Proceedings of the 4th Postgraduate Colloquium for Environmental Research (POCER 2017)

Melaka, Malaysia
25 – 26 July 2017

“GREEN TECHNOLOGIES: INNOVATIONS, CHALLENGES AND PROSPECTS”

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Preface

The Postgraduate Colloquium in Environmental Research (POCER) was conceived as a platform to bring together postgraduate and early career researchers, to encourage exchange of ideas and issues amongst peers, as well as experience-sharing from more senior researchers. POCER was first held in 2011 at the University of Nottingham Malaysia Campus (UNMC), Selangor. Subsequent POCERs had been organised bianually, which took place at Genting Highlands, Pahang (2013) and Kuching, Sarawak (2015), respectively. POCER 2017 is the fourth in the series, having expanded to a wide range of local and international participants from Asia Pacific (China, Japan, Taiwan), as well as Southeast Asia (the Philippines, Thailand and Vietnam). POCER 2017 is organised by the Centre of Excellence for Green Technologies (CEGT) at The University of Nottingham Malaysia, and supported by our international partner, the Department of Chemical Engineering & Biotechnology at National Taipei University of Technology (NTUT).

The theme for POCER 2017 is: "***Green Technologies: Innovations, Challenges and Prospects***". We strongly believe this theme is particularly pertinent to the current global outlook, with increasing demands to address issues arising from the over-exploitation of environment, and the necessity to develop more efficient and sustainable techniques, as well as responsible practices. We are delighted to inform that the conference programme includes 52 technical papers, all of which have been subjected to stringent peer-review process. These papers are compiled to a collection of proceedings with eISBN.

We would also like to take this opportunity to thank the organising committee from UNMC and NTUT who have done a wonderful job, providing valuable time in formatting and editing the papers. In addition, I wish to express my gratitude to the scientific committee who have contributed significantly in reviewing the papers to ensure that high quality is maintained. POCER 2017 would not have succeeded without your dedication and hard work. Also noteworthy are our generous sponsors, KLK Oleochemicals and Novozyme, who have been highly supportive of this conference, as well as our plenary and keynote speakers.

Finally, we wish to thank all POCER 2017 participants who have supported the event, and worked hard in preparing the papers, presentations and posters; and their generosity in showcasing their knowledge and findings with members in the environment research community. We sincerely hope that all participants will have a fruitful experience, leading to more interdisciplinary collaborations, which will ultimately make a great impact in benefitting the society and industries.

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August 2017

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POCER171: Multi-objective Molecular Design with Analytic Hierarchy Process

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Keywords: Analytic Hierarchy Process (AHP); Computer Aided Molecular Design (CAMD); Multi-objective optimisation.

1. Introduction

This work presents a systematic procedure to solve multi-objective molecular design problem. Computer Aided Molecular Design (CAMD) techniques have been widely employed to design molecules which satisfy a set of predefined target properties. Thus, in order to design molecules which fulfills a set of performance objectives, multiple target properties are often considered in a typical molecular design problem. Nonetheless, the relative importance of each property in molecular design problem is not always definable. Moreover, target properties which belong to different categories make it even harder to compare them on a common scale. Thus, there is a need to develop a procedure to compare the properties on a common platform in order to derive their relative importance between each property. In this paper, Analytic Hierarchy Process (AHP) approach is integrated with CAMD techniques to systematically evaluate the relative importance of properties involved in molecular design problem. AHP approach has the ability to compare both qualitative and quantitative elements by pairwise comparison. Besides, the consistency of pairwise comparison can be tested using AHP approach. After obtaining the final relative weight of each property, weighted sum method is then employed to model the multi-objective molecular design problem. The developed procedure will be further discussed in section 2.

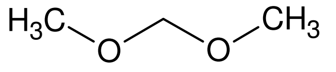
2. Methodology

The procedure starts with determining design objective for molecular design problem by the identification of product needs. Product needs are usually identified based on operating condition of industrial processess or from customers' requirements. The qualitative product needs can then be translated in terms of measurable target properties. The following step is to identify the suitable property prediction models to estimate the target properties. In order to ensure that the molecular structure and properties of the designed product are similar to those existing product, molecular groups are identified based on the nature of the target molecule. Besides, structural constraints are applied to assure that the designed molecule is structurally feasible. Since there are multiple target properties to be optimised simultaneously, AHP approach is utilised to determine the weightage of each property by evaluating the relative importance between those identified properties. The first step of AHP approach begins with structuring the decision problem in the form of hierarchy framework. The hierarchy framework is structured in the way where overall design objective is represented on the top, criteria and/or sub criteria in the intermediate leaving the decision alternatives at the bottom. Next, pairwise comparison using Saaty's 9 point scale [Satty, 1980] is performed to determine the relative importance of property of a particular level with respect to a specific property in the immediate upper level. The consistency of the pairwise comparison is determined using consistency ratio. The weights of each sub-property is then multiplied by the weight of its main property in order to calculate its final weights in the overall system.

The multi-objective product design problem is then modelled using conventional weighted sum method. In order to generate alternative feasible solution, integer cuts are applied.

3. Case study

To illustrate the developed methodology, a case study on extracting residual oil from palm pressed fibre (PPF) is performed. Among all the available oil extraction technologies, solvent extraction using hexane is the most widely used technology due to its low cost and high oil solubility [de Oliveira et al., 2013]. However, hexanes' high boiling point will lead to the degradation of carotenoids during the oil recovery. Thus the main objective of this case study is to design solvents for oil extraction which will aid in reducing the degradation rate of carotenoids. In addition, environmental aspects of solvent are considered to ensure that the designed solvent possess desirable environmental characteristics while attaining high performance. The selected physical target properties include boiling point, surface tension, viscosity and the Hildebrand solubility parameter (δ) difference between solvent and carotenoids. In addition, the selected environmental properties include aquatic toxicity potential, terrestiral toxicity potential, photochemical oxidation potential, soil sorption coefficient and bioconcentration factor. All these targeted properties can be estimated using group contribution methods and empirical relationships. These nine target properties are then optimised simulatenously to generate the structure of optimal solvent. The identified optimal solvent is shown in Figure 1.



Solvent A1: Dimethoxymethane

Figure 1: Optimal solvent generated

4. Conclusion

A novel methodology with the combination of AHP and CAMD techniques has been developed to solve multi-objective molecular design problems. With such approach, the relative importance of target properties is more systematically defined as various target properties can be compared under the same analysis. A case study on the solvent design for oil extraction from PPF is performed to demonstrate the proposed methodology. The results show that the designed solvents are able to achieve good functionality while having favorable environmental characteristics. Hence, it can be concluded that by using the developed methodology, solvents which simultaneously excel in performance and possess low environmental impacts can be generated.

Acknowledgements: The financial support from the Ministry of Higher Education, Malaysia through the LRGS Grant (LRGS/2013/UKM-UNMC/PT/05) is gratefully acknowledged.

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POCER172: Deoxygenation of Triolein to Green Hydrocarbon by using Cu supported on Titania

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Keywords: Deoxygenation; Supported Copper Catalyst; TiO_2; Triolein and Biofuel.

1. Introduction

Research interest in biofuel production has increased significantly due to the necessity for a renewable energy source [Shim et al., 2014]. There are more worrying issues associated with the utilization of these non-renewable fuels including deterioration of health standards and environmental pollution [Amin, 2009, Ho et al., 2014]. Special attention has been given to the deoxygenation, an important method for a sustainable supply of biofuel for future generations. This work reports deoxygenation of triolein as non-edible oil model compound via copper catalyst supported on titania (Cu-TiO2).

2. Methodology

A series of Cu-TiO2 with different amount of Cu loading was prepared via wet-impregnation method. The physiochemical properties of Cu-TiO2 was characterized by X-ray diffraction (XRD), BET surface area, HRTEM, XRF and Raman and correlated to the catalytic performance of Cu-TiO2. Typically, metal supported TiO2 is employed in hydrodeoxygenation reaction at high pressure condition [Manyar et al., 2010].

3. Results and Discussion

Based on diffraction peaks for the pristine TiO_2 and all Cu-TiO_2 samples are anatase phase. The diffraction peaks for the anatase phase of TiO_2 were detected at $2\theta = 25.1°$, 37.6°, 47.9°, 53.7° and 54.9° that correspond to the (101), (004), (200), (105) and (211) planes, which are diffractions of the pure anatase phase tetragonal TiO_2 (ICDD Card No: 01-071-1168) structure. While XRD spectra of pristine copper oxide was observed at $2\theta = 35.3°$, 38.4°, 48.5° and 53.2°, it represents the characteristics diffraction of CuO (ICDD Card No: 01-074-1021) structure. However, it is least efficient catalyst in deoxygenation at ambient pressure condition. In this study, 7.5 wt.% Cu-TiO2 showed remarkable catalytic performance (82% conversion) and high selectivity (67%) to C8-C18 hydrocarbon. The superior catalytic performance of Cu-TiO2 is ascribed to higher dispersion and synergistic action between Cu and TiO2. This study suggests that the Cu-TiO2 is a promising catalyst for deoxygenation of non-edible oil.

The influence of Cu metal loading on the deoxygenation catalysis and product selectivity of TiO_2 was evaluated for the conversion of triolein. Fig 1 demonstrated the total conversion of triolein to green hydrocarbon over Cu-TiO_2. Focusing on the best results obtained over each catalyst, 7.5Cu-TiO_2 is capable of affording conversion as high as 82% which indicated that triolein was effectively converted in the reaction. Pristine TiO_2 and CuO showed a much lower activity (49% and 53%, respectively).

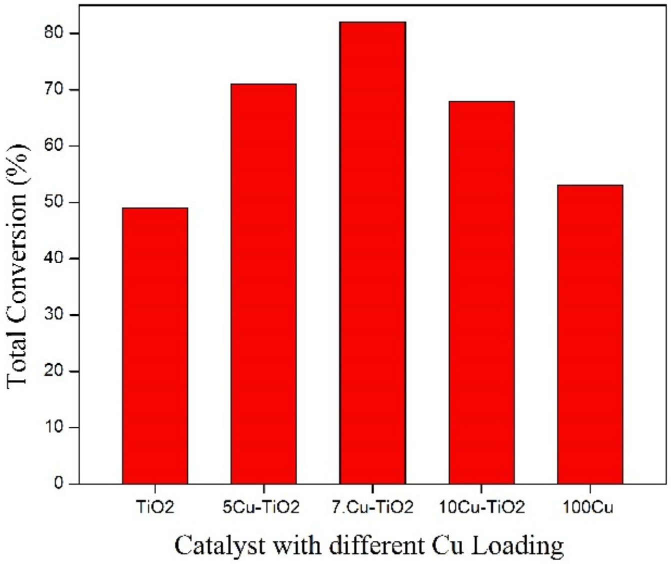

Figure 1: Total conversion of triolein over pristine TiO_2, CuO and Cu-TiO_2 with different Cu loading

Acknowledgements: This work is supported by the University of Malaya under SATU grant (RU018D-2016), Postgraduate Research Grant (PPP) grant (PG071-2014B) and University of Malaya Research Grant (RP025A-14AET).

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POCER173: Hydrothermal Synthesis of Strontium Titanate Nanoparticles for Photoelectrochemical Water Splitting Application

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Keywords: Electrophoretic Deposition; Hydrogen; Hydrothermal Synthesis; Photoelectrochemical; Strontium Titanate; Water Splitting.

1. Introduction

$SrTiO_3$ (STO) is a promising perovskite-type photocatalyst for water decomposition, it offers favorable energy for photocatalysis since its conduction band edge is 200 mV more negative than TiO_2. STO can be synthesized through a different pathway such as solid-state reaction [Kim et al., 2013], balling milling reaction [Liu *et al*., 2008] and molten salt synthesis [Mao, Banerjee, & Wong, 2003]. Hydrothermal reaction [Zhang, Zhong, & Duan, 2015] is a promising method to obtain nanoparticles having narrow particle size distribution, small particle size, and high crystallinity. It can be readily performed by a simple process with low temperature without calcination. Generally, the morphology can affect their photocatalytic activity since the nano-sized photocatalysts might have advantages of large surface area and short diffusion distance of photo-excited electrons to the surface [Kimijima *et al*., 2014]. STO nanoparticles were successfully obtained directly by the hydrothermal reactions under alkaline condition using titanium dioxide (TiO_2) and strontium hydroxide octahydrate as the precursors in this study. Hydrogen is a potential energy carrier and used for power generation and photoelectrochemical (PEC) water splitting is one the promising technologies for hydrogen production to assure a clean and sustainable supply of energy. Researcher was synthesized STO by polymerized complex method but the hydrogen production was only 3.2 mmol h^{-1} g^{-1} [Liu et al., 2008]. Also, a study was done STO thin films for PEC water splitting and 0.53 mA/cm^2 of photocurrent density was generated [Sharma *et al*., 2014]. STO widely used in different applications but for PEC water splitting is still uncommon. This study aims to observe the morphology of STO in different synthesis temperature and to optimize the synthesize condition to produce uniform and high crystallinity STO nanoparticles that can lead to a good performance in PEC water splitting. These obtained STO were also systematically characterized by XRD, FE-SEM, EDX, PL, UV-Vis and BET.

2. Results and Discussion

The X-ray diffraction (XRD) patterns identified the products synthesized at different temperatures (60 ^oC to 180 ^oC) were compared with standard STO data (JCPDS Card No. 00-035-0734). The diffraction peaks for synthesized STO were detected at $2\theta = 22^o, 32^o, 40^o, 46^o, 52^o, 58^o, 68^o, 77^o$ which corresponds to (100), (110), (111), (200), (210), (211), (220), and (310) planes. The sharp and narrow peaks imply that the nanoparticles are highly crystalline and $D_{Scherrer}$ values were calculated to determine the crystalline size values. The FE-SEM displayed the samples prepared were perovskite STO nanoparticles having regular morphology and small particle size as shown in Figure 1. The spherical particles agglomerated into a cubic shape. The particle size increased with an increase in the reaction temperature. Based of FE-SEM micrographs, the particle sizes estimated in between 20-100 nm in diameter. STO nanoparticles show the optimal performance when the catalyst is prepared by 150 ^oC of synthesis temperature. The efficiency of PEC water splitting was examined under illumination of 100 W UV light and 1 M of KOH electrolyte. Figure 2 shows the j_p-V characteristic curves of synthesized

STO in different synthesize temperature. The highest photocurrent density generated was 0.65 mA/cm^2 at 0 V vs Ag/AgCl. Besides that, the photoconversion efficiency (PCE) was calculated and the hydrogen production performance was recorded.

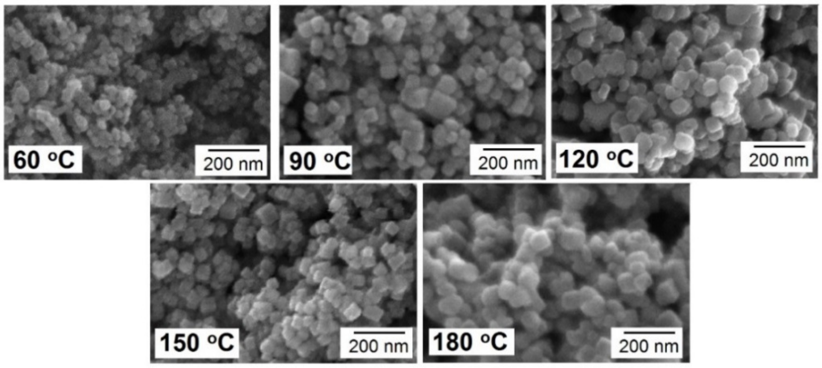

Figure 1: The FE-SEM image of STO synthesized in different temperatures.

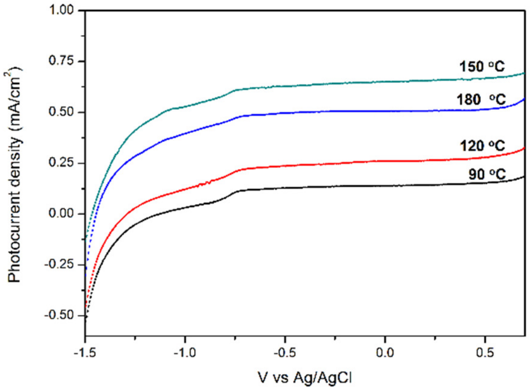

Figure 2: The j_p-V characteristic curves of STO in different synthesis temperatures.

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POCER174: Photodeposition of Ag Nanoparticles on $Sio_2@Fe_2O_3$ Nanocomposite Sphere: An Efficient Photocatalytic System for Conversion of CO into CO_2

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Keywords: CO adsorption; DRIFT; Nanocomposites; Visible-light catalyst.

1. Introduction

Recently magnetic semiconducting materials are most important for photocatalyst research and are used for many applications such as dye degradation, gas sensors, pigments and photoanodes in photoelectrochemical cells.,etc [Sun et al., 2011], [Thomas et al., 2001], [Zhu et al., 2011]. The conversion of solar energy in to chemical energy has been considered as one of the most perspective long term solutions in photocatalytic process to solve the global energy and environmental problems. Solar water splitting, carbon dioxide (CO_2) reduction, and photodegradation of organic pollutants are the recent methods which solar energy is converted into chemical energy. Photocatalyst chemical composition, surface state, crystallinity, band structure and morphology of semiconductor materials are important parameters to affect the photocatalytic performance. The excellent photocatalytic performance should possess high surface area, efficient light adsorption and photogenerated carrier separation and transfer, good crystallinity, stability and suitable band structure [Asahi et al., 2014], [Liu et al., 2010].

2. Methodology

In this study, a sol-gel method was used for the synthesis of a core-shell structure of $SiO_2@\alpha\text{-}Fe_2O_3$ nanocomposites. The different weight percentage of Ag nanoparticles was successfully photodeposited on the surface of the $SiO_2@\alpha\text{-}Fe_2O_3$ nanocomposites for employment as a visible light photocatalyst. The chemical composition and structure analysis of Ag nanoparticles on the $SiO_2@\alpha\text{-}Fe_2O_3$ composite spheres were characterized by X-ray diffraction (XRD), Field emission electron microscopy (FE-TEM), UV-vis spectroscopy, Photoluminescence spectroscopy (PL) and Fourier transform infrared spectroscopy (FTIR).

3. Results and Discussion

We observed that the Ag nanoparticles acted as centers of the photo induced electrons and enhanced photocatalytic activity on $SiO_2@\alpha\text{-}Fe_2O_3$ nanocomposites and this is due to the exposed high surface area under visible light irradiation. Further $SiO_2@\alpha\text{-}Fe_2O_3$ with different Ag nanoparticles for CO adsorption and oxidation reaction conditions also investigated. The mechanism of the CO adsorption and oxidation over the catalyst were explored based on the DRFIT-MS spectroscopy study. The results provide experimental evidence of the effects of crystal phases and surface chemistry on photocatalytic activity of visible-light active photocatalyst. The result shows that adsorption and oxidation are independent of chemical reactions and structure of the material and they mainly depend on the presence of OH group.

Figure 1 shows the DRIFT spectroscopy of the $Ag\text{-}SiO_2@\alpha\text{-}Fe_2O_3$ nanocomposites for CO adsorption and oxidation reaction with different temperatures. The introduction of CO at room temperature, the appearance of band at 2176 and 2142 cm-1 are due to doublet of gaseous carbon monoxide. When increasing the temperature to 100oC the new peaks visibly appeared at 2353 cm-1 and 2362 cm-1 that corresponds to the produced and adsorbed doublet carbon dioxide, respectively. The doublet of the carbon dioxide peaks increased up to 250 °C. Further, the new bands also appear at 1621, 1414 and 1222 cm^{-1} indicating formation of bicarbonate after adsorption of CO_2. Bicarbonates are stable at temperatures up to 400°C. Above the temperature of 250 °C, the band at 2134 cm^{-1} diminished when increasing the temperature up to 400 °C suggests that the reaction occurs between CO reversibly adsorbed on Ag surface. These results confirm that the main reason for oxidation of oxygen is based on Ag nanoparticle and temperature to reach a high activity in CO oxidation.

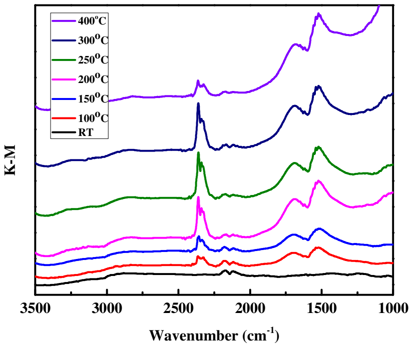

Figure 1: DRIFT spectroscopy of the Ag-SiO_2@α-Fe_2O_3 nanocomposites for CO adsorption and oxidation reaction with different temperatures.

Acknowledgments: The authors thank the Centre for Precision Analysis and Research, National Taipei University of Technology, Taipei, for their financial support of this research.

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POCER175: Safety and Health Assessment in Chemical Product Design

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Keywords: Chemical Ingredients, Chemical Product Design; Safety and Health Assessment.

1. Introduction

Chemical product design (CPD) is an established approach that convert the consumer needs into marketable products.The ingredients present in the chemical products may be of a variety of chemicals namely, pigments, solvents, polymers, surfactants, solids and odors. Based on CPD, consumers will determine the properties of the products based on their needs and following that, the products are developed via different formulation to provide the desired properties [Conte and Gani, 2011]. For instance, one of the consumer needs in a cosmetic product is the one that gives less stickiness on the skin. On the other hand, there is regulatory act to monitor emissions of volatile organic compounds (VOCs) for a spray product [Conte *et al.,* 2010]. VOCs are harmful to human health which affect central and peripheral nervous system [Awodele *et. al.*, 2014]. Therefore, in ensuring a chemical product has a successful marketability, consumer demands including safety and health aspects must be satisfied [Conte *et al.,* 2010].

Safety aspects of a product are those related to their properties of flammability, explosiveness, reactivity, toxicity and corrosivity of a product. A flammable chemicals may present in the ingredients of a chemical product and or in the packaging. For example, a highly flammable solvent contains in a product may cause fire if it is being exposed to high heat and any ignition source. Besides, the health impact of chemical product is also a major concern. In the late 1970s and 1980s, lead has been regulated as controlled substance by most of highly industrial countries. Lead acts as pigment in the paint formulation. Nevertheless, lead causes adverse effects to human and is categorized as an endocrine-disrupting chemical [CAP, 2016; Goldsmith *et al.*, 2014]. In addition, control measures have been employed to household pesticides that contain chlorpyrifos as an active ingredient due to which will overstimulate the nervous system and can even lead to death [Goldsmith *et al.,* 2014]. Therefore, a systematic approach is desirable to assess safety and health aspects in chemical product design.

2. Methodology

A case study on paint will be carried out to demonstrate the method developed. In the conventional paint industry, the consumer needs are commonly focusing only on basic needs such as protection, decoration and odor. Basic needs for paint is protection from weather conditions and decoration refers to the color for a better surface appearance. Furthermore, consumers prefer a paint that is easily spread on the wall [Conte *et al.,* 2010] and simultaneously emit less odours. Odor of a paint is depends on the content of VOCs [Schieweck and Bock, 2015]. Since VOCs result in health impact, selection of a solvent with low content of VOC is desirable. Other ingredients like pigment contain heavy metals which contribute to middle-term and long-term health risks such as abdominal pain and illness to the human fetus. So, less hazardous pigment should be chosen to prevent such negative health effects [Awodele. *et. al.,* 2014]. Indeed, the potential risk to human safety and health are depends strongly from the contents of the chemicals in finished products [Rebelo *et al.*, 2015]. Elucidation on how safety and health aspects are integrated into chemical product design is presented in Table 1.

Table 1: Chemical Product Design for Paint

Needs	Description	Ingredients	Product Quality Factor	Safety and Health Issue	Safety and Health Factor
Decoration	Color	Pigment	Opacity, Lightfastness, Glossy	Content of heavy metals	Flammability Explosiveness Reactivity Toxicity level (LD_{50}) Acute and chronic effects (R phrase)
Protection	Weather resistance	Binder	Acid, alkali, solvent and water resistance	n.a	
Main Function	Spread ability	Solvent	Durability, quick drying time, less odor emission	Content of VOC	
Odor	Less odour	Solvent			

The method developed will include all the factors shown in Table 1. Every factors will be quantified based on the available information such as material safety data sheets (MSDS). In our approach, every subcategory for each factor will be assigned with a score. The lower the score indicates the better quality, safer and healthier ingredients. As an example, the toxicity level of an ingredient is assessed based on its LD_{50} value; an ingredient with a higher LD_{50} value will receive a lower score as this indicates the substance to be less toxic. For each ingredient, the scores for all factors will be totaled up before the ingredients are ranked based on the total score calculated.

3. Conclusion

The assessment method proposed in this study will greatly assist users in making decisions related to product formulation where safety and health aspects are emphasized.

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POCER176: The Covalently Functionalized Reduced Graphene Oxide-Polyaniline Nanocomposites for Supercapacitor Applications: A One-Pot Strategy

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Keywords: Diazotization; Grafting; Graphene oxide; One-pot synthesis; Polyaniline; Supercapacitors.

1. Introduction

The enormous utilization of fossil fuels especially crude oils and petrochemical products are in its draining stage that leads to face the energy crisis in next century or near in future. In addition to that, we are struggling against severe pollution problem due to unlimited consumption of burning of non-renewable energy resources and their harmful effluents. To date, we must conserve the nature and environment by avoiding over exhaustion of carbon dioxide, carbon monoxide, and various greenhouse gasses from fossil fuels. In other words, generating energy from solar, wind, and tidal is the best alternative renewable energy resources from nature in order to reduce the utilization of non-renewable energy sources like coal, crude oil, and natural gas (hydrocarbons). Although the energy conversion from natural sources is seasonal or limited, their environmental benignity factors are dominated as compared to lethal nuclear energy conversion from nuclear power plants. The energy storage and conversion are one of the contemporary research in the 21st century worldwide, after the Fukushima disaster in japan. Supercapacitors are electrochemical energy storage devices having the potential to store and deliver the electric energy very rapidly for long billions of life cycles in a safe manner. In recent years, developing the high-performance electrode materials in supercapacitors to improve their energy density without losing its existing advantages have been paramount research in the scientific society [Chua et al.,2014, Criado et al.,2015, Wu et al.,2014, Zhang et al., 2014, Zhao et al.,2014, Zhong et al., 2015]

2. Methodology

Herein, the high-performance electrode material was prepared by commercially facile one-pot synthesis, through well-known diazotization reaction followed by grafting strategy. The 4-Nitroaniline was taken as the grafting substrate for covalent functionalization on graphene oxide (GO). The two parallel reaction was carried out under the same conditions of the grafting method as described above, one the hand for characterization in each tandem step (Grafting, reduction, and polymerization), and the another hand for control experiment by using graphene instead of GO. The final composite was washed with ethanol and water several times until the washings were colorless and then dried in an oven at < 60 °C for overnight. The chemical composition and structure analysis of RGO-PANI nanocomposites were characterized by X-ray diffraction (XRD), Field emission scanning electron microscopy (FE-SEM), UV-visible spectroscopy, Raman spectroscopy, and Fourier transform infrared spectroscopy (FTIR). The electrochemical behavior of the nanocomposites was analyzed through cyclic voltammetry, galvanostatic charge and discharge, and electrochemical impedance spectroscopy. The one-pot tandem reaction does not require any hydrazine to reduce the GO, instead, the $SnCl_2$ itself acted as a reducing agent for both graphene oxide and nitro group simultaneously.

3. Results and Discussion

In FTIR spectra it is commonly observed, the quinonoid band at 1564 cm^{-1} is less intense than the benzenoid band at 1461 cm^{-1}. The characteristic band attributable to the N-Q-N-Q stretch of the quinonoid ring was also found at around 1144 cm^{-1}, which clearly supports our hypothesis that the PANI has been covalently grafted onto the surface of the graphene oxide sheets. The composites are clearly different from the crystalline pristine graphite, as also evidenced from the Raman scattering. In XRD, the substantial shift of the (002) reflection during the processing of GO also confirms the formation of reduced graphene oxide from GO. Three new broad peaks of PANI-RGO centered at $2\theta = 13°$ and 20.6° and the intense peak at around 25.1° corresponding to (011), (020), and (200) crystal planes are almost the same as that of pure PANI, which are also the characteristic Bragg diffraction peaks of the polymer [Kumar et al.,2012]. The prepared material possessing the specific capacitance of 490 Fg^{-1} in the 1M Na_2SO_4 electrolyte solution (Figure 1) with outstanding cell voltage (2V) and excellent cyclic stability (10000). The covalent functionalization is the principal factor for both stability and high charge-discharge cycles. From the CV results, revealed that the as-prepared nanocomposite was a promising candidate for the supercapacitor applications and the proposed one-pot synthetic method could be the paradigm for commercially feasible electrode material preparation.

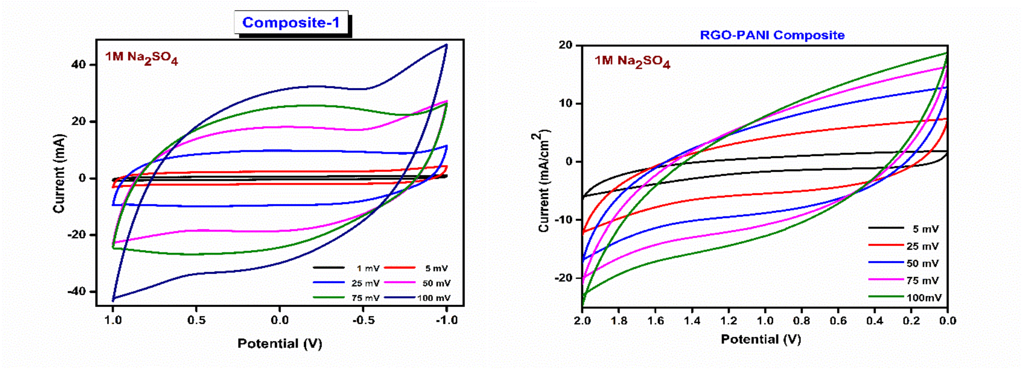

Figure 1: The cyclic voltammetry study of the Covalent-RGO/PANI nanocomposite in different scan rates

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POCER177: Enterprise Decision Making Framework for Chemical Product Design in Integrated Biorefineries

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Keywords: Decision Making; Integrated Biorefinery; Inverse Design Techniques; Integrated Product and Process Design; Product Design.

1. Introduction

In near decades, the feedstock utilized in industries for the production of heat, power, commodities and specialty chemicals has been gradually shifting from petroleum to biomass. Factors causing this shift include the awareness of finite fossil fuel resources, environmental imperatives, discovery of renewable energy resources and advancements in technologies [Xu et al., 2008]. To convert biomass into energy and value-added products, an integrated biorefinery is utilized. An integrated biorefinery is a processing facility that integrates multiple chemical reaction pathways to convert biomass into value-added products along with heat and power. To date, there are a large number of established biomass conversion pathways available to convert biomass into a wide spectrum of products. Various approaches have been developed for process synthesis and screening of potential conversion pathways for integrated biorefineries. These approaches focus on facilitating the process in synthesizing the end product. According to Skibar et al., (2009), biomass has the potential to be converted into value-added products which include fine chemicals and novel products. In most cases, these products are designed to fulfill customer requirements and product needs. Hence, in order to synthesise an integrated biorefinery, product design aspects have to be considered such that the integrated biorefinery would produce products which satisfy product needs [Chemmangattuvalappil and Ng, 2013]. Initially, business-to-business (B2B) exists as the nature of market in chemical industry where products are manufactured in terms of purity while emphasis is given on the process design and optimization. Throughout the years, the priority in manufacturing B2B products has been expanded to business-to-consumer (B2C) products, where products are sold for their performances. The transformation of market from B2B to B2C products introduces the consumer-centered concept to chemical product design [Fung et al., 2016]. Hence, the task of chemical product design that is traditionally dedicated to chemists has nowadays become a multifaceted process that does not only take engineering component as part of the process, but at the same time consider other important aspects as well [Heintz et al., 2014]. For instance, market analysis, chemical reaction pathways, processing technologies, environmental impacts and economic measures are among the important aspects to be considered while producing a chemical product from biomass. This complex process requires collective efforts from various fields. Thus, a methodology capable of evaluating the integrated process is needed to design the potential products, identify the conversion pathways that produce the products from biomass and determine the product demand and price.

