PM Break			
2:00 - 3:00 PM Plenary session by Plenary Speaker 2	"Innovating Sustainable Catalysts and Membranes for Tackling CO ₂ and H ₂ Challenge"		Professor Sibudjing Kawi Department of Chemical and Biomolecular Engineering, National University of Singapore.
3:00 - 4:00 PM Keynote session by Keynote Speaker 1	"Supported Gold-Palladium Alloy Catalysts for Highly Efficient Hydrogen Storage System"		Professor Tetsuya Shishido Department of Applied Chemistry for Environment, Tokyo Metropolitan University. (Associate Editor, Catalysis Science & Technology)
4:00 - 5:15 PM Oral presentation	Day 1 - Second Session		
5:30 PM Closing Day 1			

ORGANISED BY: UNIVERSITI TEKNOLOGI MALAYSIA (UTM) AND NATIONAL UNIVERSITY OF SCIENCE & TECHNOLOGY (NUST), PAKISTAN
SCHOOL OF CHEMICAL AND ENERGY ENGINEERING (SCEE) AND CHEMICAL REACTION ENGINEERING GROUP (CREG), UTM, MALAYSIA
AND U.S.-PAKISTAN CENTER FOR ADVANCED STUDIES IN ENERGY (USPCAS-E), NUST, PAKISTAN

CONFERENCE PROGRAM
DAY 2: WEDNESDAY, FEBRUARY 17TH, 2021

TIME (GMT +8) EVENT	PROGRAM SCHEDULE		
8:00 - 9:00 AM Registration	Registration of Conference Participants & Presenters		
9:00 - 11:00 AM Oral presentation	Day 2 - First Session		
11:00 - 12:00 PM Plenary session by Plenary Speaker 3	"Development of Biomass Pyrolysis Polygeneration and the High Value Utilization"		Professor Haiping Yang Huazhong University of Science & Technology, Wuhan, China. (Associate Editor, Fuel Processing Technology)
12:00 - 1:00 PM Keynote session by Keynote Speaker 2	"The Role of Renewable Energy in Global Transformation for a Sustainable Energy Future"		Professor Lee Keat Teong School of Chemical Engineering, Universiti Sains Malaysia. (Editor, Energy Conversion and Management)
1:00 - 2:00 PM Break			
2:00 - 3:00 PM Plenary session by Plenary Speaker 4	"Solving the Plastic Waste Problem by Chemical Recycling"		Professor Kevin M. Van Geem Laboratory for Chemical Technology, Faculty of Engineering, Ghent University, Belgium. (Associate Principal Editor, Fuel)
3:00 - 4:00 PM Keynote session by Keynote Speaker 3	"Has Sustainable Bioenergy Systems Been Effective to Meet National Emission Reduction?"		Professor Haslenda Hashim School of Chemical and Energy Engineering, Universiti Teknologi Malaysia (Associate Editor, Energy Reports).
4:00 - 5:00 PM Oral presentation	Day 2 - Second Session		
5:00 - 5:15 PM Industrial sharing session	"Biomass and Plasma Technologies for a Sustainable Future"		Ir. Dr. Lim Mook Tzeng Principal Researcher, Biomass and Plasma Technology, Renewable Energy and Green Technology, Tenaga Nasional Berhad (TNB) Research Sdn. Bhd.
5:15 - 5:30 PM Closing ceremony			

ORGANISED BY: UNIVERSITI TEKNOLOGI MALAYSIA (UTM) AND NATIONAL UNIVERSITY OF SCIENCE & TECHNOLOGY (NUST), PAKISTAN
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ORAL PRESENTATION SESSION	SCOPE	NO	PRESENTER ID	NAME	TITLE
DAY 1: Catalysis for Future Energy Sustainability					
DAY 1, 16th February 2021 FIRST SESSION 10:30 AM - 1:00 PM, GMT +8	Fundamentals of Catalysts and Applied Catalysis	1	ICSEC102	Mohammad Ismail	A Study of the Hydrogen Sorption Properties and Catalytic Mechanism of the CoTiO ₃ -Doped MgH ₂ System for Solid-State Hydrogen Storage Material
		2	ICSEC207	Wong Yee Jie	Dissociative Adsorption of CO ₂ on Stepped Co Surfaces: A DFT Study
		3	ICSEC205	Van Dung Nguyen Linh Thi Kim Nguyen (Presenter)	Facile Synthesis of Magnetic Porous Carbon from Nipa Frond for Catalytic Degradation of Tartrazine
		4	ICSEC208	Dr Asif Khoja	Partial Oxidation of Methane using Ash Derived Co/Zelite Catalyst for Hydrogen-rich Syngas Production
		5	ICSEC219	Prof. Dr. Andanastuti Muchtar	Synthesis of Ce _{0.85} -xLa _{0.15} Ca _{0.2} Supported Catalyst for Partial Oxidation of Methane
		6	ICSEC103	Anisah Sajidah Saud	Study of Solvent Effect on Dispersion of LTF/Al ₂ O ₃ Catalyst for Facile Synthesis of o-carbonyl-α-d-mannopyranose
		7	ICSEC227	Sohaib Khan Asad A. Zaidi (Presenter)	Comparison of Nanoparticles Synergistic Effect with Substrate Pretreatment on Biogas Production from Algae Waste
		8	ICSEC107	Sharifah Najihah Timmiati	Production of Hydrogen and Multiwalled Carbon Nanotubes by Methane Decomposition over Mesoporous Silica Nanoparticle-supported Nickel
		9	ICSEC113	Kamsi Nur Oktavia	Potential Cellulose as a Source of Bioethanol using Solid Catalysts: A Mini Review
	Photocatalysis and Nano-Materials Based Catalysts for Clean Energy Production	10	ICSEC108	Kanticha Jaiyen	Development of Cation Exchange Sulfonated Nanocrystalline Cellulose/SPEEK Composites Membrane
		11	ICSEC221	Poppy Puspitasari	Determination of the Magnetic Properties of Sm ₂ Co ₁₇ as a Soft Magnetic Material at Low-Temperature Sintering Process
		12	ICSEC111	Boon Junn Ng	Interstitial Phosphorus-Doped Zinc Blende/Wurtzite Twinned Photocatalyst with Homojunctions And S Vacancies for Pure Water Splitting under Ambient Condition
	Catalytic Application for Clean Fuel Production	13	ICSEC110	Shakhawan	Synthesis of Pure Phase Bismuth Ferrite
DAY 1, 16th February 2021 SECOND SESSION 4:00 PM - 5:15 PM	Catalytic Application for Clean Fuel Production	14	ICSEC214	Hamad Almohamadi	Catalytic Pyrolysis of Municipal Solid Waste: Effects of Reaction Temperature and MgO Catalyst
		15	ICSEC112	Mohd Asmadi Mohammed Yussuf	Ethanolysis of Cellulose to Ethyl Levulinate using Ionic Liquid, 1-Sulfonic acid-3-Methyl Imidazolium Tetrachlorozincate
	Advanced Catalysis Approach for Biofuel Production	16	ICSEC201	Dr Zaki Yamani Zakaria Dr. Nur Nazlina (Presenter)	Development of Microwave-Assisted Sulfonated Glucose Catalyst for Biodiesel Production from Palm Fatty Acid Distillate (PFAD)
		17	ICSEC101	Nattawadee Munbupphachart	Effect of SrO Loading of CaO/Al ₂ O ₃ Extruded on Biodiesel Production
		18	ICSEC209	Mustafa Jawad	Role of Microalgae as a Source for Biofuel Production in the Future: A Review

ORAL PRESENTATION SESSION	SCOPE	NO	PRESENTER ID	NAME	TITLE
DAY 2: Bioenergy for Green Future					
DAY 2, 17th February 2021 FIRST SESSION 9:00 AM - 11:00 PM, GMT +8	Fundamentals & Applied Chemical Reaction Engineering	1	ICSEC205	Van Dung Nguyen	Soft-Template Synthesis and Activation of Mesoporous Carbon Nitride for CO ₂ Adsorption
		2	ICSEC212	Amirul Hafiz Ruhaimi	Synthesis of Mesoporous Magnesium Oxide by Lime Peel Biotemplating for Carbon Dioxide Capture
		3	ICSEC228	Zaharah Wahid	Study on Photochromic Behaviour of Organic Dyes in Solution Form using Multilevel Factorial Design
	Energy Engineering	4	ICSEC104	Nurul Hayati Idris	Synthesis and Electrochemical Performances of Mn ₂ O ₃ as an Anode For Na-Ion Batteries
		5	ICSEC220	Tariq Abbas	Electrocatalytic CO ₂ Conversion and Water Splitting using Modified Titanium Dioxide
		6	ICSEC226	Avita Ayu Permanasari	Diesel Engine Performance and Exhaust Gas Emission using Waste Cooking Oil B20 Biodiesel Fuel with Lemon Essential Oil Bioadditive
		7	ICSEC106	Ruzinah Isha	Effect of Municipal Waste Composition in Municipal Waste Pyrolysis to Fuel
	Modeling&Simulation for Biofuel Production	8	ICSEC218	Abrar Inayat	Development of Reaction Kinetics Model for the Production of Synthesis Gas from Dry Methane Reforming
DAY 2, 17th February 2021 SECOND SESSION 4:00 PM - 5:00 PM, GMT +8	Energy Conversion and Waste Management	9	ICSEC204	Muhamad Iqbal Hakim Mohd Tahir	Impact of Separation at Source Program on the Sustainability of Feedstock Supply for Waste to Energy Plant in Kuala Lumpur
		10	ICSEC210	Imran Ahmad	Potential of Microalgae in the Treatment of Wastewater
		11	ICSEC211	Prof Ir Dr Nor Aishah Saidina Amin	Ozonolysis Pretreatment of Empty Fruit Bunch for Enhanced Total Reducing Sugar Yield
		12	ICSEC213	Dr Zaki Yamani Zakaria	A Perspective on Catalytic Conversion of Glycerol to Value Added Chemicals

FULL PAPERS

BENEFICIAL RE-USE OF INDUSTRIAL CO₂ EMISSIONS USING MICROALGAE

Mark Crocker^{1*}

¹ *Department of Chemistry and Center for Applied Energy Research, University of Kentucky, United State of America*

ABSTRACT

Carbon dioxide utilization through algal biomass production has undergone extensive research, mainly focusing on the replacement of traditional petroleum fuels. However, achieving economic viability for algae-based fuels has proven difficult due to their low value and comparatively high production costs. Consequently, the algae industry has experienced a shift in focus away from fuels towards more valuable products, examples including nutraceuticals, specialty chemicals and human food additives. Unfortunately, these higher value products tend to have very limited markets, which have the potential to saturate when scaling algae production facilities to large scales. In principle, bioplastics derived from algal biomass offer a pathway to solve these problems. Algae-based bioplastics represent a drop-in replacement for many everyday products ranging from flexible foams to synthetic fibers, food packaging films and even 3-D printing filament. As proteins are the most desirable component of the algal biomass in bioplastic production, fuel production techniques based on lipid extraction can potentially be employed to improve the bioplastic quality (and thus value) while producing a useful fuel co-product. This seminar will summarize our work aimed at algae cultivation using flue gas from a coal-fired power plant as the CO₂ source. The results of techno-economic and life cycle analyses will also be presented, conducted to assess the economic viability and environmental impact of an algae biorefinery that integrates the complementary functions of bioplastic feedstock and fuel production.

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INNOVATING SUSTAINABLE CATALYSTS AND MEMBRANE FOR TACKLING CO₂ AND H₂ CHALLENGES

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ABSTRACT

Anthropogenic carbon dioxide production is widely accepted as a major reason for accelerated climate change and global warming. In recent years, there has been wide amount of global interest in finding sustainable ways to reverse the increasing CO₂ levels in the atmosphere. Globally, treaties such as the Kyoto Protocol and the Paris Agreement identify reduction in carbon emissions as vital in preventing the potentially disastrous effects of further global warming. Carbon Capture and Utilization (CCU) is one of the key areas that can achieve CO₂ emission targets while at the same time contributing to the production of energy, fuels and chemicals to support the increasing demands. In CCU, carbon dioxide is captured and separated from emission gases and then converted into valuable products. CO₂ maybe used as a soft oxidant, reforming agent and raw material for conversion into syn-gas and hydrocarbon for energy applications. Many of the technologies to convert CO₂ into value-added products are still immature and the focus of active research. Over the past 10 years our group has been focusing on developing catalysts technologies to tackle the challenges associated with CO₂ and H₂ economy. In addition, in order to intensify the process for aforementioned reactions, our research group has also been developing novel catalytic membrane reactor systems to tackle challenges related to CO₂ and H₂ economy. By simultaneous removal of product from the reaction stream or uniform distribution of one of the reactants across the catalytic membrane reactor ensures higher activity, stability and product selectivity. A catalytic membrane reactor not only can combine reaction and separation in one unit but also can synergistically enhance the membrane permeability and catalyst activity, selectivity and stability, resulting in process intensification. Therefore, the application of catalytic membrane reactors shows great promise for industrial processes to produce value-added chemicals due to their ability not only to increase the yield of selective products beyond thermodynamic limitation and but also to increase energy efficiency.

This presentation shall cover our current catalyst and membrane technologies for tackling CO₂ and H₂ challenges, with the focus on 3 main technologies; 1) direct CO₂ conversion processes, 2) simultaneous CO₂ capture/separation and utilization and 3) CO₂-neutral H₂ production processes. Specifically, this presentation shall cover the strategies that our research group has been developing to design and prepare stable catalysts and membrane systems for various CO₂ conversion processes such as CO₂ reforming of methane, CO₂ hydrogenation, r-WGS, and CO₂-neutral H₂ production reactions such as steam reforming of biomass tar, propane dehydrogenation, water gas shift and CH₄ decomposition.

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DEVELOPMENT OF BIOMASS PYROLYSIS POLYGENERATION AND THE HIGH VALUE UTILIZATION

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¹ State Key Laboratory of Coal Combustion Huazhong University of Science and Technology, Wuhan Hubei, 430074

ABSTRACT

As the only carbon contained renewable energy resources, the utilization of biomass is the key for the problem between energy and environment. Pyrolysis can convert biomass to gas fuel, liquid oil and solid char efficiently, it can convert biomass to high quality fuel, and is one of the main route for biomass utilization. Technology of polygeneration based on biomass pyrolysis was put forward with target product controlling theory, and the operation experiment on the pilot and commercial size had also finished. The volume content of combustible composition in bio-gas would be above 70 vol %, especially, the volume content of CH₄ would be above 22 vol %, while the LHV of gas would up to 15 MJ/Nm³. It is a good quality gaseous fuel for user. At the same time, a higher performance on the adsorption and combustion was obtained for the solid char product while the liquid oil was enriched more light weight composition such as phenols and acetic acid. The technology economic and environmental analysis shown that this technology has a good economy and environment performance compared with other biomass conversion technology. A further upgrading of the pyrolytic products for H₂ rich gas fuel, liquid chemicals and solid carbon contained materials were carried out. For example, after nitrogen doping, the char product was converted to a good electrode material with the specific capacitance ~300 F/g. It will be expected as a better biomass conversion technology to enhance the utilization level of abundant biomass resources in China.

Keywords : biomass, pyrolysis, polygeneration, H₂ enriched gas, oxygen contained chemicals, Carbon contained materials

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SOLVING THE PLASTIC WASTE PROBLEM BY CHEMICAL RECYCLING

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ABSTRACT

Carbon dioxide utilization through algal biomass production has undergone extensive research, mainly focusing on the replacement of traditional petroleum fuels. However, achieving economic viability for algae-based fuels has proven difficult due to their low value and comparatively high production costs. Consequently, the algae industry has experienced a shift in focus away from fuels towards more valuable products, examples including nutraceuticals, specialty chemicals and human food additives. Unfortunately, these higher value products tend to have very limited markets, which have the potential to saturate when scaling algae production facilities to large scales. In principle, bioplastics derived from algal biomass offer a pathway to solve these problems. Algae-based bioplastics represent a drop-in replacement for many everyday products ranging from flexible foams to synthetic fibers, food packaging films and even 3-D printing filament. As proteins are the most desirable component of the algal biomass in bioplastic production, fuel production techniques based on lipid extraction can potentially be employed to improve the bioplastic quality (and thus value) while producing a useful fuel co-product. This seminar will summarize our work aimed at algae cultivation using flue gas from a coal-fired power plant as the CO₂ source. The results of techno-economic and life cycle analyses will also be presented, conducted to assess the economic viability and environmental impact of an algae biorefinery that integrates the complementary functions of bioplastic feedstock and fuel production.

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SUPPORTED GOLD-PALLADIUM ALLOY CATALYSTS FOR HIGHLY EFFICIENT HYDROGEN STORAGE SYSTEM

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ABSTRACT

Hydrogen (H₂) is considered to be an attractive candidate as a chemical energy carrier for a sustainable energy technology, because the only byproduct of its reaction with oxygen is water, and efficient energy conversion can be realized by combining with fuel cell technology. However, the advancement of sustainable H₂ economy is hindered by the lack of the successful integration of H₂ generation from renewable materials and its storage/transportation. A considerable amount of challenge is currently devoted to exploring new storage methods, including the use of metal hydrides, carbon nanostructures, and metal-organic frameworks. Ammonia borane (NH₃-BH₃:AB) has attracted attention as a promising hydrogen carriers due to its high hydrogen content (19.6 %) and H₂ release at ambient conditions. In this study, the correlation between the catalytic activity toward methanolysis of AB and the state of supported PdAu alloy was investigated in detail. PdAu/AC showed higher H₂ production rate than Pd/AC, whereas Au/AC exhibited no activity. The TOF value normalized amount of adsorbed CO was increased with decreasing Pd/Au ratio and 10Au1Pd/AC showed the highest TOF. Structural characterization elucidated the formation of random PdAu alloy NPs. As for the catalyst with a low Pd/Au ratio (cf. 10Au1Pd/AC), electron-deficient and isolated single Pd atom surrounded by Au atoms were formed. We proposed that methanolysis of AB included i) cleavage of B-H bond in AB, ii) cleavage of B-N bond, iii) coordination of oxygen atom in methanol to unoccupied orbitals of boron atom and H₂ formation, and iv) recombination of B-N bond. Kinetic analysis indicates that electron-deficient Pd atom surrounded by Au atoms in random PdAu alloy NPs promotes cleavage of methanol to form proton (step iii), in other word, stabilize conjugate base of methanol, resulting in acceleration of H₂ formation. Based on structural characterization and kinetic analysis of methanolysis of amine boranes, we conclude that electron-deficient Pd atom surrounded by Au atoms in random PdAu alloy NPs work as active sites.

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THE ROLE OF RENEWABLE ENERGY IN GLOBAL TRANSFORMATION FOR A SUSTAINABLE ENERGY FUTURE

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ABSTRACT

Renewable energy has a very crucial role in meeting the sustainability of energy demands in the future. It was reported that renewable energy, primarily biomass, solar PV and wind can meet at least two-thirds of the global energy demand. Although the cost of renewables have considerably been on the decline due to intensive research and development activities, but it is still relatively expensive for many developing and less developed countries. In this regard, enabling policy and regulatory framework has a very crucial role and especially support from developed countries can further mobilize and accelerate the utilization of renewable energy. Nevertheless, the recent decision by European Union to gradually ban the use of biofuels derived from palm oil may be seen by many as a step backward in the development of renewable energy. Although having access to affordable and sustainable energy is one of The Sustainable Development Goals (SDGs), one has to remember that another equally important goal is to end extreme global poverty. The palm oil industries primarily in Malaysia and Indonesia has lifted millions of people out from the poverty bracket and this fact should not be ignored for future decisions on the fate of oil palm utilization as feedstock for biofuels. On the other hand, a truly sustainable energy future can only be achieved with a shift in societal mind-set and life-style change to go hand-in-hand with technological and economical advancement in renewable energy development.

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HAS SUSTAINABLE BIOENERGY SYSTEMS BEEN EFFECTIVE TO MEET NATIONAL EMISSION REDUCTION TARGET?

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ABSTRACT

Malaysia has committed to reducing her emissions by 45 percent however efforts are happening independently of each other. If COVID-19 has taught us anything, it is that with synergy, better outcomes can be reached. In order to reach the 45% target, multisectoral optimisation is the way to go. We can tap into the abundance of biomass resources we have; such as palm oil biomass and agricultural waste; to generate power, fuel for transportation and other sectors within the economy. Moreover, techno-economic models that can capture the dependencies of bioenergy supply chain variables among end-use sectors still need to be explored. The new policies prioritizing bioenergy in the power and transport sectors also becomes an effective means of attaining desired emission reduction. This work examined a spatio-temporal techno-economic approach for cross-sectoral policy evaluations under high spatial and long-term temporal resolution. The spatio-temporal model demonstrates the urgency for synergetic strategies between cross-sectoral policies to satisfy CO₂ reduction at the national-level without resource conflicting. The finding indicate that the substantial synergies between sectoral can be realised by substitution up to 30%, 27%, and 12% of power, heat, and transport energy demand with bioenergy which lead to 58 Mt/year of CO₂ emission as compared to CO₂ reduction target, 49 Mt/year. Although less in CO₂ reduction, the policy prioritizing CO₂ reduction can provide up to 37% of cost savings while delivering less ambitious renewable electricity mix in the near term. The model highlighted the bioenergy and decarbonisation policy in tandem could realise Malaysia's palm oil industry inspiration to contribute towards national emission reduction target.

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EFFECT OF SrO LOADING OF EXTRUDED CaO/Al₂O₃ ON BIODIESEL PRODUCTION

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ABSTRACT

This work aims at enhancing catalytic performance and biodiesel yield by loading SrO on extruded CaO/Al₂O₃. The 20 wt.% SrO was added on extruded CaO/Al₂O₃ by the incipient impregnation method using aging times of 12 and 24 h. For transesterification of palm oil at 65°C using a methanol to oil molar ratio of 12:1 with a catalyst loading of 10 wt.%, the order of biodiesel yield at 6 h was 79, 76 and 63% using 20%SrO_24h-CaO/Al₂O₃, 20%SrO_12h-CaO/Al₂O₃ and CaO/Al₂O₃ catalyst, respectively. The SrO dopant on the CaO/Al₂O₃ extruded catalyst played a key role in increasing the catalytic activity because of the increase in basicity as compared to the bare CaO/Al₂O₃ extruded catalyst.

Keywords: FAME yield, Transesterification, Heterogeneous catalyst, SrO loading, Aging time.

INTRODUCTION

Biodiesel is one of the biofuels which is nontoxic for the engine, biodegradable and environmentally friendly. The CaO catalyst in powder form has been widely used to catalyze transesterification. However, using a small and fine particle-sized catalyst in a continuous process would suffer from large pressure drop. An extruded catalyst could be a practical choice, but its catalytic activity can decrease due to its lower surface area per unit volume. Various factors affected the design of catalysts. Basicity of the biodiesel catalyst is one factor affecting the catalyst activity in transesterification. In general, a catalyst with high basicity can produce a higher biodiesel yield. Strontium oxide (SrO) showed high catalytic activity for transesterification as compared to CaO and MgO catalysts (Palitsakun, Koonkuer, Topool, Seubsai, & Sudsakorn, 2021). Therefore, this work aims to enhance catalytic activity of the CaO/Al₂O₃ extruded catalyst using the impregnation of SrO on the extruded catalyst for transesterification.

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MATERIALS AND METHODS

Transesterification was employed for biodiesel production at a methanol to oil molar ratio of 12:1, temperature of 65°C and reaction time 6 h using 10 wt.% catalyst. Fig. 1 shows the

biodiesel yield with SrO loading on the CaO/Al₂O₃ extruded catalysts with various aging times and the bare CaO/Al₂O₃ extruded catalyst. The induction period was obtained for both SrO loading on CaO/Al₂O₃ extruded catalysts because of the mass transfer limitation. However, biodiesel yields obtained from both SrO loading on CaO/Al₂O₃ catalysts were higher than that of the bare CaO/Al₂O₃ catalyst when the reaction time was increased to 6 h. The order of biodiesel yield at 6 h was 79, 76 and 63 % using 20%SrO_24h-CaO/Al₂O₃, 20%SrO_12h-CaO/Al₂O₃ and CaO/Al₂O₃ catalysts, respectively.

RESULT AND DISCUSSION

Transesterification was employed for biodiesel production at a methanol to oil molar ratio of 12:1, temperature of 65°C and reaction time 6 h using 10 wt.% catalyst. Fig. 1 shows the biodiesel yield with SrO loading on the CaO/Al₂O₃ extruded catalysts with various aging times and the bare CaO/Al₂O₃ extruded catalyst. The induction period was obtained for both SrO loading on CaO/Al₂O₃ extruded catalysts because of the mass transfer limitation. However, biodiesel yields obtained from both SrO loading on CaO/Al₂O₃ catalysts were higher than that of the bare CaO/Al₂O₃ catalyst when the reaction time was increased to 6 h. The order of biodiesel yield at 6 h was 79, 76 and 63 % using 20%SrO_24h-CaO/Al₂O₃, 20%SrO_12h-CaO/Al₂O₃ and CaO/Al₂O₃ catalysts, respectively.

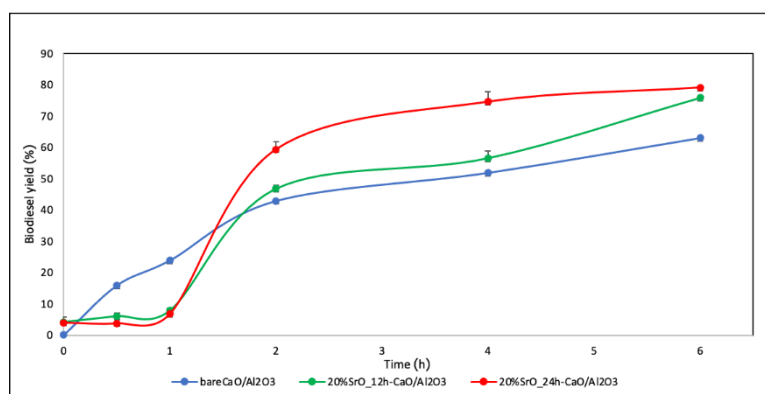


Fig. 1: Biodiesel production when using 20%SrO_12h-CaO/Al₂O₃ and 20%SrO_24h-CaO/Al₂O₃ extruded catalysts and bare CaO/Al₂O₃ extruded catalyst

CONCLUSIONS

The SrO-CaO/Al₂O₃ extruded catalyst prepared by the incipient impregnation method can improve the catalytic activity to produce biodiesel via transesterification. Biodiesel yield of 79 % was obtained using the 20%SrO_24h-CaO/Al₂O₃ extruded catalyst at 65°C using the methanol to oil molar ratio of 12:1 and the reaction time 6 h. The SrO dopant on CaO/Al₂O₃ extruded catalysts played a key role in increasing the catalytic activity because of the increase in basicity as compared to the bare CaO/Al₂O₃ extruded catalysts.

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STUDY OF SOLVENT EFFECT ON DISPERSION OF $\text{LT}/\text{Al}_2\text{O}_3$ CATALYST FOR FACILE SYNTHESIS OF CYCLIC CARBONATE FROM RENEWABLE SUGAR

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ABSTRACT

The previous approached to transform sugar into sugar carbonate was based on phosgene technique and pyridine as a base solvent which is seriously hazardous also overexposures will associate to illnesses. In short, the use of D-mannose and urea as feedstock are an advantage for waste into wealth besides being an environmentally friendly process to nature. Apart from that, the role of Aluminium oxide (Al_2O_3) supported Lanthanum triflate $\text{La}(\text{Otf})_3$ also were studied to enhance the catalytic process of 2,3-O-Carbonyl- α -D-mannopyranose synthesis.

Keywords: Sugar, cyclic carbonate, impregnation solvent, lanthanum triflate, Al_2O_3 .

INTRODUCTION

Organic carbonates receive significant amount of attention from academicians and industries due to the fact that it serves as an important chemical intermediate for the industrial production and as useful monomers for organic glasses, polymers, plasticizers, surfactants, curing agents, cross-linking agents, and also solvents (Clements, 2003; Kudlik, Benkhof, Blochowicz, Tschirwitz, & Rössler, 1999). Sugar carbonate is one of the organic carbonate compounds; however, in the realm of the preparation, carbohydrate chemistry has practical difficulties which severely limit the usefulness of the compound. The application of phosgene technique to sugar carbonate preparations has been restricted by the poor yields obtained (frequently lower than 5%), and the obvious practical hazards involved. Meanwhile, of the two more convenient methods of synthesis using chloroformic esters, the reaction in organic base is less versatile since fully substituted O-alkyloxycarbonyl- and O-aryloxycarbonyl- derivatives are usually obtained (Hough, Priddle, & Theobald, 1961), whereas the reaction in aqueous alkali can give both cyclic and open-chain carbonates (Allpress & Haworth, 1924). In this research, D-mannose and urea are introduced

as feedstock for synthesis of 2,3-O-Carbonyl- α -D-mannopyranose as an efficient one-step method. Hence, for the first time focuses on the role of Aluminium oxide (Al_2O_3) supported Lanthanum triflate $\text{La}(\text{Otf})_3$ catalyst influenced the yield of 2,3-O-Carbonyl- α -D-mannopyranose. Different catalyst design approach are taken in order to obtain the optimised active-sites, with the aims to achieve the target objectives. The catalysts were prepared by wet-impregnation method. Different solvent such as water, ethanol (et), ethylene glycol (eg), and glycerol (gly) are used as impregnation solvents.

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MATERIALS AND METHODS

At first, $\text{La}(\text{OTf})_3$ denoted as LT was dissolved in different alcohol solvent. The solution was then allowed to react with the Al_2O_3 to give $\text{LT}/\text{Al}_2\text{O}_3$. Solvent is not only improved the dispersibility but also provided suitable sites ($\text{Al}-\text{OH}$) for surface functionalization of $\text{LT}/\text{Al}_2\text{O}_3$. The catalytic reaction was performed in a three-neck round bottom flask by adding D-mannose, urea, and catalyst under the flow of nitrogen gas.

RESULTS AND DISCUSSION

The highest D-mannose conversion was obtained with the catalyst prepared using ethanol as a solvent. It also should be noted that 2,3-O-Carbonyl- α -D-mannopyranose yield is increased to 85.32 %. The selectivity of the all catalysts is almost 100 %. Compared the activity of the catalysts prepared by different solvent, it was clearly shown that the catalytic activity greatly depended on the impregnation solvent. The excellent catalytic activity of $\text{LT}/\text{Al}_2\text{O}_3$ (et) catalyst was owing to the better dispersion of active sites.

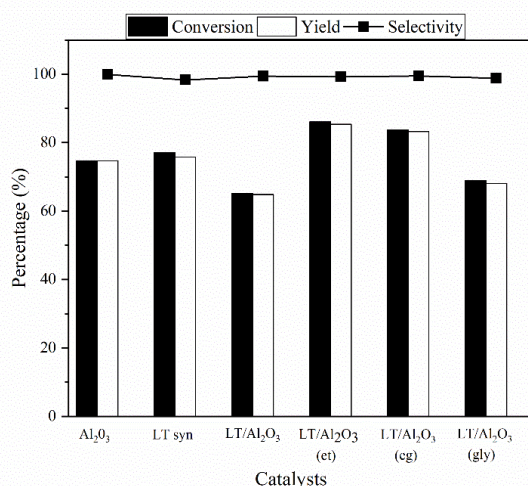


Fig. 1: The effect of impregnation solvent of catalysts on the activity of $\text{LT}/\text{Al}_2\text{O}_3$. Reaction conditions: Temperature, 100 °C; Reaction time, 3h; D-mannose: Urea, 1: 1.5 (Molar ratio); Catalyst load, 2 wt. %; Gas, N_2 ; Standard stirring rate, 340 rpm

CONCLUSIONS

The catalyst prepared from ethanol exhibited the higher 2,3-O-Carbonyl- α -D-mannopyranose yield.

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EFFECT OF MUNICIPAL WASTE COMPOSITION IN MUNICIPAL WASTE PYROLYSIS TO FUEL

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ABSTRACT

In this research, pyrolysis on municipal waste ie. food waste, paper, plastics waste, and real municipal waste to produce fuel grade liquid product was studied. Plastics waste was contained of 35% of HDPE, 35% of LDPE, 19% of polypropylene, and 11% of polystyrene. A municipal waste sample was a mixture of 43% of food waste, 25% of plastics waste and 23% of paper. The sample was pyrolysed at 400°C for an hour in nitrogen gas flow rate at 50 ml.min⁻¹ and 1.5 barg. The product yield was determined and the liquid product was analyzed. The pyrolysis of food waste produced highest yield of liquid product (55.8%), followed by paper (38.3%), municipal waste (26.7%) and plastics waste (25.1%). Plastic waste pyrolysis liquid product is rich in parafins compared to other samples where 23.6% of alkane, 47.9% of alkene, and 27.3% of aromatic compound was found in the liquid product. Meanwhile, food waste pyrolysis liquid product has the least quality of liquid product, in which only 0.2% of alkene but high acid (39.8%) was obtained. In addition, highest calorific value (39.9 MJ/kg) was achieved from liquid product of plastics waste pyrolysis. Thus, liquid product from plastics waste pyrolysis has better quality compared to food waste, municipal waste, and paper pyrolysis liquid product. In conclusion, plastics waste is the most promising waste to convert to fuel via pyrolysis process.

Keywords: municipal waste, pyrolysis, gasoline, plastics waste, physical properties.

INTRODUCTION

Municipal solid waste is everyday items that are discarded by people which mainly consists of food waste, plastic, and paper. Municipal solid waste generation is one the biggest challenge for Malaysia as it is an emerging country with a growing population, economic rate, and business activity. In recent years, a chemical recycling process like pyrolysis, known as an economically and environmentally acceptable manner has become the topic of the issues arise. Pyrolysis of municipal waste involves thermal decomposition of organic and synthetic material at elevated temperatures in the absence of oxygen to produce fuel. Plastics waste, food waste and papers are major components in municipals waste. In Malaysia, organic fraction municipal solid waste (OFMSW) including food waste contributes the largest amount of waste composition at 45%, follow by 13% of plastics, 12% of diapers, 9% of paper, 6% of garden wastes and others (Ministry of Housing and Local Government Malaysia., 2015). Recycling municipal waste via pyrolysis is an interesting method to applied and initiates income generation. In this research, the impact of pyrolysis of a different waste composition were comprehensively studied in order to obtain high yield of product and produce better quality of liquid product.

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MATERIALS AND METHODS

All samples were obtained from Taman Gambang Damai residential area and Tapak Pelupusan Sisa Pepejal Sanitari Belenggu Halt. The bread was used to represent food waste. A 35 wt% of shampoo bottle, 35 wt% of plastic bag, 19 wt% of plastic wrapper and 11 wt% of polystyrene were used to represent plastics waste. A newspaper was used to represent paper. A mixture of 43% food waste, 25% plastics waste and 23% paper were prepared to represent municipal waste.

About 25 g of the sample was placed into the three neck round bottom flask that was placed on the heating mantle and connected to the condenser, thermocouple, and nitrogen gas tank. The nitrogen gas was supplied at a flow rate of 50 ml.min⁻¹ at 1.5 barg. The pyrolysis was run at 400°C for an hour. The gas product and liquid product were collected and analyzed. The liquid product composition was determined using Mass Spectrometry Gas Chromatography (GC-MS), Agilent 5975C. The calorific value of the liquid product was also determined.

RESULT AND DISCUSSION

At 400°C of pyrolysis process, plastics waste has the highest solid percentage of solid (48%), followed by municipal waste (40%), paper (32%) and food waste (24%). Meanwhile, the food waste produced the highest liquid product (55.8%), followed by paper 38.3%, municipal waste 26.7%, and plastics waste 25.2%. Zornoza et al., (2016) also claimed that more solid product was obtained at lower operating temperature <500 °C in biochar production from municipal waste.

It is found that the liquid product from food waste pyrolysis contain no alkane, and aromatic compound. High content of acid in the liquid product was high, which make it less favorable to become liquid fuel and contributes to corrosion problems and instability of liquid fuel. According to Dewayanto et al., (2013), high content of oxygen produced liquid fuel with high acidity value including acetic acids in his work of biomass pyrolysis. The liquid product from pyrolysis of paper and municipal waste contains alkane, alkene, acid, and alcohol too. Further separation process of acids is necessary to make the liquid product feasible and applicable to use commercially. Alkene, alkane and aromatic compound are found in the liquid product of plastic waste pyrolysis. It is also observed that plastics waste liquid product has the highest calorific value (39.9 MJ/kg) and about the same value of commercial gasoline calorific value (42.90 – 45.70 MJ/kg) ((Martinez, 2018). The food waste, paper and municipal waste liquid product calorific value are 5.00, 4.96 and 4.98 MJ/kg respectively. The high amount of calorific value indicated that the liquid fuel has a higher efficiency for engine combustion purpose. Food waste, paper, and municipal waste had the lowest calorific value, which indicating poor combustion efficiency fuel. It can be concluded that plastics waste is the most favorable waste type to be used in pyrolysis due to liquid product composition and characteristic towards commercial gasoline product.

CONCLUSIONS

Plastics waste pyrolysis liquid product has the most alkane, alkene, aliphatic compound, and aromatic compound content with 39.9 MJ/kg calorific value. Meanwhile, paper and municipal waste pyrolysis liquid product content alkane, alkene and some acids. However, food waste pyrolysis liquid product is the least favourable fuel liquid product because it contains high amount of acids which contributes to instability of liquid fuel and corrosion problems. Thus, it can be concluded that plastics waste has the highest potential to be converted into liquid fuel in pyrolysis process.

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MESOSTRUCTURED SILICA NANOPARTICLE SUPPORTED NICKEL CATALYSTS FOR CATALYTIC DECOMPOSITION OF METHANE INTO HYDROGEN AND CARBON NANOTUBES

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ABSTRACT

Hydrogen is an alternative source of renewable energy that can be produced by methane decomposition without any CO_x formation. 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 use of MSN as an effective support for nickel in methane decomposition was reported here. 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 catalytic activity of the 50% Ni/MSN catalyst showed that this catalyst was highly efficient and stable compared with other catalysts. 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.

Keywords: Methane Decomposition, Mesostructured silica nanoparticles, Carbon nanotubes.

INTRODUCTION

The methane decomposition is an endothermic process involving the use of high temperature to decompose methane because of the strong bond between C and H, which are very difficult to break. Therefore, the use of the catalyst can reduce the reaction temperature to break the C–H bond. Hydrogen production through methane decomposition is an approach that has a considerable prospect and has been studied extensively. The natural properties of metal species, the thermal stability of catalyst supports and the surface area of the catalyst considerably influence the catalytic activity. The transition metals such as Ni, Fe, Cu and Co-based catalysts that are supported on various supports are commonly used in methane decomposition due to its low cost. Among the studied metal catalysts in methane decomposition, Ni is one of the most effective catalysts and commercially available. The selection of a catalyst support helps in determining catalytic performance in terms of methane conversion and improving its stability for long periods on stream. Therefore, catalyst support with high surface area is highly favourable. Many studies have been performed

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on Ni catalyst by varying catalyst supports, such as metal oxides (SiO₂, TiO₂, and Al₂O₃) and carbonaceous materials [Pudukuty et.al, 2015, Li et. al., 2017]. Here we report the use of MSN as a catalyst support for the application of Ni catalyst in methane decomposition. The effect of Ni loading on the physicochemical properties and activity for methane decomposition is investigated.

MATERIALS AND METHODS

A wet impregnation method was used to synthesise the MSN supported Ni catalysts. The catalytic performances of the catalysts

in methane decomposition were tested in a tubular fixed-bed reactor made of stainless steel (height of 60 cm, inner diameter of 2.5 cm) that was heated in an electric muffle.