2. Methodology

This work presents an enterprise decision making framework for chemical product design in integrated biorefineries. A two-stage optimisation approach developed by [Ng et al. 2015] is applied to integrate four major organizational units of an enterprise in designing the chemical product, identifying the conversion pathways and determining the product demand and price. In the first stage, the overall goals of a chemical enterprise are first identified through corporate unit. Financial aspects such as economic potential and legislative consideration such as environmental impacts caused during the chemical production are among the possible corporate goals to be achieved. These goals will be evaluated in stage two of the framework during the synthesis of conversion pathways and identification of product demand and price. Other than corporate unit, business unit is proposed to identify product needs, evaluate available market and potential competitor, and determine demand and price of potential product. Product needs and available market are assessed and identified by utilizing market analysis while pricing model developed by Bagajewicz., (2007) is applied to determine the demand and price of the potential product. The demand and price of the potential product will be identified together with the chemical production cost in stage two of the framework. Research and development (R&D) unit is proposed to design the potential product. Under R&D unit, product needs identified from the business unit are translated into target properties. By using computer-aided molecular design (CAMD) techniques, the design of potential product is then solved as inverse property prediction problem where the aim of the problem is to determine a molecule that meets the specified target properties from a given set of molecule building blocks. Hence, chemical product that fulfils the product needs in terms of target product properties can be identified. In the second stage, production unit is proposed to synthesize the conversion pathways that convert biomass into the identified chemical product. This is done by using superstructural mathematical optimization approach. A superstructure which includes all possible conversion pathways and technologies that process biomass into intermediate, and convert the intermediates into final products is constructed as the representation of an integrated biorefinery. Objectives set by other organizational units are considered and included in the development of the superstructure. Thus, conversion pathways that lead to the identified chemical product can be determined while fulfilling the objectives set by different organizational units. By integrating and solving these organizational units, the proposed framework designs product that fulfils product needs, determines conversion pathways that convert biomass into the product and identifies product demand and price while fulfilling enterprise's goals.To illustrate the proposed decision making framework, a product design problem of producing dry cleaning solvent from palm-based biomass is solved for two different scenarios that represent different enterprise's goals. In Scenario 1, the enterprise aims to generate maximum profit while the objective of the enterprise in Scenario 2 is to generate positive profit while producing minimum environmental impact.

3. Conclusion

By utilising the developed framework, dry cleaning solvent in terms of optimal target properties is designed, optimal conversion pathways for different scenarios are identified while the price and demand of the product are determined.

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POCER178: In-situ Catalytic Pyrolysis of Cellulose with CaO

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Keywords: CaO; Catalytic Pyrolysis; Cellulose.

1. Introduction

Fast pyrolysis is one of the popular methods to produce bio-oil, a potential environmentally friendly substitute/additive for crude oil and source of chemicals. However, bio-oil that is derived from lignocellulosic biomass cannot be used directly as fuel currently. One of the many concerns is the high acidity of the bio-oil, which was contributed by the presence of organic acids. This property causes the bio-oil to be unstable and will also corrode the equipment. Besides that, having a high percentage of oxygenated compounds and water content in the bio-oil reduces the energy density [Bridgwater and Peacocke, 2000]. Therefore, upgrading techniques has be imposed to improve the qualities of the bio-oil by decreasing the amount of oxygen in the bio-oil.

Studies have been taking interest in utilizing acidic zeolites catalysts in catalytic fast pyrolysis due to their acidic properties and shape selectivity [Liu *et al.*, 2014]. Nevertheless, the application of different acidic zeolite catalysts generally produced low bio-oil yield of the pyrolysis products. So, basic oxide, here, Calcium Oxide (CaO) became the focus of some studies to replace acidic catalysts in catalytic pyrolysis. These basic metal oxides are easily available and thus, comparatively lower cost than that of acidic catalysts [Nokkosmäki *et al.*, 1998].

Lignocellulosic biomass consists mainly of three polymers: cellulose (35-50 wt%), hemicellulose (15-30%), and lignin (12-35%). Hence, to gain a better understanding on the kinetics and mechanisms of fast pyrolysis of lignocellulosic biomass, study on cellulose pyrolysis can be done. This study aims to investigate the catalytic effect of CaO on cellulose in terms of degradation, bio-oil yield, and pH values.

2. Methodology

The cellulose (fibers, medium) used was produced by Sigma Aldrich. Characterization of the cellulose were done for moisture content (wt%), ash content (wt%), volatile matter (wt%), fixed carbon (wt%), and higher heating value (MJ/kg). The results are presented in Table 1.

Table 1: Proximate Analysis and HHV of Cellulose

Proximate analysis				
Moisture content (%)	Volatile matter (%)	Ash content (%)	Fixed carbon (%)	HHV (MJ/kg)
1.96 ± 0.14	95.86 ± 0.55	0.98 ± 0.02	1.18 ± 0.36	16.62 ± 0

Thermogravimetric analysis (TGA) was done to understand the degradation behaviour of the cellulose. TGA was carried out in programmable TGA DSC 1 Mettler Toledo at a heating rate of 20 ˚C /min with nitrogen (N_2) purge of 20 ml/min. In each run, approximately 10 mg of cellulose was heated from room temperature to 900 ˚C, and held at that temperature for 10 min. Thermogravimetric (TG) curve reveals the weight loss of cellulose with temperature whereas derivative TG (DTG) curve shows the weight loss rate of cellulose with temperature. With the aim to conduct physical analysis on the bio-oil, cellulose-derived bio-oil was produced in a lab scale reactor. 15 g of samples with different CaO catalyst amount (0, 5, and 10 wt%) were used. The furnace was preheated to a temperature of 575 ˚C prior to the insertion of the reactor, which was connected to two condensers in series. Both TGA and lab scale experiments were duplicated to ensure reproducibility of results.

3. Results and Discussion

TGA graphs are presented in Figure 2. As observed, the presence of CaO at various wt % posed insignificant effect on both the mass loss and mass loss rate of the cellulose. Generally, pyrolysis of cellulose occurred between a temperature of 300 – 500 ˚C with the highest conversion rate at a temperature range of 367 ± 1.23 ˚C.

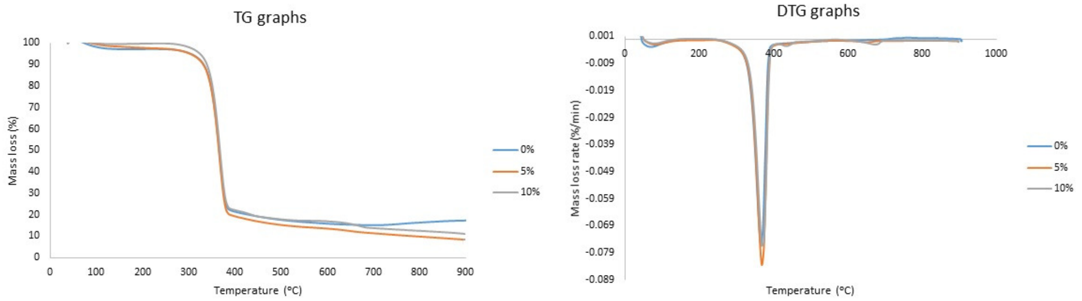

Figure 2: TG and DTG curves of Cellulose with Various Amount of CaO Catalyst (0, 5, and 10 wt%) at Heating Rate of 20°C/min

To further analyse the data, Coats-Redfern method was employed to calculate the activation energies when the chemical reaction is in first order. The results are presented in Table 2. Negligible differences were observed from the activation energies, giving an average of 192.13 ± 6.01 kJ/mol.

Table 2: Activation Energies of Cellulose with Various Amount of CaO Catalyst (0, 5, and 10 wt%)

CaO (wt %)	Activation energy (kJ/ mol)
0	192.13 ± 1.98
5	186.94 ± 0.15
10	198.72 ± 0.19

Upon producing bio-oil in a lab scale reactor, the bio-oil yield and the respective pH values are presented in Table 3. As the amount of CaO catalyst increases, bio-oil yield increases as well as the pH values.

Table 3: Cellulose-derived Bio-oil Yield and pH Values

CaO (wt %)	Bio-oil yield (wt %)	pH
0	48.51 ± 5.36	1.69
5	50.69 ± 4.22	1.78
10	53.73 ± 5.79	1.84

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POCER179: Fabrication of Asymmetric Supercapacitor based on Mn-Co Oxide and Nitrogen-Containing Activated Carbon

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Keywords: Asymmetric Supercapacitor; Mn-Co Oxide; N-Containing Activated Carbon; PM2.5.

1. Introduction

Particulate air pollution caused by fossil fuel combustion has become primary issues in Asia. More specifically, the particulate air pollution resulted from fine particulate matter under 2.5 μm diameter (PM 2.5) has been reported to impact the respiratory system as described by scientific publications in the area of observational epidemiology [Dockery, 2009]. To reduce PM 2.5 pollution, contemplation on low-carbon energy scenarios like the renewable energies is requisite [Gschwind et al., 2015]. The uncertainties of solar irradiation and wind direction directly affect the performance of solar energy and wind energy; thus, studies on renewable energy conversion and storage are imperative for the development of renewable energy technologies. Compared to rechargeable lithium (Li)-ion batteries, supercapacitors are much safer with higher power density, longer cycle lifetimes and shorter charging time, but they have lower energy density [Wang et al., 2012]. In this work, an asymmetric supercapacitor with high energy density was assembled for application in energy-storage systems with high-performance.

2. Methodology

For preparation of nitrogen-containing activated carbons (NAC), cleaned and dried waste Hygrophila salicifolia with nitrogen content of 3.5 wt% was used as the raw material. Via pyrolysis, KOH activation, and carbonization, activated carbon specific surface area of 1090 m^2/g was produced. The NAC/Nickel (NAC/Ni) electrodes were fabricated by first mixing NAC, conductive materials (KS-6 carbon, 10 wt. % and super-P carbon, 10 wt. %), and polyvinylidene fluoride (5 wt.%) to form slurry, which was coated on a piece of Ni foam under a pressure of 10.0 MPa for 10 s and dried at 110 °C under a reduced pressure for 2 h. To fabricate the manganese (Mn)-cobalt (Co)-oxygen/stainless steel (SS) electrodes, abbreviated as MCO/SS, 0.01 mol of manganese (II) acetate tetrahydrate, 0.02 mol of cobalt (II) acetate tetrahydrate and 0.02 mol of sodium sulfate were first dissolved in 300 ml of DI water and the solution was stirred for 30 min at room temperature. During electrodeposition, the SS working electrode was dipped into the Mn and Co-mixed solution and a potential of +1.1 V was applied for 300, 450 and 600 s, followed by a potential of −1.1 V for 600, 900 and 1200 s, respectively. After electrodeposition, the MCO coated SS was dried at 110 °C for 2 h, followed by annealing at 500 °C for 2 h, and finally these samples are denoted as (MCO/SS)-5 min, (MCO/SS)-7.5 min, and (MCO/SS)-10 min, respectively, in which the time shown denotes the electrodeposition time for Mn.

3. Results and Discussion

As depicted in Fig. 1(a), the XRD patterns exhibited nine significant peaks. The peaks at 29.4°, 31.3°, 32.9°, 36.4 °, 50.6°, 60.7°, and 65.3° can be indexed to the tetragonal spinel $CoMn_2O_4$ (JCPDS No. 77-0471). The peaks at 43.7° and 59.1° can be assigned to the cubic $MnCo_2O_4$ (JCPDS No. 23-1237) [Aukrust and Muan, 1963]. Obviously, the XRD pattern of Mn-Co spinel ($Mn_{1.5}Co_{1.5}O_4$) deposited onto

SS reveals the formation of a dual phase mixture of Mn_2CoO_4 and $MnCo_2O_4$ after calcination at 500 °C in air. The sharp peaks at 29.4°, 32.9°, 36.4 °, and 43.7° of (MCO/SS)-7.5 min and (MCO/SS)-10 min indicate that the tetragonal spinel $Mn_{1.5}Co_{1.5}O_4$ is well crystallized. SEM images of MCO/SS electrodes show that $Mn_{1.5}Co_{1.5}O_4$ films consists of thin microflakes, which are randomly interlaced together and form a nest-like porous structure (Fig. 1(b)). In addition, the cyclic voltammetry studies of the obtained MCO/SS electrodes were carried out in 0.3 M $LiNO_3$ electrolyte within 0 to + 1.2 V vs. SCE operational windows. At a scan rate of 5 $mV{\cdot}s^{-1}$, the capacitance values of (MCO/SS)-5 min, (MCO/SS)-7.5 min, and (MCO/SS)-10 min electrodes are 33, 43, and 34 $F{\cdot}g^{-1}$, respectively.

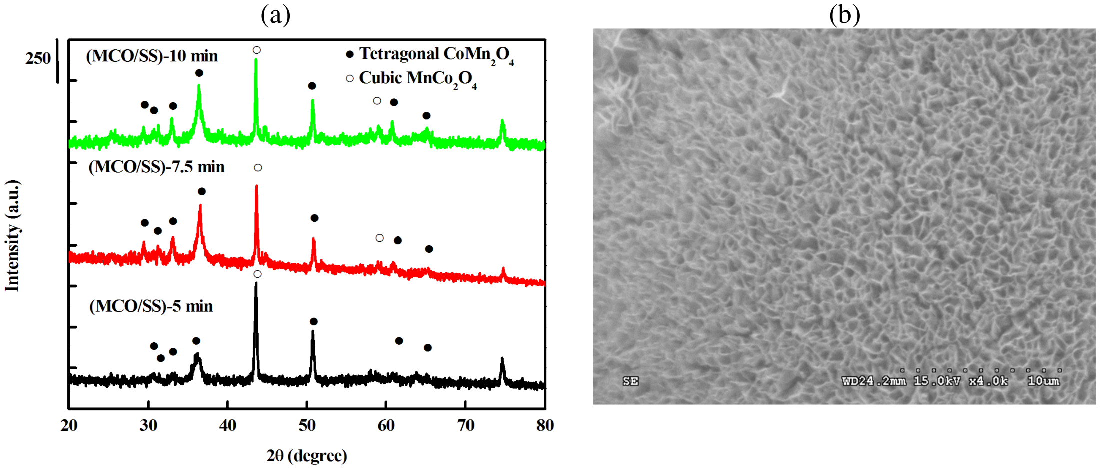
(a)
(b)

Figure 1: (a) X-ray diffraction patterns of $Mn_{1.5}Co_{1.5}O_4$ powders scratched from MCO/SS composite electrodes; (b) SEM image of MCO deposited for 7.5 min

4. Conclusion

In summary, a novel approach was provided in this study on the fabrication of an asymmetric supercapacitor consisting of a MCO/SS positive electrode and an activated carbon (NAC)/Ni negative electrode.

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POCER180: The Synthesis of Highly Efficient Gold Nanoparticles Supported on Titanium Dioxide for Carbon Monoxide Oxidation

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Keywords: Carbon Monoxide; Catalyst; Gold Nanoparticles; Oxidation.

1. Introduction

The plasmonic effects in wide-bandgap catalysts loaded with noble metal nanoparticles (NPs) have been proven to be a significant factor in carbon monoxide (CO) oxidation [Ding *et al.*, 2014]. This study aims to explore the relationship between the plasmonic effects and the various microwave power of gold-titania (Au/TiO_2) catalyst.

2. Methodology

Uniform spherical Au/TiO_2 were prepared via photo-deposition method as well as microwave approach. The detailed preparation parameters used in this study are shown in Table 1. The effects of microwave power on the surface/internal pore structure, morphology, and optical properties of the catalyst were evaluated in order to establish an optimal operating condition at which the oxidation efficiency is maximal. The samples were labelled as Samples (a)-(d) for microwave powers of 50, 100, 150, and 200 W respectively. The CO concentration in the annular reactor gas cell was recorded in a FTIR spectrometer (Perkin-Elmer Spectrum GX). Before the experiments, Au/TiO_2 catalyst was pretreated at 120°C for 1 h under Argon atmophere. The reactant gas mixture which was comprised of 1000 ppm CO and synthetic air, was then introduced into the gas cell at a flow rate of 450 sccm. All spectra were recorded by accumulating 64 scans with resolution of 4 cm^{-1}.

3. Results and Discussion

Figure 1(a) displays the X-ray diffraction (XRD) patterns of the as-prepared Au/TiO_2. As seen, the diffraction peaks of Sample (a) are strong, and occurred at 25.33°, 36.99°, 37.84°, 38.60°, 48.07°, 53.95°, 55.11°, 62.17°, 62.75°, 68.84°, 70.35°, 74.16°, 75.22°, 76.10°, 78.75°, 82.76°, indicating that Sample (a) is an anatase tetragonal TiO_2. Au was not observed in the XRD results probably due to low Au loading or small Au particle size. The UV-Visible diffuse reflectance spectra of all samples are given in Figure 1(b). It can be seen that TiO_2 has a relatively broad absorption in the UV range. In Au/TiO_2, visible light absorption is significantly increased due to surface plasmons oscillation. A higher TEM magnification in Figure 2 provides a clearer image of the randomly decorated TiO_2 particles. The atomic ratio of [Ti]: [O]: [Au] for the Au/TiO_2 surfaces are in the range of 27.52-31.67: 68.21-72.32: 0.12-0.16. In accordance with the XRD results, the molar ratio of Ti reduces with an increase in the molar ratio of Au in the reaction solution, probably due to the collapse of the TiO_2 crystalline phase with an increase of the microwave power. At an initial CO concentration of 1,000 ppm, Au/TiO_2 using a microwave power of 100 W (Sample (b)) achieved complete CO conversion in 7 min, halved than that without microwaved which required 14 min to achieve the complete conversion. This outstanding performance can be attributed to the plasmonic effects of Au/TiO_2. The interfacial heterostructures form Schottky junctions that act as charge reservoir, thus improving carrier transport.

Table 4: Operating parameters of the microwave method and the molar ratio of each element for Au/TiO_2 catalysts.

Sample	Microwave power (W)	Microwave Temperature (°C)	Microwave Time (min)	Annealing temperature (°C)	Annealing time (min)	The molar ratios of Ti: Au
(a)	50	80	60	400	300	1: 0.1
(b)	100	80	60	400	300	1: 0.1
(c)	150	80	60	400	300	1: 0.1
(d)	200	80	60	400	300	1: 0.1

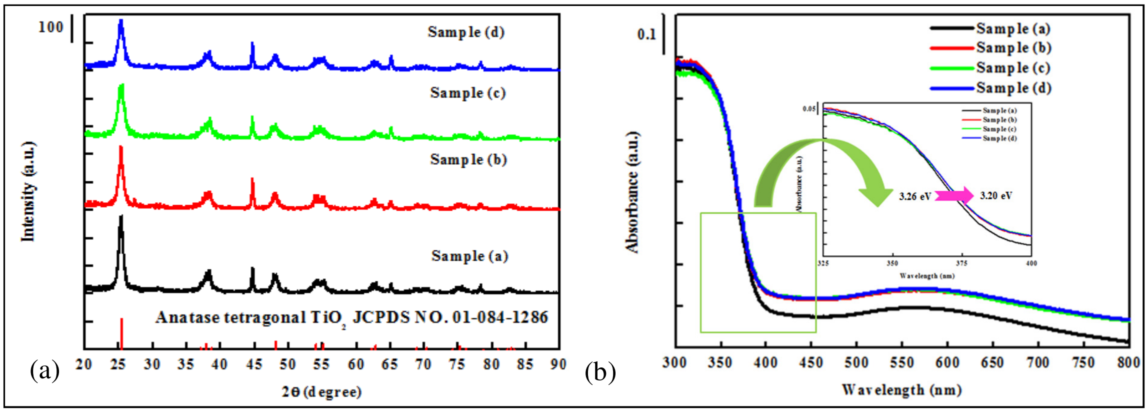
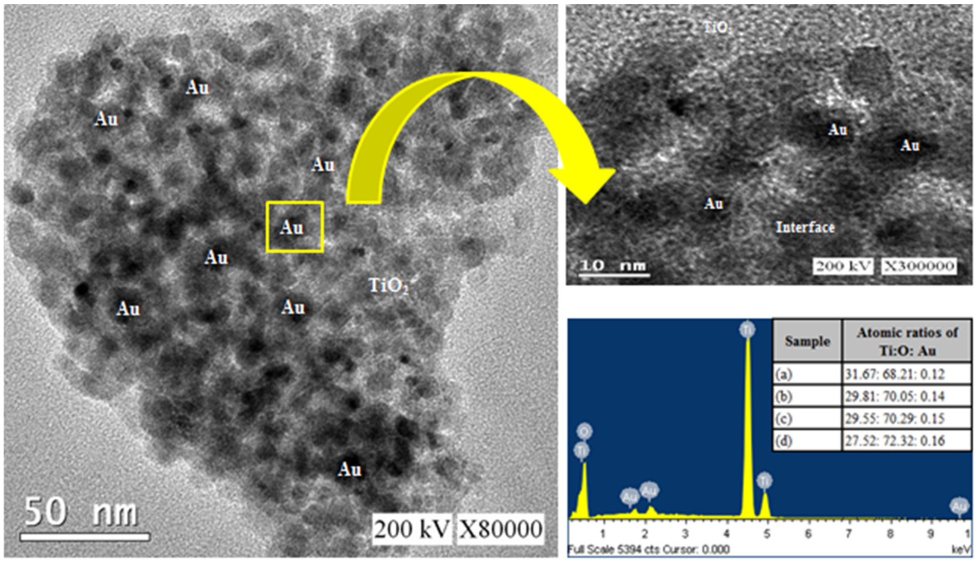


Figure 3: (a) XRD and (b) UV-VIS diffuse reflectance spectra of various Au/TiO_2 catalysts



Sample	Atomic ratios of Ti:O: Au
(a)	31.67: 68.21: 0.12
(b)	29.81: 70.05: 0.14
(c)	29.55: 70.29: 0.15
(d)	27.52: 72.32: 0.16

Figure 2: TEM images of various Au/TiO_2 catalysts

4. Conclusion

In summary, application of microwave power in the synthesis of Au/TiO_2 was shown to impose a positive contribution for the removal of carbon monoxide.

Acknowledgements: The authors thank the Ministry of Science and Technology of ROC for the Science Fund project of MOST 104-2119-M-027-001.

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POCER181: Synthesis and Characterization of Cu- doped Lanthanum Perovskite Catalyst for Nitrous oxide oxidation

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Keywords: Modelling; Sol-gel method; Wastewater Treatment.

1. Introduction

In recent years, nitrous oxide (NOx) has been confirmed to cause critial environmental and human health issues to be the major air pollutant. However, few studies have evaluated the catalytic properties of transition metal doped Lanthanum perovskite catalyst for removing volatile organic compounds (VOCs) [Blasin-Aubé *et al.*, 2014]. The main aim of this study is to find novel materials for nitrous oxide oxidation.

2. Methodology

The copper (Cu)-doped $LaMnO_3$ ($LaMn_{1-x}Cu_xO_3$) catalysts were synthesised using a sol-gel process developed from a reported procedure [Pan *et al.*, 2016]. The detailed preparation parameters used in this study are shown in Table 1.

Table 5: The parameters of the sol-gel method and the molar ratios of each element for $LaMn_{1-x}Cu_xO_3$ catalysts.

Sample/ Reagent	**5 M $La(NO_3)_3$/ mL**	**5 M $Mn(NO_3)_2$/ mL**	**5 M $Cu(NO_3)_2$/ mL**	**1 M $C_6H_8O_7$/ mL**	**Molar ratios of La: Mn: Cu in the reaction solution**
(a)	5	5	-	10	1.0: 1.0: 0.0
(b)	5	4	1	10	1.0: 0.8: 0.2
(c)	5	3	2	10	1.0: 0.6: 0.4
(d)	5	2	3	10	1.0: 0.4: 0.6
(e)	5	1	4	10	1.0: 0.2: 0.8

3. Results and Discussion

Figure 1 shows the XRD patterns of the $LaMn_{1-x}Cu_xO_3$ films. As seen, the diffraction peaks of sample (a) are strong, and occurred at 22.97 °, 32.77 °, 40.35 °, 46.91°, 52.73°, 58.29°, 68.86°, and 77.84°, confirming the formation of rhombohedral $LaMnO_3$ (JCPDS NO. 01-075-0440). There are no other impurity diffraction peaks in the XRD patterns. The diffraction peaks of rhombohedral $LaMnO_3$ phase reduced with an increase in the molar ratio of Cu in the reaction solution. Agglomeration of spherical particles were observed as in Figure 2, regardless of the copper molar ratio. The atomic ratios of [La]:

[Mn]: [Cu]: [O] are 1: 0.77-1.05: 0.00-0.95: 2.84-3.47. It was found that the Mn-site more electron hole and oxygen vacancies created with an increase of the copper concentration, which consequently increases the conductivity. Similar result was reported by Mahata et al. [Mahata *et al.*, 2017], in which the micro-structure changes with the concentration of galcium (Ca) in lanthanum mangatites ((LaMnO3) film due to the replacement of In^{3+} by La^{3+} ions in the crystal structure. The BET surface area of $LaMn_{1-x}CuxO_3$ increases from 9.8 to 15.68 m^2/g as the ratio of Cu/La increases, due to the particle size decrease during the substitution process of Mn^{2+} by smaller Cu^{2+} will decrease. The maximum nitrous oxide oxidation efficiency of samples prepared in this study with reaction temperature kept at 200°C was found to be 55.68% under VOCs concentration kept at 176 ppm.

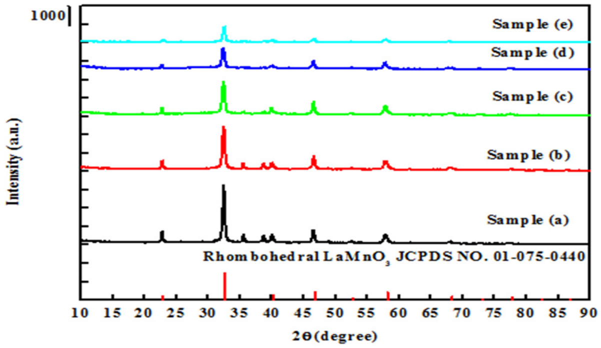

Figure 4: XRD patterns of all samples

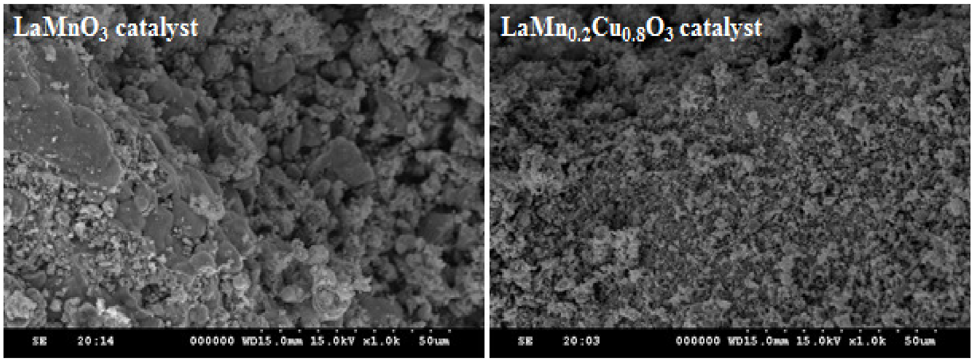

Figure 2: SEM images of various $LaMn_{1-x}Cu_xO_3$) catalysts

Acknowledgements: The authors thank the Ministry of Science and Technology of ROC for the Science Fund project of MOST 104-2119-M-027-001.

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POCER182: Influence of the Calcination Temperature on Physico-chemical Properties of Mesoporous TiO_2 for Deoxygenation of Triglycerides

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Keywords: Biofuel; Calcination; Deoxygenation; Mesoporous titanium dioxide; Triglycerides.

1. Introduction:

Worldwide environmental concern owing to greenhouse gas emission through combustion of fossil fuel and depletion of fossil fuel urged the need for sustainable biofuel production (Shim et al., 2014). Special attention has been given to pyrolysis of biomass to produce bio-oil. However, the high oxygen content of bio-oil hinders the direct application as a fuel substitute [Zhang et al., 2016]. Thus, further processing via deoxygenation is necessary. Deoxygenation is an important method to convert bio-oil into green hydrocarbon which having same properties as petroleum fuel [Seifi & Sadrameli, 2016]. Titanium dioxide (TiO_2) have passionately studied over the past decades due to its potential applications in many areas. TiO_2 is widely utilized because of its redox property, chemical stability, availability, environmental friendly, and low cost [Tian, Zhang, Scott, Ng, & Amal, 2014]. The development of a mesoporous framework on TiO_2 has gained great attention because such structure could improve diffusion transfer of reactant, coupled with high surface area [Chen, Wang, & Fu, 2009].

2. Methodology:

This work reports the deoxygenation of triglycerides to hydrocarbon-like biofuel over mesoporous TiO_2 ($mTiO_2$) at different calcination temperature of 400, 500, 600, and 800 °C. $mTiO_2$ was synthesized by sol-gel method with the addition of triblock copolymer (Pluronic F127) as a surfactant. The influence of the calcination temperature on physico-chemical properties of $mTiO_2$ was investigated by XRD, FESEM, BET, Raman and FTIR. Based on the nitrogen adsorption-desorption results, BET surface areas gradually decreased on increasing calcination temperature, with an observed phase transformation from amorphous to crystalline phases (anatase, rutile, and brookite) through XRD. The $mTiO_2$ calcined at 500 °C allowed for more ordered condensation (S_{BET} = 51.90 m^2/g, Pore Volume = 0.16 cm_3/g), which estimated that to enhance the deoxygenation activity due to higher surface area and uniform pore size. While higher calcination disorders the mesostructured framework of $mTiO_2$ and decrease BET surface area.

3. Results and discussion:

The influence of calcination temperature of $mTiO_2$ on deoxygenation of triglycerides was evaluated for the conversion of triglycerides. Figure 1 demonstrated the total conversion of triolein (model compound of triglycerides) to hydrocarbon like fuel over $mTiO_2$ calcined at different temperatures. Among the catalyst, $mTiO_2$ calcined at 500 °C showed the excellent catalytic activity of 84% conversion for deoxygenation of triglycerides.

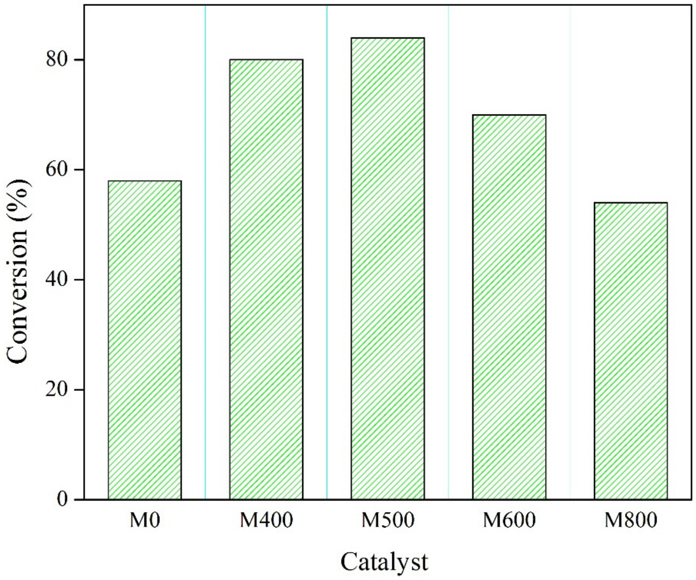

Figure 1: Total conversion of triolein over $mTiO_2$ calcined at different temperature

4. Conclusion

This study suggests that the synergistic effect of phase transformation, surface area, and porosity which play an essential role in determining deoxygenation activities. This finding shows that the $mTiO_2$ is a potential candidate in producing sustainable hydrocarbon like biofuel from triglyceride.

Acknowledgments: This work is supported by the University of Malaya under SATU grant (RU018D-2016), Postgraduate Research Grant (PPP) grant (PG071-2014B) and University of Malaya Research Grant (RP025A-14AET).

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POCER184: Carbon Capture and Utilization: Using Alkaline Wastes from Industries

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Keywords: Alkaline Materials; Carbon Sequestration; Feedstock; Utilization.