RESULT AND DISCUSSION

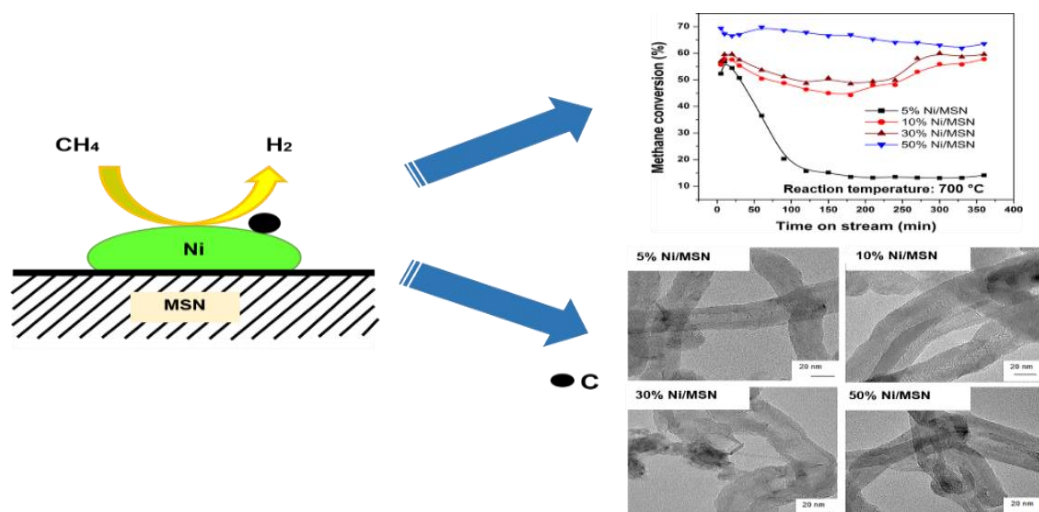


Fig. 1: Schematic of Ni/MSN catalyst for catalytic methane decomposition and carbon nanotubes produced.

The catalytic performance of the Ni/MSN catalysts with different Ni loadings such as 5%, 10%, 30% and 50% that were synthesized by an impregnation method was investigated for undiluted methane decomposition. 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 catalytic activity tests revealed that the 50% Ni/MSN displayed the highest hydrogen yield of 68% with improved stability for 360 min of reaction. The pronounced catalytic performance of the catalyst could be assigned to the improved synergistic effects of nickel species with MSN support. 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.

CONCLUSIONS

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.

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DEVELOPMENT OF CATION EXCHANGE SULFONATED NANOCRYSTALLINE CELLULOSE/SPEEK COMPOSITES MEMBRANE

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ABSTRACT

Sulfonated nanocrystalline cellulose/sulfonated poly(ether ether ketone) (sNCC/SPEEK) composite membrane was fabricated as a promising proton exchange membrane (PEM). The sNCC was prepared via sulfonation of sugarcane bagasse paper which its functionality, crystal structure, and crystallinity were confirmed by FTIR and XRD. sNCC/SPEEK composite membranes (0 – 5 wt% of sNCC) were prepared by a solution casting method. The proper amount of sNCC enhanced proton transfer of the pristine SPEEK membranes, ion-exchange capacity (IEC) and water uptake of 4 wt% sNCC/SPEEK composite membrane were 1.96 mmol·g⁻¹ and 58.1%, respectively which were higher than that of pristine SPEEK. The addition of *n*-butanol also induced self-organization of the composite membranes.

Keywords: sulfonated nanocrystalline cellulose, proton-exchange membrane, proton conduction

INTRODUCTION

Nafion is a commercially available membrane for fuel cell and electrodialysis applications but the price is expensive and many steps for preparation. From this reasons, this work focuses on sulfonated poly(ether ether ketone, SPEEK) which would be a candidate for the Nafion membrane replacement due to their lower cost, high thermal stability, good mechanical properties, and simple preparation (Kreuer, 2001). Non-fluorinated proton exchange membranes are limited by poor proton conductivity due to weak phase separation and narrow hydrophilic channels. Therefore, *n*-butanol (*n*-BuOH) was used as a self-organization inducer. Multiple hydrogen bonds between SPEEK and *n*-BuOH facilitate the clustering of hydrophilic domains and increase the ionic clusters (Wang et al. 2015). The sNCC was produced as reinforcement by preparing cellulose from sugarcane bagasse paper via sulfonation. Therefore, this work focuses on the addition of sNCC for improving the mechanical properties and dimensional stability of the SPEEK membrane and the addition of *n*-BuOH for proton conductivity improvement.

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MATERIALS AND METHODS

Composites membranes were prepared by a solution casting method using dimethylacetamide as a solvent. 7%wt SPEEK solution and sNCC/DMAc suspensions (0-5% wt of sNCC) were prepared separately. SPEEK solution was added into the sNCC suspension and mechanically stirred along with ultrasonication for 4.5 h to ensure well dispersion of sNCC into the polymer solution, then casted onto a glass plate and

sequential dried at 35 °C for 24 h, 60 °C for 24 h, and 80 °C for 24 h. The membrane was soaked with 3.0 M H₂SO₄ at room temperature for 24 h, then washed with DI water until neutral. The composite membranes were named as sNCC/SPEEK-1, sNCC/SPEEK-2, sNCC/SPEEK-3, sNCC/SPEEK-4 and sNCC/SPEEK-5 where numerical values denote the wt% of sNCC. The effect of *n*-BuOH addition also observed.

RESULT AND DISCUSSION

From Fig. 1, FTIR peaks at 3335, 2889, and 1646 cm⁻¹ indicated -OH stretching, C-H stretching, and -OH bending of sNCC, respectively. XRD pattern of sNCC exhibited characteristic diffraction peaks of cellulose II with crystallinity index of 66.5%. Water uptake, swelling ratio, and IEC of the composite membranes were higher than that of the pristine SPEEK. An increase in sNCC concentration led to increase in the water uptake, swelling ratio, and IEC values due to strong water absorption ability caused by abundant hydrophilic groups (-OH and -SO₃H) on the surface of sNCC. The addition of sNCC supposed that the presence of hydroxyl groups on sNCC could form hydrogen bonds with the water molecules and the presence of water molecules in membranes play a key role in protons (H⁺) transfer from one electrode to another which implied to the increasing in membrane conductivity. However, for overloading of sNCC (at 5 wt%), the water uptake, swelling ratio, and IEC values trend to decrease compared with others according to agglomeration of sNCC which lower the membrane performances. The addition of *n*-butanol also induced self-organization of the composite membranes which enhanced the permance of proton exchange membrane.

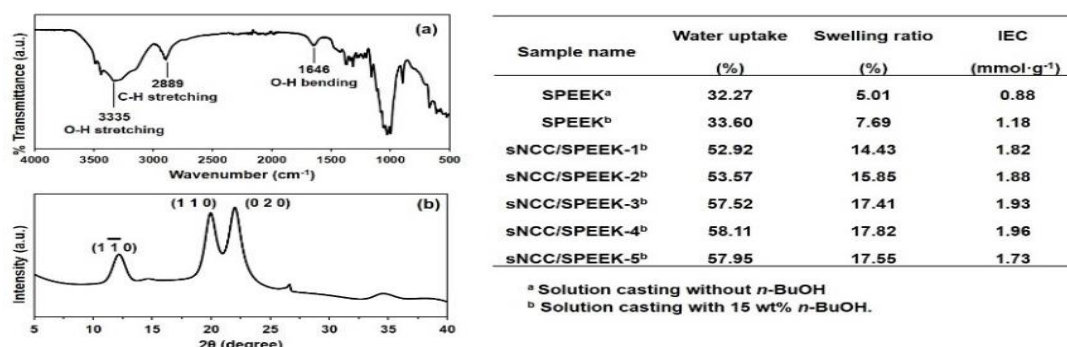


Fig. 1: (a) FTIR, (b) XRD of sNCC, and membrane properties.

CONCLUSIONS

The presence of sNCC in composite membrane enhanced the water uptake, swelling ratio, and IEC values. Particularly, sNCC/SPEEK composite membranes with 4% of sNCC showed good compatibility with sNCC and display maximum values of water uptake, swelling ratio, and IEC which is comparable to pristine SPEEK.

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INTERSTITIAL PHOSPHORUS-DOPED ZINC BLENDE/WURTZITE TWINNED PHOTOCATALYST WITH HOMOJUNCTIONS AND S VACANCIES FOR PURE WATER SPLITTING UNDER AMBIENT CONDITION

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ABSTRACT

The forefront of photocatalytic water splitting research focuses on H₂ production from pure water condition. Pseudo-binary Zn_xCd_{1-x}S ternary metal chalcogenide has been regarded as one of the most efficient photocatalysts for H₂ evolution. However, sacrificial reagents are generally needed to overcome the issues of severe photocorrosion and rapid charge recombination. As is known, effective charge isolation has been a critical element to enhance the photocatalytic performance. In this context, heteroatom doping has been highlighted to introduce midgap level into the electronic structure of semiconductor which can serve as an electron trapping site that prolong the lifetime of photogenerated carriers. Herein, we report the fabrication of P-doped twinned Zn_{0.5}Cd_{0.5}S_{1-x} nanorods (NRs) with one-dimensional homojunction incorporated with defect-induced S vacancies. The new hybridized state formed via the orbital hybridization of Zn, Cd, S and P can propel the upshifting of valence band (VB) and Fermi level to be in close proximity with the midgap impurity level. This imparts an efficient electron capturing effect that enhance the spatial charge separation. Consequently, the P-doped twinned Zn_{0.5}Cd_{0.5}S_{1-x} NRs demonstrated visible-light-driven water splitting under pure water condition without any sacrificial reagent, resulting in H₂ evolution rate of 0.97 μmol h⁻¹. The AQY of H₂ production was measured to be 0.15% under monochromatic 420 nm.

Keywords: interstitial doping, homojunction, water splitting, S vacancies.

INTRODUCTION

Photocatalytic water splitting using semiconductor to produce hydrogen (H₂) fuel is a promising approach to solve the onslaught of global energy crisis. To date, interest has peaked in developing metal chalcogenides, particularly Zn_xCd_{1-x}S, for H₂ evolution attributed to its narrow band gap and suitable band

structure. One step beyond can be witnessed in twinning Zn_xCd_{1-x}S to create periodic arrangement of zinc blende/wurtzite (ZB/WZ) segments in a specific dimension that can confer “back-to-back” potentials between the twin boundaries. The induced “mini-band” in the twin nanostructures, also known as homojunction, can improve the spatial charge isolation. Even so, there is still large room to further increase the lifetime of photogenerated charges. Interstitial doping of heteroatoms into metal chalcogenides has been proven to create midgap impurity levels below conduction band (CB) that serves as electron

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trapping sites. Even so, the electron seizing effect of these midgap states is highly dependent on their void distance with the Fermi level. To maximize the electron trapping effect, midgap states should be as close as possible to the Fermi level. In this contribution, we present a fine-tuned P-doped twinned $\text{Zn}_{0.5}\text{Cd}_{0.5}\text{S}_{1-x}$ with S vacancies to drive H_2 production from pure water under visible light (Ng et al., 2020). Upon introduction of P dopants, the electronic structure was tuned with new hybridized state that upshift the VB and Fermi level towards the impurity level, resulting in longer lifetime of carriers.

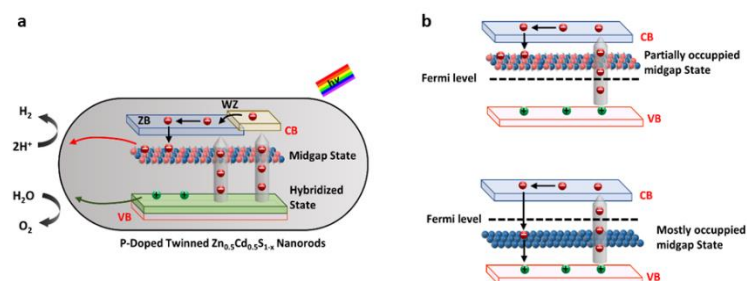


Fig. 1: (a) Proposed electron/hole transfer mechanism for P-doped twinned $\text{Zn}_{0.5}\text{Cd}_{0.5}\text{S}_{1-x}$ NRs. (b) Schematic of electron trapping effect according to Fermi-Dirac distribution function (Ng et al., 2020).

MATERIALS AND METHODS

Preparation of P-doped twinned $\text{Zn}_{0.5}\text{Cd}_{0.5}\text{S}_{1-x}$ NRs

Firstly, twinned $\text{Zn}_{0.5}\text{Cd}_{0.5}\text{S}_{1-x}$ NRs with homojunctions were synthesized using a co-precipitation-hydrothermal strategy. Subsequently, the sample was subjected to thermal phosphorization using phosphine (PH_3) gas as the P dopant source which decomposed from sodium hypophosphite at an elevated temperature. The resultant sample was denoted as P-doped twinned $\text{Zn}_{0.5}\text{Cd}_{0.5}\text{S}_{1-x}$ NRs.

RESULT AND DISCUSSION

Attributed to the presence of homojunctions, a localized charge separation happens before the photogenerated electrons are trapped by the midgap level (Fig. 1a). This speculation infers an efficient dual-stage electron capturing concept on the P-doped twinned $\text{Zn}_{0.5}\text{Cd}_{0.5}\text{S}_{1-x}$. According to Fermi-Dirac distribution function, the midgap level should be positioned between CB and Fermi level and in close proximity to impart a substantial electron trapping effect (Fig. 1b). Thus, the degree of P dopant was varied to modulate the band structure of the sample in achieving efficient pure water splitting.

CONCLUSIONS

In summary, P-doped twinned $\text{Zn}_{0.5}\text{Cd}_{0.5}\text{S}_{1-x}$ NRs was successfully devised to drive pure water splitting under visible light, resulting in H_2 evolution rate of $0.97 \mu\text{mol h}^{-1}$ and AQY of 0.15%.

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ETHANOLYSIS OF CELLULOSE TO ETHYL LEVULINATE USING IONIC LIQUID, 1-SULFONIC ACID-3-METHYL IMIDAZOLIUM TETRACHLOROZINCATE

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ABSTRACT

1-sulfonic acid-3-methyl imidazolium tetrachlorozincate ([SMIM][ZnCl₂]) was used as catalyst for cellulose conversion to ethyl levulinate. Parameter studies that affect the ethyl levulinate production namely, effects of cellulose loading, [SMIM][ZnCl₂] loading, reaction temperature, and reaction time, were investigated. As result, the optimum yields of ethyl levulinate obtained was 52.4% after 10 hr at 180°C with catalysts and ionic liquid loadings of 0.4 and 3 g, respectively.

Keywords: ethyl levulinate, ionic liquid, ethanolysis, cellulose.

INTRODUCTION

Biomass is one of the resources which promising alternatives for sustainable supply of biofuels, biomaterials, and biochemicals. Biomass-based ethyl levulinate is produced from renewable resources and it is a significant fuel additive that can be used in petrol diesel. The production of ethyl levulinate is constantly being review so that it can be used as renewable energy and reduce CO₂ emission (Weide et al. 2019). Recently, ionic liquid has been used as a medium for depolymerization of biomass derivatives since it has dual-functionality properties, which can act as solvent and catalyst (Ramli et al. 2015). These unique properties of ionic liquid have attracted many researchers to use it in various biomass conversion processes. Hence, the main aim of this study is to conduct cellulose conversion to ethyl levulinate via a new synthesis catalyst, 1-sulfonic acid-3-methyl imidazolium tetrachlorozincate ([SMIM][ZnCl₂]). The effect of using [SMIM][ZnCl₂] ionic liquid as catalyst towards the product yield and the percentage of cellulose conversion are determined.

METHODS

The conversion of cellulose to ethyl levulinate was carried out by filling the batch reactor with cellulose (0.2 g), ethanol (40 mL), and ionic liquid catalyst (4 g). Then, the mixture was heated to the desired temperature at a constant stirring speed 200 rpm. After the reaction, the mixture was cool down, filtered, and further non-residue were analyzed by using GC-FID. Parameters studies namely, cellulose loading (0.2-1.0 g), ionic liquid loading (1-4 g), reaction time (4-12 hr), temperature (140-200°C) were investigated to obtain the optimum conditions for higher ethyl levulinate yield.

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RESULT AND DISCUSSION

As shown in Fig. 1, increasing the cellulose loading (0.2–0.6 g) resulting in the increasing ethyl levulinate yield. This effect shows the excess reactive sites are significant for cellulose conversion. However, further increases in cellulose loading cause a decreased in ethyl levulinate yield (31–5%). The decreasing of ethyl levulinate yield was suggested due to insufficient catalytic sites available for the interactions with cellulose and also might be due to byproducts formation. For the effect of [SMIM][ZnCl₂] loading, it shows the ethyl levulinate increases along with the increasing [SMIM][ZnCl₂] loading (1–3 g). When the amount of [SMIM][ZnCl₂] increased, the amount ZnCl₂⁻ anion and SO₃H⁺ cation were also increased, which favor the cellulose conversion. A similar trend can also be observed by increasing the Lewis acid sites. Further increasing in [SMIM][ZnCl₂] loading from 3 to 4 g caused the decrease in ethyl levulinate yield from 36% to 29%. This tendency probably due to condensation reaction that occurred at high catalyst loading that contributes to a decrease in ethyl levulinate yield

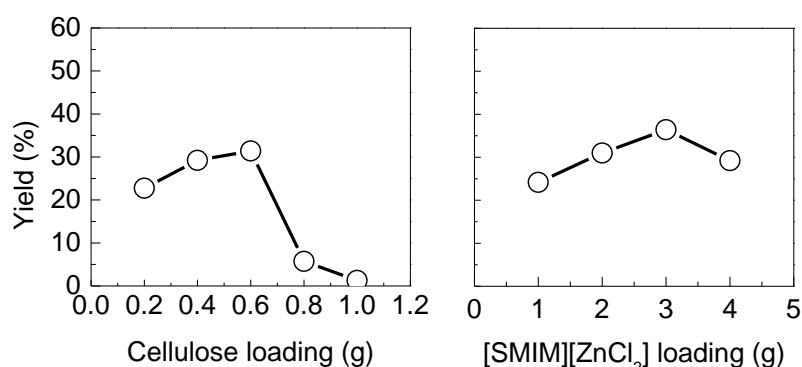


Fig. 1: Effects of cellulose loading and [SMIM][ZnCl₂] loading on ethyl levulinate yield

As for the temperature effects, the optimum temperature for high ethyl levulinate yield at 180°C, which suggested higher temperature has lowered the activation energy of the reaction. However, depolymerization reaction might occur and side products are more favored to be formed at temperature > 180°C caused the decrease in ethyl levulinate yield from 36% to 8%. A similar trend as other parameters, 10 hr of reaction time produced the highest ethyl levulinate yield due to more ethyl levulinate produced for prolonged reaction time. However, further prolonged reaction time to 12 hr causes reversed reaction or hydrolysis of ethyl levulinate and subsequently decreases in the ethyl levulinate yield (52.4% to 34%).

CONCLUSIONS

High cellulose conversion was achieved using [SMIM][ZnCl₂] with 52.4% of ethyl levulinate yield under optimum conditions (catalysts loading: 0.4; ionic liquid loading: 3 g; reaction temperature: 180°C; reaction time: 10 hr). Thus, the presence of Brønsted and Lewis acid sites were suitable for cellulose conversion to ethyl levulinate.

ACKNOWLEDGEMENTS

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MICROWAVE-ASSISTED SULFONATED GLUCOSE CATALYST FOR BIODIESEL PRODUCTION FROM PALM FATTY ACID DISTILLATE (PFAD)

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ABSTRACT

Microwave-heating method for catalyst preparation has been utilized recently due to its shorter operation time compared to the conventional method. Glucose, a renewable carbon source can be partially carbonized and sulfonated via microwave heating which could result in highly potential heterogeneous carbon-based acid catalyst. In this study, the impacts of the carbonization and sulfonation parameters during the catalyst preparation were investigated. Catalysts prepared were characterized using X-Ray Diffraction (XRD) and Brunauer-Emmet-Teller (BET). Best incomplete carbonized glucose (ICG) prepared was at 20 minutes, 20g of D(+)-glucose with medium microwave power level (400W) that exhibited highest % yield (91.41 %) of fatty acid methyl ester (FAME). Total surface area and acid site density obtained were 16.94 m²/g and 25.65 mmol/g, respectively.

Keywords: biodiesel; sulfonated glucose; esterification; microwave-assisted, palm fatty acid distillate.