1. Introduction

Carbon utilization and sequestration (CCU) is an encouraging method, whereby carbon dioxide which would have been released into the atmosphere in high concentrations is being captured, used and stored in a solid form for further usage [Pan *et al.*, 2012]. Mineral sequestration is an important method for permanent carbon storage [Bobicki *et al.*, 2012]. One of the promising approach is the accelerated carbonation. This procedure uses alkaline materials which reacted with CO_2 in the presence of moisture to speed up the reaction by reducing the timescale from years to few minutes or hours. This accelerated carbonation uses feedstock consisting of natural silicate-minerals (e.g. olivine, serpentine and wollastonite) and industrial residues (e.g. steelmaking slag, municipal solid waste incinerator ash, and air pollution control deposits) [Pan *et al.*, 2012]. The CCU helps to mitigate the effect of global warming potential [Cuellar-Franca and Azapagic, 2015]. These alkaline solid waste has shown to be an attractive way to capture CO_2 by carbonation and to remove the contents of Ca(OH)2 in solid deposits. Nevertheless, the economic viability and the optimal conditions for CO_2 reaction technology must be studied [Pan *et al.*, 2012]. This write-up offers a summary of the types of wastes from the industries that can be used for mineral sequestration and the process methods available.

Table 1: Description of Alkaline Solid Wastes for Accelerated Carbonation and Utilization [Pan *et al.*, 2012]

			Applications	
Waste group	**Management issues**	**Major Compounds in Carbonation**	**Conventional Method**	**Utilization Potency after Carbonation**
MSWI fly ash	Heavy metals such as cadmium, lead, and zinc (hazardous) and high levels of dioxin, soluble salts	Lime (CaO); Portlandite (Ca(OH)2); Ca(OH)Cl; Gehlenite (Ca2Al2SiO7	90% of fly ash produced in UK was sent to landfill	Reuse as construction Aggregates
Steelmaking Slag	The release vanadium and Risk of chromium	Larnite (Ca2SiO4); Brownmillerite (Ca2FeAlO5); Lime (CaO); Ettringite (Ca6Al2OH12(SO4)3•26H2O); Portlandite (Ca(OH)2)	Disposed of in landfills, if not recovered	Reuse as an aggregate for civil engineering
MSWI bottom ash	Heavy metals Leaching, like Cu, Zn, Pb	Gehlenite (Ca2Al(AlSiO7)); Portlandite (Ca(OH)2); Ettringite (Ca6Al2OH12(SO4)3•26H2O)	More than 50% is used as a secondary building material, road bases, and civil engineering structures in Europe	Replace the sand or gravel fraction in concrete bricks or Reuse as secondary raw construction material
Cement kiln dust	Applied in agriculture, still, increased worries over the health and environmental hazards	Lime (CaO); Portlandite (Ca(OH)2); Calcium silicates; Gehlenite (Ca2Al(AlSiO7))	Recycling and reuse as a road base material is an established process	Reuse as road base or construction material. No free-CaO was observed in the reacted samples

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POCER185: Degradations of Aqueous Bisphenol A via a Iodine-Bismuth–Codoped- Titanium Dioxide Photocatalyst under Simulated Solar Light Irradiation

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Keywords: Bisphenol A; Interparticle Electron Transfer; Photocatalytic; Titanium Dioxide.

1. Introduction

In this study, synthesized iodine-bismuth-codoped-titanium dioxide (I–Bi–TiO_2) particles, in comparison to commercial titanium dioxide (TiO_2, P25), on the degradation of bisphenol A (BPA) in water was investigated under simulated solar light irradiation. The photogenerated carriers with the process of generation, transfer, and consumption can be considered as the photocatalytic reaction [Zhao *et al*., 2005; Zhao *et al*., 2013], figure 1 presents that under simulated sunlight irradiation, the photogenerated electrons of the TiO_2 conduction band (CB) will transfer to the CB of Bi_2O_3 ; duo to the holes transfer in the opposite direction from the electrons, the photogenerated holes of the Bi_2O_3 from valence band (VB) move to the VB of TiO_2, which charge separates [Ren *et al*., 2015], this process is called interparticle electron transfer (IPET); the oxygen from air will be reduct back to superoxider adicals (• O_2^-) by accepting electrons on CB; the hydroxyl radicals (• OH) produced by H_2O reacting with the holes on VB [Kuo *et al*., 2016], Then radical formed at the surface quickly undergoes degradation reaction. I^{7+}, I^{5+} and I^- were produced with adding IO_3^- that act as electron acceptors, to inhibit electron–hole pairs recombination and promoting the separation of photo-generated, enhancing photocatalytic activity [Kuo *et al*., 2015].

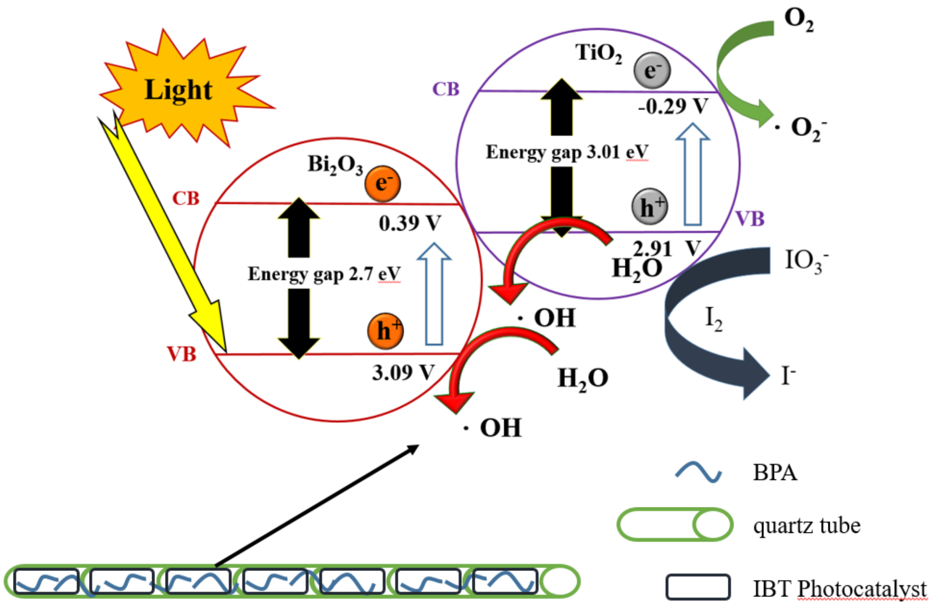

Figure 5: Proposed Mechanism for BPA degradation by I–Bi–TiO_2 under Simulated Solar Light Irradiation.

2. Results and Discussions

Results indicated that I–Bi–TiO_2 acted favorably as a photocatalyst, Figure 2 presents the photodegradation of BPA with the prepared photocatalysts. After 22 minutes, T, 1.0BT, 0.1IBT, 1.5IBT, 3.0IBT removed 76.1, 82.7, 87.8, 89.5 and 100.0% of BPA, respectively, by photodegradation under simulated solar light.The degradation of BPA using I–Bi–TiO_2 photocatalysts were more efficient than using TiO_2. Furthermore, 3.0IBT is the most active and completely degraded BPA in 22 minutes under simulated solar light. After the degradation process of 3.0 IBT, We found out that there was a little iodine ions dissloving in the solution.

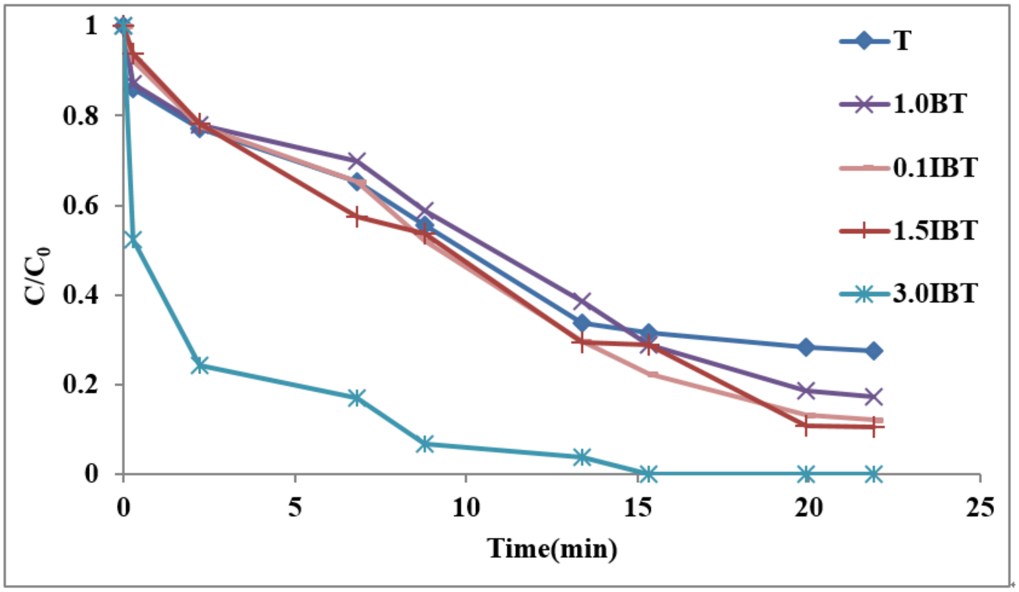

Figure 2: BPA Degradation of Various Photocatalysts under Simulated Solar Light.
(BPA= 20 mg/L；Q= 3.6 cm^3/min；t= 22 min ; ISL= 1011.7 mW/cm^2)

Acknowledgements: The authors thank the Ministry of Science, Technology and Innovation for the Science Fund project of No. NSC 101-2221-E-151-038-MY3.

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POCER186: Antibacterial Study of Tungsten Oxide Particles on Staphylococcus Aureus and Pseudomonas Aeruginosa

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Keywords: *Pseudomonas aeruginosa*; *Staphylococcus aureus*; Tungsten Oxide.

1. Introduction

Civilization and development of the country has bring along chain of pollutant problems. Industralization containminates rivers and lakes, reducing drinkable water resources. The intense research works to treat waste water have been widely discussed. Using of semiconductor photocatlysts for waste water treatment has received attention due to its simple preparation method, low material and operational cost [Yu *et al.*, 2011]. Nevertheless, efforts are still needed to produce low cost semicondoctor photocatalysts with high antibacterial perfomance. In this work, the antibacterial performance of tungsten oxide (WO_X) was studied. It was selected because it has a smaller bandgap (2.6 – 2.8 eV) that allow a better photo absorption in visible light irradiation, non toxicity and high oxidation power of valence band holes [Adhikari *et al.*, 2015]. This nanoparticles are promising material which suit to be used in solar cells, phototransistors and opto-electronic applications [Chekin *et al.*, 2013].

2. Methodology

The WO_x particles were synthesized by sodium tungstate dihydrate ($Na_2WO_4{\bullet}2H_2O$) and hydrochloric acid (HCl) via solution precipitation method. Briefly, sodium tungstate dihydate was dissolved in deionised water and constantly heat and stir. HCl was added drop by drop into the solution and stirred continously. Then the solution was placed in water bath for 21 hrs and maintain at 90 °C. The yellow precipitation was separated from solution via centrifugation. Subsequent, it was rinsed with deionized water and followed by ethanol for several times to remove chemical residuals. Then the sample was dried in oven. Different analysis techniques were used to characterize the structure, morphologies and antibacteria behaviour of WO_x particles. The samples were characterized by XRD Bruker D8 Advance diffractometer (Cu K_α, $\lambda = 0.154$ nm), FESEM (Zeiss Supra 35 VP instrument) and Energy Dispersive X-ray Spectroscopy (EDX), FTIR (Spectrum One - PerkinElmer precisely) and Zeta Potential (Zetasizer Nano ZS -Malvern). The antibacterial tests were carried out through microdilution method. The bacterial strains used in this study were Staphylococcus aureus (ATCC 29213) representive as gram positive bacteria and Pseudomonas aeruginosa (ATCC 27853) as gram negative bacteria. The major difference of gram positve and gram negative bacteria were illusratrated in Figure 1. These different types of bacterial allow us to evaluate the potential antibacterial activity of the nanoparticles. Dffferent concentration of nanoparticles were suspended into ultrapure water. MHB were subjected into the 96 well plate and follow by the nanoparticles. After that, cultured bacteria was added into the well too. Different concentrations of nanoparticles, ranging from 8 ug/ml to 2048 ug/ml, were prepared in order to study their effect against the bacteria in liquid media. The antibacterial activities of WO_x nanparticles were determined by their minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC).

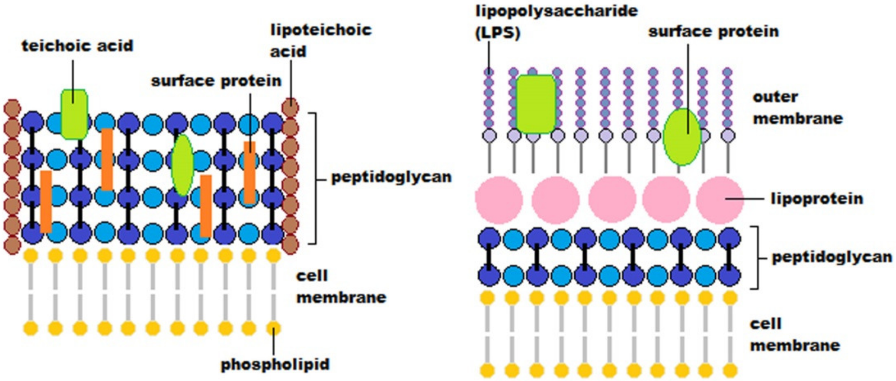

Figure 1: Schematic Diagrams of the Cell Walls of Gram Positive and Gram Negative Bacteria

3. Results and Discussions

The XRD result shows the sample was WO_x nanoparticles, consists of WO_3, $W_{18}O_{49}$, and WO_2. The WO_x nanparticles are irregular in shape with size 194.698 ± 89.44 nm. The EDX analysis reveals that it composed of W and O elements, with atomic ratio of 1:1.11. No other element (impurity) was found. In addition, FTIR analysis verifies the sample is WO_x with high purity. The antibacterial study shows that WOx nanopartices suppressed the growth of *Staphylococcus aureus* more effective than *Pseudomonas aeruginosa*. The gram negative bacteria have a lipopolysaccharide (LPS) that form cytoplasmic membrane, protecting them from external chemicals. On other hand, gram positve bacterial have a simple wall and lack of outer membrane. This structure is more vulnerable to external chemical and thus it has less resistant to the present of WO_x nanoparticles.

Acknowledgements: The authors are grateful to the Ministry of Higher Education, Malaysia for providing the research funding under Fundamental Research Grant Scheme (FRGS) (203/PBAHAN/6071327) to support the present study.

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POCER187: Comparison between Aqueous Bisphenol A and Acute Toxicity Removal Using a $KH(IO_3)_2/Bi_2O_3/TiO_2$ Composite Photocatalyst

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Keywords: Bisphenol A; Electron-Hole Pairs; Microtox®; Photodegradation; Ultraviolet light.

1. Introduction

Synthesized iodine-bismuth-codoped-TiO_2 (potassium biiodate-bismuth trioxide-titanium dioxide, IBT) photocatalyst, in comparison to commercial TiO_2 (P25, Degussa 99%), were conducted to survey the performance of the acute toxic unit (TU_a) and the photocatalytic degradation of bisphenol A (BPA, Aldrich 97%),with the concentration is 20 mg/L, which is a model pollutant in aqueous solutions. These $KH(IO_3)_2/Bi_2O_3/TiO_2$ composite photocatalysts were filled in the columns with continuous-flow system under Ultraviolet light (UV) and one degraded process took about 22 minutes to finish (Figure 1). In order to make sure that the degraded value did not be affected by the adsorption on the photocatalyst surface, before the degraded process began, there was a series of adsorption in the dark and also took about 22 minutes when the concentration of BPA did not change.

2. Results and Discussions

In the result of the performance of the photocatalytic, the degradation of bisphenol A were 88.2% and 60.7% using the IBT (I:Bi:Ti=2:1:97) photocatalyst and TiO_2, respectively (Figure 2). The former with the higher removal ratio might because the synergistic effect between bismuth and iodine, which leading to the narrowing of bandgap and extending the time of electron-hole pairs recombination. Its high performance was attributed to the combined efforts of both iodine (similar ionic radius) and bismuth (improved charge separation). [Ma *et al.*, 2011] reported that iodine-doped on titanium dioxide acted as scavengers of conduction band electrons, moreover, it altered the surface charge and bulk bandgap of TiO_2 to avoid the recombination of these electrons with valence band holes. [Li *et al.*, 2013] also reported that bismuth on titanium dioxide enhance the photocatalytic activity of TiO_2 due to trap photo-generated e^-, reducing recombination of electron-hole pairs. On the other hand, although TiO_2 could also degrade BPA, the performance was not good enough, and the reason leading this result might because its large bandgap semiconductor (3.2 eV).

3. Conclusion

BPA is a kind of toxic chemical substances, and is also harmful to humans. [Xu *et al.*, 2002] demonstrated that BPA induced the death of some cells and caused adverse effects in the reproductive systems of humans and animals. To understand how much BPA remaining in the solution after working one degraded process, it measured by Microtox® toxicity analyses. The result indicated that the residual of acute toxic unit were respectively 1.75 (TU_a) with IBT and 6.41 (TU_a) with TiO_2 (Figure 2). [Chiang *et al.*, 2004] observed that an aqueous BPA (20 ppm) was degraded after 120 minutes of UV illumination (20 W) in the presence of TiO_2 particles. The differences between this study and [Chiang *et al.*, 2004] was the reason possibly why this study only took 22 minutes instead of 120 minutes.

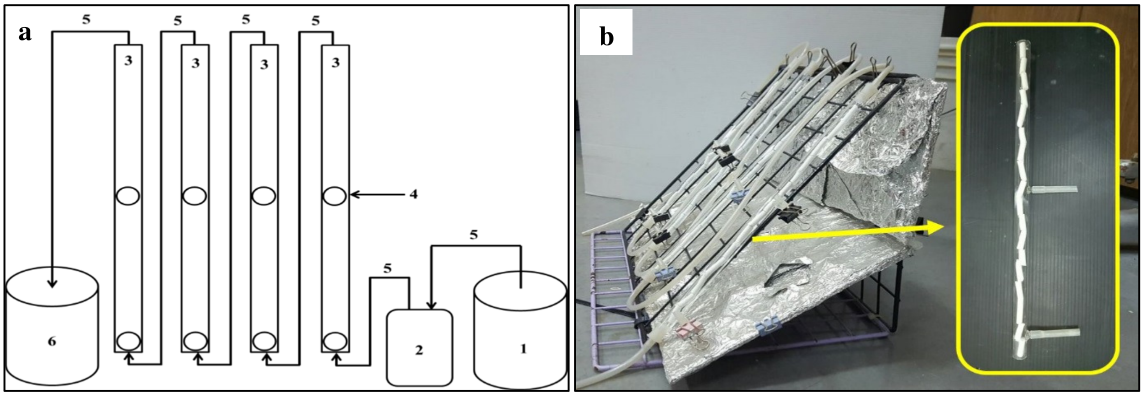

Figure 6: (a) the flowchart of photocatalytic experiment and (b) the photocatalytic reactor. the storage barrel of 20 ppm BPA(1); pump(2); quartz tube(3); the place of getting samples(4); conveyor pipe(5); the storage barrel of the outlet waste water(6)

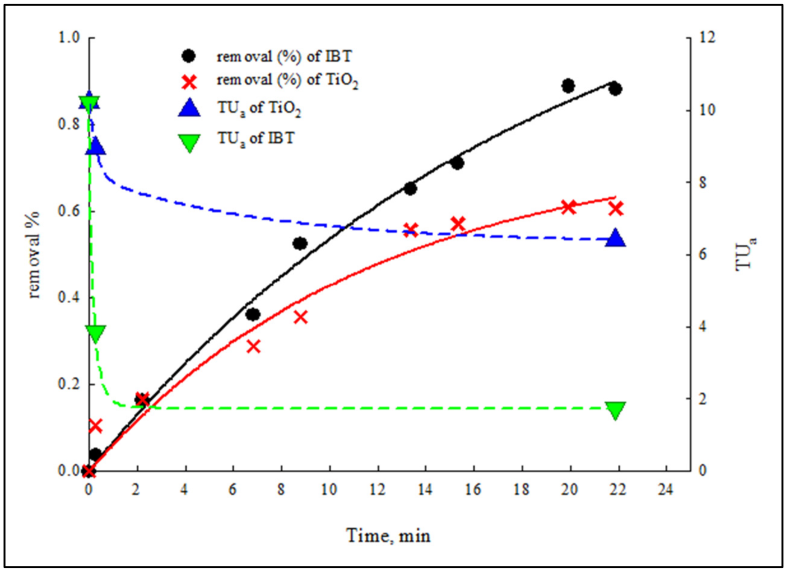

Figure 2: The performance of BPA removal and acute toxic unit in UV light with IBT and TiO$_2$

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POCER188: Biodegradable and Biocompatible Wound Dressing Membrane: Effect of Chitosan Concentration on Membrane Properties

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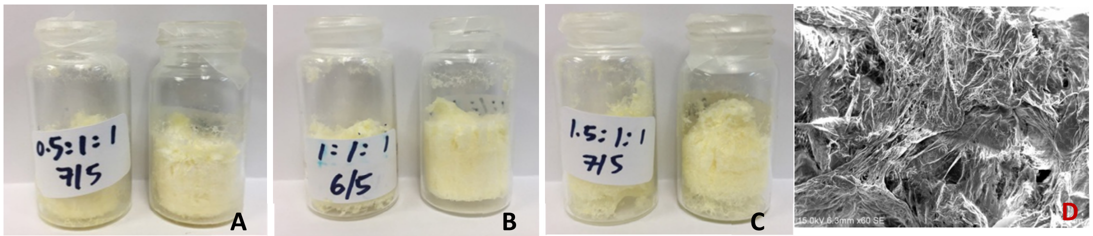
Keywords: Alginate; Biopolymer; Chitosan; Wound Dressing.

1. Introduction

Exuding wounds such as ulcers, pressure sores and burns are common conditions in both acute and chronic medical illnesses. Depending on the severity of wound, some patients has to frequent hospitals to have their wound dressing changed, distrupting daily routine as it occasionally involves long waiting time. Thus, significant amount of work was done in search for an alternative to replace this time consuming routine.The wound healing properties of tocotrienol were previously established in pre-clinical models. Oral and topical palm tocotrienols were found to enhance wound contraction and rate of wound healing in rat models [Nurially *et al.*, 2011; Shahrim *et al.*, 2015]. Cellular proliferation and collagen synthesis at the wound site were also found to be elevated in groups of rats treated with palm tocotrienols [Shahrim *et al.*, 2015]. The strong anti-oxidant and anti-inflammatory effect of tocotrienol serve as a promising natural therapeutic agent for wound management. In order to develop a wound dressing that can (1) incoporate the therapeutic effects of tocotrienol for enhanced wound healing and (2) can be easily applied at home, it is essential to identify a suitable material that can be used to (1) load and release tocotrienol efficiently, (2) provides moist environment, (3) allow gas exchange, (4) provides barrier to microorganisms and (5) ability to remove excess exudates. Also, the material used should not cause allergic reactions where the wound dressing is applied. Meanwhile, chitosan exhibits hemostatic characteristics as an agent that encourages natural blood clotting. A study by [Oh *et al.*, 2016] also found that incorporation of alginate layer on chitosan membrane for greywater filtration improved the water retention property of the membrane. This study aims to develop a biodegradable and biocompatible wound dressing membrane that consists of 3 main elements – chitosan, alginate and tocotrienol to assist in the healing of cuts, open wounds and burns. Chitosan concentration in the membrane was varied from 0.5 to 1.5% w/w with fixed proportions of alginate, polyethylene glycol (PEG), and tocotrienol to investigate the changes to freeze dried membrane properties which can be shown in Figure 1 below.

Figure 1: Images of (A) 0.5% w/w (B) 1% w/w (C) 1.5% w/w Chitosan (D) SEM Image of Freeze-Dried Membrane



2. Results and Discussions

All membranes exhibited a sponge-like texture due to sublimation of water in the freeze drying process, generating porous structure (Figure 1D). The 0.5% w/w chitosan membrane was very fragile, collapsed as soon it was removed from the casing. Hence, no further characterisation was done for the 0.5% w/w chitosan membrane. The 1 and 1.5% w/w chitossan membranes were subjected to water contact angle test and shown highly hydrophilic properties as water droplets were immediately absorbed into the membrane. Hydrophilicity of the membrane is desireable as as it has the abilty to absorb exudates, assisting healing and closure of a wound. The maximum water uptake per gram of 1 and 1.5% w/w chitosan are 5.24 g H_2O/g membrane and 6.67 g H_2O/g membrane respectively. This shows that higher chitosan concentration contributes to higher absorption of water. However, the trend of water uptake (Figure 2) for 1% w/w chitosan membrane is more gradual and water retention is more stable, unlike 1.5% w/w chitosan membrane.

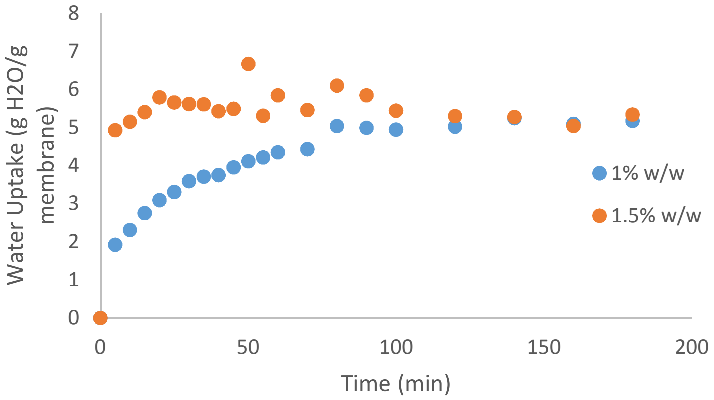


Figure 2: Water Uptake of Freeze Dried Membranes Loaded with Tocotrienol

Figure 3 shows the trend of tocotrienol release, represented as ‘derived count rate per gram’. There is a higher rate of tocotrienol release for 1.5% w/w chitosan membrane. Despite 1.5% w/w chitosan membrane has better characteristics in terms of water absorption and release of tocotrienol, however, the structure of the membrane was less stable due to greater weight loss upon water uptake. Therefore, 1% w/w chitosan membrane is preferable due to more gradual release of drug and absorption of water.

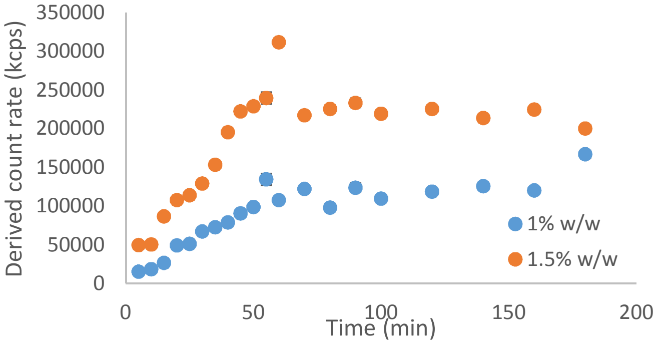


Figure 3: Release of Tocotrienol from Freeze Dried Membrane

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POCER189: Comparison of Training Algorithms for Synthesis of Polycaprolactone via Biopolymerization using Feedforward Neural Network

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Keywords: Bioreactor Training Algorithms; Enzymatic Polymerization; Feedforward Neural Network Modelling; Polycaprolactone (PCL).

1. Introduction

In recent years, one of the most emerging biodegradable plastic is Polycaprolactone (PCL). PCL is a synthetic biodegradable polyester which is largely produced based on chemical polymerization method under momentuous chemical and conditions. Even though chemical production of PCL has been established and matured, it has a major draw back of having residues of metallic catalyst which will cause the adverse effect especially in biomaterial application. As a result, new methods of producing PCL is being studied and researched, which is known as biopolymerization. Biopolymerization also known as enzymatic polymerization meaning "enzyme" is used as catalyst to synthesise the polymer using ring opening polymerization (ROP) technique. Biopolymerization overcomes the challenges such as residues of metal catalysts which are mostly causing acute/chronic effect and perfect removal of them are no more present. Thus, biopolymerization does give a better outcome as biocatalyst is non-toxic and renewable as compared to chemical processes. However, it has its own limitation such as the high cost and limited availability of enzymes, less choices for reaction substrates and conditions, etc. Lately the ROP of ε-CL has been carried out with several enzymes for example, lipase CA (*Candida Antarctica*), lipase CC (*Candida cylindracea*), lipase PF (*Pseudomonas fluorescens)*, PPL (porcine pancreas lipase), lipase PC (*Pseudomonas cepacia*), and *Rhizopus japonicus* lipase (lipase RJ) and also by non-lipase enzymes like Humicola Insolens Cutinase (HIC) [Husen *et al.*, 2008]. Thus, it can be seen that the scope and significance of biopolymerization are still wide and to be explored. Empirical modeling has gained a lot of importance in the recent years and ANN is one of them. Very limited studies have been carried out in bio-polymerization. The objectives of this research are to develop a feedforward neural network model and a comprehensive comparison study on the application of different artificial neural network training algorithm for biopolymerization of ε-Caprolactone to PCL with candida antartica lipase B as catalyst (CALB) as catalyst.

2. Methodology

The scale up production of PCL from ε-CL was carried out in an Infors-HT Labfors bioreactor. Two important parameters namely reactor temperature and reactor impeller speed were considered for the study. The chemicals used were ε-CL (substrate/monomer), Toluene (solvent), CALB (enzyme). The ratio of solvent to monomer to catalyst is 2:1:10 (v/v/wt) [Kumar and Gross, 2000]. The effective volume of the reactor is 2 litres which is also the total volume for enzyme, solvent and monomer. The chemicals and enzyme were fed into the reactor. The reactor was switched on and the desired reactor temperature value was keyed in the computer connected to the reactor. This allowed the temperature to rise to the desired value. Once the desired temperature is reached the stirrer was switched on using the control panel in the reactor and set to the desired speed. As the mixture starts to react and the sample were removed every 1 hour until 7th hour. This procedure was carried out for the reactor temperatures of 60°C, 70°C and 80°C and impeller speed of 250 RPM, 500 RPM, 750 RPM, and 1000 RPM. The reactor temperature range optimized from conical flask study was 60°C to 80°C based on conclusion from the conical flask results and the reactor impeller speed chosen were 250, 500, 750 and 1000 RPM based on the literature review [Chaibakhsh *et al.*, 2012]. The experimental procedure and data for this work are taken from the author's previous work [Arumugasamy *et al.*, 2013].

3. Results and Discussions

Artificial Neural Network (ANN) simulates the neural networks that exist in the human brain. Even though the ANNs are not smart, however they are capable to analyse and recognise patterns of the input and target data inserted and eventually creating simple rules to solve complex problems [Lee-Cosio *et al.*, 2012]. Their training and learning capabilities are vast. Therefore, they are used widely in artificial intelligence research. Feed-forward artificial neural network (FANN) is one of the architecture in ANN, in which the information or signals will generate only in one direction, from input to output, which is also the most common neural network architecture. In this project, FANN was introduced, and there are 11 different training algorithms with its optimum hidden layers which were used to train the network and the results and error and compared. In this work, FANN was developed with time, temperature, reactor impeller speed as input and number average molecular weight (Mn), weight average molecular weight (Mw) and polydispersity index (PDI) were used as the output. 11 different training algorithms were used and the best training algorithm shown is Levenberg-Marquardt with MAE=46.38, MSE=0.109 and MAPE=9.78%. The regression from this model is 97.89%. The figure below shows the difference between the predicted values from the model and experimental values. It can be observed that the trendline of the two datas are similar which means the data predicted by the system is capable to follow the trend of the targeted data.

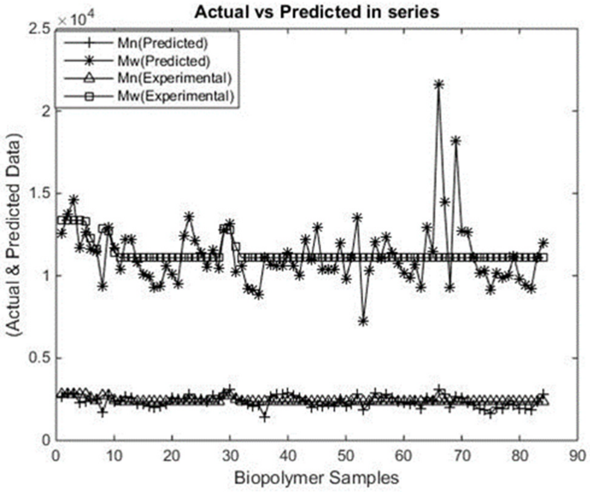

Figure 7: Actual vs Predicted in series

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POCER190: Carbon Dioxide Adsorption Using Activated Carbon Impregnated with Metal Oxides

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Keywords: Activated Carbon; Adsorption; Carbon Dioxide; Hydrothermal Treatment.