INTRODUCTION

Heterogenous solid acid catalyst has been proven great replacement for liquid H₂SO₄ for the biodiesel production. As good as it sound, there are still areas where solid catalyst are lacking off. The duration to synthesize solid catalyst is quite long. A lab scale production can take up to nearly 2 days. This is mainly due to the long drying time in oven and calcination process in furnace which occupies up to 12 and 5 hours, respectively. This can be costly in terms of time, energy and dollars. One potential strategy to solve this is to adopt microwave (MW) as the ultimate heating source. MW is more effective because the system uses thermal radiation with sensational penetrability. In this study, natural carbon-based materials in the form of D(+)-Glucose was employed as a source to produce solid as catalyst to esterify palm fatty acid distillate (PFAD) to biodiesel. This catalyst has been prepared conventionally by Lokman and colleagues (2015). The aim of this study is to screen best performing incomplete carbonized glucose (ICG) using MW irradiation technique. Parameters include heating time (min), weight of D(+)-glucose (g), and microwave power level.

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MATERIALS AND METHODS

Materials

D(+)-glucose and H₂SO₄ were used for sulfonated catalyst preparation. PFAD and methanol on the other hand were used for catalytic reaction. Standard for methyl esters such as methyl linoleate, methyl myristate, methyl oleate, methyl palmitate and methyl stearate were used for GC analysis. Equipment employed for sulfonated catalyst preparation was Microwave brand SHARP R213CST.

RESULT AND DISCUSSION

Catalyst synthesis, characterization and esterification experimental works have been conducted. Catalysts characterization of XRD revealed that a broad and a weak diffraction existing at 2θ of 2° – 10° and 25° – 35° . At 2° – 10° , the graphitic C(002) plane is attributed for the amorphous carbon and shows both of the catalysts and precursor comprising considerably random fashion of aromatic carbon sheets. Through carbonization process, surface area of the catalyst decomposed thus reducing the particles size. Pores formation on the sulfonated glucose defines a high surface area values. Using low power level of microwave exhibited insignificant surface area ($2.03 \text{ m}^2/\text{g}$) because of reasonably low heating provided to the incomplete carbonized glucose. Fig. 1 summarizes the important results from this study. It is important to note that during carbonization process, weight of D(+)-glucose and microwave power level was set constant at 20g and Medium Power Level 400W, respectively. Esterification reaction was run at 75°C reaction temperature; 2.5 wt% catalyst loading; 10:1 molar ratio of methanol to PFAD; 2 hours reaction time.

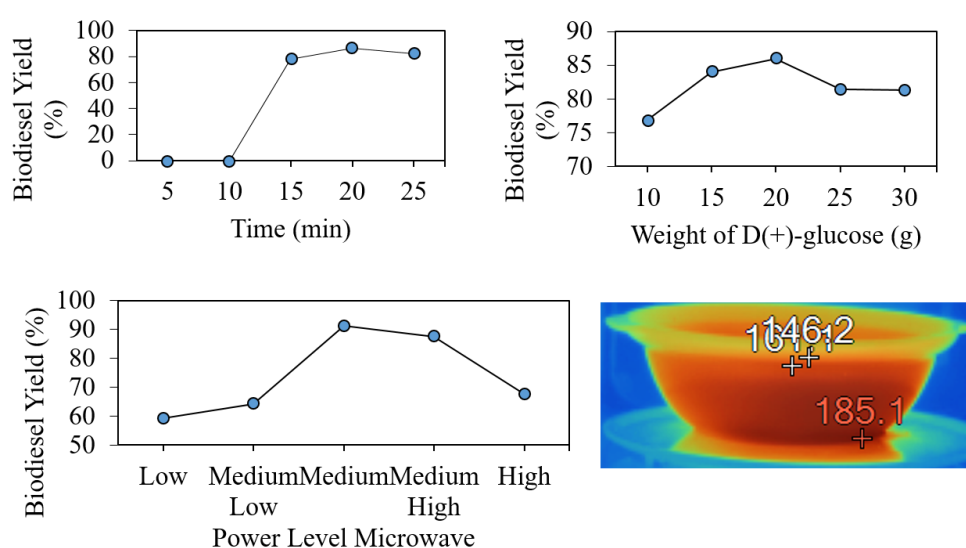


Fig. 1(a) Effect of D(+)-glucose carbonization heating time versus % Biodiesel Yield. (b) Effect of D(+)-glucose carbonization weight versus % Biodiesel Yield. (c) Effect of carbonization power level versus % Biodiesel Yield (d) Temperature contour at 720W for the prepared catalyst.

CONCLUSIONS

The best catalyst was prepared using 20 g D(+)-glucose, heated for 20 min by using medium microwave power level, sulfonated using 100 ml H_2SO_4 and heated for 7 min at medium high power level. Yield of methyl ester produced was up to 91.41 % at 2 hour reaction time, 2.5 wt% catalyst loading, 75°C reaction temperature and 10:1 molar ratio of methanol to PFAD.

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IMPACT OF SEPARATION AT SOURCE PROGRAM ON THE SUSTAINABILITY OF FEEDSTOCK SUPPLY FOR WASTE TO ENERGY PLANT IN KUALA LUMPUR

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ABSTRACT

Malaysian government proposed to construct Waste to Energy (WtE) plant to solve the waste management problem in Kuala Lumpur. Recent implementation of compulsory separation at source (SAS) program might disrupt the sustainability of the waste supply. Sufficient feed rate of waste is required to achieve the designated temperature and autothermic combustion. Results of the study showed that, the annual average daily generation rate was reduced by 105 tonnes/day or 5.5% after the implementation of separation at source program. This might be due to the low public awareness of the program. The annual average daily collection of recyclable materials was only about 1.3 tonnes/day, which might be due to illegal collection by recycling vendors, poor enforcement by the authority and selling of the recyclable materials by residents directly to vendors. 3 regression models were proposed to describe the overall correlation behaviour between waste generation and per capita GDP. The waste generation rate was forecasted to be 2927 tonnes/day or 1.3 kg/capita/day in 2043.

Keywords: water to energy, waste generation, separation at source.

INTRODUCTION

Kuala Lumpur had faced a problem with high generation of waste. Currently, there is no available area in the city for the waste disposal. The waste is sent to Bukit Tagar Sanitary Landfill in Selangor via Taman Beringin Transfer Station, the only operating waste management facility within the city. The station received solid waste from residential, commercial, industrial, and institutional areas; excluding bulky and construction wastes. The government proposed to develop Waste to Energy (WtE) plant to solve the current issue. The selection of plant capacity requires the understanding of local waste generation trend to ensure the sustainability of the plant feedstock. Sufficient feed rate of waste is required to achieve the designated temperature and autothermic combustion (Starting from September 2015, government implemented Separation at Source (SAS) program that obligated the residents to separate their waste into recyclable and non-recyclable materials. The separated recyclable materials were sent to recycling facilities. The effect of this program on the WtE feedstock sustainability is not yet discovered. This research aimed to analyse the impact of this program on the local waste generation rate. This research also accessed the impact of this program on the correlations between waste generation rate with gross domestic product (GDP) and population density. The established correlations were modelled and used to forecast the future trend of waste generation rate.

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MATERIALS AND METHODS

Data Collection

Waste generation data and recyclable material tonnage were collected from the operator of Taman Beringin Transfer Station that were based on weighbridge data of the waste facility. Data on

population and GDP were obtained from Department of Statistics Malaysia.

Data Analysis

Impact of separation at source program was accessed based on the waste generation trends and recyclable material collection rate. This research use Pearson correlation method to access the correlations between the waste generation with population density and per capita GDP.

Model Development and Forecasting

Prediction model for waste generation was develop through regression model based on the established correlations. Forecasting of waste generation rate was conducted using the developed model.

RESULT AND DISCUSSION

Results of the study showed that, the annual average daily generation rate was reduced by 105 tonnes/day or 5.5% after the implementation of separation at source program as shown in Fig. 1. The annual average daily collection of recyclable materials was only about 1.3 tonnes/day, which might be due to illegal collection by recycling vendors, poor enforcement by the authority and selling of the recyclable materials by residents directly to vendors. 3 regression models were proposed to describe the correlation behaviour between waste generation rate and per capita GDP. The waste generation rate was predicted to be 2927 tonnes/day or 1.3 kg/capita/day in 2043.

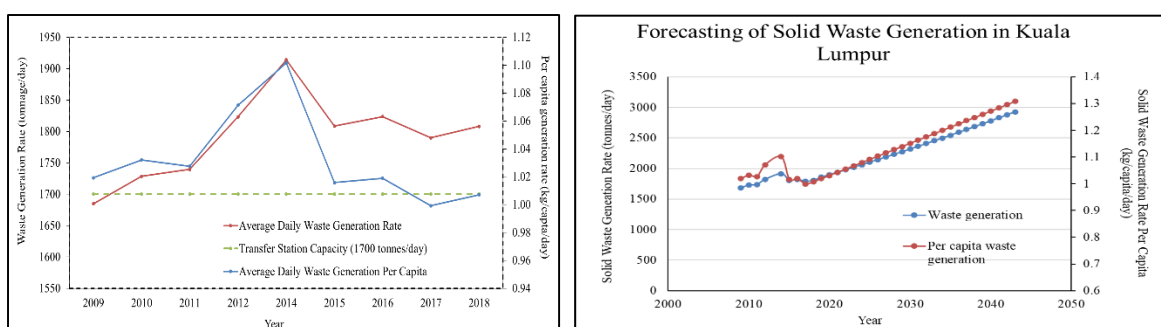


Fig. 1: Current and Future Trends of Waste Generation in Kuala Lumpur

CONCLUSIONS

Results of the study showed that, the annual average daily generation rate was reduced by 105 tonnes/day or 5.5% after the implementation of separation at source program. 3 regression models were proposed to describe the overall correlation behaviour between waste generation and per capita GDP. The waste generation rate was forecasted to be 2927 tonnes/day or 1.3 kg/capita/day in 2043

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FACILE SYNTHESIS OF MAGNETIC POROUS CARBON FROM NIPA FROND FOR CATALYTIC DEGRADATION OF TARTRAZINE

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ABSTRACT

In this study, magnetic porous carbon was prepared from abundant nipa frond via one-step pyrolysis. The results revealed that magnetic Fe₃O₄ particles along with zero-valent iron particles were formed over porous carbon support at 600 °C in 2 h. The material possesses high specific surface area of 268 m²/g, total pore volume of 0.178 cm³/g and saturation magnetization of 7.65 emu/g. The magnetic porous carbon was subsequently utilized for catalytic oxidation of tartrazine by H₂O₂. At pH 3, H₂O₂ concentration of 200 ppm, 0.80 g/L catalyst removed 89.1% tartrazine within 120 min. The used catalyst was recovered, separated from the treated mixture easily by a magnet bar. Overall, magnetic porous carbon could be potentially an efficient catalyst for tartrazine degradation in wastewater.

Keywords: nipa frond, magnetic carbon, pyrolysis, catalytic oxidation, tartrazine decoloration.

INTRODUCTION

Nipa (*Nypa fruticans*) is a monoecious palm, which thrives wildly in river estuaries and coastlines. This trunkless species consists of frond, shell, husk and leaf. These under-utilized parts of nipa are mainly left to decompose in its habitat (Tamunaidu and Saka, 2011). Therefore, this biomass could be an abundant raw material for fabrication of porous carbon materials via pyrolysis processes. In order to facilitate separation and recovery, magnetic iron oxide particles could be immersed on carbon base to form magnetic porous carbon (MPC). Recently, one-step pyrolysis of iron precursor-loaded biomass was introduced to prepare MPC facilely. The advanced route could form magnetic iron oxide particles and activate carbon surface simultaneously during heating (Nguyen et al., 2020). As reviewed by Thines et al. (2017), recent research about the application of MPC mainly focuses on the adsorption ability of carbon support and recoverability of magnetic particles, and does not pay attention on the catalytic activities of iron oxide particles for oxidation of organic compounds. To valorize nipa frond resource and explore catalytic activity of MPC, the current research was conducted.

MATERIALS AND METHODS

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Materials

Nipa fronds were collected from Chau Thanh district, Dong Thap province, Vietnam. The chemicals were purchased from Sigma-Aldrich.

Preparation of magnetic porous carbon

3.00 g dried nipa frond was added into FeCl₃ solution. The mixture was stirred for 24 h and dried at 105 °C for 24 h. The

dried sample was then pyrolyzed under a continuous nitrogen flow of 50 mL/min at 600 °C in 2.0 h. The obtained material was washed with distilled water until pH became neutral. Product samples are denoted as MPC-Rx (x: the mass ratio of FeCl₃ to nipa frond).

Tartrazine removal by magnetic porous carbon

0.80 g/L MPC was added into 100 ppm tartrazine solution at pH 3. A magnetic stirrer was used to mix the suspension continuously. After 10-minute adsorption, 200 ppm H₂O₂ was rapidly poured into the mixture. At different time intervals, each 2.5 mL suspension was withdrawn from the mixture for further analysis.

RESULT AND DISCUSSION

Fig. 1 shows that XRD patterns of MPC exhibited peaks of crystal Fe₃O₄ and zero-valent Fe (Nguyen et al., 2020). The magnetic hysteresis curve of MPC-R0.1 sample reveals superparamagnetic properties with the saturation magnetization of 7.65 emu/g. In addition, the material possesses high specific surface area of 268 m²/g, total pore volume of 0.178 cm³/g.

As presented in Fig. 2, MPC samples could adsorb tartrazine with their capacities of 9 – 15 mg/g. In oxidation step, porous carbon without iron element (R = 0) did not perform catalytic activity. On the contrary, MPC samples show excellent catalytic activity in the tartrazine decolorization by H₂O₂. Hence, iron constituents were the dominant catalytic sites of MPC.

CONCLUSIONS

MPC was prepared facilely via one-step pyrolysis of FeCl₃-loaded nipa frond. The material shows good magnetic properties and prove to be an promising catalyst for tartrazine decoloration.

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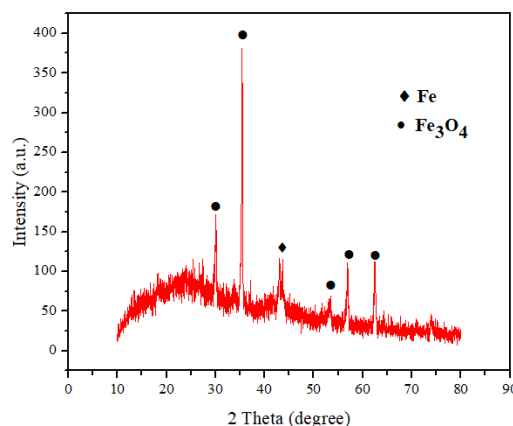


Fig. 1: XRD patterns of MPC-R0.1

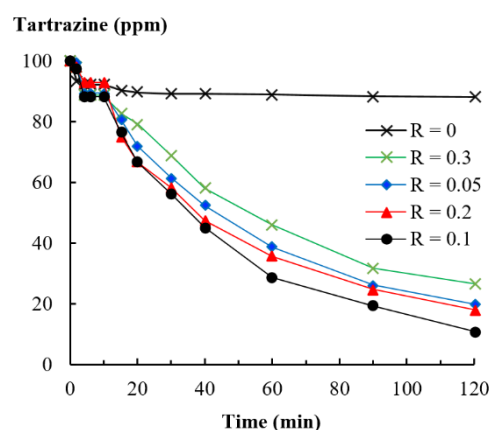


Fig. 2: Adsorption and oxidation of tartrazine by MPC samples

SOFT-TEMPLATE SYNTHESIS AND ACTIVATION OF MESOPOROUS CARBON NITRIDE FOR CO₂ ADSORPTION

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ABSTRACT

In this study, mesoporous carbon nitrides were nanocasted with triblock surfactant Pluronic F127 as a soft-template, resol as a carbon precursor and dicyandiamide as a nitrogen precursor. The obtained materials were characterized X-ray diffraction, N₂ adsorption and desorption isotherm, transmission electron microscopy, Fourier transformation infrared spectroscopy and energy dispersive X-ray spectroscopy. The results show that ordered mesoporous carbon nitride possess tunable mesostructures (p6m symmetry) with total volume of 0.26 cm³/g, specific surface area of 414 m²/g and nitrogen content of 3.1 wt%. Furthermore, the activation of mesoporous carbon nitride significantly increased its specific surface area from 414 to 951 m²/g and total volume pore from 0.26 to 0.33 cm³/g. The obtained materials were subsequently applied for CO₂ adsorption. As a result, CO₂ uptake of non-activated and activated mesoporous carbon nitrides at room temperature and atmospheric pressure were 3.7 and 4.1 mmol/g, respectively.

Keywords: mesoporous carbon, soft template, activation, adsorption.

INTRODUCTION

Ordered mesoporous carbons have received considerable attention due to outstanding features such as their large surface area, porous structure, physical-chemical stability and good conductivity. However, synthesized mesoporous carbons show hydrophobic surface and lack of active sites, which limit their application (Lakhi et al., 2017). To enhance the properties of the material, nitrogen-doped mesoporous carbons could be a good strategy. Mesoporous carbon nitrides (MCN) could improve the surface polarity and electric conductivity which enables their application in electric double-layer capacitors, fuel cells, and catalytic processes. Similar to synthesis of mesoporous carbons, Meng et al., (2006) developed soft-template method to facile preparation of MCN. A triblock polymers like P123, F127 is used as soft-template for appropriate carbon and nitrogen precursors. It is well known that CO₂ plays an important role in the greenhouse effect and global warming, leading to serious climate change. Therefore, much effort has been made to develop many chemical and physical methods for CO₂ capture and sequestration as a means of alleviating this problem (Wei et al., 2013). Due to high specific surface areas, high total pore volume, large pore size and basic nitrogen sites, MCN could be a promising material for CO₂ adsorption.

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MATERIALS AND METHODS

Materials

The chemicals used in this research were purchased from Sigma–Aldrich.

Preparation of MCN

MCN was prepared according to previous procedures (Wei et al., 2013). 1.00 g F127 and 1.00 g DCDA were dissolved in 20.0 g ethanol and 10.0 g water. Then 5.00 g of 20 wt% ethanolic solution

of resol was added. After stirring for 3 h, the homogeneous solution was let evaporate ethanol at room temperature for 12 h, followed by drying in an oven at 100 °C for 24 h. The composite products were crushed into powders. Calcination was carried out in a tube furnace under N₂ atmosphere at 250 °C for 2 h, then, raised to 600 °C and kept for 3 h.

Activation of MCN

The MCN was placed in the centre of a quartz tube and heated to 950 °C with heating rate of 5 °C/min under nitrogen. Next, the nitrogen stream was switched to CO₂ one (50 cm³/min) for activation. Finally, the tube was cooled to room temperature under nitrogen.

CO₂ adsorption

MCN samples were degassed at 300 °C in 2 h. CO₂ adsorption was conducted at 0 - 40 °C and 1 atm.

RESULT AND DISCUSSION

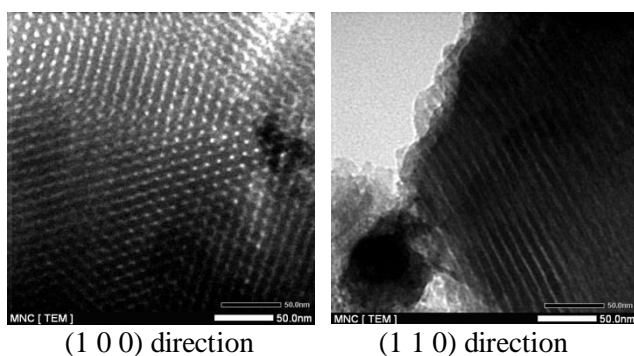


Fig. 1: TEM images of MCN

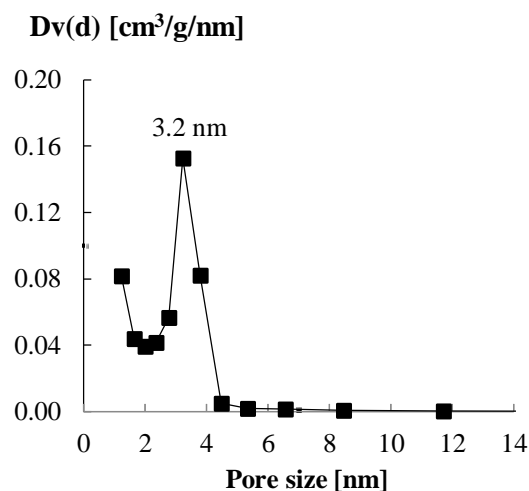


Fig. 2: BJH pore-size distribution of MCN

TEM images (Fig. 1) reveal that the obtained MCN possesses ordered stripe-like and hexagonally arranged mesostructure. Furthermore, ordered mesopore is determined to be around 3.2 nm (Fig. 2). Regarding to active sites of MCN, FT-IR result present peaks of -NH-, -NH₂, C-N bonds.