1. Introduction

The rise in concern towards the earth climate has attracted extensive effort to introduce efficient and cost-effective technologies for capturing or reducing carbon dioxide (CO_2), from large point sources like coal-fired power plant. Adsorption was considered as one of the most promising technologies in capturing CO_2 because of the low energy requirement, cost advantage, and ease of applicability over a relatively wide range of temperatures and pressures [Thiruvenkatachari *et al*., 2009]. Activated carbon (AC) as an agent for adsorption has been used for many years in many field due to the large pore volume and surface area. The aims of this study are to synthesis activated carbon with various metal oxides via hydrothermal impregnation method, to perform the physical-chemical properties of the AC impregnated AC-Metal oxide samples and to determine the performance of the impregnated activated carbon in capturing CO_2 from flue gas stream.

2. Methodology

In this study, a commercial activated was used as unmodified adsorbent. High purity commercial powder metal nitrates, copper nitrate ($Cu(NO_3)_2{\cdot}3H2O$) and cerium nitrate ($Ce(NO_3)_3{\cdot}6H_2O$) were used as metal oxide precursor to modify AC. AC is treated with metal nitrate of an appropriate concentration to obtain around 10 wt% of metal content per gram of PSAC (10 mL of 10 wt% metal solution/g of PSAC). 200 mL of 10 wt% metal solution/g and 20 g of AC are mixed at 200 ˚C in the autoclave for 20 min and then calcinated at 450 ˚C for 5 hours [Sumathi *et al*., 2010]. The samples are raw AC, AC impregnated with cerium oxide, AC impregnated with and lastly AC impregnated with both cerium oxide and copper oxide which are named as ACR, ACCe, ACCu and ACCeCu respectively. The sample with the best adsorption performance were characterized by different techniques using BET analysis and Scanning electron microscopy (SEM). The removal activity of the prepared sorbent is carried out in a fixed-bed reactor. The sorbent (5.0 g) is placed in reactor. A stream of CO_2 and helium gas (He) mixture is passed through the prepared sorbents with the ratio of 1:4. The reaction temperature of this process is preset to 30 ˚C. The concentrations of CO_2 are recorded continuously for every 10 seconds until it reaches the breakthrough point. The adsorption capacity of CO_2 on each samples is obtained by using breakthrough curve as following equation [Adelodun *et al*., 2014]:

$$q = \frac{C_0 F}{W} \int_0^{t_b} \left(1 - \frac{C}{C_0}\right) dt \qquad (1)$$

3. Results and Discussions

Based on the experiment, it is found that the adsorption capacity for ACR, ACCu, ACCe and ACCuCe are 0.652, 0.585, 0.856 and 0.560 mmol/g respectively. Figure 1 shows the performance of the sorbents which has highest adsorption capacity for the samples for removal of CO_2 based on the breakthrough curve. It can be observed that the adsorption pattern for each samples are almost the same. The longer the CO_2 maintain in contact with the sorbents, the better the adsorption. The highest breakthrough time was 19.33 min which is the adsorption using ACCe. Similar trends can be observed for modified AC. [Hosseini *et al*., 2015] reported that, AC impregnated with metal oxides has better adsorption capacity compared to unmodified AC. The characterization of ACCe using BET shows that the surface area and pore volume are decreasing after the adsorption. The surface area and pore volume before adsorption are 1,157 m^2/g and 0.397 cm^3/g respectively. After adsorption, the reduced to 1,041 m^2/g and 0.274 cm^3/g. This happened because the CO_2 particles has filled up the surface area and pore of the AC. This result correspond to the morphology of SEM as shown in Figure 2. The image shows that before adsorption, the sample has high porosity with CeO_2 particles on the surface, but the pores and surface are filled with CO_2 particles after the adsorption.

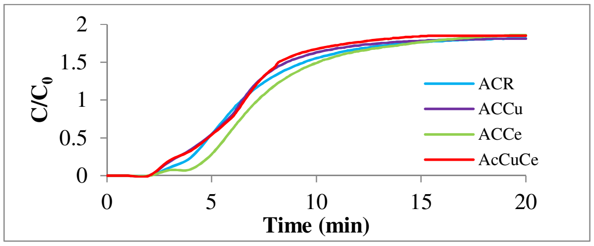

Figure 1: Breakthrough Curve of CO2 Adsorption using ACCe, BAKR and BAMR.

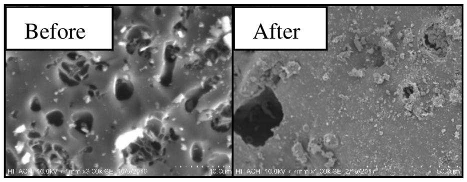

Figure 2: SEM images of ACCe before and after adsorption.

4. Conclusion

It can be concluded based on the experiment and observation, it can be said that the CO_2 adsorption can be done using activated carbon impregnated with metal oxides. ACCe showed the best removal compared to other impregnated metals based on it high adsorption capacity which is comparable to previous studies. The small pore size and the large surface area of AC are the important factor for physisorption in gas adsorption. Futhermore, the metal oxide, impregnated on AC provides chemisorption where the acidic CO_2 gas reacted with metal oxides particles by forming chemical bonding. Hence, the adsorption capacity was improved.

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POCER191: Feasibility of Alginate Beads as Packing Media for Anaerobic Palm Oil Mill Effluent (POME) Treatment

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Keywords: Alginate; Anaerobic Digestion; Packing Media; Palm Oil Mill Effluent.

1. Introduction

POME is a liquid waste generated from crude palm oil (CPO) processing facilities that has to be carefully treated prior discharge to water course due to high level of contamination. With the increasing production of CPO in the nation, the amount of POME produced is also expected to escalalate [Chin *et al.*, 2013]. Conventionally, POME is treated anaerobically in ponds prior post treatment to polish the effluent quality to meet the discharge standards set by the Department of Environment (DOE) [Poh and Chong, 2009], with a lot of research done to tackle issues in POME treatment. In fact, high-rate anaerobic reactor can be the remedy to resolve inconsistency in quality of treated effluent. However, one of the difficulties in the implementation of high-rate anaerobic reactor for POME treatment is the ability to retain microbial population for efficient anaerobic digestion.Combination of an upflow anaerobic sludge blanket (UASB) and anaerobic filter was found to be able to improve treatment efficiency as packing in the filter was able to retain fine sludge. Nevertheless, generation of packing wastes during maintenance creates another set of issue towards sustainability of operating such systems for POME treatment. In this study, the feasibility of a biopolymer – alginate to be used as an attachment material to enhance the performance of anaerobic POME treatment and eliminate packing wastes was explored.

2. Methodology

Two different sizes of alginate beads (4.07 mm and 4.78 mm) were fabricated to investigate the effect of bead size on the treatment efficiency of POME. Batches of anaerobic POME treatment were conducted in 500 mL Schott bottles for 7 days. Table 1 lists the conditions of the various experimental runs conducted throughout this study and each run was conducted in duplicates. MLSS of the seed sludge is 14000 mg/L.

Table 1: Conditions for batch experiments conducted in this study

Runs	**Constant variables**	**Manipulated variables**	
		Bead size (mm)	**Feed COD concentration after dilution (mg/L)**
1 2 3 4	Bead volume: 40 mL Seed sludge volume: 40 mL POME volume: 320 mL	4.07 4.78 4.07 4.78	43700 43700 43700 43700
5 6	Bead volume: 40 mL Seed sludge volume: 0 mL POME volume: 360 mL	4.07 4.78	43700 43700

3. Results and Discussions

For all bead sizes tested, the beads have a translucent appearance prior use but transformed to dark brown colour after two weeks of anaerobic digestion of POME, as shown in Figure 1 (A) and (B). Besides change in colour, the conditions of the beads varied over time, particularly the size of the spent beads (Figure 1(C)). The COD removal performance of the different set of studies is illustrated in Figure 2. Based on the results, it was found that the bead size did not have significant effect to the COD removal performance of the system. In addition, both sizes of beads tested fully disintegrated after 2 weeks of experiments in the treatment of POME. The disintegration can be related to the fact that alginate beads contain nutrient to assist microbe's growth. Instead of consuming the nutrient in POME, the microbes adapted to alginate as a nutrient and consumed the beads. Furthermore, alginate beads tend to disintegrate under harsh environment. Though having better COD removal efficiency, those with alginate beads did not show great difference from the control set. However, the fact that the pigmentation on the used beads indicated that melanoidin compound can be adhered on to the beads, helping to remove the colour from the wastewater if the beads can be strengthened. In conclusion, alginate beads can be used to aid decolourisation of POME but encapsulation or addition of other additives has to be done to strengthen the beads and improve retainment of microbes in the system.

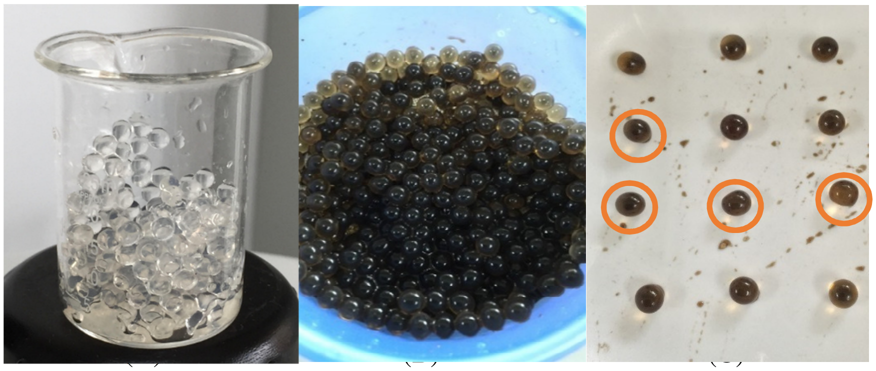

Figure 1: Images of Alginate Beads (A) Before Use (B) After Use (C) Beads with Reduced Size. Red Circles on the Beads Represent Disfigured Beads.

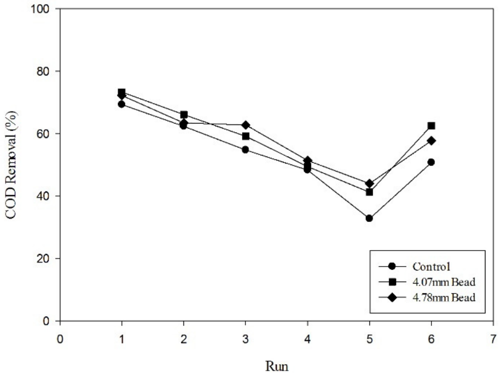

Figure 2: Cod Removal Efficiency of Anaerobic Digestion of POME

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POCER192: Optimization of Microwave-Hydrothermal Extraction of Malic Acid from Cactus (*Euphorbia Trigona*) using Response Surface Methodology

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Keywords: Cactus; Malic acid; Microwave-hydrothermal extraction; Optimization; Response surface methodology.

1. Introduction

Recently, we have been exploring the potential of malic acid from abundant fruits and plants for the synthesis of environmental friendly green solvents [Yiin *et al.*, 2016]. Lower amount of biomass particles could be observed after the delignification of lignocellulosic biomass with the malic acid derived mixtures [Francisco *et al.*, 2012]. Despite the fact that the conventional extraction methods such as heat reflux, maceration and Soxhlet extraction are of easy operation, they are time consuming and laborious with low yields [Wu *et al.*, 2012]. Besides, there are many examples of hydrothermal extraction of polar organic compounds using water [Matsunaga *et al.*, 2013] which is suitable to be used as a green alternative for the extraction of natural product at high temperature and high pressure conditions. The combination of both techniques is termed as microwave-hydrothermal (MH) extraction which has been used to extract the bioactive components from henna leaves [Zohourian *et al.*, 2011] at low temperatures and short extraction times. The main objective of this study is to investigate the MH extraction of malic acid from cactus (*euphorbia trigona*) using CEM MARS 5 microwave digester and the optimization of the interaction of process variables.

2. Methodology

A JASCO high performance liquid chromatography (HPLC) with Wakosil-II 5C18 HG Prep column and UV-Vis detector at λ=210 nm was used to measure the amount of malic acid extracted from cactus. The design of experiments was conducted by using response surface methodology (RSM) under central composite design (CCD) technique. The process variables investigated in this study were temperature, solvent-to-feed ratio, reaction time and hydrogen peroxide, H_2O_2. The manipulated variables with their respective ranges are shown in Table 1.

Table 6: Central Composite Design of Experiments for MH Extraction Process

Process Parameters	-2	-1	0	+1	+2
Solvent-to-feed ratio (molar ratio)	0.002	0.008	0.014	0.020	0.026
Hydrogen peroxide, H_2O_2 (g)	0.1	0.4	0.7	1.0	1.3
Reaction time (min)	5	20	35	50	65
Reaction temperature (^oC)	90	120	150	180	210

3. Results and Discussions

Figure 1 shows an increase in temperature decreases solvent viscosity and increases diffusion which further enhances extraction efficiency. The increase in diffusivity also causes improved mass transfer rate, thereby reducing extraction time. A remarkable increase in the extraction concentration was also observed when increasing the solvent-to-feed ratio from 0.002 to 0.008. This was due to the reduction in the solution concentration gradient at plant cells wall, brought about by high solvent-to-feed ratio, which consequently increased the diffusion rate of solute particles into the solvent [Li *et al.*, 2003]. The concentration of malic acid slowly reduced at extraction time longer than 20 min for the studies of the interaction among temperature, solvent-to-feed ratio and oxidant, H_2O_2 due to the degradation of compounds of interest at extreme conditions [Zohourian *et al.*, 2011]. MH extraction was intensely affected by the oxidant, H_2O_2 through the generation of low molecular weight carboxylic acids and OH radicals from H_2O_2. The hydrolytic deamination of aspartic acid and hydrolysis of fumaric or maleic acid formed from predominant reaction such as deamination also contributed to the formation of malic acid [Sato *et al*., 2004]. Hence, the ideal process conditions were found to be at solvent-to-feed ratio of 0.008, 120 °C and 20 min in the presence of 1.0 g of oxidant, H_2O_2.

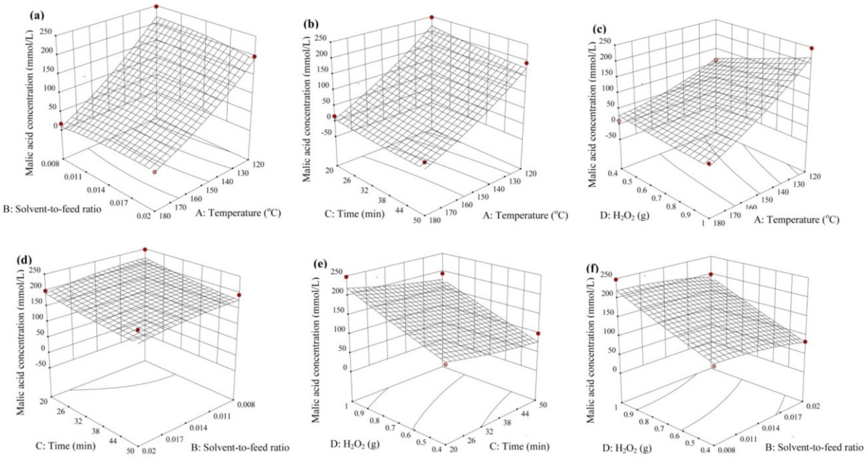

Figure 8: Response Surface Plots for MH extraction

Acknowledgements: The authors thank the funding supports from Fundamental Research Grant Scheme (FRGS) and Japan Society for the Promotion of Science (JSPS) Bilateral Joint Research Program.

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POCER193: Bio-Decolorization of Malachite Green and Reactive Black 5 in Anoxic-Aerobic Moving Bed Biofilm Reactor

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Keywords: Anoxic-aerobic; Bio-decolorization; Malachite Green; Moving Bed Biofilm Reactor (MBBR); Reactive Black 5.

1. Introduction

Biological treatment such as conventional activated sludge process is the most feasible and inexpensive approach to remove dyes from wastewater as compared to physicochemical methods. Dye reduction usually requires anaerobic conditions, whereas bacterial biodegradation of aromatic amines is an exclusively aerobic process [Pandey *et al.*, 2007]. Despite of its feasibility, increase efficiency of anaerobic color removal requires higher hydraulic retention times, higher biomass concentrations, higher primary substrate concentrations and lower dye concentrations, which are usually the drawbacks of conventional biological process. Moving Bed Biofilm Reactor technology is developed on the concept of combination of conventional activated sludge process and bio-film process. Each individual biocarrier increases productivity through providing protected surface area to support the growth of heterotrophic and autotrophic bacteria within its cells. Thus, this high-density population of bacteria that achieves high-rate biodegradation within the system with short hydraulic retention time, strong tolerance to organic loading impact, high biomass, no sludge bulking problem, compact design with expandable capacity, while offering process reliability and ease of operation [Jonstrup *et al.*, 2011]. Successful application of the MBBR process for the treatment of municipal domestic wastes and in the biodegradation of some aromatic compounds such as aniline [Delnavaz *et al.*, 2010], phenol [Ayati *et al.*, 2007] and polycyclic aromatic hydrocarbons [Plósz *et al.*, 2010] have been reported and published.

2. Method

The potential of the anoxic-aerobic bioreactor to decolorize and mineralize Malachite Green (MG) and Reactive Black 5 (RB5) was evaluated. For MG, two anoxic-aerobic Moving Bed Biofilm Reactors with Fill: React: Settle: Draw: Idle modes (hour) of 1: 21: 1: 0.5: 0.5 were operated sequentially with anoxic and aerobic condition during React mode; namely sq-MBBR1 and sq-MBBR2, respectively (Figure 1a). The treatment performance of these sq-MBBRs in treating MG containing wastewater was investigated in term of increasing MG concentration and the presence of biocarriers. Whilst for RB5, a single integrated anoxic-aerobic reactor (int-MBBR) was used (Figure 1b). The operational modes of int-MBBR was similar to sq-MBBR but with both anoxic and aerobic conditions integrated in the React mode; which was 16.5 hrs anoxic React and 4.5 hrs aerobic React. Int-MBBR was employed in treating RB5 instead of sq-MBBR so as to shorten the retention time and to reduce footprint. All treatment performances were conducted in air-conditioned room and with initial MLSS of 2000-3000 mg/L.

3. Results and Discussion

The sequential anoxic–aerobic (in sq-MBBRs) treatment of synthetic dye wastewater feed having 20, 30 and 40 mg/L of MG dye resulted up to 92% color removal after anoxic decolorization in sq-MBBR1. Addition of 10% and 20% biocarrier into sq-MBBRs further enhanced color removal to 94 and 95%, respectively, after anoxic decolorization. For all various feed of MG concentrations without biocarrier, 99% of color removal was observed after another 21 hrs of aerobic mineralization in sq-MBBR2. This long duration of aerobic mineralization was tremendously shortened to 7 and 4 hrs with the addition of 10 and 20% biocarriers, respectively. As for int-MBBR, decolorization of RB5 declined from 82% to 62% when the concentration of RB5 increased from 10 to 50 mg/L. Further deterioration to around 35% was exhibited after continue exposing the int-MBBR to 50 mg/L RB5 for another 10 days. Effluent COD after the anoxic process was found to be three times higher as compared to the influent COD, indicating the built up of aromatic amine intermediates after anoxic decolorization. Whilst elevated effluent COD after aerobic mineralization suggesting the possibility of the occurrence of autoxidation of the degraded RB5.

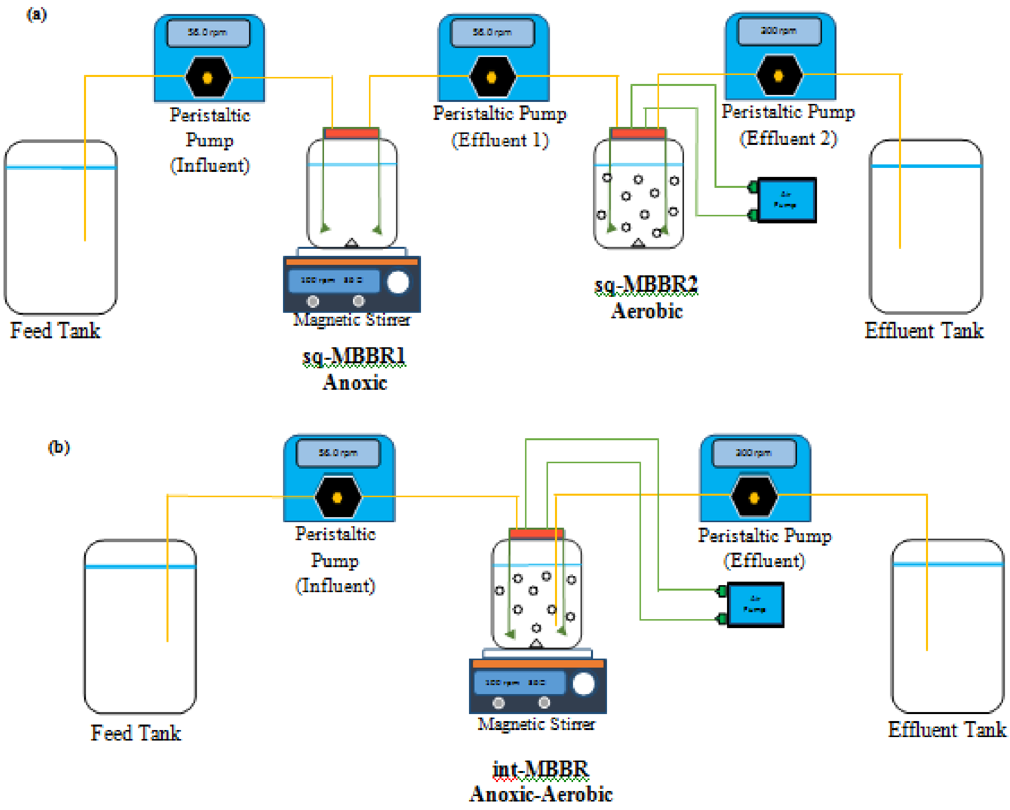

Figure 1: Schematic Diagram of (a) Sequential Anoxic-Aerobic System for MG and (b) Integrated Anoxic-Aerobic System for RB5

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POCER194: Hydrothermal Liquefaction of Palm Kernel Shell to Bio-Oil under Sub- And Supercritical Conditions: A Global Kinetic Study

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Keywords: Kinetics; Liquefaction; Palm Kernel Shell; Subcritical; Supercritical.

1. Introduction

As one of the top producers of palm oil in the world, Malaysia has generated a substantial amount of oil palm (*Elaeis guianensis*) wastes, therefore creating problems such as disposal difficulties and increased operating cost of oil palm mills [Awalludin *et al.*, 2015]. These wastes can be utilized in several conversion processes to generate value-added products. Aside from mechanical processing into organic fertilizers, soil conditioner or animal feedstock, thermochemical processes are also used to convert these biomass wastes into fuels in the form of solid, liquid and gas. Recently, liquefaction of biomass for the production of bio-oil (biocrude) has received extensive research due to the simplicity and energy-saving nature of the process compared to pyrolysis [Fan *et al.*, 2011]. In hydrothermal liquefaction (HTL), multiple reactions occur, including decomposition of biomass macromolecules into fragmented species and secondary reactions such as repolymerization, condensation and isomerization and forming bio-oil [Dimitriadis and Bezergianni, 2017].

In this context, kinetic studies are essential in order to gain insights of the rate of reaction, with which reactor sizing and reaction (residence) time can be determined for large-scale production. Besides, the knowledge on kinetic parameters enables the process to be operated at the optimum conditions, which improves the process efficiency. To the best of our knowledge, the kinetic study of hydrothermal liquefaction of palm kernel shell (PKS) has not been reported and the application of kinetic equation in modelling bio-oil yield is limited.

2. Methodology

In this study, PKS was hydrothermally liquefied at three temperatures (330, 360 and 390 °C) and at constant initial pressure of 25 MPa for reaction time of 30, 60, 120 and 240 min. The global kinetics of the liquefaction based on the overall conversion of biomass was analyzed using kinetic equation adopted from the literature (Eq. 1) [Harry *et al.*, 2014], and the kinetic parameters were estimated by Arrhenius fitting.

$$\ln \frac{dX}{dt} = \ln k + n \ln (1-X) \tag{1}$$

where X is the overall conversion of PKS with respect to time t, while k and n are apparent rate constant and reaction order, respectively. Figure 1 shows the fitting of kinetic data based on Eq. 1.

In addition, the global kinetics of bio-oil formation was fitted using the modified Reverchon-Sesti Osseo equation (Eq. 2) [Yim *et al.*, 2017].

$$Y = 100(1-e^{at+b}) \tag{2}$$

where Y is the normalized bio-oil yield, a and b are constant and correction term, respectively. Figure 2 shows the experimental bio-oil yields (normalized) obtained and compared with the equation's prediction. The global kinetic data obtained fitted reasonably well with the kinetic equations adopted.

3. Results

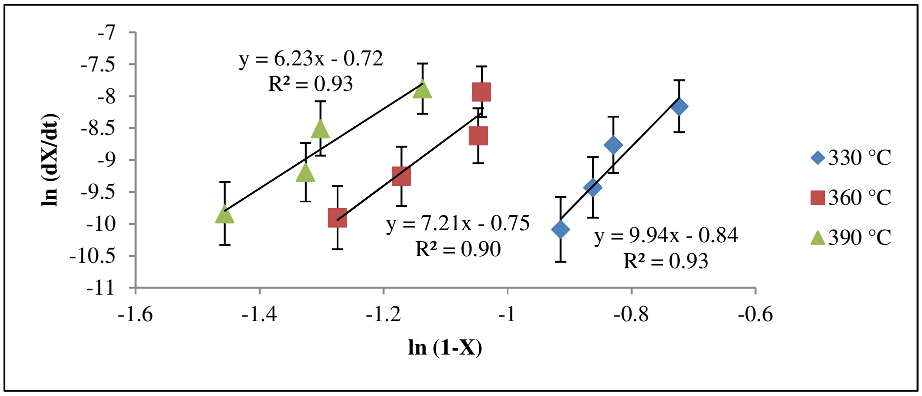

Figure 9: Relation Between Liquefaction Reaction Rates and Solid Residue Contents

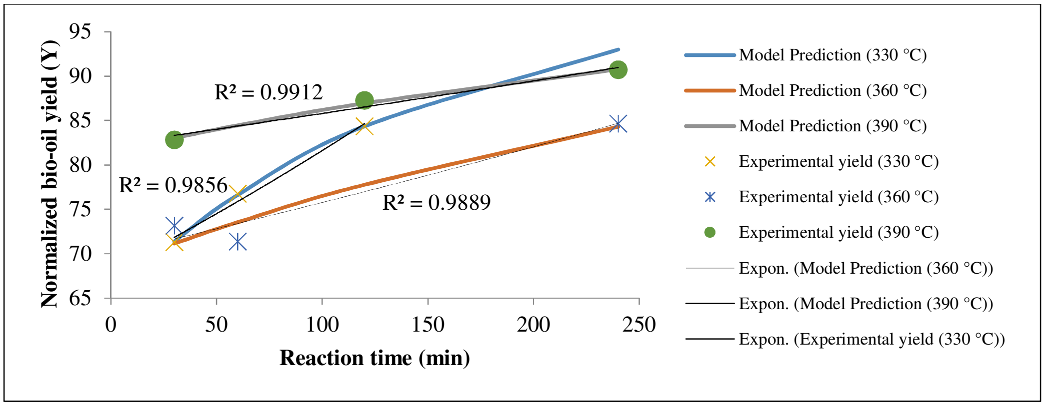

Figure 2: Relation Between Liquefaction Reaction Rates and Solid Residue Contents

Acknowledgements: This research is supported by Long-Term Research Grant Scheme (LRGS) under Ministry of Higher Education (MOHE), Malaysia and Japan Society for the Promotion of Science (JSPS) Bilateral Joint Research Program in collaboration with Universiti Teknologi PETRONAS, Malaysia and Graduate School of Science and Technology (GSST), Kumamoto University, Japan.

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POCER195: Extraction of Essential Oil from *Leptospermum flavescenes* and *Melaleuca cajuputi* Leaves for Herbicides Allelopathy

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Keywords: Allelopathy; Essential Oil; Herbicides; Phytotoxic; Soxhlet Extraction; Supercritical Extraction; Weeds.

1. Introduction

Rice which is known as *Oryza sative* scientifically is the major staple food consumed by about 2 billion of people in Asia as well as other regions of the world [Pareja *et al*., 2011]. However, one of the threats facing by the farmers that caused the enormous losses in crop production is weeds as they constantly compete with the crop plants for nutrients, sunlight, water and others [Jabran *et al*., 2015]. In recent times, herbicides and other modern mode of weed control have been utilised for suppression of the emergence of weeds. The major constraints regarding the repeatable use of herbicides are herbicide-resistant weeds, health and environmental concerns [Jabran *et al*., 2015]. Due to the pressure on importance of food security, sustainable approach of implanting plants allelopathy is introduced to ensure sustainable weed management.

Allelopathy is defined as interaction between plants and microorganisms by a variety of compounds known as allelopathins, allelochemicals, or alleopahic compounds which occurred in natural environment [D.Soltys *et al*., 2013]. One of the advantages of utilizing of allelochemicals is that due to its diversity, it can be targeted in specific sites in acceptor plants to eliminate the weeds that are already resistant to commercialized herbicides with the same mode of action. Essential oil is one of the potential alleopathins to be developed as bioherbicides [D.Soltys *et al*., 2013]. Essential oil is constituents of monoterpenes (C10), sesquiterpenes (C15), aromatic phenols, oxides, ethers, alcohols, esters, aldehydes and ketones.

In this context, *Leptospermum flavescenes* and *Melaleuca cajuputi* are used as the precursors for the extraction studies in terms of yield and purity. The chemical composition of the *Leptospermum flavescenes* and *Melaleuca cajuputi* extract from both Supercritical carbon dioxide extraction and Soxhlet extraction are studied to examine the possible allelopathy compounds for weeds inhibition in paddy field. Both Supercritical carbon dioxide extraction and Soxhlet extraction were also compared in terms of yield and the percentage of specific composition of allelopathy compounds extracted.

2. Results and Discussion

From the GC-MS results, it was found that caryophyllene is one of the major components for both *Leptospermum flavescenes* land and hills species as well as *Melaleuca cajuputi* after undergone Supercritical and Soxhlet extraction. Caryophyllene is a natural bicyclic sesquiterpene which has anti-inflammatory, insecticidal, fungicidal as well as herbicidal activities (King-Diaz and Lotina-Hennsen, 2012). Other major compounds determined from each plant extract are Trans-Calamenene, Spathulenol and Bicyclogermacrene for *Leptospermum flavescenes* land species; Pinosylvin, dimethyl ether, Bicyclogermacrene, Aromandendrene for *Leptospermum flavescenes* hills species respectively. For *Melaleuca cajuputi* extract, the major compounds are Humulene and tetradecamethyl-Cycloheptasiloxane.

From the findings, it is highlighted that supercritical carbon dioxide extraction is more selective in extracting of caryophyllene which is the desired allelopathy compound in the essential oil, for instance, Leptospermum flavescenes land for supercritical extraction (7.80%) has higher composition of caryophyllene than the Soxhlet extract (1.67%).

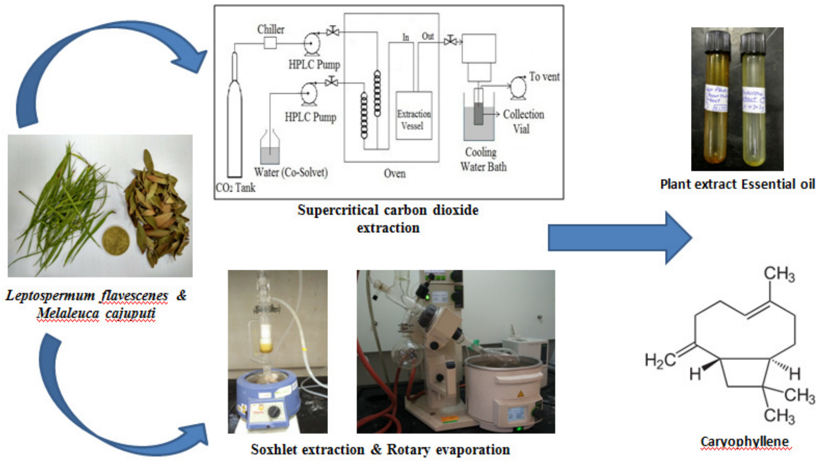

Figure 10: Graphical Abstract

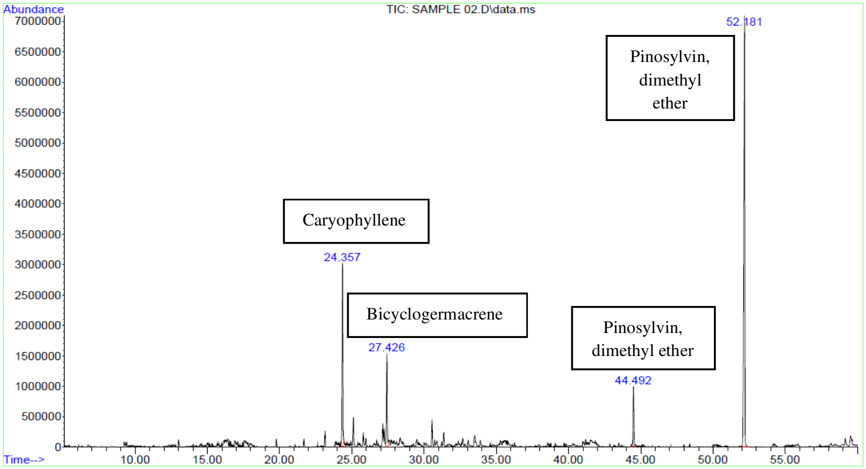

Figure 2: Gas Chromatograph for Supercritical Extraction for *L. flavescenes* Hills

Acknowledgements: This research is supported by Biomass Grant in collaboration with Universiti Teknologi PETRONAS, Malaysia.

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POCER196: Addressing Criticality via Redundancy Allocation in Energy Systems Design: A Systematic Approach

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Keywords: Criticality; Process Bottleneck; Process Intensification; Redundancy Allocation.

1. **Introduction**

A biomass energy system (BES) consists of highly integrated process units within a network. Via process integration, such system able to achieve higher thermodynamic efficiency levels and economic performance as compared to conventional stand-alone system. However, such benefits may not be realised if an energy system is not equipped to cope with failure of its component process units. A failure event can cause "ripple effects" to propagate throughout the BES and disrupt its overall performance. To address this, designers often allocate additional or redundant process units for the entire BES. However, this approach requires high capital investment; thus, redundancy allocation (RA) for the entire BES would not be possible. Therefore, an appropriate resolution for this issue would be to identify the most critical process unit in the BES prior to allocating equipment redundancy. In this respect, this work proposes an integrated framework for planning system redundancy based on criticality analysis (as shown in Figure 1). This new approach combines the criticality analysis concept [Benjamin *et al.*, 2015] with an engineering intervention [Andiappan and Ng, 2016] to allow the results of the prior analysis to be used to make design adjustments.

2. Methodology

As shown in Figure 1, the proposed framework begins with criticality analysis. The criticality analysis approach based on input-output (I-O) analysis. In criticality analysis, the most critical unit in a BES is identified. This is achieved by quantifying the effects of a disrupted or inoperable process unit to its corresponding final output (e.g., product stream). The quantification of the mentioned effects is denoted by a criticality index. The process unit with the highest criticality index is deemed the most crucial unit in the BES. Once the most critical unit is determined, the subsequent tasks comprises of two possible design modifications. These modifications include (but not limited to) redundancy allocation (RA) [Andiappan *et al.*, 2015] and process intensification [Stankiewicz and Moulijn, 2000]. RA increases the reliability of a process unit via additional or back-up facilities. In this work, the framework considers systematically allocating equipment redundancy based on budget restrictions via *k*-out-*m* system modelling. It is important to note that each step in Figure 1 is performed based only on one critical unit at a time. For instance, if a critical unit is addressed by allocating redundancy, it is important to ensure that the same unit does not appear to be a critical unit in the network before moving to the next step. Once the network design is clear of a criticality, it is up to the designer to assess for the next criteria which is process intensification, as shown in Figure 1. When the critical unit is addressed, subsequent step includes economic feasibility assessment. The economic feasibility assessment is performed based on benefit-cost ratio (BCR). BCR is the ratio of overall savings gained from proposed modifications in a system to the additional investment for modifications. If the BCR is greater than 1, it would mean that the benefits of the modifications outweigh the investment costs associated with the modifications.

On the other hand, if the BCR is not greater than 1, recommendation on new modifications are proposed. In this respect, it is possible to consider an entirely new design all together.

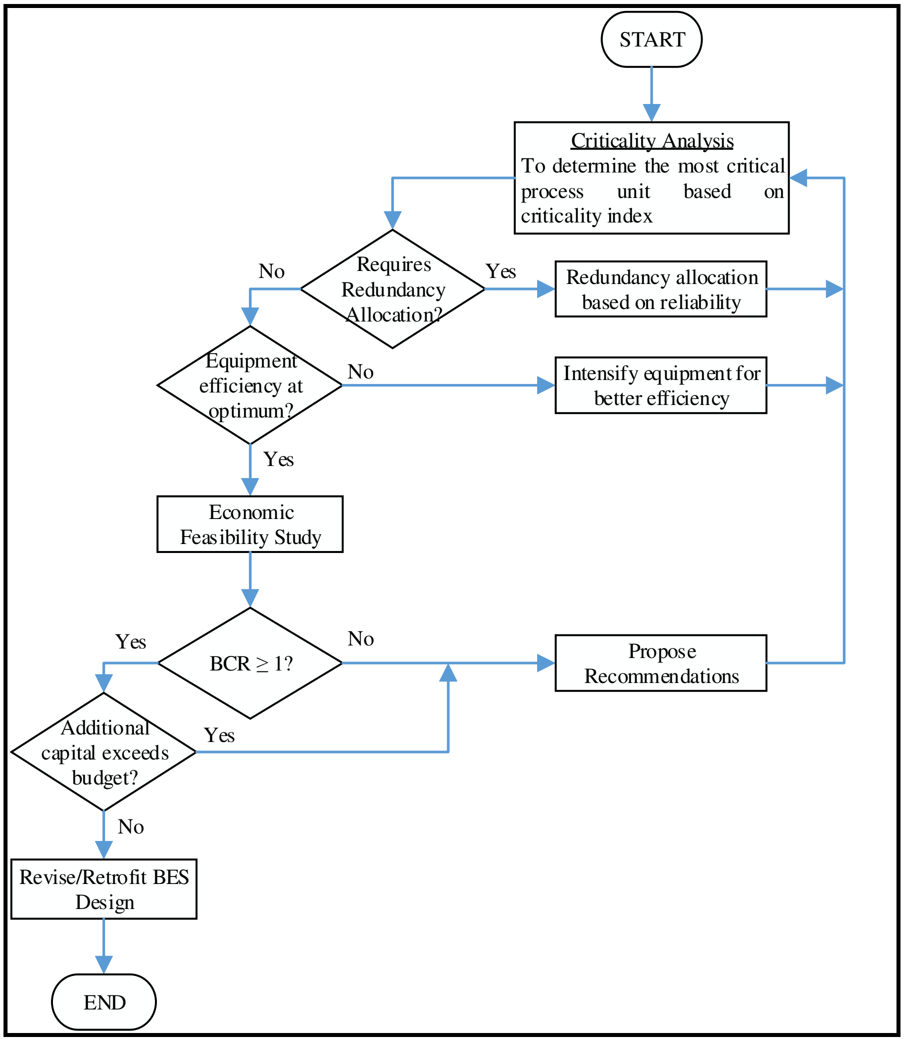

Figure 11: Proposed Framework for Addressing Criticality Issues via Redundancy Allocation or Process Intensification

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POCER200: Debottlenecking for Sustainable Biomass Supply Chain: PCA Approach

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Keywords: Biomass supply chain; Debottlenecking; PCA; Sustainability.

1. Introduction

After the painful oil crisis held in 1973 and 1979, several industries have decided to shift their traditional business models which are highly reliant on non-renewable energy to a more sustainable model. In order to keep pace with the snowballing energy demand, an alternative and sustainable energy source has to be explored. Biomass has been proved as a significant renewable energy source due to its abundant availability and substantial energy content [Duić *et al.*, 2011]. Hence, the implementation of biomass supply chain, which convert biomass into valuable products is shown as a prospective solution. These has been a vast amount of studies presented on the biomass supply chain optimisation which mainly focusing on economic and environmental performances. Notably, Lam *et al.* [2013] developed a two-stage optimisation model to synthesis a palm biomass supply chain with the aim of maximising annual profit and minimising carbon emission simultaneously. Ng *et al.* [2013] had evaluated the economic potential of rubber seed oil for the biofuel production. However, social impacts have seen less attention compared to economic and environmental sustainability. In order to cover the final piece of sustainability spectrum, this paper presents a novel evaluation model to evaluate the economic, environmental and social sustainability:

1. Economic dimension**:** It is evaluated based on the annual profit gained. It encompasses of gross profit, annualised hub investmnet cost and transportation cost [How *et al.*, 2016].
2. Environmnetal dimension**:** The impact categories, *q* (e.g., global warming potential, acidification potential, etc.) which introduced by Heijungs *et al.* [1992] is used to evaluate the environmental impacts.
3. Social dimension**:** Human toxicity potentials (HTPE and HTPI), inherent safety of the processing hubs (ISI index developed by Hurme and Heikkilä [1998]), estimated job creation and transportation safety (based on risk of pedestrian fatality).

There are quite a number of works have discussed the bottlenecks of the biomass supply chain (e.g., Foo [2015]), but none of them have developed a systematic debottlenecking approach for the biomass supply chain. Thus, this paper introduced a debottlenecking technique which utilise Principal Component Analysis (PCA). PCA is a multivariate statistical technique that allows to convert a series of correlated variables into a set of uncorrelated variables known as principal components (PCs), without losing too much information [Aitchison, 1983]. In other words, PCA can substantially reduce the complexity of the proposed problems by removing the redundancies in variables. To-date, this technique has been used abundantly in various forms of study (e.g., image compression [Dash *et al.*, 2014], chemical plant design [Pozo *et al.*, 2012], but has not been used as a debottlenecking tool.

2. Methodology

Figure 1 shows the flowchart for the proposed de-bottlenecking approach. Firstly, perform a PCA study to analyse the all the possible solutions. Then, select one of the solutions that is intended to be debottlenecked or improved. The principal component (PC) scores of the selected solution are compared and benchmarked with the optimum solution (highest satisfaction). The PC that has the largest difference is notified as critical PC, while the variables that contribute a substantial portion to the PC is notified as critical variables. The critical variable that contributes the most will be the first potential variable to be improved. The remaining critical variables will be improved one by one according to their contribution rate (from highest to lowest), until the selected result is successfully debottlenecked (increase ranking) or all the critical variables are analysed. If the result is not satisfied till this stage, the entire process will be repeated by analysing other PC.

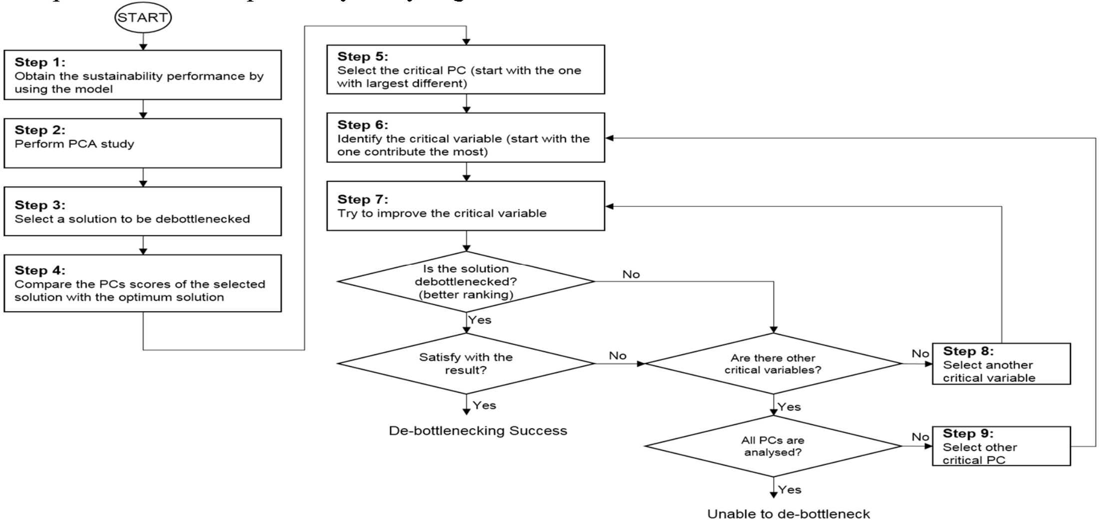

Figure 12: Debottlenecking flowchart

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POCER201: The Role of Natural Organic Matters in Water and Soil Remediation

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Keywords: Activated carbon; Humic acid; Natural organic matters; Soil remediation; Water treatment

1. Introduction

This paper summarizes the major progress over the recent decades toward the understanding of the role of natural organic matter (NOM) in soil and water treatment. NOM is among the major wastewater pollutants. They are formed by the breakdown of animal and vegetable matters in soil and will be carried to water reservoirs [Newcomb, 1994]. NOM consists of a mixture of the hydrophilic fraction including carboxylic acids, carbohydrates and proteins, and hydrophobic fractions named as humic substances [Matilainen *et al*., 2006]. NOM in water and wastewater treatment can be a pollutant, adsorbate, or even an adsorbent, individually or in combination with other adsorbents.

2. Possible interactive pathways of NOM in environment

The possible pathways of environmental interaction of NOM and its subfractions are depicted in Figure1. From several points of view the presence of NOM in water is undesirable such as its potential in making halogenated by-products like trichloromethane during disinfection processes by chlorine (pathway 1 in Figure 1) [Hartono *et al*., 2009; Han *et al*., 2003].

Humic acid (HA), a part of NOM, can enable the transportation of other organic and inorganic pollutants in soil and water through partition/adsorption processes (pathway 2 in Figure 1) [Hartono *et al*., 2009; Han *et al*., 2003]. Drinking water processes like sedimentation, disinfection, chemical coagulation, membrane separation and advanced oxidation are not able to remove NOM completely and some of them are costly which had led to more interest in adsorption processes [Lai *et al*., 2001; Hartono *et al*., 2009]. Different adsorbents have been used for removal of NOM (pathway 3 in Figure 1), such as activated carbon, fly ash [Wang *et al*., 2007], chitosan hydrogel beads [Yan *et al*., 2005], granular ferric hydroxide [Genz *et al*., 2008], and iron oxide [Lai *et al*., 2001]. HA due to its potential to form complexes with organic and inorganic matters has been used as an additive to other adsorbents to improve their efficiency (pathway 4 in Figure 1).

3. Effects of SOM on soil remediation

In soil remediation, soil organic matter (SOM) exerts both positive and negative effects. It plays an important role in binding organic pollutants such as pesticides and polycyclic aromatic hydrocarbons. The binding of organic matters with SOM over a long period makes them indistinguishable. It can be positive if SOM does not release it, but in the case of separation, it can be a source of contamination.

Humic matter consists of some sub fractions, fulvic acid, HA, and humin. Each of them have a different affinities toward adsorption and desorption of pollutants from soil. Their different potential is attributed to their different aromatic and aliphatic moieties. These diverse features lead to different linearity and non-linearity characteristics in adsorption and desorption processes.

SOM also have effects on Fenton reaction in the treatment of contaminated soil. SOM can affect the Fenton reaction by competing with target pollutants for hydrogen peroxide, but it can promote the production of hydroxyl radicals.

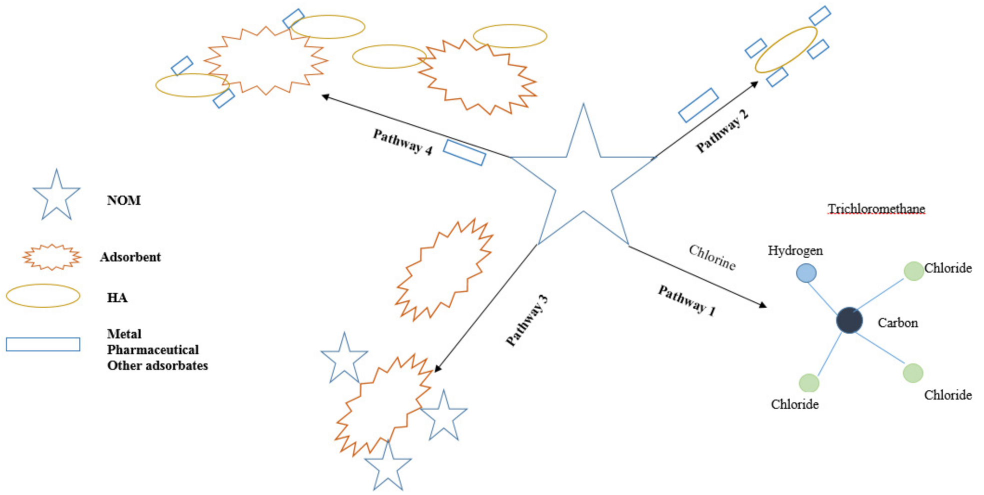

Figure 1. Possible environmental engagements of NOM

Bissey *et al*. [2006] showed that soil organic matters does not affect the Fenton reaction at pH=3 whereas increasing the pH to 5 by increasing production of hydroxyl radicals and decreasing decomposition of hydrogen peroxide can enhance the efficiency of the reaction.

4. Cocnclusion

In summary, there are limited works that report the change in NOM/SOM characteristics after remediation processes and the different groups involved during different remediation processes. The interactions of SOM with solvents which are used in soil treatment processes are still not fully studied. These are the areas that need more research attention and work.

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POCER202: Sustainbility of Green Building Construction in Malaysia

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Keywords: Construction; Green Building; Sustainability.

1. Introduction

The world is facing two main perplexing problems; climate change and energy security. With augmenting cognizance of the current world problems, sustainable construction is slowly put forth globally. Green building has the potential to save energy usage at 24% up to 50%, CO2 emission 33% to 39%, water usage at 40% and reduce solid waste to 70% [Turner and Frankel, 2008]. Constructing green building is one of the measures to mitigate substantial impacts of the building performance towards environment, economy and society. In Malaysia, a building is considered green if it has met the requirements under the Green Building Index (GBI), which requires the building to be both energy and water efficient, improves indoor environmental quality, sustainable site planning and management, with green material and resources selection [GBI, 2015]. Despite its multiple definitions, a green building simply means a building that is both energy and resource efficient and has little impact to the environment. However, the construction of green building in Malaysia is still at infancy as project managers' encounters impediments in implementing such projects at large.

Thus, the objectives of this research are to compare the main dissimilarities between conventional and green construction projects, to identify common challenges that are encountered in managing green building construction, their impact on project performances and to propose plausible solutions to improve the current green construction project in Malaysia.

2. Methodology

Primary data were collected from contractors, consultants, developers, project managers and professional green building experts from the construction field. The outcome of this study has managed to understand the challenges faced by project managers, its solutions and the effect of green technology on construction of green buildings in Malaysia.

3. Results and Discussion

Based on this research finding, currently there is insufficient approach available for managing green building projects in Malaysia. When constructing a green building in Malaysia, environment management program centred to GBI must be adopted for sustainable projects construction. Requirements under the GBI include energy efficiency (EE), indoor environment quality (EQ), materials and resources (MR), sustainable site planning and management (SM), water efficiency (WE) and innovation (IN) must be met as well.

This paper has equally explored, the challenges and solutions encountered when managing green building and it is found that the challenges are interrelated. Overall, the lack of government involving in green building projects brings up the barrier to the public where benefits of green buildings are not well presented. As such, public should be educated about the benefits of having green building and its role in sustaining the environment to create a better environment for the future. On top of that, educating stakeholders is equally critical to enhance their interest and participation in the construction of green building projects. In this manner, consultants plays a vital role in advising the return of investment in green building projects as the high capital cost prevents project managers from adopting green practices. The key solution that will ensure the construction of green buildings are R&D must be established to educate the benefits of going green as well as solving problems associated with green buildings in Malaysia, by making GBI mandatory for all new and existing buildings.

The government too needs to provide initiatives to offset high cost of green building projects for the country's development, and demonstrate the benefits of green buildings to increase the awareness and knowledge level. Future studies for this research involves proposing a project management framework contributing to green building construction that can be implemented in the Malaysia market and a better solutions for green roofs in the aspect of vegetation type sustainable for Malaysia climate.

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POCER203: Analysis of Specific Energy Consumption in Turning and Milling Processes

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Keywords: Energy Consumption; Machining; Milling; Turning.

1. Introduction

In the past decades, environmental concerns awareness in the world has increased. The energy consumption of machining tools has become one of the major issues nowadays. With the soaring energy cost and rapidly increasing production demands in Malaysia, the electric energy cost on manufacturers has become a heavy burden on them. In addition, using high energy in manufacturing operation will contribute to higher CO_2 emission that gives impact on environmental degradation.

This study is to construct a practical analysis model for predicting specific energy consumption (SEC) of different machine tools with different sets of machining parameters. Energy models was developed based on 2 types of machines which are lathe and milling machine using empirical modeling approach which focuses on (i) range of work piece material, (ii) variation sets of machining parameters and (iii) different types of machine. This analysis model focuses on dry cutting for both machine tools.

2. Methodology

Material Removal Rate (MRR) is treated as a comprehensive variable which dominant by cutting parameters, work piece machinability and tool capacity [Cecimo, 2009]. Therefore, work piece material, rotational speed, feed rate and depth of cut were used as the process variables for Design of Experiment (DOE) [Velchev *et al.*, 2014]. Response Surface Method (RSM) as suggested by is used to define three level of variance according to machine capacity and work piece machinability [Bhushan, 2013] as shown in Table 7.

Table 7: Materials Used and Variance of Parameters

Material	**Factors**	**Variance of Parameter**		
		Level 1	**Level 2**	**Level 3**
1050A Aluminium Alloy	n (rpm)	650	950	1350
	$f\ (\frac{mm}{rev})$	0.14	0.24	0.31
	d (mm)	0.5	0.8	1.2
AISI 1010 Low Carbon Steel	n (rpm)	330	490	650
	$f\ (\frac{mm}{rev})$	0.11	0.21	0.31
	d (mm)	0.2	0.4	0.6

Through analysis and modelling, SEC was calculated adopted from [Kara and Li, 2011] and the curve estimation indicates that an inverse model is the best fit for the relationship between SEC and MRR as shown in equation below:

$$SEC = C_0 + \frac{C_1}{MRR} \quad (1)$$

The experiment of turning process will be performed on high speed, heavy duty lathe machine: Mastika 430×1100 with 5 HP spindle drive motor and speed range from 35 to 2000 rev/min.

3. Results and Discussion

An example of analysis result of turning process using 2-axis lathe machine tool Mastika 430 is shown in Table 2 below:

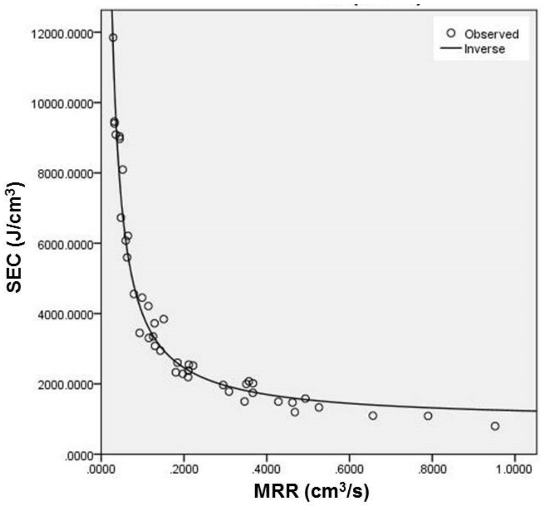

Figure 1: Inverse Curve Estimation for Turning Process

Table 2: Turning Process SEC Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
0.983	0.967	0.966	528.139

ANOVA

	SS (10^6)	df	MS (10^6)	F	Sig.
Regression	335.062	1	335.062	1201.240	0
Residual	11.436	41	0.279		
Total	346.498	42			

	B	Std. Error	t	Sig.
1/MRR (cm^3 /s)	304.344	8.781	34.659	0.000
(Constant)	937.131	117.317	7.988	0.000

Figure 1 shows the inverse curve estimated to find the best fit line for data using SPSS. A summary of ANOVA results of turning machine model is shown in Table2. R-square value shows the accuracy of this model is 96.6%, which shows the good reference to the experiment data. Hence, the close fits model to observed data can be obtained from eq . (1). The predicted model from eq. (1) is further improved by using non linier regression model. The specific energy model for turning process is then become:

$$\boldsymbol{SEC = 500.906 + 15.775\frac{N}{MMR} + 204.829\frac{1}{MMR}} \qquad (2)$$

The finding proves that spindle power consumes large portion of energy from the total power demand. It also implies that MMR is a significant variable that need to be controlled in order to obtain lower environmental impact during turning and milling process. The energy models allow the manufacturer to acquire the cutting power for wide range of sets of parameters as input variables without the necessity of measuring from the power bus on machine tools.

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POCER204: Need for a Lean and Green Manufacturing Integrated Approach

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Keywords: Continuous Improvement; Green Manufacturing; Lean Manufacturing; Sustainability.

1. Introduction

With the worldwide global technology and climatic change, the manufacturing and service industries are facing challenges of scarce resources, dynamic technology change, and environmental issues. Ultimately these industries are seeking different continuous improvement methods to encompass competition and sustain in the global market. Lean and green are two management philosophies, with the initial focus upon process improvement and the later concerning environmental protection and preservation.

2. Lean and Green Manufacturing

Lean manufacturing was developed by the Toyota Production System (TPS) when there was scarce resources after World War II. This philosophy focus in adding value to the product, by process improvement within limited resources and minimise waste during the process. The traces of Lean manufacturing now also found in manufacturing to service sectors. Green manufacturing means making process more efficiently in terms of resources, producing minimum waste towards environment pollution by recycling. There are 12 principles of green manufacturing to achieve sustainability for the environment to be discussed in this research.

This conceptual research describe the overview of both management philosophies, each potential integration approach and successful cases in both manufacturing and service sectors. The literature review revealed that there are potential ways to implement lean in parallel with green system which help to achieve green manufacturing and improves environmental performance via an integrated approach. Additionally, cases will be presented with evidences of successful stories of the integrated implementation approach that raise the environment protection and sustainability awareness. The commonality found between Lean and Green are its focus on wastes, utilising limited resources efficiently and customer satisfaction. The integration of both philosphies predicts optimistic results on resolving interrelated issues and build innovative implications in specific research areas. The manufacturing and service sector organisation can integrate both philosophies through Lean and green stategies.

Acknowledgements: This research will benefits the manufacturing and service sectors from professionals, practitioners and researchers in designing an integrated Lean and Green manufacturing approach for continuous improvement in the organization. It also benchmark to identify the benefits and methods with potential outcomes of the integrated approach.

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POCER205: New Risk Assessment Method for Green Financing in Malaysia with Analytic Network Process Approach

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Keywords: Analytic Network Process; Green growth; Green financing; Risk; Risk assessment.

1. Introduction

The increasing concern on climate change, energy security has diverted the world's attention towards green economy that aim to enhance human well-being and social equity while sustaining the environmental condition and ecological balance. Over the last decade, the Malaysian government has showed its clear intent to be a front-runner in the green economy through its various green economy policies and programs. Green Growth is also served as one out of six strategic thrusts in the 11th Malaysia plan 2016-2020 that set a development blueprint for Malaysia to achieve the target to become a developed country by 2020. Policies and regulations that are introduced to spur up the green growth are such as National Renewable Energy Policy and Action Plan [2009], National Policy on Climate Change [2009], National Green Technology Policy [2009], Bioeconomy Transformation Program (BTP) and Renewable Energy Act [2011]. Malaysia is also signatory of multiple international agreement in combatting environmental issues for green economy such as Kyoto Protocol, Montreal Protocol and Paris Agreement and Convention on Biological Diversity. Despite various effort initiated by the government to spur up the green growth in Malaysia, the diffusion of the green aspects in economic development has been insignificant.

Literature, anecdotal evidence, and advocates as well as businesses have identified that one of the non-technical factors that contributes to the slow diffusion rate of green growth is the financing difficulties. Green projects often engaged with high risk profile, capital intensive and long payback period which is unfavorable for financing based on conventional risk assessment [Karltorp, 2016]. As green project is an emerging trend in Malaysia, local banks and investors are lack of capacity, experiences to evaluate them. Thus, financial institutions offer few, if any, financial products for green projects while demanding high premium and interest rate. In relation to this, Malaysia government also introduced a series of solutions to encourage public and private investors to contribute to green growth. Clean development mechanism (CDM) under Kyoto Protocol encourages developed country provides financing aid in the form of non-concessional loans, grants, and carbon finance in developing country in effort to combat carbon reduction worldwide [Begum et al., 2011]. Besides, fiscal incentives, Feed-in-tariff (FiT) mechanism and Green Technology Financing Scheme (GTFS) are also introduced with the objective to promote the investments for green technology sector. While the government-led financing serves to stimulate the uptake of green growth, the government financing schemes are not able to match the investment costs required for scale-up clean technology projects. This paper aim to assess the risks associated with green financing in Malaysia in order to provide a comprehensive risk profile for the industry stakeholders.

2. Methodology

Analytic Network Process (ANP) is adopted in this study to assess and evaluate the importance and relationship of various risk factors related to green financing. As risk arises from both tangible and intangible factors and involves interaction and dependence with each other, ANP enable a clear indication of the correlation of each risk factors and risk group through forming a network. The ANP risk assessment starts with model development where the main objectives, to assess the risks related to green financing in Malaysia is positioned at the center of the network and connected with the 5 risk group clusters namely regulatory risk, financial risk, technology risk, supply chain risk and technology risk. Each risk cluster consist of a set of risk elements. The model is illustrated in Figure 1. The risk clusters and elements are coincide with decision criterions (i.e. the probability of occurances and the magnitide of consequences). Next, the stakeholders of green related industry such as business owner, investor/financier, policy maker, and researchers are invited to assess the relationship and interdependencies of clusters and elements by using pairwise comparisons method. The outcome of pairwise comparision is then converted into cluster priority matrix to obtain the local priority vector. The final step of ANP risk assessment method involved transforming the cluster priority matrix to weighted supermatrix and limit matrix which yields priorities reflecting the direct and indirect influences of each elemnt on every other element in the model. SuperDecision software in conjunction with the Microsoft Excel are used in this work to run the ANP.

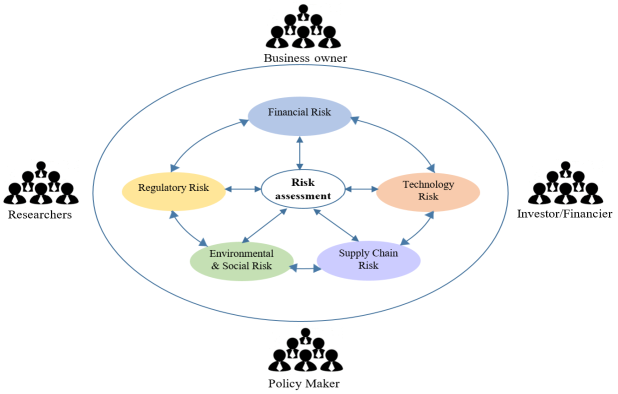

Figure 13: ANP risk assessment model

3. Conclusion

Malaysia plays a leading role to promote and support the growth of green businesses through green financing and investment in this region, as Malaysia is the only ASEAN country that represent as one of the founding members of the world's first Green Bank Network (GBN). Understanding risk profile for green growth in an integrated manner is critical for the Malaysia to transition into green economy successfully. Financier and investors will be equipped with sufficient information to fully assess the risk involved and competitive advantages of green projects to offer financial products that customized the need of green projects without losing great business opportunity. Policy makers can utilise the information to undertake policy reviews and for the private sector to register their interest in green growth investments and innovations as well as for consumers and producers to internalize costs and benefits of green growth. Besides, business related party can fully comprehend the risk profile of the green industry to take advantages of the incentives offered by government and prepare solutions to mitigate the risk prior incurring any real losses to enhance the decision in venturing into green economy.

Acknowledgements: The financial support from Ministry of Higher Education, Malaysia through LRGS grant (LRGS/2013/UKM-UKM/PT/06) and Universiti Kebangsaan Malaysia is acknowledged.