CONCLUSIONS

MCN was synthesized via soft-template method using Pluronic F127 as surfactant to navigate the structure. The activation of MCN improved its specific surface area from 414 to 951 m²/g and CO₂ uptake from 3.7 to 4.1 mmol/g.

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DISSOCIATIVE ADSORPTION OF CO₂ ON STEPPED CO SURFACES: A DFT STUDY

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ABSTRACT

The surface activation of CO₂ is the most important step in determining the activity of one catalyst toward CO₂ conversion. Often, stepped and defective surfaces are the most active sites compared to flat surfaces. Hereby, we studied the dissociative adsorption of CO₂ to CO + O on the stepped Co surfaces, namely Co (211) and Co (221), using density functional theory (DFT) with standard GGA Perdew-Burke-Ernzerhof (GGA-PBE) exchange-correlation functional and dispersion correction (DFT-D2). Several adsorption configurations of CO₂ were observed and the adsorption on the upper terrace of the stepped edge was identified as the most stable configuration, with adsorption energy (E_{ads}) of -1.03 eV and -1.02 eV for Co (211) and Co (221), respectively. Next, the climbing image nudged elastic band (CI-NEB) method was applied to investigate the CO₂ dissociation pathways. The activation energies of the most possible pathway for CO₂ dissociation on Co (211) and Co (221) were 0.53 eV and 0.55 eV, respectively. We found that the mechanisms of CO₂ adsorption and dissociation are exothermic and thermodynamically favorable for both Co (211) and Co (221). Comparatively, the activation of CO₂ on stepped Co is more exothermic than on flat Co (111).

Keywords: CO₂ adsorption, CO₂ dissociation, stepped surfaces, DFT

INTRODUCTION

Adsorption and reaction of CO₂ on solid surfaces are of great importance due to their application in industrial, energy, and environmental management. In particular, CO₂ and CH₄ gas mixtures are used in dry reforming (DRM) with Co-based catalysts, where CO₂ is considered to be the reactant and oxidizing agent to remove surface carbon. Previous CO₂ adsorption and dissociation studies have focused on the reaction of CO₂ on flat surfaces of Co. For example, using the Perdew–Burke–Ernzerhof (PBE) functional

in a generalized gradient approximation (GGA) with the inclusion of semiempirical DFT-D2 method, Ko et al.(2016) calculated that the adsorption energy (E_{ads}) of CO₂* on Co (0001) is -0.31 eV. The corresponding CO₂* dissociation activation energy (E_a) is 0.11 eV. Furthermore, De la Pen'a O'Shea et al. (2018) and Liu *et al.* (2012) also studied CO₂ activation on several FCC Co surfaces; however, the calculated results are not comparable due to the exclusion of van der Waals (vdW) forces. Theoretically, for catalytic reactions, higher indexed surfaces are assumed to be more active. However, specifics of CO₂ adsorption

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and dissociation reactions have not been previously documented and remain elusive on stepped Co surfaces. In particular, it is not clear which surfaces are more efficient in the activation of CO₂. Hence, in this study, we investigated the surface interaction of CO₂ over stepped FCC Co using the Co (211), and (221) as models. DFT calculations combined with the climbing image-nudged elastic band (CI-NEB) method were used to calculate the CO₂ adsorption and activation.

METHODOLOGY

The standard GGA Perdew-Burke-Ernzerhof (GGA-PBE) exchange-correlation functional was used for all the DFT calculations (Perdew, 1996). The electron-ion interaction was described using Vanderbilt's ultrasoft pseudopotential (Vanderbilt et al. 1990). The dispersion correction (DFT-D2) proposed by Grimme was used to describe the van der Waals interaction between the metal surfaces and adsorbates (Grimme, 2006). All calculations were carried out by using the STATE (Simulation Tool for Atom Technology) package.

RESULTS AND DISCUSSIONS

Several adsorption configurations of CO₂ were observed and the adsorption on the upper terrace of the stepped edge was identified as the most stable configuration, with adsorption energy (E_{ads}) of -1.03 eV and -1.02 eV for Co (211) and Co (221), respectively. The activation energies of the most possible pathway for CO₂ dissociation on Co (211) and Co (221) were 0.53 eV and 0.55 eV, respectively.

CONCLUSIONS

The mechanism of CO₂ adsorption and dissociation are exothermic and thermodynamically favorable for both Co (211) and Co (221). Comparatively, the activation of CO₂ on stepped Co is more exothermic than on flat Co (111).

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PARTIAL OXIDATION OF METHANE USING ASH DERIVED Co/Zeolite CATALYST FOR HYDROGEN RICH SYNGAS PRODUCTION

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ABSTRACT

Catalytic performance of series of cobalt-modified Zeolite- 4A-supported catalysts were analysed for the syngas (CO and H₂) production at 800 °C through the partial oxidation of the methane (POM). The Co/Zeolite-4A catalyst was synthesised using a two-step hydrothermal method. The synthesised catalysts were characterized by XRD, SEM/EDX TGA and Raman spectroscopy. The catalyst shows a crystalline structure with stability up to 900 °C. The catalytic performance analysis shows the CH₄ conversion is increasing from 29 to 68% for 0-10 wt.%Co over Zeolite-4A. The H₂ and was also improved from 28- 56% while CO selectivity from 24-52 %making H₂/Co ratio >1. The stability analysis shows the 10% Co/Zeolite-4A withstand for 24 hrs a time on stream the same performance. Finally, the spent catalyst was carried out to check the carbon formation and structure analysis.

Keywords: Partial oxidation of Methane, Zeolite 4A, Hydrogen production

INTRODUCTION

World's concerns towards climate preservation is increasing every day and the demand for transportation fuel is also increasing as well. Methane (CH₄) is the most abundant component of natural gas and is considered a greenhouse gas. CH₄ can be catalytically converted to its derivatives (CO and H₂) known as synthesis gas and other derivatives. Steam Reforming and Dry reforming of methane are very well-established practices but catalyst deactivation and carbon accumulation on the catalyst are the biggest problems in these processes which not only hinder maximum conversion but also contaminates the hydrogen. Partial oxidation of methane to attain the syngas has many advantages as it has the least problem associated with the syngas ratio and but carbon formation is one of the known issues to address (Fakeeha et al., 2020). It is well known that Co-based catalyst improves the stability and in turn termed as economic and efficient as compared to the other metal catalysts (Fonseca et al., 2020).

MATERIALS AND METHODS

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Z-4A was prepared by two-step hydrothermal treatment method. Fly ash was introduced into 5M NaOH solution in 700 mL beaker reactor. The solution was stirred at 100 °C and 300 RPM for 2 hours. Primary gel was prepared by aging the solution for 12 hours overnight. After this, the solution was filtered and the filtrate was kept in Teflon autoclaves and placed in the oven for 1.5 hours for 90 °C and then for 2 hours at 95 °C. The solution was then cooled

for 12 hours and was again filtered and this time residue on filter paper was dried in the oven. This dried

product is zeolite 4A. 10 wt % solution of Cobalt was prepared by $\text{Co}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$ (Sigma Aldrich) precursor. Then Zeolite was added to the solution and stirred for 15 minutes at 60 °C. The samples were washed with distilled water and were dried overnight at 110 °C. Before usage of prepared catalyst were calcined at 800°C for 4 hours.

RESULT AND DISCUSSION

The catalytic activity of POM is presented in Fig. 1. The CH_4 conversion exponentially increases while increasing in Co loading from 2.5-10 wt%. The H_2 and CO selectivity are increasing while increasing in Co loading and kept the H_2/CO ratio above than unity. The catalyst physicochemical properties are supporting the catalytic activity of the reported catalyst. The fine crystalline structure and uniform Co dispersion over Zeolite-4A are the main reasons for better catalytic activity.

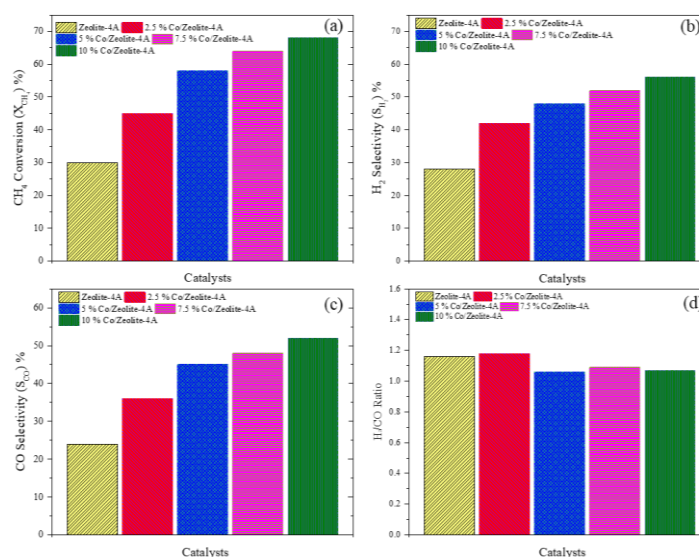


Fig. 1. Catalyst screening (a) CH_4 conversion (b) H_2 selectivity (c) CO selectivity (d) H_2/CO ratio; flow rate 30 mL min^{-1} , cat loading 0.25 g, reaction temperature 800 °C, $\text{CH}_4/\text{O}_2 = 2$

CONCLUSIONS

Various altered cobalt catalysts were examined for the POM with $\text{CH}_4/\text{O}_2 = 2$. No significant catalyst deactivation was observed during the 24-hour long test for 10% Co/Zeolite-4A. Hence, it can be concluded that the material under study is an excellent catalyst for POM.

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ROLE OF MICROALGAE AS A SOURCE FOR BIOFUEL PRODUCTION IN THE FUTURE: A REVIEW

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ABSTRACT

The continued burning of fossil fuels led to higher emissions of greenhouse gases and thus leads to global warming. Microalgae are one of the most important sources of green hydrocarbons because this type of algae has a high percentage of lipids and has rapid growth, consumes carbon dioxide in large quantities. Besides, the cultivation of these types of algae does not require arable land. This review aims to explain the suitability of microalgae as a biofuel source depending on the fat content, morphology, and other parameters and their effect on the conversion processes of microalgae oil into biofuels by different zeolite catalytic reactions. It also discusses the major chemical processes that convert microalgae oil to bio-fuels. The most important methods of production, their advantages and disadvantages are also deliberated in this work.

Keywords: biofuels, zeolite, rare earth metals, microalgae, deoxygenation.

INTRODUCTION

The limited reserves of fossil fuels and global warming caused by excessive carbon dioxide emissions have sparked global research on alternative and sustainable energy sources (Baamran et al. 2020). Therefore, microalgae as characterized by the efficiency of photosynthesis, grow rapidly, consume large quantities of carbon dioxide and produce large quantities of oxygen gas can contribute to reducing the effects of global warming. Microalgae can grow all over the world, where they can grow in the Scandinavian soil where the temperature is low and also possible to grow in desert soils where the temperatures are high and also possible to grow in freshwater and saltwater, we can say that microalgae can grow in all environmental conditions on the earth's surface. Microalgae are a promising and important resource for renewable energy due to their high content of triglycerides (up to 60%). Several studies have been conducted regarding the possibility of producing biofuels from microalgae fat to contribute to reducing the total dependence on fossil fuels.

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Microalgae Biomass: The selection of microalgae strains with high lipid content to obtain large amounts of biofuels is an important issue.

Obstacles to Using Microalgae Biomass: There are biological, chemical, and mechanical obstacles.

Microalgae Morphology: cell wall, and the cytoplasm (the mitochondrion and the chloroplast).

Production and Growth Techniques: The autotrophic growth, the heterotrophic growth, the mixotrophic growth, and other growth techniques.

The Composition of the Microalgae: The proteins, the lipids, the carbohydrates, the pigments, the minerals and the vitamins, and the minerals and the vitamins.

TABLE 1: Chlorella Vulgaris amino acid profile compared to other resources expressed in grams of protein per 100 grams.

Amino acids	C. Vulgaris	C. Vulgaris	Reccomendation from FAO/WHO	Eggs	Soya
Threonine	5.15	6.09	4.00	4.00	5.00

Microalgae Drying: Solar energy can be considered the main method for drying the biomass.

Extraction Techniques of Microalgae Oil: Solvent technique and ultrasound technique.

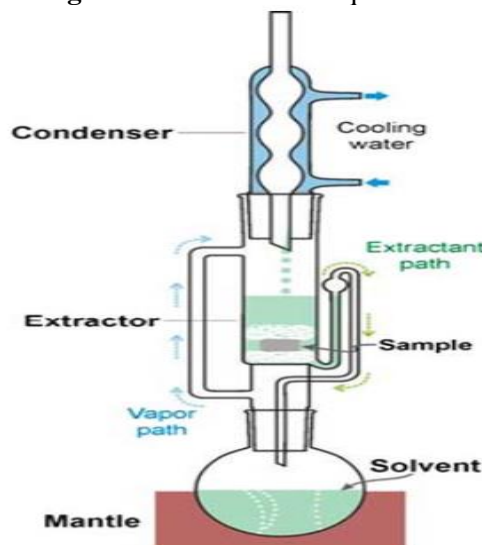


Fig.1 : The schematic diagram of the soxhlet apparatus [104]

Microalgal Biofuel Production: Thermal pyrolysis technique, gasification technique, hydrothermal liquefaction technique, fermentation technique, hydrodeoxygenation and deoxygenation technique, and simultaneous isomerization, cracking, and deoxygenation technique.

HZSM-5 Zeolite Modifications: Rare earth doping of HZSM-5 zeolite, phosphorus doping of HZSM-5 zeolite, and different Si/Al ratio for HZSM-5.

Advantages and Disadvantages of the Biomass Generations: There are four biofuels generations.

CONCLUSIONS

The use of catalysts in the production processes of biofuels from microalgae, such as zeolite (ZSM-5) is highly effective in the deoxygenation reaction.

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POTENTIAL OF MICROALGAE IN BIOREMEDIATION OF WASTEWATER

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ABSTRACT

The increase in global pollution, industrialization and fast economic progress are considered to inflict serious consequences to the quality and availability of water throughout the world. Wastewater is generated from three major sources i.e., industrial, agricultural, and municipal which contain pollutants such as xenobiotics, microplastics, heavy metals and augmented by high amount of carbon, phosphorus, and nitrogen compounds. Wastewater treatment is one of the most pressing issues since it cannot be achieved by any specific technology because of the varying nature and concentrations of pollutants and efficiency of the treatment technologies. The degradation capacity of these conventional treatment technologies is limited, especially regarding heavy metals, nutrients, and xenobiotics, steering the researchers to bioremediation using microalgae (Phycoremediation). Ongoing research in microalgae indicates that they have the required metabolic potential to effectively reduce high concentrations of C, N, P, K (causing eutrophication) from the wastewaters. Several types of microalgae like *Chlorella* and *Dunaliella* have proved their applicability in the treatment of wastewaters. The bottlenecks concerning the microalgal wastewater bioremediation need to be identified and elucidated to proceed in bioremediation using microalgae. This paper will provide an insight about the treatment of different wastewaters using microalgae and the challenges faced by the researchers to make it a viable technology.

Keywords: Wastewater, microalgae, Bioremediation, photobioreactors, emerging contaminants

INTRODUCTION

The vitality water is well known throughout the world and the issue of sustainable water management is a critical issue of discussion in all the sections of society, but the water resources are still under the risk of either being depleted or polluted raising an alarming situation. The reasons behind this overwhelming condition are the tremendous increase in population, industrialization, urbanization and economic growth (Sousa et al., 2018). As a cross sectional element, it has been reported that around 80% of the rivers in China are already polluted by organic and/or inorganic substances as well as by heavy metals (HMs) and emerging contaminants (ECs) (Li et al., 2019). Intensified research led to the advent of microalgae because

of its metabolic flexibility (can possess autotrophic, heterotrophic and mixotrophic metabolism) they can become a sustainable and efficient biological system for the treatment of various types of wastewater. Microalgae (Microphytes) are microscopic organisms either eukaryotic or prokaryotic in structure and are typically found in fresh or marine water bodies (Yousuf, 2020).

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BIOREMEDIATION OF WASTEWATER USING MICROALGAE

Microalgae based wastewater treatment (MBWT) is considered as one of the most convincing technologies because of the potential of microalgae in the removal of pollutants and nutrients. MBWT is having various advantages like (i) Bioremediation of wastewater (removal of wastewater pollutants: COD, HMs, ECs); (ii) Nutrients removal and recovery (e.g., Total Nitrogen, Total Phosphorus). (iii) Recovery of water and reusability of culture medium. Microalgae possess numerous advantages such as its adaptability with varying climatic conditions as well as varying nature of wastewater, removal of exclusive contaminants like polycyclic aromatic hydrocarbons (PAHs), pesticides, endocrine disrupting compounds (EDCs) etc., high growth rates and valorization of microalgal biomass for biofuels and value added product (Ahmed et al., 2017). Municipal waste effluent (MWE) treatment with microalgae shows good results in the removal of N and P, increase the DO content in the effluent and checks the growth of bacteria. Two examples of microalgal treatment of wastewaters are shown in Table 1.

TABLE 1: Effectiveness of Microalgae in the treatment of different wastewater

Type of wastewater	Cultivation conditions	Species of Microalgae	Pollutants/Nutrients Removal	References
Municipal Wastewater	Twin layer Photobioreactor	<i>Halochlorella rubescens</i>	PO ₄ -P=73.2%, NO ₃ -N=83.2%	(Shi et al., 2014)
POME ^a	Anaerobically treated POME	<i>Arthrospira platensis</i>	COD=50.8%, N=96.5%, P=85.9%	(Hadiyanto et al., 2013)

^aPOME-Palm Oil Mill effluent

CONCLUSIONS

Bioremediation of wastewater using microalgae represent a wider area of future research and development. Microalgae is having great potential in terms of removal of pollutants such as COD, N, P, HMs, and ECs. Furthermore, the high values of N and P in different wastewaters make it possible to use them as nutrient source to produce microalgal biomass which can be valorized for biofuels and other value-added products.

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OZONOLYSIS PRETREATMENT OF EMPTY FRUIT BUNCH FOR ENHANCED TOTAL REDUCING SUGAR YIELD

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ABSTRACT

In Malaysia, abundance of agricultural waste especially empty fruit bunch (EFB) is available for utilization as feedstock in biochemical synthesis or biofuel production. Hence, ozone pre-treatment is introduced to break the EFB structure and enhances lignin degradation as well as increases sugar release. In this study, EFB was pre-treated using ozone in a ribbon-mixer reactor where the effect of ozone on lignin degradation and the total reducing sugar yield are studied. The highest delignification and total reducing sugar yield obtained are 95.7 wt.% and 0.85 g/g ozone treated EFB (OTE), respectively. The longer reaction time and excessive ozone concentration contributed to high ozone consumption which added to production cost. The total reducing sugar (TRS) yield decreases as the production of inhibitory compounds occurs due to reaction between low molecular lignin compounds and degraded sugar after 740 g/g ozone consumption.

Keywords: Ozone, Biomass, Pre-treatment, Delignification, Empty Fruit Bunch, Oil Palm.

INTRODUCTION

Waste lignocellulose has huge potential to be a promising material for the production of second-generation biofuels (Ab Rasid et al. 2020). In Malaysia, EFB is produced as a waste from crude palm oil, and has been abundantly left underutilized. One of the main constraints to utilize EFB for industrial application is the needs for pre-treatment steps to break down the recalcitrant structure of lignocellulose into its fibrous components of holocellulose and lignin. However, there are several limitations that challenge the biorefinery industry. The most crucial one is the low efficiency of enzymatic hydrolysis of structural polysaccharide. Several factors have been proven to account for this, including particle size, cellulose crystallinity, degree of polymerization, and lignin content (Travaini et al. 2016). Among these factors, lignin content impacts on biomass degradability is the highest. Lignin removal enhances binding of enzymes to the cell walls and the extent of degradation; hence the best pre-treatments should maximize lignin removal. Although a lot of research has been done, the full-scale development of biomass ozone pre-treatment has not been established due to several problems related to the amount of ozone consumption and the cost of ozone generation (Neely 1984). A series of samples with a range of particle size and

moisture content was pre-treated with ozone in a ribbon mixer semi-batch reactor under various conditions (Fig. 1). Total reducing sugar (TRS) yield of untreated sample (raw) and OTE were investigated. The study of lignin modification by ozone pre-treatment could provide useful information for the development of ozonolysis pre-treatment process.