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POCER206: Superstructure Optimization for Chilled and Cooling Water System Utilizing Waste Heat from Multiple Sources

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Keywords: Absorption Chiller; Eco-Industrial Parks; Heat Exchanger Network; Heat Integration; Vapor Compression Chiller.

1. Introduction

Vapor compression refrigeration (VCC) system is the conventional method to generate chilled water. Absorption refrigeration system (ARS) has recently gained much attention from both researchers and industry players to minimize electricity usage by utilizing industrial waste heat to generate chilled water. In our previous work, inter-plant chilled and cooling water network integration (CCWN) within an eco-industrial park (EIP) has proven to be more sustainable in terms of cost effectiveness and environmental performance. However, the proposed CCWN was configured using VCC. The purpose of this paper is to study the synergy between ARS and VCC to achieve sustainable EIP performances when a variety of waste heat is available. Additionally, heat integration is performed on the waste heat recovery network to investigate its effect towards the performance of ARS. Three cases are presented to demonstrate the effect of waste heat recovery by ARS towards total annual cost (TAC) savings and environmental impact reduction. The main contribution of this paper is to prove that integrated VCC-ARS is able to reutilize waste heat and improve cost saving.

Various studies have been carried to investigate performance of ARS on different aspects. Exergy and energy analysis are performed on a combined heat and power (CCHP) integrated with VCC and ARS [Li and Hu, 2016]. The economic feasibility of CCHP integrated with ARS is evaluated [Moné et al., 2001]. An economic analysis is carried out to compare between ARS and propane refrigeration using low grade waste heat, and finding showed that the ARS is less profitable [Kwak et al., 2014]. However, the comparison between the ARS and the VCC utilizing different types of waste heat was not addressed. Besides, recent studies focused on the optimization and synthesis of individual chilled water network [Lee et al., 2013] and cooling water network [Kim and Smith, 2001]. A research gap is present on the integration of CCWN with waste heat recovery network within an EIP. As the previous study by [Leong et al., 2016] investigated the cost and energy savings of an integrated CCWN with free cooling and centralized VCC, this paper focuses on the integration of centralized VCC and/or ARS with three different types of waste heat, i.e. hot water, steam and flue gas generated within an EIP.

2. Methodology

The approach used in this paper is to first develop a superstructural model for an integrated CCWN superstructure with VCC and/or ARS, followed by global optimization to minimize the overall total annual cost (TAC) and lastly, comparison is carried out to evaluate the economic and environmental performance between the proposed superstructure and the other cases. The proposed superstructure (Figure 1) consists of primary and secondary waste heat recovery network (WHRN), which is used for chilled water generation and further recovery of waste heat, respectively. Each chiller has a maximum capacity of 3,300 RT, according to the chiller size available in the market. The equipment and plant life time is assumed to be 25 years. An annualized factor of 0.298 is used for TAC calculations [Leong et al., 2016]. Time value of money is not addressed in this paper.

The objective function for the optimization is to minimize the overall total annual cost:

$$\min TAC = CAPCT + CAPVCC + CAPARS + CAPHEN + CAPPC + OPC \tag{1}$$

where $CAPCT, CAPVCC, CAPARS, CAPHEN$ and $CAPPC$ denote the capital costs of CT, VCC, ARS, HEN and interplant piping. OPC is the operating cost for CCWN (i.e. electricity, makeup water) and WHRN (i.e. flue gas treatment cost and how water and steam purchase cost).

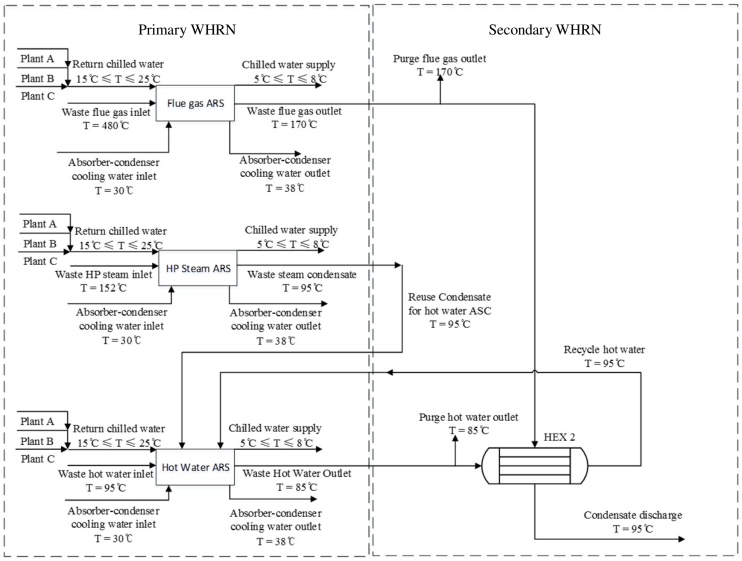

Figure 14: Superstructure presentation for the proposed WHRN

3. Results and Discussion

The superstructure is solved as an Mixed Integer Nonlinear Programming (MINLP) model using LINGO v16.0. Based on the result, although the integration of ARS led to a more complex network and more chiller units, the cost and environmental performance of the overall system is improved significantly. Despite a higher investment cost, ARS reduced the overall *TAC* by 13% and the CO_2 emission by 50%, the utilization of waste heat has led to remarkable reduction in electricity consumption. Additionally, the integration of secondary WHRN further reduced both *TAC* and CO_2 emission by 5%, as the flue gas outlet from ARS is recovered to supply heat for the hot water recycle.

Acknowledgements: The authors thank Monash University Malaysia for the financial support.

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POCER207: Primary Capture of *Bacillus subtilis* Xylanase from Fermentation Broth with an Alcohol/Salt Aqueous Biphasic System

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Keywords: Aqueous Biphasic System; *Bacillus subtilis*; Fermentation; Recovery; Xylanase.

1. Introduction

Xylanase is an enzyme that degrades linear polysaccharide beta-1, 4 xylan into xylose, which is able to break down the hemicellulose of plant cell [Collins *et al*., 2005] and widely applied in food, chemical, and pharmaceutical industries [Uday *et al.*, 2016]. There is a growing demand in finding a cost-effective alternative to produce xylanase in industrial scale. Aqueous biphasic system (ABS) has been widely used in purification of enzymes such as chitinase [Chen and Lee, 1995] and protease [Amid *et al*., 2011], proteins and nucleic acids [Garai and Kumar, 2013]. ABS is formed when two incompatible reagents are mixed above a critical concentration and the most common types of ABS is polymer/salt ABS. However, alcohol/salt ABS with lower viscosity offers the easy recovery of the phase constituent is able to reduce the overall settling time in industrial scale as compared to the polymer/salt ABS. Therefore, alcohol/ salt ABS was adopted to recover xylanase from *Bacillus subtilis* fermentation broth in this study.

2. Methodology

ABS parameters such as type and concentrations of alcohols (i.e. ethanol, 1-propanol, and 2–propanol), type of salts (i.e. sulphate, phosphate, and citrate), crude load, pH, and addition of neutral salt (NaCl) were evaluated for optimum recovery of xylanase. The desirable ABS conditions for recovery of xylanse were evaluated based on partition coefficient of xylanase (K_E), selectivity (S), purification factor (P_{FT}), and yield (Y_T) of xylanase. The enzyme activity of the xylanase was determined using modified dinitrosalicylic acid (DNS) method and the protein content in both phases of the ABS was quantified with a Bicinchoninic acid (BCA) assay with Bovine serum albumin (BSA) as the protein standard.

1. Partition coefficient, K_E of enzyme xylanase was calculated using Equation (1) :

$$K_E = C_T / C_B \qquad (1)$$

Where C_T and C_B are concentration of xylanase in the top phase and concentration of xylanase in the bottom phase of the ABS, respectively.

2. Selectivity (S) was defined as the ratio of xylanase partition coefficient (K_E) to the protein partition coefficient (K_P) using Equation (2) :

$S = K_E/K_P$ (2)

3. Purification fold, P_{FT} was determined as the specific activity (SA) in the top phase to initial specific activity (SA) in the crude feedstock as shown in equation (3) :

P_{FT} = SA of top phase sample/ SA of crude feedstock (3)

4. Yield of xylanase in the top phase, Y_T (%) was evaluated according to equation (4) :

$Y_T (\%) = 100/ 1 + (1/V_R \times K_E)$ (4)

Where V_R is the ratio of top phase to the bottom phase of the ABS

3. Results and Discussion

The results showed that high partition coefficient of 6.88 and selectivity of 4.84 ± 0.33 were achieved in an ABS composed of 26% (w/w) 1-propanol, 18% (w/w) ammonium sulphate and 4% (w/w) NaCl at pH 8. The xylanase enzyme was recovered with a Y_T of 74.67% ± 0.66 and a P_{FT} of 5.74 ± 0.33. Alcohol/salt ABS was used for purification of xylanase because the open conformation of the xylanase can be maintained for the stimulation of enzyme activity. Higher Y_T of xylanase was obtained with propanol/salt ABS as compared to ethanol/salt ABS because propanol contains a longer hydrophobic chain which enhanced the interaction between the xylanase and the phase-forming components. 20% (w/w) of crude xylanase loading into the ABS showed highest Y_T (Table 1) due to the increase of the amounts of both xylanase and contaminants in ABS with higher crude loading. The pH of an ABS can alter the protein surface charge, leading to the change of the partition behaviour of xylanase in the system. Optimum Y_T of xylanase was achieved at pH 8. In addition, the Y_T of xylanase has significantly increased in the presence of 4% (w/w) NaCl (Table 2). The addition of NaCl enhanced the electrical potential difference between the phases in the ABS. Therefore, more of the xylanase can be segregated to the alcohol-rich top phase of the ABS.

Table 1: Selectivity, P_{FT} and Y_T of Xylanse with Different Amounts of Crude Loading

Crude load	**Selectivity, S**	**Purification Fold, Pft**	**Yield, Y_T (%)**
10%	1.079± 0.407	1.987± 0.225	56.973± 0.207
20%	1.450± 0.157	1.904± 0.035	60.102± 0.197
30%	0.672± 0.267	1.986± 0.052	54.143± 0.377
40%	0.941± 0.139	2.152± 0.084	53.279± 0.193

Table 2: Selectivity, P_{FT} and Y_T of Xylanase with Addition of Different Concentration of NaCl

Concentration of NaCl (% w/w)	**Selectivity, S**	**Purification Fold, Pft**	**Yield, Y_T(%)**
1%	5.021± 0.193	4.395± 0.124	58.100± 0.339
2%	3.553± 0.760	3.582± 0.476	56.363± 0.736
3%	3.725± 0.497	3.464± 0.318	57.531± 0.220
4%	4.839± 0.328	5.744± 0.328	74.665± 0.664
5%	4.905± 2.933	3.481± 0.297	62.295± 0.208

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POCER208: Concepts of Photobioreactor Design for Microalgae – A Mini Review

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Keywords: Mass culture; Microalgae; Photobioreactor Design.

1. Introduction

Energy has become an important issue for the modern world due to growing civilizations and all the machines that bring about the advancements. Currently, about 80% of the global energy demand comes from burning fossil fuels. As a result, large amounts of CO_2 gas were released into the atmosphere, causing global warming, environmental pollution and health issues [Hallenbeck and Benemann, 2002]. The disadvantages of fossil fuels have led to the development of various types of renewable energy, such as solar, wind, tidal, biofuels, biomass energy etc. Of these, biofuels have the potential to play a crucial role in the global energy sector. This is because biofuels have high energy density and high portability, making them an ideal energy carrier. An example is biodiesel [Chisti, 2007].

Many countries have already started to adopt a blend of biodiesel and diesel as vehicular fuel. Commercialized biodiesel are mainly sourced from animal fats, waste cooking oil and vegetable oils such as rapeseed and oil palm [Barnwal and Sharma, 2005]. The competition between oil rich crops and food crops for arable land and nutrients still remains a controversial issue [Mata et al., 2010]. In this situation, microalgae has presented itself as a potential candidate for the production of biofuels. The benefits of utilizing microalgae include high oil content (30-70% of dry cell weight), ability to culture using wastewater or brackish water, does not compete with food crops for arable land and grows well with minimum attention [Chisti, 2007]. The fatty acid profile of most oil rich microalgae strains have been found to be suitable for the production of biodiesel [Gouveia and Oliveira, 2009].

2. Challenges in Design of Photobioreactor

Despite this, there are still many technological hurdles facing the mass culturing of oil rich microalgae strains. The most common mass culture systems are open pond systems and closed systems. Open systems are normally open ponds or raceway ponds, whereas closed systems refer to photobioreactors. The most widely used photobioreactors are tubular, flat plate and column photobioreactors [Brennan and Owende, 2010]. Each system has its own advantages and disadvantages. For instance, open pond systems are cheaper to construct and operate but the culture is prone to contamination and evaporation. Closed systems tend to have very high capital and operating costs but the risk of contamination is low and the culture conditions can be easily manipulated [Chen et al., 2011] . The main advantages and disadvantages of open ponds and photobioreactors are listed in Table 1. It is necessary, although difficult, to develop a mass culture system that is low-cost yet efficient. Therefore in this mini review, the different types of open systems and closed systems will be discussed and compared. Recent advancements in the two systems will also be included.

Table 1: Advantages and Disadvantages of Open Ponds and Photobioreactors [Brennan and Owende, 2010]

Culture system	Advantages	Disadvantages
Raceway pond	Relatively inexpensive Easy cleaning and maintenance Uses non-agricultural land Low energy input	Poor biomass production Poor mixing, light and CO_2 usage Large area of land needed High risk of contamination
Tubular photobioreactor	Large surface area for light Relatively cheap for photobioreactor Good biomass production	Wall growth Fouling Large area of land needed
Flat plate photobioreactor	Large surface area for light High biomass production Easy to sterilize Low oxygen build-up	Difficult to scale up Difficult to control temperature Wall growth
Column photobioreactor	Compact High mass transfer Low energy consumption Good mixing with low shear stress Easy to sterilize	Small area for light Shear stress Complicated construction

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POCER209: Extraction of Betacyanins from Red Pitaya Employing Liquid-Liquid Fractionation

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Keywords: Alcohol; Betacyanins; Liquid-liquid fractionation (LLF); Red pitaya; Salt; Sublation effect

1. Introduction

Betacyanins are the red-purple pigments abundantly found in red pitaya. They have received a great deal of research attention owing to its promising antioxidants properties. This study presents an effective yet simple technique, namely alcohol/salt-based liquid-liquid fractionation (LLF), for the extraction of betacyanins from peel of red pitaya, as shown in Figure 1. In addition, sublation effect (gas bubbles) assisted in the separation in two phase solution. LLF is an eco-friendliness separation technology. The operating parameters of LLF including types/concentrations/volumes of alcohol and salt, addition of sodium chloride, sublation time and crude amount were optimised.

2. Methodology

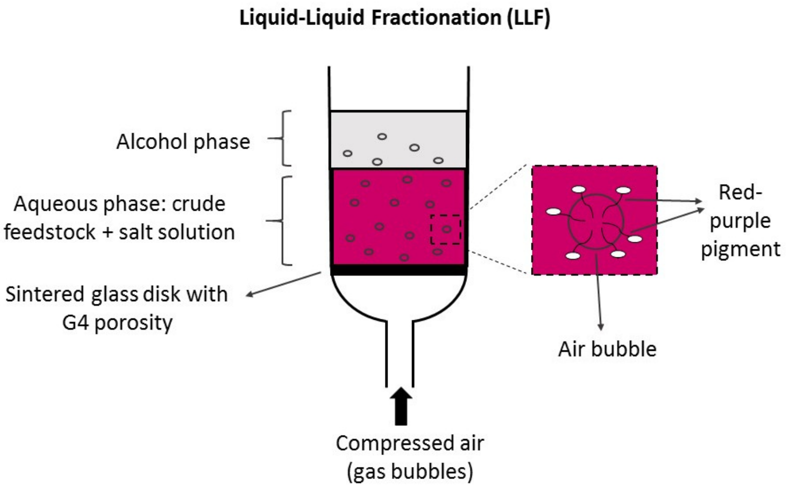

Figure 1. Schematic view of alcohol/salt-based LLF. Sublation effect assists in the extraction of betacyanins in the aqueous phase to the alcohol phase.

Equations:

$$\text{Total betacyanins content, TBC (mg BEs/100 g FW crude)} = \frac{A_{538} \times MW \times V \times DF}{\varepsilon L W} \times 100$$

[Ramli *et al.*, 2014] (1)

$$Y_T = \frac{\text{TBC in top phase}}{\text{TBC in crude extract}} \times 100 = \frac{C_T}{C_T + C_B} \times 100 \qquad (2)$$

$$Y_B = \frac{\text{TBC in bottom phase}}{\text{TBCt in crude extract}} \times 100 = \frac{C_B}{C_T + C_B} \times 100 \qquad (3)$$

$$E\,(\%) = \left(1 - \frac{C_W}{C_{Wi}}\right) \times 100 \qquad \text{[Mathiazakan \textit{et al.}, 2016](4)}$$

3. **Results and Discussion**

Overall, a satisfactory extraction of betacyanins from the peel of red pitaya was successfully achieved. The total betacyanins content, yield and separation efficiency of betacyanins were 6.0 mg BEs/100g FW crude, 98.4% and 98.3%, respectively.

Acknowledgements: This work was financially supported by Crops for the Future (CFF) and the University of Nottingham Malaysia Campus (UNMC) through the CFF-UNMC Doctoral Training Partnership scholarship scheme, as well as Fundamental Research Grant Scheme (Malaysia), Ministry of Science, Technology and Innovation (MOSTI-02-02-12-SF0256). The authors gratefully acknowledge all the funding units.

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POCER210: Sugaring Out Effect of Lipase via Aqueous Biphasic Sublation (ABS)

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Keywords: Aqueous biphasic sublation (ABS); Biotechnology; Lipase; Purification; Separation; Sugaring-out.

1. Introduction

In the recent years, the extensive market growth of industrial biotechnology has initiated bio-based production that provides us with a great array of beneficial products. One of the major breakthroughs in the biotechnology industry is the utilization of enzyme in various productions of products. Lipases are a class of enzymes of a catalyst that hydrolyse long chain triglycerides to glycerol and free fatty acids [Sharma & Kanwar, 2014]. Lipases are applied in various industries such as food, cosmetic, pharmaceutical, detergent and pesticide industries. Due to their wide array of industry applications, there is a demand for the vast production of lipase. Separation and purification of lipase have become the most expensive phases and in recent years, aqueous two-phase system is found to be an effective liquid-liquid separation technology for biomolecules recovery. There are few studies done using salting-out effect for lipase extraction however, there are several limitations that need to be considered such as for large scale production, high concentrations of salt is required which raises a concern on the environmental issue due to large amount of chemicals consumption. In addition, it may causes destructive effect to some biological products and corrosion of equipment. In this study, sugaring out extraction as a novel phase separation was proposed to extract lipase from the fermentation broth.

2. Methodology

Aqueous Biphasic Sublation (ABS) method was used to extract lipase by partitioning them using sugar and acetonitrile. Lipase that was produced from the fermentation was extracted from the broth using two-phase partitioning method by adding salt and alcohol into the flotation system as soon the fermentation process done. Sugar is added to the flotation system and was mixed, subsequently acetonitrile was added to form two-phases.

3. Results and Discussion

Table 8: Stability of lipase in acetonitrile

Acetonitrile concentration (%)	Relative activity after 30 min (%)	Relative activity after 24 hours (%)
40	75.84	93.46
50	54.83	84.57
60	83.33	95.56
70	73.42	71.14
80	65.42	94.02
90	74.19	97.60
100	79.47	90.78

The organic solvent tolerance of the lipase was studied following [Liu et al., 2009]. Based on the lipase stability test, results obtained showed that the lipase activity is not affected with high concentration of acetonitrile. After 24 hours of incubation, the lipase activity increases this may possibly due to substitution of several water molecules of the enzyme with acetonitrile molecules sometimes stabilizes the structure of the enzyme or the solvent improves the solubility of substrates and products [Hun, Rahman, Salleh, & Basri, 2003].

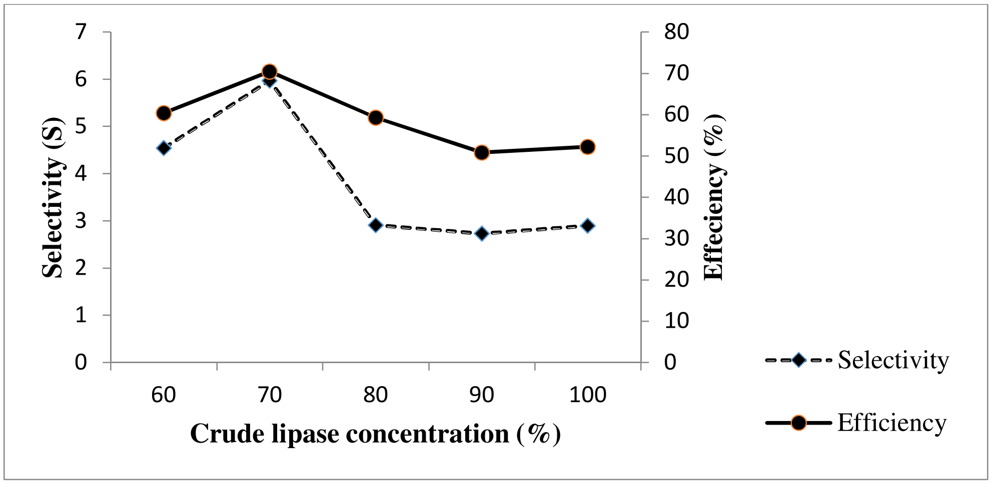

Figure 15: Influence of concentration of crude lipase feedstock on the selectivity and separation efficiency.

The concentration of crude feedstock plays a significant role in aqueous biphasic sublation (ABS). Thus, it is vital to select the optimum crude load in the ABS system for effective lipase separation. The experiment was carried out by varying the concentration of the crude feedstock from 60-100% (w/w). Based on the Figure 1, it can be seen that the separation efficiency and selectivity of lipase demonstrates the highest with 70.45% and 5.97 respectively at 70% w/w of crude feedstock concentration. The optimum crude concentration is found to be at 70%, as the concentration increases it lead to reduction in volume ratio which then ultimately reduces the quantity of lipase partitioned to the top phase [Lin et al., 2015].

4. Conclusion

In this study, a novel method of sugaring-out was proposed for lipase extraction from fermentation broth. This approach was able to partition lipase from the fermentation broth with minimal damage to the products and environment which makes sugaring-out method is promising for large number of applications in the pharmaceutical and biotechnology industries. Further optimization of ABS could be done to achieve high separation efficiency and yield of lipase.

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POCER211: Nutrient-Enriched Biowaste from Food Industry as Organic Fertilizer for Improving Growth and Yield of Crops

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Keywords: Biowaste; Compost; Environmental friendly; Fertilizer;

1. Introduction

The increasing population globally has led to increase in demand for food production and this eventually leads to more chemical fertilizers being used for crops production. The effect of excessive use of these chemical fertilizers can lead to water pollution and bring harm to the environment. Many of the waste generated contains valuable nutrient and minerals which can be reused as fertilizers. These wastes which includes household food wastes, animal manure, aquatic wastes, food processing wastes and many more shows potential to be processed into fertilizers. This conversion of biowaste will contibute to a more environmental friendly, economical and sustainable alternative to chemcial fertilizers. Besides that, these wastes can also be used for the production of animal feed and fishmeal, depending on its content and suitability for the respective application.

2. Waste to Biofertilizer

As plants grow, the nutrients from the soil will be extracted and absorbed into the plants, leaving a nutrient depleted soil plot. Without the replenishment of these nutrients, subsequent growth of plants will eventually ceased as plants depends on nutrient for metabolic reactions. Hence, it is essential to replace these nutrient artificially by applying fertilizers to the soils. The food waste are segregated into usable and non-usuable categories, where the usable section will be turned into compost through aeration. The compost pile will take some time to matured and the matured compost can then be harvest and grinded. The composting process would contribute in the sustainable management of organic wastes as these wastes can be reused as valuable sources of fertilizer to soil [Lalevic, Sivcev et al., 2013]. The compositions of the compost will be determined to evaluate its suitability for soil use. The addition of these compost into the soil is expected to enhance the growth and yield of crops (Figure 1). Furthermore, the composting is a relatively simple operation and is a sustainable method to convert organic waste into useful products due to its eco-compatibility [Raut, William et al., 2008].

Food waste obtained from the university cafeteria is collected and brought to the composting station for composting through the aerobic decomposition of the organic material by microorganisms. The compost pile will consists of food waste and a mixture of green waste. The food waste will be fed intot the compost piles and covered with canvas. The compost pile will be aerated and effective microorganisms will be added for composting. After a few months, the compost pile will be stored in a large tank for maturaiton and the final dry compost will be grinded. The grinded compost will be coated with a nutrient-enriched powder waste which contains valuble nutrients such as iron, zinc, copper, manganese and calcium. The coated compost will be granulated into fertilizer granules to be applied on plants to observe its effects on plant growth. The evaluation of the biowaste fertilizer on plant growth will depend on the final height of plants, biomass weight of plant, chlorophyll content of leaves, number of leaves, and many others factors. The application of biowaste as fertilizers will bring a significant impact to the environmental through biowaste utilization.

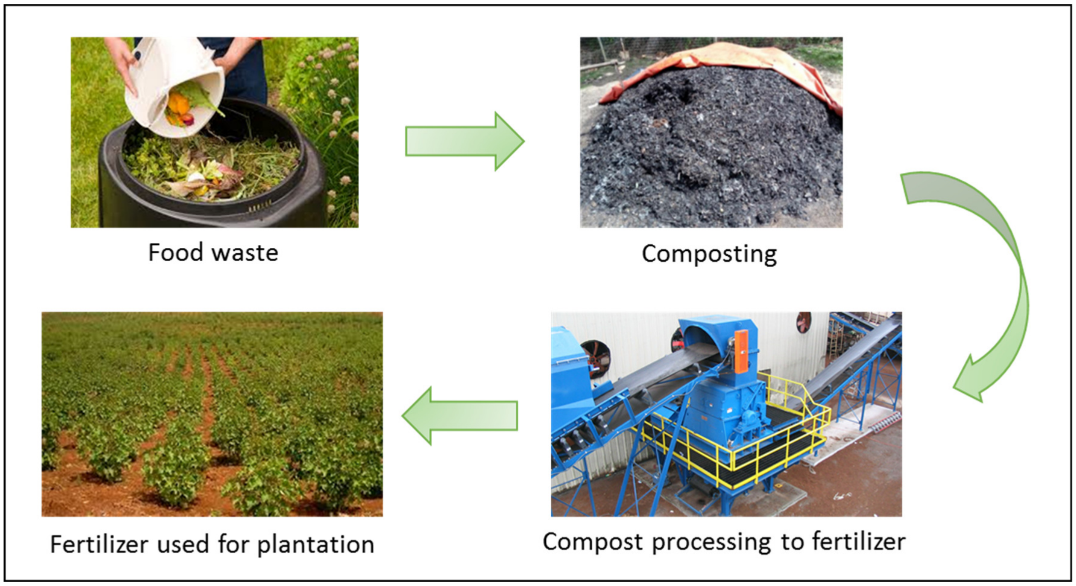

Figure 16: Fertilizer production cycle from food waste composting.

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POCER212: Advanced Treatment of Landfill Leachate via Effective Physical Technology

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Keywords: Adsorption, Coagulation, COD Removal, Landfill Leachate, Leachate Treatment

1. Introuction

Sanitary landfill is the most common solid waste management globally. However, the key success of the sanitary landfill depends on its leachate management. In physical technology, coagulation and flocculation process is one of the promising methods to treat the non-biodegrable matters especially COD, TSS and heavy metals. In the past, this conventional technology applying inorganic chemicals was commonly used in the leachate treatment process. While this traditional method is still practiced currently, new emerging non-conventional methods have also been developed by using organic synthetic polymers, natural bio-polymers and grafted polymers. They have received great attention from the researchers to compare with the conventional inorganic chemicals for the effectiveness in treating the constituents of the landfill leachate. Therefore, various types of coagulants and flocculants are explored and reviewed for its characteristics and working mechanism in order to achieve maximum removal rate of the contaminants.

2. Physical treatments for leachate

The results of this paper review show that targetting the respective parameters for the removal of the leachate is the key selection of coagulants or flocculants. Adsoprtion process using non-conventional adsorbents is another field of physical technology that seems to be an alternative way of leachate treatment. Without fully understanding the perfomance of the non-conventional adsorbents quantitatively, conventional activated carbon is always recognized for its high removal rate when treating the non-biodegradable matters. Among of the non-conventional adsorbents to be explored is rice husk carbon composite, durian peel, palm shell, sugarcane baggase, tamarind fruit seed, orange peel, coffee ground, banana frond, bone meal and iron fines. Based on the results conducted by the researchers, the performance of the non-conventional adsorbents could be in par with the treatment efficiency achieved by using the conventional activated carbon. Neverthelesss, dealing of residual impact for the application of the physical technology should be a future field of study for the researchers to optimise the leachate treatment process. Moreover, since the previous research studies were still conducted under the lab scale, more field studies using the non-conventional methods should be carried out either under the pilot scale or under the industrial scale to determine its leachate treatment performance as compared with the conventional method prior to any commercialisation in future.

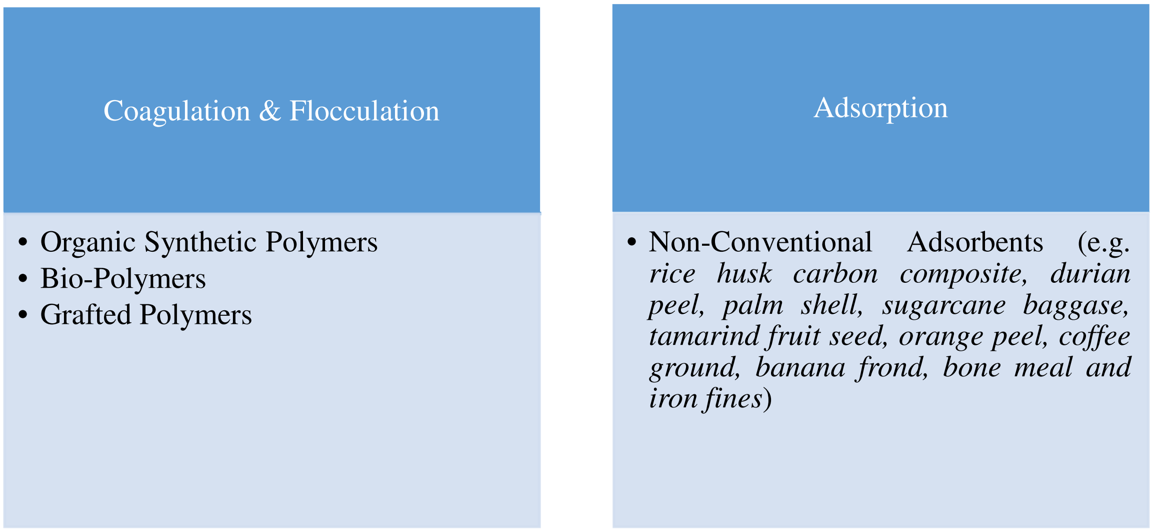

Figure 1: Physical Technology for Advanced Leachate Tretment

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POCER213: Biomass and Lipid Productions of Microalgae in Palm Oil Mill Effluent (POME)

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Keywords: Biodiesel;Microalgae; Palm oil mill effluent; Wastewater treatment

1. Introduction

The cultivation of microalgae in wastewaters have been studied in the past decades due to its potential towards commercial scale microalgae cultivation for biofuel productions. The utilization of wastewater is promising solution allowing cost-effective commercial scale microalgae cultivation. Malaysia generate palm oil mill effluent (denoted as POME) in great amount daily. This polluting POME carries high amount of nutrients. POME could be used as the cultivation medium for microalgae species in addition to POME remediation. Previous studies showed effectiveness of using POME to cultivate *Chlorella sorokiniana*. Thus, optimised cultivation conditions and additions of supplements to cultivate *Chlorella sorokiniana* CY-1 in POME were further investigated. The pollutants removal in POME were determined. These serve dual purpose to allow more feasible microalgae cultivation and wastewater bioremediation (Figure 1). The study indeed aiming towards greater biomass and microalgae-based lipid productions from POME. Overall, this enhancement approach serve as the reference towards more economic and feasible cultivation of microalgae in POME. This consequently contributing for microalgal-based biodiesel development and environmental sustainability achieving the concept of waste to wealth.