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MATERIALS AND METHODS

Materials

EFB samples, in shredded form, was collected from a palm oil mill located at Penggeli, Kulai, Johor, Malaysia. The chemicals used in this study were sulphuric acid, H_2SO_4 (95–98%) (Qrec, NZ), sodium carbonate (Qrec, NZ), potassium iodide (Qrec, NZ), potassium permanganate (Fisher Brand, UK), oxygen gas (170 bar, 8.4 m^3), cellulose (Sigma–Aldrich, USA) and d-glucose (Qrec, NZ).

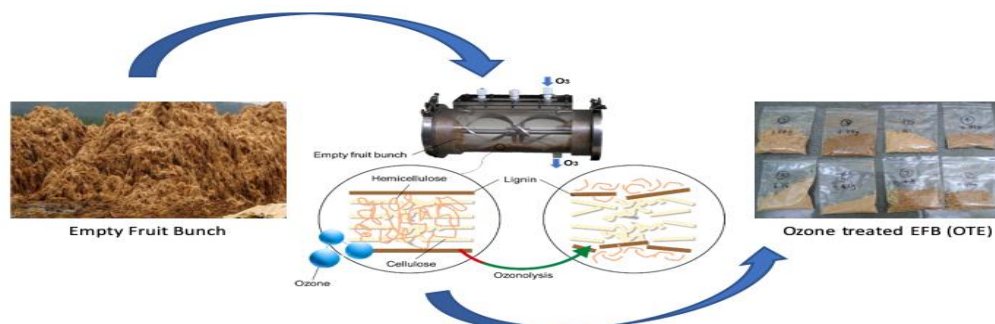


Fig. 1: Ozonolysis pretreatment of EFB

RESULT AND DISCUSSION

The optimum process parameter for ozonolysis process of EFB is shown in Table 1. The axial mixing of the ribbon mixer helps to increase reaction rate and interfacial contact of the biomass with ozone to enhance the oxidation reaction. The pre-treatment of EFB with ozonolysis is more effective with higher lignin degradation rate and hence, increases the total reducing sugar yield from 0.19 g/g OTE to 0.85 g/g OTE.

TABLE 1: Optimum process parameters of ozonolysis pretreatment of EFB

Raw Material	Reactor Design	Moisture Content (%)	Ozone Conc. (g/m^3)	Volumetric Flow rate (L/h)	Time (h)	Lignin Degradation (%)	TRS Yield (g/g OTE)
EFB	Ribbon mixer	40	60	60	1	95.7	0.85

CONCLUSIONS

This study shows that the optimum reaction parameters of EFB in ribbon mixer reactor could increase TRS yield in the pre-treatment of EFB by ozonolysis. The mixer in the reactor increases the interaction between EFB particle with ozone and enhances lignin degradation and TRS yield.

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SYNTHESIS OF MESOPOROUS MAGNESIUM OXIDE ADSORBENT USING LIME (*CITRUS AURANTIFOLIA*) PEEL TEMPLATE FOR CO₂ CAPTURE

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ABSTRACT

Mesoporous magnesium oxide (MgO) was synthesised using lime (*Citrus aurantifolia*) peel as a template. This approach has resulted in the improvement of MgO-LPT structural properties, and this impact an excellent CO₂ uptake capacity. Prepared MgO adsorbents were characterised through N₂ physisorption isotherms, Fourier-transform infrared spectroscopy, and Thermogravimetric analysis. The CO₂ uptake testing of prepared adsorbent was conducted using a fixed U-shaped gas column equipped with CO₂ analyser instrument at ambient temperature and pressure under 100% CO₂ gas. The MgO-LPT exhibited higher BET surface area, BJH pore volume and pore diameter of 23 m²/g, 0.142 cm³/g, 24.6 nm, respectively than MgO (thermal decomposition), which indicates a mesoporous structure adsorbent. This MgO-LPT structural properties enhancement has resulted in the higher CO₂ uptake capacity of 3.79 mmol CO₂/g, which is 15-times higher than MgO-TD. It is showed that the utilisation LPT as a template is a promising approach to enhance the adsorbent's surface area, thus contributing to the increase of the CO₂ capture performance.

Keywords: magnesium oxide, lime peel template, bio-templating, CO₂ capture, *citrus aurantifolia*

INTRODUCTION

Adsorption is one technique proposed to replace the current CO₂ capture method (absorption) since absorption has several drawbacks. For instance, the absorption method possesses poor sorbent stability, high equipment corrosion rate, solvent (amine) degradation and high regeneration cost (Ruhaimi, Aziz, & Jalil, 2021). However, preparing high surface area adsorbent through the conventional method using surfactant as a template such as CTAB seems costly due to expensive surfactant templates and complex synthesis processing procedures (Abarna, Preethi, Karunanithi, & Rajarajeswari, 2016; Wang, Zhang, & Chen, 2009). Therefore, utilising biomass as a template would be an alternative approach to fabricating adsorbent with excellent textural properties. Several studies have reported on adsorbent's physicochemical properties enhancement via utilisation of jute root, rose petal, etc. and result in the enhancement of sample performance. In addition, common metal oxide adsorbent such as magnesium oxide (MgO) possess a low specific surface area, which results in low CO₂ uptake capacity (Ruhaimi et al., 2021). Hence, in this study, mesoporous MgO was synthesised using lime (*Citrus aurantifolia*) peel as a bio-material template.

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MATERIALS AND METHODS

Materials

Lime peel waste used in this study was obtained from the local market. The chemical reagents used were ethylene glycol,

magnesium nitrate hexahydrate ($\text{Mg}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$), and ammonia solution (NH_3) 28% were purchased from QR&C.

RESULT AND DISCUSSION

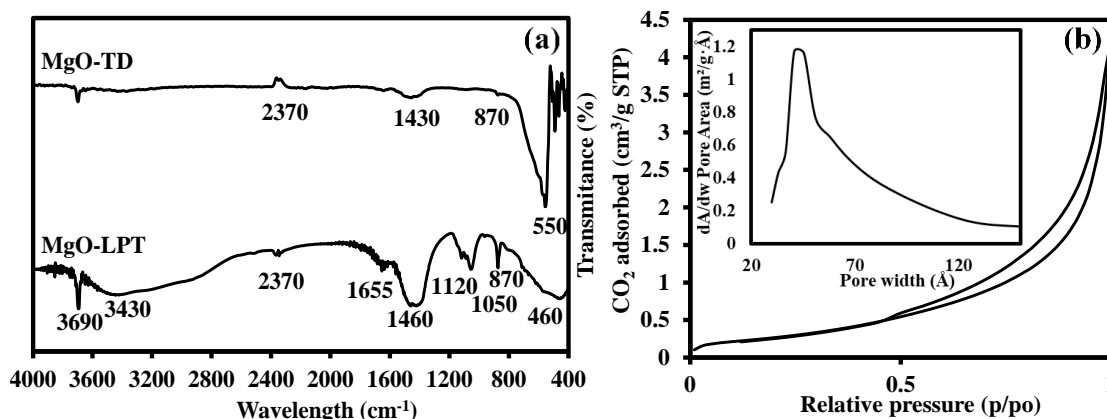


Fig. 1: a) FTIR spectra of MgO-TD and MgO-LPT and (b) N_2 adsorption-desorption isotherm of MgO-LPT. (Insert: BJH pore distribution curve of MgO-LPT)

As depicted in Fig. 1a), MgO-LPT has exhibited more peak than MgO-TD associated with adsorbed atmospheric CO_2 . Those peaks were assigned to the existence of monodentate carbonate, bicarbonate and bidentate carbonate. It could be an indicator for the adsorbent which possess a more active site that is induced to the high CO_2 uptake capacity. In addition, CO_2 adsorption testing has revealed that the MgO-LPT (lime peel template) exhibited higher CO_2 uptake capacity of 3.78 mmol CO_2/g , which 15-times higher than MgO-TD (thermal decomposition). It might be due to the enhancement of the adsorbent surface area ($23 \text{ m}^2/\text{g}$) resulting from the LPT bio-templating method.

CONCLUSIONS

The lime peel template utilisation has improved MgO textural properties, which finally influences adsorbent CO_2 capture performance.

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CHALLENGES & OPPORTUNITIES ON CATALYTIC CONVERSION OF GLYCEROL TO VALUE ADDED CHEMICALS

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ABSTRACT

With the rapid expansion of biodiesel industry, its main by-product, crude glycerol, is anticipated to reach a global production of 6 million tons in 2025. It is actually a worrying phenomenon as glycerol could potentially emerge as an excessive product with little value. Glycerol, an alcohol and oxygenated chemical from biodiesel production, has essentially enormous potential to be converted into higher value-added chemicals. Using glycerol as a starting material for value-added chemical production will create a new demand on the glycerol market. Among these chemicals are lactic acid, propylene glycol, alkyl lactate, methyl lactate, acrolein, hydrogen, olefins and others. This paper reviews the challenges and opportunities the catalytic conversion of glycerol to value added chemicals. Focus must be given on the catalyst design robustness, reactor technology, reaction mechanism and thermodynamic to uplift the potential of glycerol as usable feedstock.

Keywords: glycerol, catalytic transformation, value added chemicals

INTRODUCTION

The notion of catalytic glycerol conversion to important chemicals and fuel is not new. Catalytic conversion of glycerol to value added chemicals has emerged as another potential process to be profitable (Muraza, 2019). This occurs in view of the abundant availability and rock bottom price of glycerol in the market (Paillet et al., 2019). Several reactions involving the catalytic transformation of glycerol to precious chemicals such as hydrogen, acrolein, propylene glycol, glycerol carbonate, epichlorohydrin, glycerol ether, olefins and others have been widely reported. Nonetheless, the ultimate issue is the feasibility of the overall process to be commercially viable. Many of the processes are not in optimum state to be invested for. Aspects such as the fundamental chemistry, catalyst design and stability, process, reactor development, modelling and simulation works are still lacking. More investigations need to be performed to seek and establish a profitable pathway for catalytic conversion of glycerol to its derivatives. The objective of this mini-review is to discuss the challenges and opportunities for catalytic conversion of glycerol to important chemicals with consideration of utilizing refined and crude glycerol. Associated features within the processes such as catalyst design, reactor technology, commercial viability, reaction mechanism and thermodynamic study will be discussed.

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CHALLENGES, OPPORTUNITIES AND DIRECTION

The transformation of glycerol (crude or pure condition) to value added chemicals is not easy as it sounds. There are numerous parameters that need to be considered, optimized and obliged. Even though vigorous researches have been conducted since the past decade (Corma et al., 2008), overall yield of value added products are still yet to reach pilot or commercial scale except for few chemicals like epichlorohydrine (ECH) and glycerol carbonate.

These are the main challenges that need to be addressed. Subsequently there will be opportunity for improvement of the process so we can head towards the correct direction.

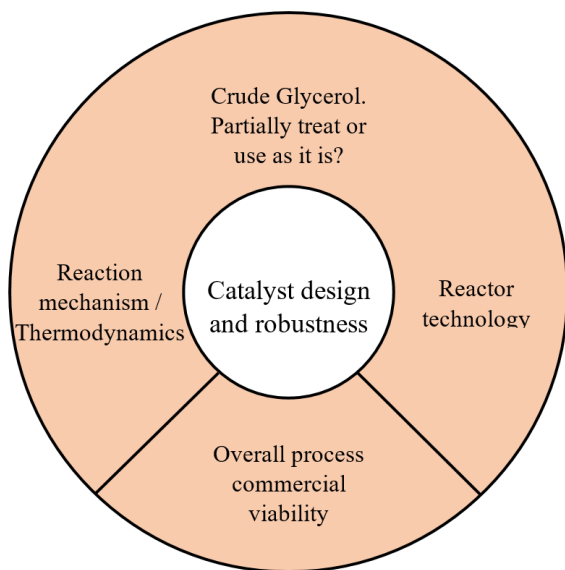


Fig. 1: Challenges to be dealt with for catalytic conversion of glycerol to value-added chemicals

There are several areas that can be focused to rapidly improve the transformation of glycerol to value added chemicals. The prime area to improve is the catalyst design and robustness. The catalyst design will have to consider whether crude or refined glycerol is employed. The physicochemical properties of the catalyst and its reactivity during reaction will affect the rate of deactivation. Hence, this is the reason main focus should be driven to catalyst design. The reactor technology will also be the next issue to be concentrated on. Different value added chemicals require different processes and reactors. One of the lacking elements for the glycerol conversion research is that, less attention are given on the reaction mechanism and thermodynamic modeling of a particular reaction. This indicates that less fundamental reaction and thermodynamic aspects are comprehended. Lacking in this area will halt the progression of upcoming development.

A significant challenge remains in the decision to select between the utilization of crude or refined glycerol. Both has its own pro and cons. Obviously opting for crude glycerol will be economical on the front end but more complex and costly during reaction and separation stage. The successfully commercial ECH production plant in Europe employs crude glycerol as feed, but they treat the crude glycerol into certain extend before processing it to produce ECH. Hence, there are massive research opportunities to seek for a proven reaction or process that can utilize crude glycerol.

CONCLUSIONS

Conversion of glycerol to value added chemicals are still in pursuit for commercial success. Only a few of the available technologies are readily available for commercialization for a few chemicals. There are massive challenges and still huge opportunities for exploration of the catalytic transformation of glycerol to its derivatives. This will eventually lead to the correct direction.

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CATALYTIC PYROLYSIS OF MUNICIPAL SOLID WASTE: EFFECTS OF REACTION TEMPERATURE AND MgO-BASED CATALYSTS

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ABSTRACT

Burning Municipal Solid Waste (MSW) increases CO₂, CH₄, and SO₂ emissions, leading to an increase in global warming that encourages governments and researchers to look for an alternative. The pyrolysis process has been investigated as an attractive alternative to incineration for MSW disposal that allows energy recovery. The pyrolysis process converts the MSW to oil, gas, and char. In this study, catalytic and non-catalytic pyrolysis of MSW to produce bio-oil using MgO based catalysts was investigated. The reaction temperature, catalysts loading, and catalysts supports were evaluated. MgO supported Active Carbon (AC) and Al₂O₃ to evaluate the support's role in MgO catalysts activity. The oil yields varied from 20.6% to 42.4% based on the experimental conditions. The results showed that adding the catalyst enhanced the bio-oils quality and decreased the oxygen content of the bio-oil.

Keywords: Municipal Solid Waste, Pyrolysis, Bio-oil, Catalytic Pyrolysis, Waste Management

INTRODUCTION

Treating the Municipal Solid Waste (MSW) by burring or dumping in landfills creates environmental and health issues that encourage governments and researchers to look for an alternative and convert the MSW into useful products. MSW, otherwise known as trash or garbage, is a biomass source containing on average 34% food, 20% paper, 18% plastic, 11% glass, 11% metals, and 6% agriculture waste (Matsakas, Gao, Jansson, Rova, & Christakopoulos, 2017). Around 1.9 billion tons of MSW are produced worldwide per year, and the average production is 218 kg per person. Fifty to sixty percent of MSW (paper, glass, plastic, and metals) could be recycled, and 40–50% of MSW could be used to produce biofuel and energy. The pyrolysis process converts the MSW to oil, gas, and char. Furthermore, it is an environmentally friendly process owing to produces fewer emissions compared to gasification. Thus, the overarching of this study to evaluate the effect of pyrolysis parameter on the yield of MSW pyrolysis products. The reaction temperature, and catalysts loading, and catalysts supports were evaluated. MgO supported Active Carbon (AC) and Al₂O₃ to evaluate the support's role in MgO catalysts activity.

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MATERIALS AND METHODS

Mg (NO₃)₂ 6H₂O (Sigma-Aldrich), commercial γ -Al₂O₃ (Sasol North America), and Darco activated carbon (AC) (Sigma-Aldrich) are used for preparing the catalysts (MgO, Al₂O₃, AC, MgO/Al₂O₃, and MgO/AC). The catalysts BET (Brunauer-Emmett-Teller) surface area, pore-volume, and average pore size

were determined from the N₂ adsorption-desorption isotherms measured at 77 K using a Micromeritics ASAP 2020 analyzer (Almohamadi & Smith, 2020). Crystalline phases present in the catalysts were identified by X-ray diffraction (XRD).

The MSW contains 42 wt% food, 16 wt% paper, 9.5% agriculture waste, and 32 wt% plastic. A Mettler Toledo TGA (SDTA851) was used to conducting a Thermogravimetric Analysis (TGA) for the MSW to assess the optimum heating rate and reaction temperature. The MSW with average particle size 2mm was used as feedstock for the pyrolysis reactor. 200 g of biomass was placed in a fixed bed reactor which operated in batch mode. Preheater N₂ was utilized to carry the reaction products (vapor and gas) toward a condenser. The oil was analyzed by using a Thermo Scientific Flash 2000 elemental analyzer to quantify the element content in the oil. Oxygen content in the oil was obtained by subtracting the C, H, and N from the total mass. The oil was analyzed using Hewlett-Packard HP 7890 Q2010 gas chromatograph-mass spectrometer (GC-MS) to analyze the composition of the oils.

RESULT AND DISCUSSION

The BET results showed that adding MgO to AC and γ -Al₂O₃ decreased the support's porosity owing to the pores of AC and γ -Al₂O₃ were filled by MgO. XRD patterns of the catalysts showed the γ -Al₂O₃, and MgO peaks are very sharp, suggesting the crystallites of γ -Al₂O₃ are small and big for MgO. The TGA results illustrated that MSW decomposition started at 380 °C and reached 75% decomposition at 500 °C. Moreover, the TGA results illustrated that the heating rate had not significantly impacted the decomposition of MSW. Increasing the temperature from 500 to 600 °C increased the decomposition just by 3-6%. The results showed that as the residence time increased from 20 min to 60 min, the char yield decreased, and the gas yield increased. The 40 min resistance time produced the highest oil yield of 42.6 wt%. The oil yields varied from 20.6% to 42.4% based on the experimental conditions. For the non-catalytic pyrolysis experiment, the results showed as the temperature increased, the gas yield increased, and char yield decreased, the maximum oil yield was 42.6% obtained at 500°C. The results showed that adding MgO, MgO/Al₂O₃, and MgO/AC decreased the oil yield and increased the gas yield. However, the catalysts showed significant deoxygenation activity, which improves the quality of the oil. Of the catalysts which had high deoxygenation activity, MgO/AC had the highest relative yield. The loading of MgO/AC varied from 5 to 30 wt.% of feed to pyrolysis reactor, and as the catalysts load increased, the oil yield decreased while increased the gas and char yields.

CONCLUSIONS

The residence time of the reaction and heating rate had not significantly impacted the bio-oil yield. Base on the reaction conditions and the feedstock compositions, the optimum temperature for MSW pyrolysis was 500 °C. Increasing the reaction temperature increased the gas yield and decreased the char yield. Adding the catalysts decreased the yield of the bio-oil and improved the quality of the bio-oil.

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DEVELOPMENT OF REACTION KINETICS MODEL FOR THE PRODUCTION OF SYNTHESIS GAS FROM DRY METHANE REFORMING

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ABSTRACT

The energy supply systems dependent on fossils and municipal solid waste (MSW) materials are primarily and largely responsible for the release of greenhouse (GHG) gases and their related environmental hazards. The increasing amount of methane (CH₄) and carbon dioxide (CO₂) is the main concern of the scientific community in this context. Reduction in the emission amount of both gases combined with the conversion technologies that would convert these threat full gases (CO₂ and CH₄) into the valuable feedstocks will contribute significantly to lower their hazardous impact on the climate change. The conversion technique known as dry methane reforming (DMR) utilizes the CO₂ and CH₄ to produce a combustible gas mixture (CO+H₂) popularly known as synthesis gas/or syngas. Therefore, the purpose for this research study is to explore and enlighten the characteristics of DMR mechanism. The conversion behavior of CO₂ and CH₄ was studied with modelling and simulation of the DMR process using MATLAB. The results showed that inlet gas flow in gas phase effect has significant effect on the reactions whereas inlet molar composition ratio of the reactions was found to have no substantial effect on the mechanism of DMR.