2. Framework for lipid production from microalgae

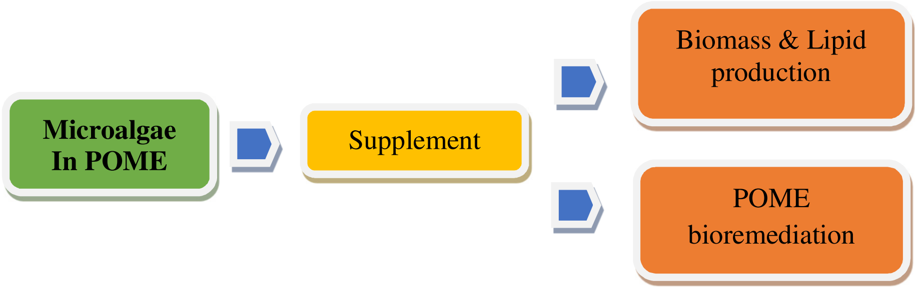

Figure 17: The conceptual framework

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POCER214: Conversion of Microalgal Biomass to Biochar in Wastewater Treatment

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Keywords: Biochar, Microalgal biomass, Wastewater Treatment

1. Introduction

Microalgae are receiving increased attention in the recent years based on its applicability in biomass production and implications in carbon capture. Microalgae can help to mitigate large amounts CO_2 emissions as about half of the dry weight of microalgal biomass is carbon. They have very high carbon fixing or photosynthetic efficiency compared to terrestrial plants and with their short life cycle that lasts a few days, they also have high biomass productivity. These attributes of microalgae contribute greatly to GHG emission reduction and simultaneous provision of a renewable feedstock for biofuels [Slade & Bauen, 2013; Ziolkowska & Simon, 2014]. Cultivation of microalgae in wastewater treatment plants simultaneously remove nutrients in wastewater and producing biomass for further bio-production. The biomass can be converted to biofuels or other products such as bio-char. The microalgal biomass obtained from wastewater bioremediation can be used to produce bio-char in a biorefinery concept, making it an interesting research approach [Bharathiraja et al., 2015] . Figure 1 shows an overall process of conversion of microalgal biomass to biochar in wastewater treatment. Recent advances in wastewater remediation with microalgae includes the use of membrane photobioreactors (MPBR) for the cultivation of microalgae. MPBRs are advantageous as they tend to protect the microalgal culture from certain harmful substances of wastewater, while still providing nutrients for the culture [Christenson & Sims, 2011; Harun et al., 2010] . The major challenges in MPBRs are the membrane costs involved and fouling in the case of continual operation.

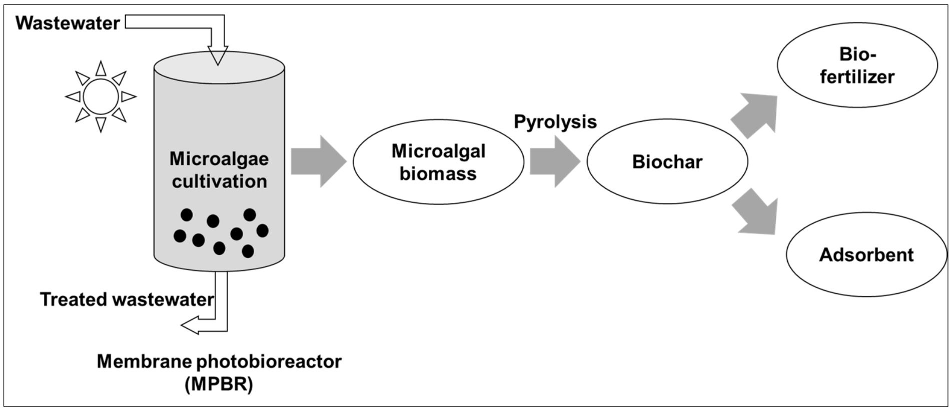

Figure 1: Overall process of conversion of microalgal biomass to biochar in wastewater treatment

2. Slow Pyrolysis

Biochar production from microalgal biomass is mainly accomplished by slow pyrolysis which yields higher biochar. processed to activated carbon.Figure 2 shows the slow pyrolysis process in biochar production from microalgal biomass. The biochar derived from microalgal biomass are generally used for soil amendment. It is also potential to be used as an adsorbent in wastewater treatment while further

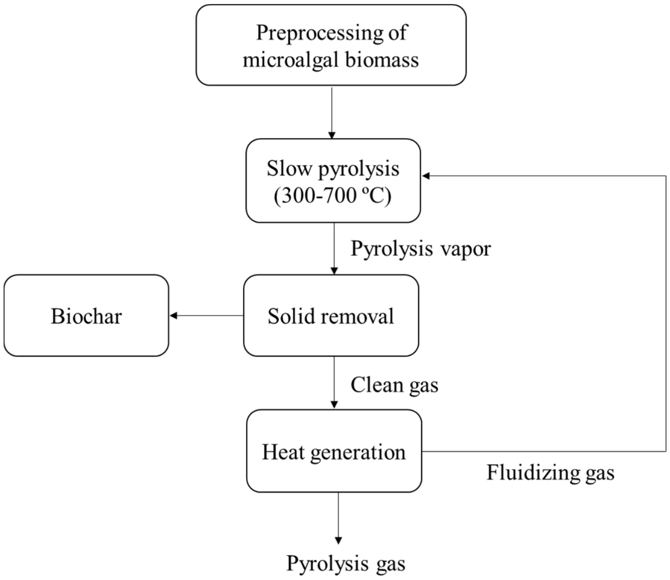

Figure 2: Slow pyrolysis process in the biochar production from microalgal biomass

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POCER215: Bioactive Compounds from Marine Macro Algae

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Keywords: Algae, Bioactive Compounds; Macroalgae; Seaweed.

1. Introduction

Marine macroalgae is commonly known as seaweed. The marine macroalgae which divided into three types are red (Rhodophyta), brown (Phaeophyta) and green (Chlorophyta) macroalgae have been widely utilised in food, health supplement, even animal feed. This nutritious biomass also valued as potential biomass for biorefineries as feedstock to produce biodiesel, biogas and bioethanol. Therefore, increasing attention on macroalgae had observed as it can be utilised in various applications and industries. The special properties of marine macroalgae such as high growth rate, renewable sources and functional biomass are the benefits of incorporating seaweed in different applications.

Nowadays, bioactive compounds are one of the high value products researchers and pharmacists looking for. Bioactive compounds could acts as functional ingredient in food to become functional food which most of the consumers looking for. The increasing demand of functional food is due to the additional health benefits other than energetic and nutritional aspects that contained within food. Bioactive compounds could be obtained from sources such as plants, marine organisms and algae. The examples of compounds that are act as functional ingredients are polyphenols, pigments, carotenoid and polyunsaturated fatty acids [Pangestuti & Kim, 2011]. Compared to other biomass, marine macroalgae have high amount of bioactive compounds within it which more than we can expect. Andrade et al. has stated that different metabolic pathway in macroalgae is capable to produce more than 15,000 primary and secondary metabolites [Andrade, et al., 2013]. These metabolites found in macroalgae have shown beneficial properties such as anti-bacterial, anti-inflammatory, antitumor, antioxidant and antidiabetic properties which are mostly related to pharmaceutical applications [Salari, Danafar, Dabaghi, & Ataei, 2016; Kosanić, Ranković, & Stanojković, 2015].

2. Algae bio-active compounds

Potential antibiotic or antifungal agents such as linolenic acid, lauric acid, stearic acid and oleic acid are found in algae extracts. It also found that the algal extract possessed immunological properties which can cure viral replication even cancer development, mostly resulting from the polysaccharides in the algae [Chojnacka, Saeid, Witkowska, & Tuhy, 2012]. Antioxidant activity of algae could be related to the protein extract from algae, which shows protection against hydroxyurea-teratogenic insult. Bioactive compounds like phlorotannin, sterols, terpenes and polysaccharides also proven to be capable of treat or prevent neurodegeneraive diseases [Barbosa, Valentão, & Andrade, 2014]. Particular species of marine macroalgae shows certain significant levels of bioactive compounds. An enrichment of bioactive compounds within macroalgae could be obtained by altering the cultivation conditions accordingly. This review will provide an overview of important bioactive compounds that have been identified in marine macroalgae. In additional, the potential of bioactive compounds for utilization as functional food to provide specific health benefits will be discussed as well.

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POCER216: Photocatalytic Activities of V-Doped, Mo-Doped and V/Mo Co-Doped Strontium Titanate

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Keywords: Mo co-doped $SrTiO_3$, Photocatalyst, strontium titanate, V-doped $SrTiO_3$, V

1. Introduction

Photocatalytic materials of V-doped, Mo-doped and V/Mo co-doped strontium titanate ($SrTi_{1-x-y}V_xMo_yO_3$) were synthesized through sol-gel method.

2. Methodology

Structure, morphology and physical properties of photocatalysts were characterized by XRD, SEM, UV-vis (DRS).

3. Results and Discussion

The single phase of strontium titanate was achieved at the calcination temperature of 700 °C for 6 hours. When V or Mo atoms was subtituted into Ti site of $SrTiO_3$ structure, the electronic structure analysis showed that the mono doping of V or Mo atoms could suppress the band-gap energy of $SrTiO_3$ from 3.22 eV to 2.29 eV or 2.00 eV, respectively (Figure 1).

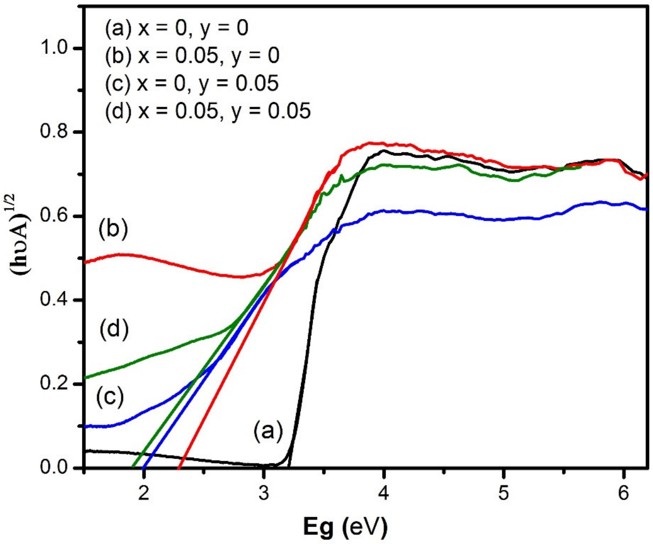

Figure 1: UV–vis diffuse reflectance spectra of the synthesized $SrTi_{1-(x+y)}Mo_xV_yO_3$ powders calcined at 700°C for 6 h

Moreover, co-doping of V and Mo further narrowed down the bandgap energy (1.90 eV) in comparison with mono-doping samples. The photocatalytic activity was evaluated through the degradation of 10 ppm methylene blue (MB) under visible-light irradiation with wavelength ranging from 390 ÷ 750 nm. The results, as shown in Figure 2, indicated that the $SrTi_{0.95}V_{0.05}O_3$ and $SrTi_{0.95}Mo_{0.05}O_3$ samples exhibited much higher photocatalytic activity than that of the un-doped sample, resulting in 83.42 and 73.8 % (after 300 min iradiation) photodegradation efficiency of methylene blue compared to 59.9 %, respectively. The co-doped sample exhibited the highest photocatalytic activity in regarding MB degradation, which was 91.8%.

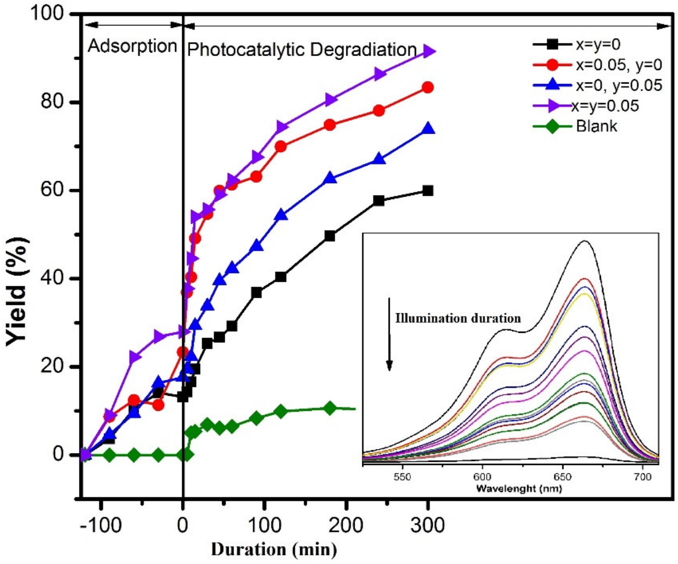

Figure 2: The methylene blue decomposition over $SrTi_{1-x-y}Mo_xV_yO_3$ photocatalyst and over $SrTi_{0.9}Mo_{0.05}V_{0.05}O_3$ photocatalyst (inset)

The kinetics of MB photodegradation reaction using visible-light radiation with wavelength of 750 ÷ 390 nm were evaluated. The decomposition of MB was investigated using Langmuir-Hinshelwood equation [Xekoukoulotakis et. al, 2010 and Hayat, 2013]: $\ln (C / C_o) = - kt$ where k is the reaction rate constant and t (min) is the reaction time, the calculation results are shown in Table 1.

Table 0. First-order rate constant and equation for $SrTi_{1-(x+y)}Mo_xV_yO_3$

$SrTi_{1-(x-y)}Mo_xV_yO_3$	k (min^{-1})	R^2
x = y = 0	$10^{-2.54}$	0.986
x = 0.05, y = 0	$10^{-2.23}$	0.901
x = 0, y = 0.05	$10^{-2.39}$	0.975
x = y = 0.05 Acid treatment	$10^{-2.14}$	0.962

4. Conclusion

The results showed that the reaction rate constant (k) of $SrTi_{0.95}Mo_{0.05}O_3$ was 2.5 times higher than $SrTiO_3$. Reaction rate constant decreased in order of $SrTi_{0.91}Mo_{0.05}V_{0.05}O_3$ > $SrTi_{0.95}Mo_{0.05}O_3$ > $SrTi0_{.95}V_{0.05}O_3$ > $SrTiO_3$. These results show that Mo and V co-doped $SrTiO_3$ is apromissing photocatalytic material for organic degradation under visible light irradiation.

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Hayat Khan, D.B., Sol–gel synthesized vanadium doped TiO_2 photocatalyst: physicochemical properties and visible light photocatalytic studies. *Sol-Gel Science and Technology*, 68 (2): 180-192 (2013).

POCER217: The Overview of Green and Lean Manufacturing

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Keywords: Energy; Lean and green manufacturing; Operation management; Resources efficiency; Sustainable.

1. Introduction

Since the industrial revolution, manufacturing industry has been the main economic driver in developing countries. With the expansion and development of manufacturing industry in South East Asia region, the demand for energy and resources has increased rapidly. The growth of manufacturing industry has contributed significantly to greenhouse gases emission which contributes to global warming. Driven by industrial globalization, challenges such as cost management on resources, energy, operation and environmental impact are affecting the sustainability of the manufacturing industry. To remain sustainable and competitive in the global market, lean and green manufacturing strategy can be implemented in the manufacturing sector. Lean approaches focus on waste elimination while green approach focus on reducing environmental impact. The synergy between lean and green approach can have significant effect to the current manufacturing industry in dealing with environmental pollution as well as operation cost.

In the current globalization economy scale, the industry is highly prone to monetary fluctuation which is the unpredictable and uncontrollable factor. The application of green and lean approach will drive the industry towards greater economic efficiency by eliminating waste and reduce environmental emission. In fact, many large manufacturers has applied lean approach to keep their competitiveness in global market [Anand and Kodali, 2008]. The lean approach provide distinctive tools, practices and strategies that can be applied to identify possible efficient production system with less resources and waste [Patterson, 2009]. Implementation of lean strategy has also been challenging for the manufacturing industry to adapt to new technology and operation procedure. Most of the companies still could not engage effectively with lean approach as they are uncertain with the application of principle, tools and practices [Belhadi et al., 2016].

Through eliminating waste, the productivity of the industry will increase resulting lower production cost and leaner production. Subsequently, less waste generated will result in lower environmental emission. As environmental impact has surfaced as a critical social issue, industry emission has became an important index to the society. Figure 1 shows factors that affect customer spending decision. Company brand and image appears to be the main factor in affecting consumer purchasing decision [Norazah, 2013]. This shows the responsibility of industry in promoting green branding plays a significant role in educating the society on green product. It was also shown that manufacturing industry that promote green product with eco-label favored by environment-concerned customer [Laroche et al., 2001].

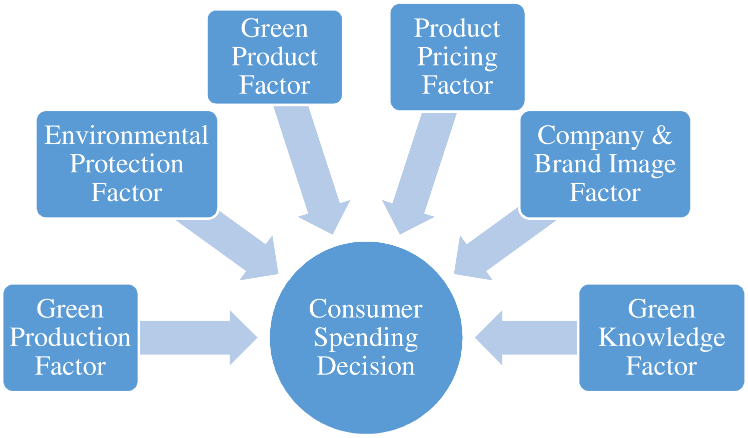

Figure 1: Consumer Spending Decision Factor

The Malaysia government has taken the initiative by promoting tax incentive for implementation of green and lean technology in the manufacturing industry. The incentives are to encourage the industry players to invest in lean and green technology to remain competitive in the market. Energy management regulation is also implemented to assist the industry to achieve efficient energy management. Malaysia government has built the lean and green platform to encourage the manufacturing industry towards lean and green manufacturing. The green and lean manufacturing industry has an critical role to play in leading the economy and society towards sustainable living. This will further resulting in maximizing efficiency of resource use and minimizing environmental impact.

Acknowledgements: We extend our sincere gratitude to the Ministry of Higher Education, FRGS/1/2016/TK03/MUSM/01/1, for supporting this project.

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POCER218: Influence of Biochar Type and Phosphorus on the yield of Green Gram (*Vigna Radiata*) in Tropical Sub-Humid Areas of Malaysia

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Keywords: Activated biochar; Biochar nanoparticles; Magnetic biochar; Phosphorus; Vigna radiata.

1. Introduction:

Biochar, a current strategy to improve soil properties and plant productivity. And on other hand particularly legumes are more prone to limited crop production due to phosphorus defciency [Chaudhary et al., 2008]. As such, a pot experiment was conducted in the screen house of University of Nottingham Malaysia Campus to assess the influence of phosphorus (P) application and biochar type on the performance of green gram (*Vigna radiata*). The novelty of the study is using biochar types and study its interaction along with phosphorus applied.

2. Methodology:

Treatments consisted of factorial combination of four biochar types at 5mg/kg (activated, magnetic, nanoparticles, normal and a control) and three (0, 20 and 40 kg P_2O_5 ha^{-1}) phosphorus levels making a total of 15 treatment combinations. Initially nitrogen @10kg/ha and potassium 40kg/ha are given to every pot along with 3kg of soil. The treatments were laid out in a completely randomized design replicated three times. The data collected will be subjected to two-way analysis of variance procedure (ANOVA) for completely randomized design (CRD) using SPSS software.

3. Results and discussion:

Standard error mean (SEM) and P values of the results obtained are presented in the Table 1. Significant ($p<0.05$) effect of phosphorus application on the number of pods per plant was observed during the trial. Figure 1 depicts the effect of biochar types and phosphorus on the yield of green gram (number of pods per plant and grains per pod). Application of 20 and 40 kg P_2O_5 ha^{-1} recorded similar and higher number of pods per plant (5.5-5.7) than treatments receiving no phosphorus application which recorded 1.8 pods per plant which was depicted in Figure 1. However, despite the higher number of pods per plant, grian yield was not influenced by application. Biochar as well did not show any influence on the yield of pods and grains. This may possibly due to the dependance on the biochar characteristics (parent biomaterial, carbonization conditions) and also type of soil [Prapagdee and Tawinteung, 2017].

Table 1: Influence of phosphorus levels and biochar type on the number of pods per plant, pod weight, grain weight and shelling percentage of green gram

Parameter	**Phosphorus (P) (P_2O_5 ha^{-1})**		**Biochar (B)**		**Interaction (PXB)**
	SEM	**P value**	**SEM**	**P value**	
Number of pods $plant^{-1}$	0.237	<.001	0.306	0.120	0.268
Grain pod^{-1}	0.44	0.077	0.120	0.782	0.897

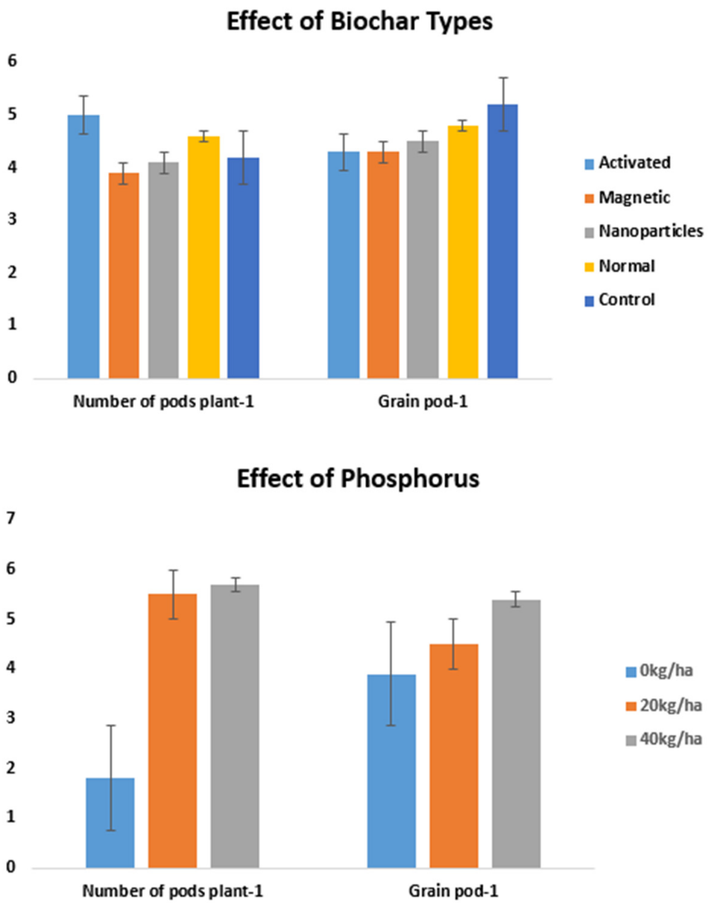

Figure 18: Effect of biochar types and phosphorus on the yield of the green gram

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4. Conclusion:

Results obtained revealed significant effect of phophorus application on the number of pods per plant. Application of 40 kg P_2O_5 ha^{-1} recorded the highest number of pods per palnt and grains per pod. Biochar application did not influence the performance of the crop. Thus, application of 40 kg P_2O_5 ha^{-1} could be adopted for increased production of the crop in the study area.

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POCER219: Feasibility Study on Polygeneration System using Sewage Treatment Plant as the Anchor in the Symbiotic Energy Network

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Keywords: Absorption chiller; Biogas; Eco-industrial parks; Incremental benefit-cost ratio; Vapor compression chiller.

1. Introduction

An issue currently faced by a sewage treatment plant (STP) with biogas production facility includes high maintenance cost of gas engines. The frequent and long downtime of gas engine also causes the unutilised biogas to be flared away which represents a waste of a valuable energy source. This paper aims to present an alternative pathway to biogas utilisation which is robust and flexible. Biogas will be utilised as a fuel source for an absorption refrigeration system (ARS), as part of a polygeneration system that produces heat, cooling water, chilled water and electricity. Noting that, a sustainable polygeneration system can be modelled when the neighbouring plants are willing to form an EIP among themselves. The main contribution of this paper is to develop an optimum eco-industrial park (EIP) design that ensures satisfaction of each individual participating plant with STP being the anchor of EIP. A centralised polygeneration system will be constructed in the anchor plant as an effort to strengthen the economic and environmental performance of the STP and it's neighbouring plants. Li et al., (2012) successfully implemented a direct fired biogas ARS in a beer brewery and greatly recommends its usage as compared to vapour compression refrigeration (VCC). However, no work has been done on chilled and cooling water network (CCWN) synthesis using biogas as the waste energy source in a STP. Previous studies in CCWN synthesis showed better payoffs in economical and environmental performances when more than one industry is integrating their waste energy sources in an EIP (Leong et al., 2015). Leong et al., (2015) used a detailed approach of game theory and stability analysis to design a sustainable EIP. On the other hand, Tan et al., (2016) utilised a cooperative game approach to systematically allocate benefits and cost to each individual plant. However, these two studies did not evaluate the sustainability of the individual participating plant and no analysis is done to evaluate if one could be better off without participating in an EIP. Hence, it is of interest to evaluate the sustainability of each participating plant before and after forming an EIP.

2. Methodology

The superstructure of CCWN and waste heat recovery network is first modelled as an MINLP using LINGO v16 software. STP is set as a centralised polygeneration system. VCC is included to supplement additional cooling requirements of each plant that is not satisfied by the waste heat sources. Figure 1 shows the proposed superstructure of biogas utilization pathways of which the STP collects waste heat from its neighbouring plants. After obtaining the overall EIP network using MINLP, incremental benefit-cost ratio (IBCR) analysis is then used to evaluate the sustainability of the individual participating plant. As a result of the IBCR analysis, plants which are deemed to be infeasible to participate in EIP will be eliminated and a final optimum EIP network is then synthesised with LINGO. To measure the IBCR, *benefits* is defined as the operating cost saving and emission saving after forming an EIP (as shown in the 4th column in Table 1), while, cost is defined as the total capital cost of ARS and cooling tower (as shown in the 3rd column in Table 1).

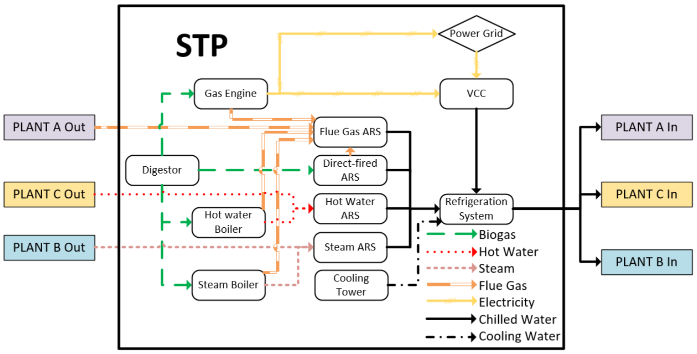

Figure 1: Superstructure of STP in an EIP Configuration

3. Results and Discussion

Table 1 shows the results of the IBCR analysis on the sustainability of each plant when participating in an EIP versus an individual configuration (without participating in EIP). Results show feasible decision for STP, Plant A and Plant C to participate in an EIP by eliminating Plant B. As shown in Table 1, Plant B is better off without participating in the EIP as indicated in the last column of IBCR selection. As shown in Table 2, a different EIP network configuration as shown in the base case will be selected before performing an IBCR analysis, which may not be a feasible option for Plant B.

Table 1: Summary of sustainability of each participating plant through IBCR analysis

Plant	**EIP Configuration**	**Capital Cost (MYR)**	**PW of Benefit (MYR/Year)**	**Selection by IBCR**
STP	Individual VCC-ARS	2,029,451	19,148,803	No
	EIP (VCC-ARS)	5,196,477	22,987,625	**Yes**
Plant A	Individual VCC-ARS	2,211,285	8,739,506	No
	EIP (VCC-ARS)	1,046,366	10,271,807	**Yes**
Plant B	Individual VCC-ARS	2,238,955	20,442,780	Yes
	EIP (VCC-ARS)	1,203,027	17,771,099	**No**
Plant C	Individual VCC-ARS	2,166,999	9,829,75	No
	EIP (VCC-ARS)	895,630	16,509,924	**Yes**

Table 2: EIP configuration for the cases studies

Case	**Participants**	**Overall TAC (MYR)**	**CO_2 Emission (CO_2 ton /year)**
EIP before IBCR analysis (base case)	STP, Plants A, B and C	19,155,590	15,853.90
EIP after IBCR analysis	STP, Plants A and C	13,858,380	15,887.04

Acknowledgements: The authors thank Monash University Student Association (MUSA) for the financial support.

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POCER220: Optimisation of Electrodeposition Parameters for N-type Bismuth Telluride Films on Carbon Fibre using Design of Experiments

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Keywords: Carbon fibre; bismuth telluride (Bi_2Te_3); Response Surface Methodology (RSM); analysis of variance (ANOVA); Seebeck coefficient; electrodposition

1. Introduction

Carbon fibre-reinforced composites are now steadily being preferred in the automotive, aerospace and industrial applications due to its lightweight, flexibility and robust mechanical properties (Shuaib & Mativenga , 2016; Marsh, 2014; Timmis et al., 2015). Though widely explored for its mechanical properties, carbon fibre is also an electrical conductor which is weakly thermoelectric. Thermoelectric modules are devices that can generate an electric potential gradient from a thermal gradient, or vice versa, without any actuating parts. In recent years, a lot of emphasis has been placed on finding flexible thermoelectric generator, in order to enhance thermal contact with heat sources of different geometry and prevent large thermal energy losses (Kim et al., 2014). In this study, carbon fibre is chosen as a viable flexible substrate due to its low electrical resistivity and weakly thermoelectric nature. Carbon fibre is coated with n-type semiconductor coatings, bismuth telluride (Bi_2Te_3) using electrodeposition technique to form flexible thermoelectric modules. The efficiency of a thermoelectric module is given by figure of merit, ZT as shown below:

$$ZT = \frac{\alpha^2 \sigma}{\kappa} T \qquad (1)$$

Whereby, α is the Seebeck coefficient, σ the electrical conductivity, κ the thermal conductivity and T is the absolute temperature. As observed in Equation 1, Seebeck coefficient has the largest contribution to the ZT value.

2. Methodology:

This study aims to improve the Seebeck coefficient of the carbon fibre by employing D-Optimal model under Response Surface Methodology (RSM) to study the combined effect of electrodeposition parameters such as deposition potential (A), deposition time (B),deposition temperature (C) , and electrolyte composition (D) on the Seebeck coefficient of Bi_2Te_3-coated carbon fibre, which have yet to be reported in literature thus far. Electrodeposition was carried out using a potentiostat (VersaStat-3, Princeton Applied Research) at varying (i) deposition potential from -0.10 to -0.60 V, (ii) deposition time from 0.5 to 3 hours, (iii) deposition temperature from 25 to 60 ^{0}C and (iv) molar concentration of electrolyte at 0.2, 0.4 and 0.6 Bi/(Bi+Te) .

3. Results and discussion:

The D-Optimal model for this study is governed by the quadratic polynomial equation as shown in Equation 2:

$$Y = -13.33 - 1.50A - 1.44B - 1.21C - 0.71D - 0.72AB - 0.49AC - 2.16BC - 1.18BD - 0.53CD - 1.05B^2 + 2.13D^2 \quad (2)$$

Whereby Y is the Seebeck coefficient (µV/K); A, B, C and D are deposition time, deposition potential, deposition temperature and electrolyte composition respectively.
From the p-value of Analysis of Variance (ANOVA), it can be concluded that parameters A, C, D, AD, BD, have significant effect on the Seebeck coefficient of Bi_2Te_3-coated carbon fibre as shown in Table 1.