Keywords: greenhouse gases; synthesis gas; dry methane reforming; reaction kinetics modelling

INTRODUCTION

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Dry methane reforming (DMR) produces less hydrogen (H₂) in comparison to the H₂ produced by steam reforming process. Therefore, dry methane process (DMR) has more feasibility for the biogas (already a mixture of CH₄ and CO₂ as the final product from anaerobic digestion (AD) process) and there is no additional need for downstream separation process for CO₂ removal. For dry methane reforming (DMR) there are several kinds of carbon formation on Ni-based catalyst. Several reactions contribute to the deposition of carbon on the catalysts surface during the complete formation process cycle. The reverse boudouard reaction is limited at high temperature. However, the methane decomposition reaction is thermodynamically

more favorable at high temperature. There should be the application of catalysts that can inhibit the carbon

formation and its deposition at the reaction condition. In this project, a reaction kinetic model developed to predict the products and to investigate the effect of temperature on final product composition using MATLAB.

MATERIALS AND METHODS

MATLAB function m-files were developed by writing a function codes. The function m-files being developed with objectives of producing final guess value of all independent variables such as activation energy (E_a) and reaction rate constant (k) throughout the optimization process. The optimization in the MATLAB simulation was carried out using the experimental data taken from literature for studying the reaction kinetics of dry methane reforming (DMR) process. Reaction kinetics constants obtained and extended for parametric study. The conditions for the gas flow at the inlet feed was set constant at 3600 ml/hr and 5400 ml/hr with equal molar ratio ($\text{CH}_4:\text{CO}_2=1:1$).

RESULT AND DISCUSSION

Fig. 1 showed the product gases CH_4 , CO_2 , H_2 , and CO using 3600 ml/hr with temperature range of 650-850°C. The mole percentages of all four components were plotted against temperature. It has been observed that as the temperature increases from 650 to 850°C, there has been a constant increase in the conversion of both CH_4 and CO_2 (decline in mole %) and consequently an increase in the amount (mole %) of H_2 and CO . Similar trends has been observed in literature by Al-Ali et al. (2014). Due to this intention, an optimization strategy was practical to implement and to understand the trade-off between high production rate and high CO_2 and CH_4 consumption rate in dry methane reforming. The increase on H_2 and CO is mainly cause by the endothermic behavior of reactions involved in the dry methane reforming process.

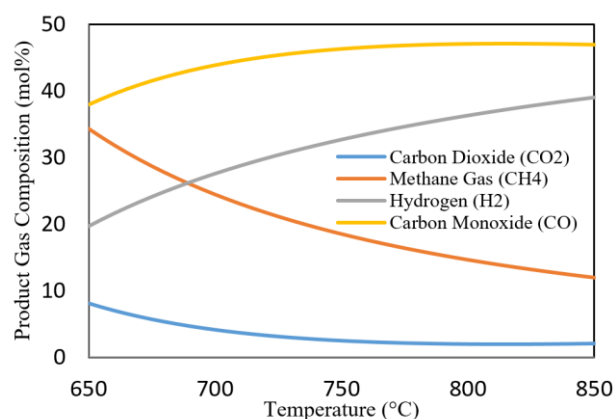


Fig. 1: Effect of temperature on product gas composition (mol%) at gas inlet flow 3600 ml/hr.

CONCLUSIONS

This research study expected to fulfill the main objective which is successfully to develop the reaction kinetics model for the dry methane reforming and to perform parametric study for the hydrogen and carbon monoxide production from greenhouse gases that produced from landfills gas which are carbon dioxide and methane as well as to calculate the reaction kinetics constant using optimization approach (MATLAB optimization toolbox).

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SYNTHESIS OF $\text{Ce}_{0.85-x}\text{La}_{0.15}\text{Ca}_x\text{O}_{2-\delta}$ SUPPORTED CATALYST FOR PARTIAL OXIDATION OF METHANE

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ABSTRACT

In this study, $\text{Ce}_{0.85-x}\text{La}_{0.15}\text{Ca}_x\text{O}_{2-\delta}$ was synthesized using sol-gel combustion method and applied for partial oxidation of methane (POM). The physicochemical properties of catalyst were analyzed using X-ray diffraction (XRD), scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy (EDS), thermogravimetric analysis (TGA), and RAMAN spectroscopy. Material shows a pure cubical structure and is highly stable up to 850 °C. The performance testing indicated the conversion of CH_4 is 65% and selectivity of H_2 and CO are 28% and 8% respectively. The performance indicated the catalyst has a potential to be used for partial oxidation of methane in larger scale.

Keywords: partial oxidation of methane, catalysis, hydrogen production, catalyst support.

INTRODUCTION

The world is starting to accept hydrogen (H_2) gas as the fuel of the future, due to its ability to produce clean energy at higher efficiencies than conventional fuels. However, production of H_2 gas is still a concern that needs to be addressed before the world can look towards it as the primary source of energy. One of the most accepted methods of H_2 production is from partial oxidation of methane (POM). It is widely studied technique for the production of H_2 rich syngas. (Pudukudy et al., 2015) POM is a stable process and of requiring a lot less energy for the production of syngas as compared to other reforming processes. Furthermore, POM has a very high conversion rate of methane and excellent H_2 selectivity (Fakeeha et al., 2020). However, the major concern is carbon deposition and lower H_2/CO ratio which is to be addressed, as reported in literature. (Kaddeche et al., 2017). In this study, the $\text{Ce}_{0.85-x}\text{La}_{0.15}\text{Ca}_x\text{O}_{2-\delta}$ is synthesized with various Ca loading and tested for POM. The characterization such as XRD, SEM/EDS and TGA were performed to analyze its suitability for POM.

MATERIALS AND METHODS

In this research, $\text{Ce}_{0.85-x}\text{La}_{0.15}\text{Ca}_x\text{O}_{2-\delta}$ was synthesized using sol-gel aided citric acid-nitrate combustion method. Cerium nitrate hexahydrate, Lanthanum nitrate hexahydrate and Calcium nitrate tetrahydrate (Sigma Aldrich) were all used as metal precursors and citric acid was used as the chelating agent and fuel for the sol-gel combustion.

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All metal precursors were mixed in deionized water and continuously stirred for 2 hours at 80 °C. Citric acid was added to the solution in the ratio of 1:1.5 (metal precursors: citric acid) and the temperature was increased to 120 °C. The mixture was further stirred at this temperature for another hour to ensure proper mixing of all precursors. After this, the temperature was increased to 400 °C and the temperature was maintained until the combustion was completed and yellowish ash was obtained. This was later dried overnight and calcined at 850 °C.

RESULTS AND DISCUSSION

The prepared samples with Ca loading (0, 5 and 10%) were tested for partial oxidation of methane. The material has been identified via XRD as shown in Fig.1(a). The pure crystal structure can easily be seen and identified via JCPDS. The catalytic performance is shown in Fig.1(b).

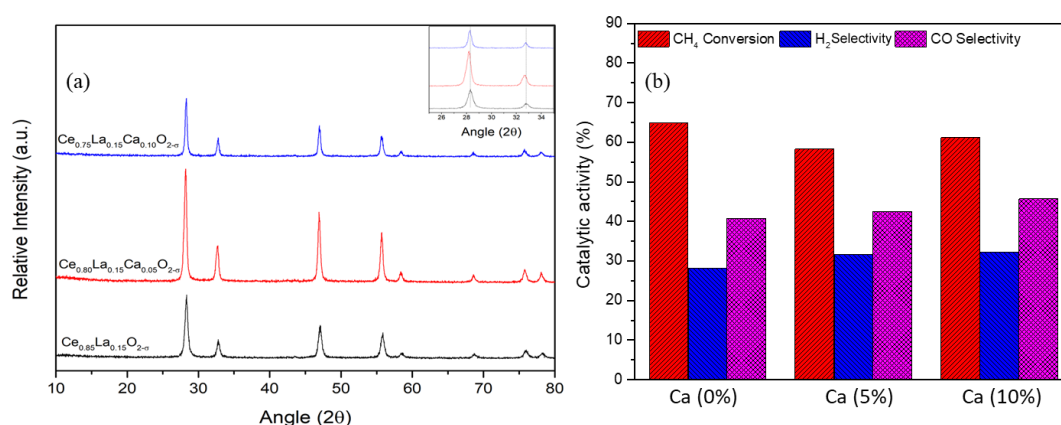


Fig. 1: Catalytic performance of all samples in POM

CONCLUSIONS

The composition with 10% Ca showed best results in terms of H₂ selectivity and yield, however it shows partly lower CH₄ conversion. As mentioned before, the tests were conducted with no active catalyst loading on the samples and still it showed better H₂ selectivity. Hence, it can be concluded that the material studied in this research can be a viable support for catalyst in partial oxidation of methane.

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CO₂ ELECTROREDUCTION USING ITO SHEET DECORATED MODIFIED-TITANIA AS ELECTRODE

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ABSTRACT

In this work, methanol and hydrogen (H₂) products are concurrently produced via CO₂ reduction and direct water electrocatalysis, respectively, using ITO sheet decorated with modified-titania (TiO₂) as working cathode. Electrochemical reactor containing 0.1 M KHCO₃ aqueous solution with CO₂ as electrolyte and modified-TiO₂ nanorods (NR) as working electrode offers an eco-friendly system to produce clean and sustainable energy system. Higher methanol and H₂ production rate are attained using ITO sheet decorated with modified-TiO₂ NR compared to ITO sheet with commercial TiO₂ microparticle (MP). At 2.0 V applied potential vs Ag/AgCl as reference electrode, modified-TiO₂ NR electrocatalyst yielded higher methanol and H₂ at a rate of 3.32 $\mu\text{mol cm}^{-2} \text{h}^{-1}$ and 6 $\mu\text{mol cm}^{-2} \text{h}^{-1}$, respectively, than commercial TiO₂ MP electrocatalyst. Enhancement of methanol and H₂ yields could be attributed to notable improvements and modification in TiO₂ structure as working electrode interface.

Keywords: CO₂ electroreduction, water electrocatalysis, methanol, hydrogen, TiO₂ nanorods.

INTRODUCTION

A cleaner production of hydrogen (H₂) and CO₂ reduction has a great potential to replace fossil fuel dependency. Presently, most of H₂ production is commercially produced by steam reforming of natural gas, which causes CO₂ emissions. Electrochemical (EC) process can be used to produce H₂ and methanol via electrocatalysis of water and CO₂ reduction under low electrical bias. The electrocatalytic efficiency of CO₂ reduction and direct water electrocatalysis depends on the working electrode or semiconductor used as electrocatalyst. Particularly, TiO₂ is considered as promising electrocatalyst and semiconductor for EC processes because of abundant availability, ecofriendly, cheap, negative flat band potential, unique electronic configuration and stable towards corrosive chemicals. However, commercially available TiO₂ microparticle (MP) suffers from low surface area and fast electrons (e⁻) and holes (h⁺) recombination rates which affects the efficiency of electrocatalytic activity (Baran & Yazici, 2016). The problem of charge recombination and surface area can be addressed by changing and modification of surface morphology of TiO₂ for better charge separation and enhanced surface area. Based on these hypotheses, herein, a simple and uniquely modified-TiO₂ nanorods (NR) electrocatalyst is synthesized for efficient CO₂ reduction and direct electrocatalysis of water to produce methanol and hydrogen (H₂).

MATERIALS AND METHODS

Materials

Titanium (IV) oxide (TiO₂) anatase, sodium hydroxide (NaOH), dimethylsulfoxide (DMSO), indium tin oxide coated glass slide (ITO) and Platinum (Pt) wire were purchased from Sigma-Aldrich.

Synthesis of electrocatalyst

TiO₂ NR was synthesized by hydrothermal method as reported elsewhere (Abbas, Tahir, & Saidina Amin, 2019). Modified-TiO₂ NR electrode was fabricated on

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ITO slide by catalyst ink method. For this purpose, 0.1g of TiO₂ NR was mixed in 10 μL DMSO and

sonicated for 6 h to synthesize an evenly dispersed and viscous catalyst ink. Then, the ITO slide was carefully covered with catalyst ink by drop-casting method which was then transferred to oven for drying at 100 °C for 6h.

RESULT AND DISCUSSION

The electrochemical (EC) experimental setup consist of electrochemical workstation (Keithley 2450-EC, Tektronix, USA) in a typical three-electrode system of EC microreactor with continuous flow of CO₂ (20 ml/min). The prepared electrocatalyst samples, Pt wire and standard Ag/AgCl electrode were used as working, counter and reference electrode, respectively. Based on Fig. 1a, the cyclic voltammetry (CV) curves shows relatively higher electrochemical surface area and current density for TiO₂ NR electrocatalyst as compared to commercial TiO₂ MP. This increment could be attributed to the reduction in charge recombination rates and increase surface area of modified-TiO₂ NR (Baran & Yazici, 2016).

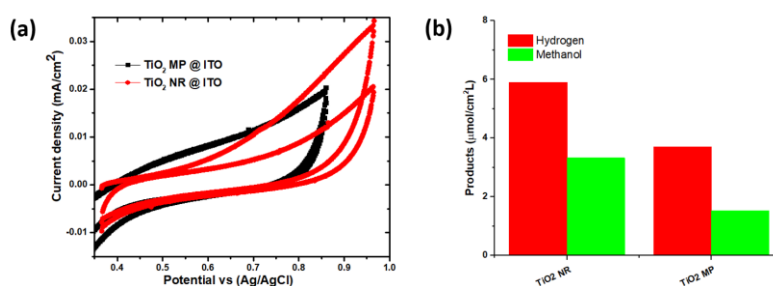


Fig. 1: (a) Cyclic voltammetry curves for various electrodes/ electrocatalyst @ 50 mV/s and ~ 0.3 to 1.0V potential range; (b) electrocatalytic activity test for different electrocatalysts.

Fig. 1b shows the electrocatalytic activity test for different electrodes. The H₂ and methanol production rate for modified-TiO₂ NR electrocatalyst was recorded as ~6.0 μmol cm⁻² h⁻¹ and 3.32 μmol cm⁻² h⁻¹, respectively, at 2 V of potential vs Ag/AgCl for 1 h. The improvement in product yields of methanol and H₂ is mainly due to notable improvements and modification in morphology of TiO₂ electrocatalyst interface. Moreover, catalytic activity improvement of modified-TiO₂ NR electrocatalyst might be contributed by enhanced charge separation of TiO₂ after structural modification. The CV results for modified-TiO₂ NR electrocatalyst also justifies the improved EC performance.

CONCLUSIONS

Modified-TiO₂ NR electrocatalyst exhibit excellent EC CO₂ reduction and water electrolysis activity for methanol and H₂ production. The CV experiments for TiO₂ NR electrocatalyst confirms the justification for improved catalytic performance. This work develops an effective and facile modified-TiO₂ NR electrocatalyst as competent EC working electrode for sustainable energy conversion.

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DETERMINATION OF THE MAGNETIC PROPERTIES OF $\text{Sm}_2\text{Co}_{17}$ AS A SOFT MAGNETIC MATERIAL AT LOW-TEMPERATURE SINTERING PROCESS

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ABSTRACT

The instability of rare-earth material has made it possible to manipulate their mechanical, thermal, and magnetic properties. Samarium–cobalt exhibits manipulative magnetic properties as a rare-earth material. However, the research on Samarium Cobalt ($\text{Sm}_2\text{Co}_{17}$) magnetic properties is still need to explored. $\text{Sm}_2\text{Co}_{17}$, which is utilized in this research, is synthesized *via* the sol–gel process at sintering temperatures of 400 °C, 500 °C, and 600 °C. Subsequently, the crystallites indicate the formation of a single-phase $\text{Sm}_2\text{Co}_{17}$ on all the samples in all temperature variations. Moreover, the peaks in the X-ray diffraction analysis of crystallite sizes calculated using the Scherrer equation are 17.730, 15.197, and 13.296 nm at 400°C, 500°C, and 600 °C. Through scanning electron microscopy, the particles are found to be relatively large and agglomerated, with average sizes of 143.65, 168.78, and 237.26 nm. The functional groups are also analyzed *via* Fourier-transform infrared spectroscopy, which results in the appearance of several bonds in the samples, for example, alkyl halides, alkanes, and esters with aromatic functional groups on the fingerprint area and alkynes, alkyl halides, and alcohol functional groups at a wavelength of above 1500 cm. The test results of the magnetic properties using vibrating-sample magnetometer (VSM) revealed high coercivity and retentivity in the samples sintered at 400 °C. However, the highest saturation occurs in the samples sintered at 600 °C.

Keywords: samarium-cobalt, rare-earth, sol-gel, heat-treatment, sintering.

INTRODUCTION

Due to the limited amount of rare-earth materials, they are difficult to find. However, they have high values as their properties are better compared with common material properties. Furthermore (Suresh et al., 2012), these materials exhibit a manipulative property, which makes them easier to develop. In short, their properties are easier to change. The magnetic properties of rare-earth materials largely influence the current technology and can be applied in mechanical, electrical, and medical fields. The examples of rare-earth materials exhibiting good magnetic properties are samarium and cobalt (Khan, 1972; Ray, 1972). Samarium exhibits good sensitivity toward the magnetic field and is also temperature-resistant, whereas cobalt has a good magnetic energy storage.

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MATERIALS AND METHODS

Materials

Precursors in the form of cobalt(II) nitrate hexahydrate and samarium(III) nitrate hexahydrate powder were obtained from Sigma-Aldrich.

RESULT AND DISCUSSION

This research demonstrates the highest saturation value from the samples sintered at 600 °C, namely, 0.457 emu/g, and classified as superparamagnetic. However, retentivity and coercivity only appeared in the samples sintered at 600 °C, with 0.003 emu/g and 0.015 T, as presented in Table 1 and Fig. 1.

TABLE 1: Analysis of the magnetic properties of $\text{Sm}_2\text{Co}_{17}$ based on the VSM graphics

Temperature [°C]	Hc [T]	Mr [emu/g]	Ms [emu/g]
400	0	0	0.239
500	0	0	0.219
600	0.015	0.003	0.457

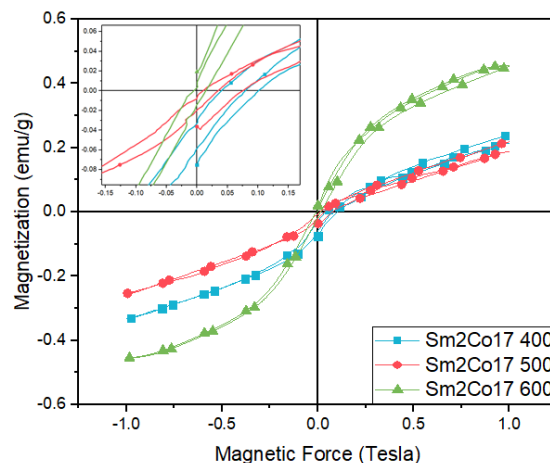


Fig. 1: Hysteresis curve comparison of $\text{Sm}_2\text{Co}_{17}$ at different sintering temperatures

CONCLUSIONS

Through the low-temperature sintering process, samarium–cobalt was found to exhibit the properties of a soft magnetic material.

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DIESEL ENGINE PERFORMANCE AND EXHAUST GAS EMISSION USING WASTE COOKING OIL B20 BIODIESEL FUEL WITH LEMON ESSENTIAL OIL BIOADDITIVE

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ABSTRACT

This research is motivated by the depletion of fossil fuels in nature which is inversely proportional to the higher level of fuel consumption of oil over time, so the need for alternative fuels, namely biodiesel. Also, fossil fuel can cause exhaust emissions and air pollution to overcome this can be added bio additive lemon essential oil to reduce exhaust emissions. This study is intended to find out the sample physicochemical properties, the effect of bio additive addition of lemon essential oil on the performance and exhaust emissions of diesel engines. The process in this study is making biodiesel with waste palm oil using esterification and transesterification process. Biodiesel samples with the addition of bio additive lemon essential oil on B20 biodiesel with a concentration variation of 0%, 0.1%, 0.15%, and 0.2%. Engine performance testing was using a 2184 cc Mazda R2 engine with variations in engine speed of 1700, 1900, 2100, and 2300 rpm. The exhaust emission testing was using the Stargas 898. The results showed that B20 biodiesel with bio additive lemon essential oil 0.2% has better physicochemical properties, where the density value, viscosity, flash point, and heat value of the sample is 0.8367 kg/L, 5.418 cSt, 98.33°C, and 40.594 MJ/kg. Based on engine performance testing, B20 biodiesel with lemon essential oil bio additive 0.2% at 2300 rpm has better results, torque, power, specific fuel consumption, and thermal efficiency of 11,193 Nm, 35.945 PS, 0.245 kg/PS.h, and 26.735%. Exhaust emissions testing showed that B20 biodiesel with lemon essential oil bio additive oil of 0.2% at 2300 rpm had the best results, carbon monoxide (CO), carbon dioxide (CO₂), hydrocarbon (HC), and oxygen (O₂) emissions were 0%, 3.28%, 9 ppm, and 16.85% respectively.

Keywords: biodiesel, waste palm oil, lemon essential oil, physicochemical properties, diesel engine performance, exhaust gas emission

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The Indonesian Government's efforts to eliminate air pollution and global warming due to exhaust gas emissions are by promoting the use of new renewable energy. The government issued a policy of using biofuel for the fuel mixture by 20% in the transportation sector, which means that the fuel used is a mixture of diesel fuel as much as 80% and biodiesel as much as 20%, a mixture of ordinary fuel called B20 biodiesel (Rahman et al., 2019). Biofuel biodiesel which consists of a monoalkyl ester is usually a methyl ester of non-toxic fatty acids. Biodiesel is made using used cooking oil or used cooking oil because in Indonesia it is abundant, cheap, and not reused or called waste. Biodiesel from palm cooking oil has

the advantage of being sustainable and has low emission levels. In addition to the use of biodiesel, there are other ways to reduce exhaust emissions produced by the engine, namely making the combustion reaction more complete by increasing the oxygen level in the fuel, oxygen levels can increase by adding natural additives, essential oils that are rich in oxygen. A complete combustion reaction due to the addition of essential oils to biodiesel fuel can also improve diesel engine performance and save fuel consumption (Nautiyal et al., 2020).

MATERIALS AND METHODS

Materials

The process of making biodiesel employed two chemical reactions, esterification and transesterification. In the esterification process, used cooking oil was reacted with methanol in a ratio of 1: 6 using 1% wt H₂SO₄ catalyst at 60 °C, which was then stirred with a magnetic stirrer for 120 min. In the transesterification process, a reaction between used cooking oil and methanol (1: 6) occurred with the help of a KOH catalyst 0.5% wt, 1% wt, and 1.5% wt at 60 °C for 120 minutes. The next stage was mixing biodiesel and diesel fuel. The ratio of 20% used cooking oil biodiesel, and 80% of diesel fuel was mixed using a magnetic stirrer for 30 minutes, then the finished B20 was added with bio additive essential oil.

RESULT AND DISCUSSION

Fig. 1 shows the brake thermal efficiency for each sample. The highest brake thermal efficiency is B20 with lemon essential oil additive 0.2% at 32.424% with an engine speed of 1700 rpm. The lowest is B20 at 24.308% with an engine speed of 2300 rpm. Brake thermal efficiency decreases with increasing engine speed. Brake thermal efficiency is influenced by kinematic viscosity, heating value, and also oxygen content in the sample. The higher oxygen content causes complete combustion and can increase thermal efficiency.

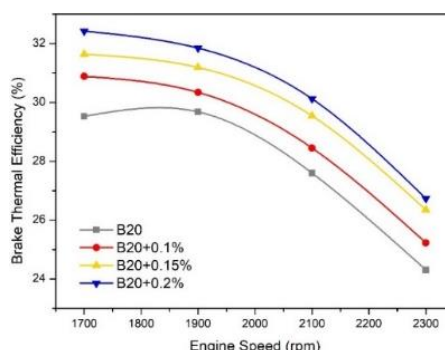


Fig 1. Comparison chart of engine speed and brake thermal efficiency

CONCLUSIONS

Physicochemical properties of waste cooking oil biodiesel (B20) were improved by addition of lemon essential oil. The lemon essential oil has more oxygen content which causes better combustion or complete combustion. The specific fuel consumption increase with the increasing engine speed and decreasing the concentration of lemon essential oil. CO emission decrease with increasing engine speed and increasing concentration of lemon essential oil.

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COMPARISON OF NANOPARTICLES SYNERGISTIC EFFECT WITH SUBSTRATE PRETREATMENT ON BIOGAS PRODUCTION FROM ALGAE WASTE

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ABSTRACT

Algae waste is one of the potential substrates for biogas and biohydrogen production and can comprehend multiple benefits of waste treatment and resource utilization. In view of the critical bottlenecks such as low substrate degradation rate and poor productivity of algae waste production process, this study analyzes the combined effect of two metallic (Ni, Co) and non-metallic (Fe₃O₄, MgO) nanoparticles with different substrate pretreatment methods (autoclave, ultrasonic and microwave methods) to investigate the effect of the fermentation of green algae (*Enteromorpha*). The results showed that, out of the three pretreatment methods (microwave, ultrasonic, and autoclave), microwave pretreatment and nanoparticles' synergistic effect significantly increased biohydrogen production.

Keywords: Algae waste, biogas, biohydrogen, nanoparticles, pretreatment methods.

INTRODUCTION

Biofuels can be produced by utilizing locally available organic feedstock. Various methods are available for organic matter to energy conversion, but Anaerobic Digestion (AD) is among the most preferable, specifically for biogas production. In this process, the absence of O₂ provides a favorable environment to bacteria for the decomposition of organic matter by breaking it into methane and other by-products (Mustaq et al. 2016). AD finds its implications of waste treatment on a broad category of waste, including sludge, wastewater, algae, and municipal waste (Abdelsalam, 2016). Algae waste is a potential substrate for biogas production. However, algae waste's strong, resilient cell walls result in a low substrate degradation rate, which hampers the AD process. Our previous study Zaidi et al. (2018) showed that the introduction of nanoparticles (NPs) as nutrients in the AD process significantly enhanced biogas production. However, it was hard for NPs to break the green algae cell wall, limiting the AD process during hydrolysis. The highly resistant and rigid cell wall restricts anaerobic bacteria to acquire intercellular polymeric components present. Therefore, to improve algal biomass's biodegradability by the dissolution of its cell wall and release of polymeric substances, numerous pretreatment techniques have been applied (Passos, 2015). Pretreatment itself is an energy and cost extensive technique. This study aims to provide an energy efficient solution by combining ultrasonic (US), autoclave (AC) and microwave (MW) pretreatment of algal biomass (*Enteromorpha*) and NPs.

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MATERIALS AND METHODS

An anaerobic sludge acquired from an Anaerobic-Anoxic-Oxic (AAO) reactor at Harbin Wenchang Sewage Treatment Plant, Harbin, China. The *Enteromorpha* was from the freshwater algae

and acquired from the Institute of Hydrobiology of The Chinese Academy of Science, Wuhan, China. Four different types of NPs were used in this study. Two were metal NPs (Ni, Co), while the other two were metallic-oxide NPs (Fe_3O_4 , MgO). NPs were purchased from China Metallurgical Research Institute, Beijing. The average size of the NPs was less than 100 nm with a spherical shape. The experiments were carried out via an anaerobic batch system. Anaerobic glass lab-scale bottles with a working volume of 500 ml were used as bioreactors and operated for 120 hours. The digestion environment has been maintained at 37 °C and 150 rpm mixing speed. The MW pretreatment was performed before anaerobic digestion with a household Panasonic microwave oven (1180W). The AC pretreatment was performed with an Autoclaves Sterilizer (MJ-78A, STIK GROUP LLC, USA). The US pretreatment was carried out using SONICS vibra cell (VCX800, Sonics and Materials INC. USA). The pretreatment condition for MW was 800W for 3.5 min. For AC, the pretreatment condition was 30 min within 120 °C. US pretreatment was carried out at 20 for 3 min.

RESULT AND DISCUSSION

The primary purpose of US, AC, and MW pretreatment was to break the algae's cell wall structure to shorten the hydrolysis stage and increase the reaction rate. Scanning electron microscopy (SEM) was used to observe changes in the physical structure of the algae. SEM micrograph showed that the un-pretreated one had a smooth surface, whereas pretreated samples showed that the surface had irregular potholes; the smaller size of particle indicated Lingocellulosic structure surface of substrates was broken by applied pretreatment methods. Results showed that all combinations resulted in an increase in biogas yield except MgO NPs groups. MW pretreatment in combination with NPs significantly improved the biodegradability of *Enteromorpha* and provided more biogas yield as compared to other combinations. Ni NPs + MW Pretreatment group achieved the maximum biogas yield of 362 ml (1.76 times higher than control), whereas MgO NPs groups combined with pretreatment methods did not perform well. The results showed that MW pretreatment initiates early hydrolysis of green algae, thus reducing lag time. NPs had a positive influence on biogas production at the later stages of AD.

CONCLUSIONS

This study has presented the experimentation results for combining NPs with pretreatment methods. Autoclave, microwave, and ultrasound pretreatments were carried out before anaerobic digestion to observe their effect on biogas production in combination with NPs. The results showed that MW pretreatment combined with NPs significantly enhances biogas yield from *Enteromorpha*.

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STUDY ON PHOTOCHROMIC BEHAVIOUR OF ORGANIC DYES IN SOLUTION FORM USING MULTILEVEL FACTORIAL DESIGN

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ABSTRACT

In this study, the statistical approach was performed in order to understand the behaviour of three photochromic dyes in solution form, namely spiropyran (SP), spirooxazine (SO), and naphthopyran (NP). The types of dyes and solvents were screened using multilevel factorial design. From the analysis of variance results, it was found that the types of dyes and solvents used as well as their interaction have significant effects on the absorbance and photostability.

Keywords: factorial design, naphthopyran, photochromism, photostability, spirooxazine, spiropyran

INTRODUCTION

Photochromism is a part of photochemistry as it involves a reversible change in colour of certain substances upon light irradiation (Dürr, 2003). The most commercialized photochromic classes are spiropyrans, spirooxazines, and naphthopyrans (Nigel Corns et al., 2009). The use of statistical approach allows the efficient estimation of the effect of each parameter and also possible interaction between the parameters using the smallest number of experiments (ReVelle & Margetts, 2009). The first aim of this paper is to investigate the behaviour of photochromic organic dyes by observing the absorption spectra and fading kinetic. The second aim of this paper is to determine the photochromic dye with the highest absorbance and photostability in solution form using multilevel factorial design. The multilevel factorial design is capable to produce an experimental design based on the combination of different independent factors at different number of levels, i.e. one factor at three levels and another factor at two levels, and also identify which factors have significant effects on the response (Montgomery, 2005).

MATERIALS AND METHODS

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Photochromic dyes that were utilised in this study are 1,3,3-trimethylindolinonaphthospirooxazine (SO), 3,3-diphenyl-3H-naphtho[2,1-b]pyran (NP), and 1',3'-dihydro-1',3',3' trimethyl-6-nitrospiro[2H-1-benzopyran-2,2'-(2H)-indole] (SP). In photolithography room, the SO, NP, and SP dyes were dissolved individually in ethanol and isopropanol at a concentration of 1 mM. The photochromic solutions were stirred at room temperature for 1 h and kept in the dark for 24 h. The absorbance and fading kinetic

measurements were performed according to the method described by Nadir et al. (2013).

RESULT AND DISCUSSION

Upon UV irradiation, all the three dyes in ethanol and isopropanol showed a colour change as illustrated in Fig. 1(a). The colourless spirooxazine (SO) and naphthopyran (NP) turned blue and orange, respectively, while the very light pink of spiropyran (SP) became brighter, indicating that the dyes exhibit mechanism of opened structure from oxazine (SO) and pyran (NP and SP) mode to merocyanine mode. This reaction suggested that all the three dyes undergo photoisomerization in the investigated solvents. The colour faded away once the UV light source is removed due to the reversion back of merocyanine to oxazine and pyran based structures.

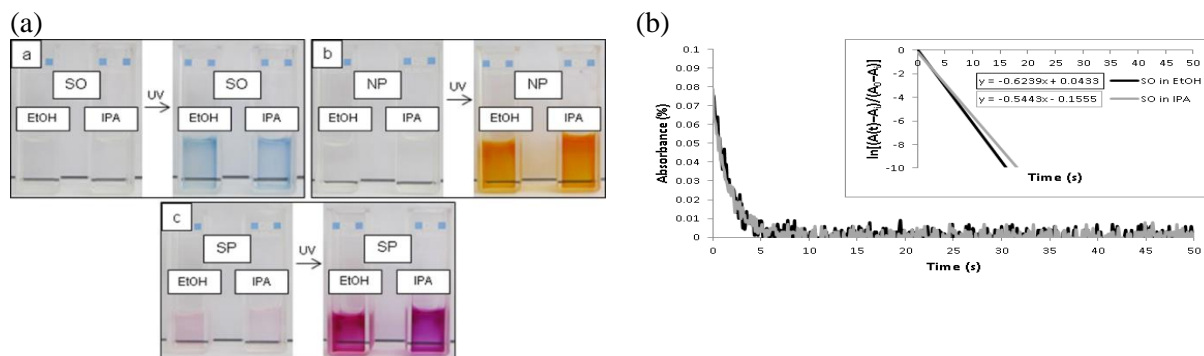


Fig. 1: (a) Photocolouration of SO, NP, and SP before and after UV irradiation in ethanol and isopropanol. (b) Fading kinetics of SO in ethanol and isopropanol after 15 s of UV irradiation, at 1 mM of dye concentration.

As seen in Fig. 1(b), the fading kinetics of SO in ethanol and isopropanol was almost similar. Both curves follow the first-order of exponential decay function. The fading rate constant of SO in ethanol ($k = 0.6239 \text{ s}^{-1}$) is slightly larger than SO in isopropanol ($k = 0.5443 \text{ s}^{-1}$) indicates that the merocyanine form of SO is less stable in ethanol. This is because the stability of the merocyanine form decreases as the fading rate constant increases. The degradation was faster in more polar solvent due to merocyanine–oxygen interaction that produced a polar intermediate which would be stabilized by a polar solvent with larger dielectric constant (Malatesta, 2002).

CONCLUSIONS

SO is the most photostable dye, followed by NP and SP. All dyes have better photostability in ethanol compared to isopropanol.

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A STUDY OF THE HYDROGEN SORPTION PROPERTIES AND CATALYTIC MECHANISM OF THE CoTiO₃-DOPED MgH₂ SYSTEM FOR SOLID-STATE HYDROGEN STORAGE MATERIAL

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ABSTRACT

High thermodynamic stability and sluggish sorption kinetics are two main problems to commercial application of magnesium hydride (MgH₂) as a solid-state hydrogen storage material [1,2]. Doping with nanocatalyst is an attractive option to improve the hydrogen storage properties of MgH₂ [3]. In this paper, we report here the synthesis of cobalt titanate (CoTiO₃) nanoparticles via a simple solid-state method, which showed high activity in catalysis of MgH₂ for hydrogen storage. The particle size distribution of the as-synthesised CoTiO₃ nanoparticles is determined to be about 160 nm. Different percentages of CoTiO₃ nanoparticles (5, 10, 15 and 20 wt.%) were added to MgH₂ and their catalytic influences on the hydrogen storage properties of MgH₂ were investigated. Results showed that the 10 wt.% CoTiO₃-catalysed MgH₂ sample was the best composite to enhance the hydrogen storage performance of MgH₂. The onset decomposition temperature of the 10 wt.% CoTiO₃-doped MgH₂ composite was decreased by ~70 °C compared to as-milled MgH₂. Meanwhile, the desorption/absorption kinetic measurements showed an improvement compared to the undoped MgH₂. It is believed that the in-situ generated MgTiO₅ species had catalytic effects on enhancing the hydrogen storage properties of the CoTiO₃-catalysed MgH₂ composite.

Keywords: hydrogen storage, solid-state storage, magnesium hydride, cobalt titanate, catalyst.

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SYNTHESIS AND ELECTROCHEMICAL PERFORMANCES OF Mn_2O_3 AS AN ANODE FOR NA-ION BATTERIES

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ABSTRACT

Sodium-ion batteries (SIBs) are attracting researcher's interest to explore their potential as an alternative to lithium-ion batteries (LIBs) due to their low cost, abundant sodium resources and possess similar storage mechanism to LIBs. Nevertheless, major research developments are still needed in order to improve their performances before commercialisations. Various transition metal oxides showing great promises as an anode for SIBs since these materials undergoing conversion reactions and could provide high sodium storage capacities and low operation potential, which could benefit the energy density of SIBs. In this work, Mn_2O_3 powders are synthesised through the thermal conversion of MnCO_3 and reported for the first time as an anode for SIBs. The cubic-like Mn_2O_3 was obtained with 1.0–1.5 μm sizes after calcination of the as-prepared MnCO_3 . Mn_2O_3 possesses a first discharge capacity of 544 mAh g^{-1} with a capacity retention of 85% after 200 cycles at 100 mA g^{-1} , indicating good cyclability of the Mn_2O_3 electrode. Our study provides a significant contribution to the practical application of SIBs with feasible anodes.

Keywords: sodium-ion batteries, anode, Mn_2O_3 , electrochemical performances.

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SYNTHESIS OF PURE PHASE BISMUTH FERRITE BY SOL-GEL AUTOCOMBUSTION ROUTE: IMPACT OF CITRIC ACID CONCENTRATION ON ITS PHYSICOCHEMICAL PROPERTIES

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ABSTRACT

In this study, pure phase BiFeO₃ was prepared via a facile sol-gel auto-ignition route using water as a solvent. The influence of citric acid to metal nitrates ratio on BiFeO₃ physicochemical properties was also investigated through FTIR, XRD, PL, UV, and BET analysis. The observed peaks from the XRD have shown rhombohedral perovskite structure and belong to space group R3c. The BFO1:2 showed lowest electron charge recombination while BFO2:1 showed the smallest crystallite size and highest purity as well as highest electron charge recombination. The surface area of BFO1:1, BFO1:2, and BFO2:1 were 1.63, 2.13, and 1.84 m²/g, respectively. The band gaps were found to be 2.17, 2.10, and 2.21 eV for the prepared BFO1:1, BFO1:2 and BFO2:1, respectively. The appearance of a near-IR band around 814 cm⁻¹ confirms the presence of the Bi₂Fe₄O₉ byproduct in the BFO1:2 sample. This approach eliminates the use of traditional solvents, and can be easily adapted to other systems and provided cost, time and energy savings. The findings of this study contribute to the improvement of the body of knowledge, particularly in the field of nanoparticle synthesis.

Keywords: citric acid, sol-gel, Bismuth ferrite, auto-combustion, PL.

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POTENTIAL CELLULOSE AS A SOURCE OF BIOETHANOL USING SOLID CATALYSTS: A MINI REVIEW

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ABSTRACT

One of the most important biofuel is cellulose ethanol, which cellulose is popular material for bioethanol production. presently, cellulosic ethanol production through the cellulolysis process, Complex cellulose, which split down to simple sugars in the hydrolysis process of pretreatment lignocellulose use with acids and enzymes afterward fermentation and distillation. But now, enzymatic and acid process forced challenges. Acid hydrolysis can cause corrosive to equipments and cause unwanted waste, while Enzymatic hydrolysis process requires a long time, enzyme prices are quite expensive and the availability of enzymes limited. New innovations need to be developed to minimize the side effects caused by the two processes. Solid catalysts green and effective catalyst for conversion cellulose to ethanol. The strength of solid catalyst are resistant to acid and base conditions, high surface area and not cause corrosion (neutral pH) for conversion cellulose. This article reviewed potentials cellulose in Indonesia as source of bioethanol in prepared solid acid catalyst for conversion to ethanol.

Keywords: cellulose, bioethanol, solid catalyst, hydrolysis

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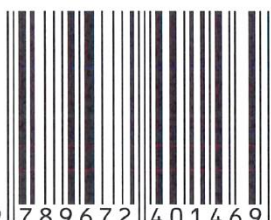
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