Table 9: ANOVA for electrodeposition parameters of Bi_2Te_3 on carbon fibre

Source	Sum of Squares	Degree of Freedom df	Mean Square	F Value	p-value
Model	204.95	8	25.62	12.33	$< 0.0001^a$
A-Deposition Potential	29.54	1	29.54	14.22	0.0023^a
B-Deposition Time	8.60	1	8.60	4.14	0.0628^b
C-Deposition Temperature	10.00	1	10.00	4.81	0.0471^a
D-Bi/(Bi+Te)	68.06	1	68.06	32.76	$< 0.0001^a$
AD	33.90	1	33.90	16.32	0.0014^a
BD	14.46	1	14.46	6.96	0.0205^a

a Significant at ‘‘p-value” less than 0.05 b Insignificant at ‘‘p-value’’ more than 0.05

Table 10: Parameters yielding the highest Seebeck coefficient for Bi_2Te_3 coated carbon fibre using D-optimal

Deposition Potential (V)	-0.370
Deposition Time (hours)	3
Deposition Temperature (^{0}C)	40.898
Electrolyte Composition (Bi/(Bi+Te))	0.6

In this study, the best Seebeck coefficient of Bi_2Te_3-coated carbon fibre obtained is -20.174 µV/K with the parameters as shown in Table 2.

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POCER221: Inclusive Wealth as Sustainable Development Measurement: A Case of ASEAN Countries

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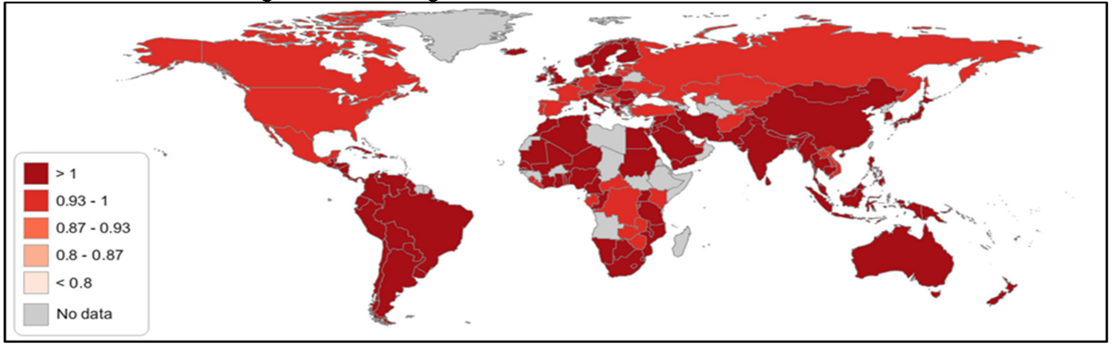
Keywords: Efficiency, Inclusive Wealth (IW), Sustainability, Total Factor Productivity.

1. Introduction

In this study, we extend current measures of sustainability by capturing the efficient utilization of natural capital and other conventional inputs. We applied the modification of natural capital by including oil-capital gain as an adjustment or correction to productivity measures for 140 countries from 1990 to 2010. The objectives of this paper are to examine the practicality of using inclusive wealth as the measurement of sustainable development and to decompose the inefficiency productivity into each inputs/ output source. We do not only measure the contribution of the physical and human capital to produce the desired outputs, but we also examine the share of natural capital to the country's economic growth. We use Gross Domestic Product (GDP) as the desired output in this paper. As a sample case, we use nine ASEAN countries. These countries consist of Malaysia, Indonesia, Singapore, Thailand, Philippines, Vietnam, Laos, Myanmar, and Cambodia

Figure 11: Average of TFP for 140 Countries, 1990-2010



2. Total Factor Productivity (TFP

Inclusive wealth (IW) introduced by United Nations University International Human Dimensions Programme on Global Environmental Change (UNU-IHDP) and the United Nations Environment Programme (UNEP) in 2012. Being theoretically consistent to the determinant of wellbeing in economics, IW which is including human, produced and natural capital continuously shows measurement for sustainability progress [Arrow *et al.*, 2012; Dasgupta *et al.*, 2015; Mäler, 2008; Yamaguchi *et al.*, 2016]. Appling this framework with the amount of capital representing the productive ability of well-being. They consider intergenerational well-being as an approach to measure sustainable development.

In their formulation, a society's economic development is sustainable at a point in time if its wealth at constant shadow prices is non-decreasing at that time. Non-declining IW implies the possibility of non-declining human well-being. In the other hand, [Arrow *et al.*, 2012] argued that Total Factor Productivity (TFP) plays an important role to assess the sustainability development using IW. Utilizing TFP as adjustment can portrait to a closer approximation the real contribution of technological innovation and efficiency played in production, as well as other implicit capital types not yet considered in developing the country's IW. However, previous studies on TFP as adjustment of IW ignores the effects of human capital and natural capital, which are key variables in their capital approach. According to [Brandt *et al.*, 2017] reported that failing to account for natural capital tends to lead to an underestimation of productivity growth. To fill the gap of incorporating natural capital to TFP as adjustment of IW, this study considers natural capital, including oil capital gain, and other conventional inputs, to productivity measures. Considering this inputs, we could analyze how these countries differ with respect to the effective utilization of their productive assets. We can understand that the same productive base of a country can lead to an increase or decrease in aggregate output over time due to productivity changes in the resource. Some countries use their endowed capital efficiently with appropriate productivity changes and future-oriented stock consumption schemes, while others do not use their capital as efficiently.

To do so, we used a deterministic nonparametric analysis called Malmquist Productivity Index, based on the Data Envelopment Analysis (DEA). This methodology is widely used in the measurement of productivity see review for [Coelli *et al.*, 1998; Färe *et al.*, 1994; Tanaka and Managi, 2013]. DEA is a linear programming technique that allows both the frontier itself and the distance from the frontier of each country to varying in every time period in an arbitrary manner. Therefore, this index that based on distance function is suitable for assessing the relationship between multivariate inputs and outputs for 140 countries, from 1990 to 2010. In addition, the measurement takes into account the efficiency of resource use and productivity changes.The measures showed significantly different TFP values among 140 countries because those values also depend on technological and efficiency advancement in terms of the use of resources (Figure 1). Natural capital, including oil capital gain related to the change in oil prices, have significant to the productivity value of the country. Based on the implementation of IW and the adjustment, we find certain countries are not sustainable. For instance, in the case of the ASEAN countries, even we find that the composition of human and physical capital is higher and contributes more to productivity from 1990 to 2010. However, the loss of natural capital is not high enough to compensate with both human and physical capital.

3. Conclusion

This study presents several important findings for economic policy evaluation and planning. For instance, as part of a country's sustainable development, the country should shift from targeting only GDP growth, but also move toward incorporating IW and TFP adjustment. Striving to improve the citizens 'well-being', this finding suggested that particular result is useful and can be considered as an alternative in assessing the sustainable development of a country.

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POCER223: Preparation and Characterisation of Bio-char from Mixed Biomass

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Keywords: Bio-char; Biomass; Pyrolysis.

1. Introduction

In recent years, bio-char is revered as inexpensive, sustainable and easily-reproducible charcoal. Bio-char is used extensively as catalyst for cleaning syngas, converting syngas into liquid carbons and producing diesel. Bio-char is found to be effective in increasing the soil quality and mitigating greenhouse gas emission. Bio-char also serves as sorbent of organic contaminants and heavy metals in water. It is also a precursor for making activated carbon. Bio-char possesses high heating value which contributes to its potential in energy production [Qian *et al.*, 2015]. It is noted that bioenergy may not be able to fulfill the ever growing energy consumption of the global population under realistic conditions. However, bio-char may be able to accord to future energy solution. Bio-char is advantageous over conventional fuel due to its sustainability. The versatility displayed by bio-char production ensures that the feedstock will never run out for bio-char production. The versatility also means that every country has access to bio-char production with the nation's major agricultural product to reduce dependency to imports of energy from other country. The net carbon dioxide emissions from biofuel use are considered zero or negative because the released CO_2 was recycled from the atmosphere captured during photosynthesis [Routa *et al.*, 2012]. Emission of nitrous oxides (NOx) and sulphur dioxide (SO_2) can be reduced by the usage of bio-char because biomass contains a low amount of sulphur and nitrogen. With the emphasis on carbon footprint reduction in recent years, bio-char is definitely showing a promising prospect in the field of energy generation. Current research investigates the mixture of two different biomass which are palm fiber from palm oil mill and durian rinds form durian fruit. To date, no other researches had been done to investigate the effects of mixing biomass on the distribution of pyrolysis yields and characteristic of the bio-char. Current research aims the novelty aspect of the effect of a mixture of biomass on bio-char production.

2. Methodology:

The research was to investigate the mixing ratio of two biomass that are abundantly available in Malaysia, namely palm fiber and durian rinds. The basis of this study is pyrolysis does not have to be limited to one feedstock and can address the seasonality of biomass like durian rinds. The bio-char yield was obtained when subjected to the pyrolysis process at a temperature of 325 °C with a holding time of 2 hours and a 5 °C/ min ramping rate. Nitrogen gas was used to purge out the gases from the reactor. Palm fiber and durian rinds was characterised using a Thermogravimetric Analyser (TGA) and the energy content before and after pyrolysis was determined using a bomb calorimeter. The preparation of bio-char from mixed biomass and the mixing ratios that were used are listed in Table 1.

Table 12: Sample Denotation

Sample	Mixing ratio
A	100 % Palm fiber
B	90 % Palm fiber – 10 % Durian rinds
C	75 % Palm fiber – 25 % Durian rinds
D	50 % Palm fiber – 50 % Durian rinds
E	25 % Palm fiber – 75 % Durian rinds
F	10 % Palm fiber – 90 % Durian rinds

3. Results and dicussion:

The char yield (%wt), higher heating value (HHV) (MJ/kg) and energy yield (%) obtained from the mixed biomass subjected to pyrolysis are shown in Table 2. The energy content % was calculated from the Equation 1 below:

$$Energy\ yield\ (\%) = \frac{weight\ of\ biochar\ yield}{weight\ of\ raw\ biomass}\ x\ 100\ x\ \frac{HHV\ of\ biochar}{HHV\ of\ raw\ biomass} \qquad (1)$$

Table 2: HHV for Biomass, Bio-char and Energy Yield

Sample	Bio-char Yield (%wt)	Biomass HHV (MJ/Kg)	Bio-char HHV (MJ/Kg)	Energy Yield (%)
A	40.78	16.76	24.07	58.57
B	40.90	16.31	25.14	63.02
C	32.85	15.92	25.11	51.81
D	29.53	15.45	25.13	48.01
E	38.27	15.04	24.52	62.41
F	33.82	14.95	25.78	58.33

The results from the raw biomass showed that the calorific value of all raw biomass range from 14.95 to 16.76 MJ/kg. Sample A (100% palm fiber) recorded the highest calorific value and decreasing trend was recored as the palm fiber mixing ratio decreased. However after pyrolysis at 325 °C, the calorificvalue seemed to differ. Samples A to F have a calorific value ranging from 24.07 to 25.78 MJ/kg. When compared to the calorific value of low rank Indonesian coal of 22 MJ/Kg, the biochar samples indicated the better quality of the fuel [Parshetti *et al.*, 2014].The bio-char yield for samples A to F also seemed to be in the range of 29.53 to 40.78 %wt with no specific trend observed. However, based on the bio-char yield and heating value obtained, the energy yield was calculated. The highest energy yield (63.02 %) was found in sample B (90 % palm fiber and 10 % durian rinds). The results from the raw biomass of sample B had a calorific value of 16.31 MJ/Kg with a bio-char yield of 40.9 % after pyrolysis at 325 °C and is the highest char yield obtained. This resulted the sample B to a calorific value of 25.14 MJ/Kg. The energy content on 1 Kg basis yielded 10.28 MJ and seems to be the highest energy content compared to the other ratios. In addition, result of calorific value of sample B has indicated that the biomass has been upgraded to a better fuel value. Conversion of mixed biomass waste into solid bio-char showed an improvement in the char yield and energy content.

Acknowledgements: The authors would like to express sincere gratitude to Seri Ulu Langat Oil Palm mill for providing the palm fiber for the research.

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POCER224: Optimisation and Evaluation of Coagulation–Flocculation Process for Palm Oil Mill Effluent (POME) Treatment using Peanut–Okra and Wheat Germ–Okra

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Keywords: Coagulation–Flocculation; POME, Peanut, Okra, Water Treatment, Wheat Germ

1. Introduction

Coagulation–flocculation has been proven as one of the effective processes in treating palm oil mill effluent (POME), which is a highly polluted wastewater generated from palm oil milling process. Two pairs of natural coagulant–flocculant were studied and evaluated: peanut–okra (PN–OK) and wheat germ–okra (WG–OK). This research study aims to optimize the operating parameters of the coagulation–flocculation process in removing turbidity (TUR), total suspended solid (TSS) and chemical oxygen demand (COD) from POME by using a central composite design (CCD), which is a response surface methodology (RSM) module in the Design Expert® software.

2. Methodology

Important parameters such as operating pH, coagulant and flocculant dosages were empirically determined using jar test experiment and optimized using RSM module. The factors and their levels for central composite design is shown in Table 1. Significant quadratic polynomial models were obtained via regression analyses (R2) for PN–OK (0.9355, 0.9534 and 0.8586 for TUR, TSS and COD removal, respectively) and WG–OK (0.9638, 0.9578 and 0.7691 for TUR, TSS and COD removal, respectively).

Table 1: Factors and their levels for central composite design

Variables	Symbol	Low Level (–1)	Zero (0)	High Level (+1)
pH	A	10	11	12
Coagulant dosage (mg/L)	B	1000	3000	5000
Flocculant dosage (mg/L)	C	100	300	500

3. Results and discussion

The highest observed removal efficiencies of TUR, TSS and COD (92.49%, 86.58% and 34.83% respectively for PN–OK; 86.55%, 87.54% and 43.62% respectively for WG–OK) were obtained at optimum pH, coagulant and flocculant dosages (pH 11.57, 1000.05 mg/L and 135.46 mg/L respectively for PN–OK; pH 12, 1170.50 mg/L and 100 mg/L respectively for WG–OK). The observed removal efficiencies were compared with the predicted removal efficiencies, which were calculated using Eq. (1). The coagulating performance of PN–OK and WG–OK were comparable to each other. Furthermore, with the comparisation with literature, the removal efficiency of TUR, TSS and COD level using PN–OK and WG–OK were found similar to chemical materials such as alum.

$$Y = \beta_0 + \sum_{i=1} \beta_i x_i + \sum_{i=1} \beta_{ii} {x_i}^2 + \sum_{i=1} \sum_{i \neq j=1} \beta_{ij} x_i x_{ij} + \varepsilon \qquad \text{– Eq. (1)}$$

Where Y is the response (removal efficiency); x_i is the independent variables (pH, coagulant and flocculant dosages); β_o is constant coefficient, β_i, β_ii, and β_ij represent coefficients for the linear, quadratic and interaction effect; ε is the random error [Mohajeri et al., 2010].

Optimization and validation experiment were performed to determine the optimum process parameters such as pH, coagulant and flocculant dosages for maximizing the removal efficiencies of TUR, TSS and COD from POME. The optimum operating parameters are tabulated in Table 2. The obtained and predicted removal efficiencies were compared for validation purpose, as shown in Table 3.

Table 2: Optimum operating parameters (Design Expert® numerical optimization)

Variables	PN–OK	WG–OK
pH	11.57	12.00
Coagulant dosage (mg/L)	1000.05	1170.50
Flocculant dosage (mg/L)	135.46	100.00
Desirability	0.957	0.978

Table 2: Observed and predicted result based on validation experiment

Response Variables	PN–OK		WG–OK	
	Observed	***Predicted***	***Observed***	***Predicted***
TUR removal (%)	92.49	92.27	86.55	88.71
TSS removal (%)	86.58	86.79	87.54	86.35
COD removal (%)	34.83	36.33	43.62	46.81

Characterizations of the natural coagulant–flocculant, as well as the sludge produced, were performed using Fourier transform infrared (FTIR), energy dispersive X-ray spectroscopy (EDX) and field emission scanning electron microscope (FESEM). Plant based coagulant and flocculant mainly consist of polysaccharides, fatty acids and proteins, which are the coagulating agent in water treatment. From the characterisation tests, it was reported that protein and fatty acid were found in peanut, okra and wheat germ. However, only polysaccharide was present in okra flocculant.

4. Future work and recommendation

This research has investigated the relationship between independent variable (pH, coagulant and flocculant dosage) and dependent response variable (TUR, TSS and COD removal). Other variables of coagulation–flocculation process such as temperature and stirring speeds in rapid and slow mixing stages can be studied and manipulated in the future work. Furthermore, the availablity and economic factor of the plant based material should be considered in the future study.

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POCER225: Co-pyrolysis of Palm Empty Fruit Bunch with Palm Oil Sludge for The Production of High pH Bio-oil

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Keywords: Bio-oil; Co-pyrolysis; Empty Fruit Bunch (EFB); Fixed Bed Reactor (FBR); Palm Oil Sludge (POS).

1. Introduction

Renewable energy sources have been discovered and studied for many years to overcome this concern. Among renewable energy sources, biomass is the only source that for carbon based liquid fuel. Pyrolysis of biomass is one of the thermochemical conversion methods, which involves the heating the feedstock to a high temperature (400 – 600 °C) in the absence of oxygen. The vapours produced would be quenced quickly and the condensate is known as bio-oil, a potential substitute of crude oil.

Bio-oil derived from the pyrolysis of lignocellulosic biomass (i.e. EFB) typically have a high acidity (pH of 2 – 3), high moisture content (20 – 30 wt%), and low HHV (16 – 19 MJ/kg) as compared to that of conventional fuels [Abdulla, N. et al, 2011]. These unfavourable properties causes the bio-oil to be unsuitable to use directly for fuel applications. In contrast, POS derived bio-oil has a high alkalinity of pH 9.4 [Thangalazhy-Gopakumar, S. et al, 2015], which is also not compatible for fuel application. Besides that, ash in sludge may contain beneficial metal contents that may be catalytic to thermal decomposition. Thus, co-pyrolysis of EFB and POS may be a solution to producing a bio-oil with the acceptable pH values. Resulting bio- oils would make the storage and downstream upgrading process easier as compared to handling of acidic bio-oil. Therefore, the objective of current study is to improve pH of bio-oil near to a neutal by fast co-pyrolysis of EFB with POS. Study utilized different ratios of EFB and POS for co-pyrolysis.

2. Methodology

The feedstock samples were dried to < 10% moisture content, ground to size < 2mm, and characterized for proximate analysis such as moisture content (wt%), volatile matter (wt%), ash content (wt%), fixed carbon (wt%), and HHV (MJ/kg). Blends of 10, 20, 35 and 50 wt.% sludge with EFB were pyrolyzed at 500±20^{0}C using a fixed bed reactor. The bio-oil collected were sent for analyses such as, pH value, moisture content, ash content, FTIR, and GC-FID. The quality of the bio-oil produced was compared to the bio-oil ASTM D7544-09 standards.

3. Results and Discussion

Figure 1 showed that when sludge content was increased from 0% to 50% , the bio-oil yield decreased from 41% to 27%. There was a negative synergistic effect for co-pyrolysis, may be due to the catalytic activity of alkali earth element and alkali metals in POS. This group of metals promoted catalyzed the biomass decomposition and the char or gas formation [Liu, C. et al., 2014]. From Table 1, it was confirmed that there were synergistic effects from the different sludge ratios on the yield and pH of bio-oils produced from EFB and sludge co-pyrolysis. Bio-oil pH of 4.5 and 7.2 were obtained for 35% and 50% sludge compositions. Overall, 35% Sludge showed promise with bio-oil quality (water content), or close to meeting ASTM requirements. A increase in phenol and its derivatives noticed in bio-oil as sludge percentage increased. Based on the yield and physical properties of bio-oil, 35% sludge was selected as the desired ratio for further co-pyrolysis for EFB.

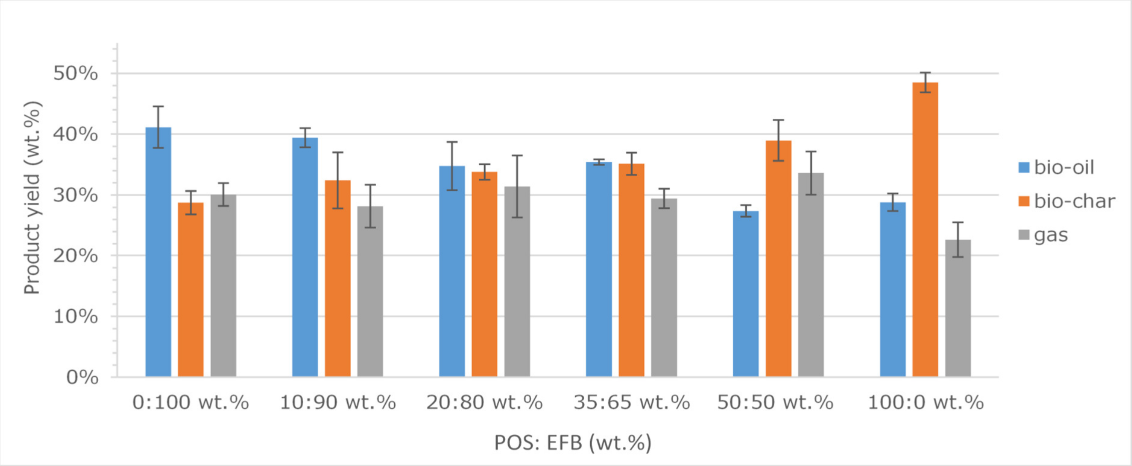

Figure 19:Product yields of pyrolysis of EFB and POS and co-pyrolysis of their mixtures

Table 13: Properties of bio-oils produced during co-pyrolysis

Properties	**0:100 wt%**	**10:90 wt%**	**20:80 wt%**	**35:65 wt%**	**50:50 wt%**	**100:0 wt%**	**[ASTM D7544-2012]**
pH	2.8±0.21	3.0±0.2	3.9±0.1	4.5±0.1	7.2±0.0	9.5±0.1	Report
Water Content (wt%)	22.6±1.5	NM	NM	30.7±1.6	NM	34.4±3.7	30 max

NM- not measured

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POCER226: Green Propulsion using Hydroxylammonium Nitrate (HAN): A Review

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Keywords: Ceramics; Green Propulsion; Hydrogen peroxide (H_2O_2); Hydroxylammonium nitrate (HAN); Microthrusters; Propellants.

1. Introduction

Ammonium perchlorate (NH_4ClO_4), hydrogen peroxide (H_2O_2) and hydrazine (N_2H_4) have been widely used as propellants for spacecraft thrusters. Although these propellants were well established owing to their performance characteristics, their limitations on toxicity, operational handling and environmental impacts have raised concerns. For example, toxicity and flammability of N_2H_4 requires special ground handling procedures which would incur higher cost whereas combustion of NH_4ClO_4 was reported to form vast amount of hydrochloric acid upon combustion [Wingborg et al.,2008]. While H_2O_2 is a green propellant, it self decompose slowly and requires special precaution measures in propellant storage. In view of this limitations, hydroxylammonium nitrate (HAN, $NH_3OH^+NO_3^-$) has emerged as a promising choice of green propellant. In the present study we report the green end products from the decomposition of hydroxylammonium nitrate and review the toxiological properties of HAN and other propellants that are commonly used.

2. Theory

HAN is an oxygen rich component which dissolves in water as ionic solution. Due to its low toxicity level, HAN requires no special ground handling and is suitable for long term storage. One proposed mechanism for decomposition of HAN in micropropulsion systems is by electrolysis. The advantages of electrolytic decompostion mechanism is that it can be initiated at room temperature, reduced power requirement and enhanced system reliablity. In this decomposition mechanism, electric current will be directly applied to the propellant to initiate decomposition through non-spontaneous redox reaction. The reaction starts with electrolysis of water:

At anode:

$$H_2O \rightarrow {}^{1}\!/_{2}\, O_2 + 2H^+ + 2e^- \quad (1)$$

Production of protons from electrolysis of water develops the reaction below:

$$(NH_3OH)^+NO_3{}^- + H^+ \rightarrow NH_3OH^+ + HNO_3 \quad (2)$$

At cathode:

$$2NH_3OH^+ + 2e^- \rightarrow 2NH_2OH + H_2 \quad (3)$$

Thus, from (1),(2) and (3) overall electrochemical reaction is as below:

$$2(NH_3OH)^+NO_3{}^- + H_2O \rightarrow 2NH_2OH + 2HNO_3 + H_2 + {}^{1}\!/_{2}\, O_2 \quad (4)$$

Ionized HAN undergoes series of thermal decomposition steps where water content is vaporized into HAN solution. This is followed by explosion period as nitric acid reacts with hydroxylamine to produce intermediate gas species (NO_2, NO and HNO_3) and later decay period to form decomposition gases

(N_2,O_2 and H_2O). The overall reaction for complete HAN decomposition is as below [Meng et al., 2009]. The complete decomposition of HAN releases only water vapour, nitrogen and oxygen gas and considered as green propellant with minimum impacts to the environment. Table 2 summarizes the toxiological properties of HAN and other propellants.

$$NH_3OH^+NO_3^- \rightarrow \boxed{N_2 + O_2 + 2H_2O + heat} \tag{5}$$

Table 14: Toxiological properties of HAN, AND and hydrazine.

	HAN	ADN	Hydrazine
Acute inhalation toxicity	Cyanosis, respiratory distress and restlessness.	Irritation to mucous membrane of the respiratory organ. Prolonged exposure causes feeling of weakness,dizziness, indisposition and sleeping problems.	Exposure to high levels of hydrazine can cause dizziness, headache, nausea, pulmonary edema, seizures, and coma in humans.
Ingestion	Swallowing will lead to a strong caustic effect on mouth and throat and to the danger of perforation of esophagus and stomach.	Anaemia, epileptic convulsion and unconsciousness.	Acute exposure can damage the liver, kidneys, and central nervous system in humans.
LD_{50} (oral rat)	139 mg/kg [Hui et al., 2008]	823 mg/kg [Kinkead et al.,1994]	60-90 mg/kg
LD_{50} (dermal rabbit)	70 mg/kg [Hui et al., 2008]	>2000 mg/kg [Kinkead et al.,1994]	91 mg/kg
Cancer/mutation / unborn child damage/ reproduction	No classification data on carcinogenic properties available from EPA, IARC, NTP, OSHA or ACGIH. No effects known on reproductive toxicity and germ cell mutagenicity.	Toxicity study: Salmonella typhimurium: positive. In vitro mammalian cell gene mutation test: negative	EPA has classified hydrazine as a Group B2, probable human carcinogen. Inhalation of hydrazine for a year resulted in effects to the ovaries, endometrium, and uterus in female rats and to the testes in male hamsters.

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POCER227: Catalytic Deoxygenation of Jatropha Curcas Oil to Green Diesel over Cocoa Pod Husk derived Carbon-supported Ni-Ag Catalyst

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Keywords: *Carbon, Coconut husk, Deoxygenation, Jatropha curcas oil, Nickel, Silver.*

1. Introduction

Diesel fuel fraction is one of the most important product in the fractional distillation of crude oil. The of crude petroleum resources had created a sustainable interest in alternative green diesel fuels of biological origin [Pradhan et al., 2012]. Albeit biodiesel is an established alternative fuel, but it is not compatible with conventional diesel engine as it contained high oxygen content in fatty ester. An alternative pathway lies in the deoxygenation (DO) of triglycerides via decarboxylation (-CO_2)/decarbonylation(-CO,H_2O) (deCOx) reaction, which produces hydrocarbons with one carbon number less than their corresponding fatty acids [Santillan-Jimenez and Crocker, 2012]. DO process is promising technology for producing less oxygenated compounds and selectiv green diesel-range hydrocarbon. In the present study, catalytic deoxygenation of *jatropha curcas* oil (JCO) was carried out for the production of diesel-range hydrocarbon fuels by using coconut husk-derived carbon-supported Ag- and Ni-Ag catalyst.

2. Methodology

The activated carbon was synthesized via using a two-step process: physical activation using milling followed by chemical activation using concentrated H_3PO_4, the treated carbon then was carbonized under N_2 stream up to 400 °C for 4 h. The metal precursor were introduced into the support by wet-impregnation method. Physiochemical properties of Ni-Ag/AC_{coco} were characterized by X-ray diffraction (XRD), BET surface area, FESEM-EDX and TPD-NH_3 analysis. The catalytic performances of the catalyst were investigated by determining the saturated and unsaturated linear or straight-chain hydrocarbons (n-alkane+n-alkene) weight fraction (X) using Eq. 1:

$$X = \frac{\sum n_o + \sum n_i}{\sum n_z} \times 100\% \quad , \text{Eq. 1}$$

where X denotes the saturated and unsaturated straight-chain hydrocarbons weight fraction (wt.%), n_o denotes the area of alkene (C_8–C_{20}), n_i denotes the area of alkane (C_8–C_{20}), and n_z denotes the area of the total product. Meanwhile, the selectivity of the deoxygenated products was determined using Eq. 2:

$$S = \frac{C_x}{\sum n_x} \times 100\% \quad , \text{Eq. 2}$$

where S denotes the selectivity (%), C_x denotes the area of the desired organic compound, and n_x denotes the area of the total organic compounds.

3. Results and Discussion

The catalytic activity profile of deoxygenation reaction was presented in Fig. 1a-b. Based on the results (Fig. 1a), the catalytic free deoxygenation reaction ((blank process) rendered low yield of hydrocarbon (18%), which indicated low deoxygenation rate of triglycerides in the absence of catalyst. As compared to carbon-supported catalyzed deoxygenation reaction, the yields of liquid hydrocarbon were significantly increased in the order of Ni-Ag/AC_{coco} > Ag/AC_{coco} > AC_{coco} > blank. According to the findings from Fig. 1b, the carbon-supported Ni-Ag catalyzed reaction capable to produce high selectivity of deCOx product (n-C_{15}, n-C_{17}) as compared to carbon-supported with Ag- oxide, which indicating the deCOx pathways was enhanced with the presence of NiO on the Ag/AC$_{coco}$ catalyst. Increment of the hydrocarbon yield and deCOx selectivity were due to the presence of large distribution of acid sites in the binary metal oxide system (Ni-Ag), which rendered a synergistic effect for C-O cleavage via deCOx of free fatty acid chain [Asikin-Mijan et al., 2016] .

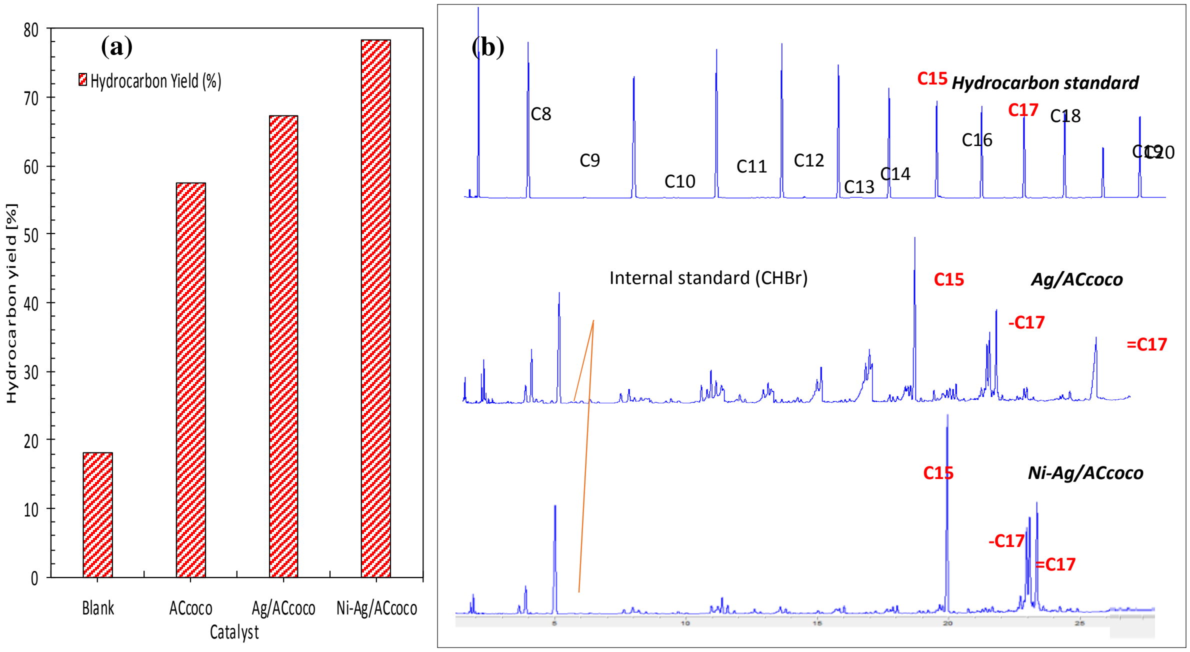

Figure 1: (a) Hydrocarbon yield and (b) GC-FID chromatogram of deoxygenated liquid product catalyzed by all catalysts.

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