UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BIODIESEL PRODUCTION FROM JATROPHA CURCAS OIL VIA MICROWAVE IRRADIATION USING WASTE MUSSEL

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Mechanical Engineering Technology (Maintenance Technology) with Honours.

by

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Tajuk: EFFECT OF WASTE MUSSEL ON BIODIESEL PRODUCTION FROM JATROPHA CURCAS OIL VIA MICROWAVE IRRADIATION

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I hereby, declared this report entitled “Effect of Waste Mussel on Biodiesel Production from Jatropha Curcas Oil via Microwave Irradiation” is the results of my own research except as cited in references.

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APPROVAL

This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Maintenance Technology) with Honours. The member of the supervisory is as follow:

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DEDICATION

To my beloved parents

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ABSTRACT

The purpose of this research is to study the biodiesel production from Jatropha curcas oil by using heterogeneous catalyst via microwave irradiation method. The Jatropha curcas oil was extracted from Jatropha seeds and waste mussel shells was used as calcium oxide (CaO), heterogeneous catalyst. A modified domestic household microwave by Samsung brand was selected to run the transesterification process. Acid esterification method was used to reduce the high free fatty acids in the Jatropha curcas oil. Transesterification process was done after that, followed by phase separation process to remove all the excess water and methanol contents. All the biodiesel parameters such as reaction time, the microwave power output, methanol to oil molar ratio and weight of catalyst is expected to give some significant effects on the overall performance. At the end, the best parameter for the maximum yield production was recorded at 300W of microwave power, 12wt% of catalyst, 6:1 methanol to oil molar ratio and 9 minutes of reaction time. All the biodiesel B100 were tested and referred with the ASTM D 6751 and EN 14124 standards.

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ABSTRAK

Tujuan kajian ini adalah untuk mengkaji pengeluaran bio-diesel dari minyak biji pokok jarak dengan menggunakan pemangkin heterogen melalui kaedah penyinaran gelombang mikro. Minyak biji pokok jarak di-ekstrak dari bijinya dan sisa cengkerang daripada kulit kerang digunakan sebagai kalsium oksida (CaO), pemangkin heterogen. Ketuhar gelombang mikro domestik berjenama Samsung telah dipilih untuk menjalankan proses transesterifikasi. Kaedah esterifikasi asid digunakan untuk mengurangkan asid lemak bebas yang tinggi dalam minyak biji pokok jarak. Proses transesterifikasi dilakukan selepas itu, diikuti dengan proses pengeringan untuk membuang semua kandungan air dan metanol yang berlebihan. Semua parameter bio-diesel seperti masa tindak balas, suhu tindak balas, kuasa keluaran gelombang mikro, nisbah metanol kepada minyak dan berat pemangkin dijangka memberi beberapa kesan penting ke atas prestasi keseluruhan. Parameter yang terbaik untuk mencapai penghasilan bio-diesel yang maksima adalah dengan menggunakan 300W kuasa ketuhar, 12wt% pemangkin, 6:1 ratio metanol ke minyak dan 9 minit masa tindak balas. Bio-diesel B100 yang dihasilkan telah merujuk kepada piawai ASTM D 6751 dan EN 14124.

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CHAPTER 1

INTRODUCTION

1.1 Background

Study by Syed Hasnain Syah et al., in 2018, stated that the world is currently confronting severe energy catastrophe in this century because of the industrialization increases and the excess use of natural resources like the fossil fuels. Approximately, it would be a raise in the energy and petroleum demands in the future. Most of the oil and gas may result in reduction. The uses of fossil fuels also have many consequences such as greenhouse gases carbon dioxide emissions. These consequences will give a bad impact on the environment. This is the cause that the world needs other sources of energy that can assure the sustainability of clean environment. Biodiesel have come into sight as one of the potential option as it is renewable and obtainable throughout the world.

The world is searching for a better way to ease the constant waste managing matters which include larger area and water for the use of managing and treating of wastes, (Jilu Lizy Stephen et al., 2018). The elimination of organic waste has become an issue because of the pollution created by it during the elimination process. Biodiesel production uses many types of organic waste or materials as the source of its existence. So, the elimination of all the organic waste from around the world can be much easier as the biodiesel productions can help to manage the waste. The conversion of the wastes into biodiesel will be using some technologies such as hydrolysis, fermentation and transesterification process.

The fear of the change in the Earth's climate has required the world to find other ways that are way less dangerous to the environment. Averagely, biodiesel burning can cause the emission of 48% less carbon monoxide; 47% less particulate material and 67% less hydrocarbon, a study by Carlos Daniel Mandolesi de Araujo et al., (2013). This is why biodiesel can be consider as one of the mechanism that can battle the global warming issue as the use of ethanol decreases the carbon dioxide, CO_2 emission. So, biodiesel are way less pollution compared to the fossil fuels as it produces lesser dangerous chemical substances during the combustion process and tends to be cleaner.

Man Kee Lam et al., (2010), stated that the production of biodiesel made from using renewable sources and renewable wastes have the greatest potential among the other renewable resources. The other renewable resources stated were like natural gas, nuclear, hydro, coal, etc. According to some prediction, renewable energies such as the biodiesel energy will be entering the energy market strength in the near future to expand global energy resources. It was also highlighted to be one of the energy sources that will be used in transportation as it can replace fossil fuels. It is like a must for the world to discover more latest renewable energies to guarantee the energy security worldwide.

Biodiesel can be produced from many kinds of vegetable oil, such as palm oil, soybean oil and sunflower oil as shown in the previous studies, (Zahira Yaakob et al., 2013). Many kinds of oil used for producing cooking oil. But in Malaysia, palm oil is the highest common used oil because of its low cost compared to the other sources. These oils will then be in transesterification process to produce biodiesel. But the use of these oils will cause many people to face hunger and starvation as it is already received criticism from nongovernmental organisation worldwide. As a solution, they come out with an idea by using the waste cooking oil, JCO as the biodiesel source. The use of JCO as biodiesel source will also reduce water pollutions and pipe blockages.

1.2 Problem Statements

i. The effect of process variables is unknown to the production yield as the correct and standardize process variables to produce biodiesel is still uncertain. There are still no standardizing process variables so that it can be produced widely by referring to the standard.

ii. Biodiesel has been produced in so many countries by using many types of oils and many types of catalyst. The way of how it is done with the use of heterogeneous catalyst is still not clear.

iii. As the biodiesel is being produced, the influences of the feedstock characteristics were not studied entirely. The effect of the characteristic of the feed stock to the final product yield is still unknown.

1.3 Objectives

i. To study the effects of process variables (microwave power, reaction rate, catalyst weight percentage and alcohol to oil ratio), production yield and apparatus embodiment.

ii. To learn on the production of biodiesel from Jatropha curcas oil by using natural heterogeneous catalyst.

iii. The study of the feedstock characteristics such as the free fatty acid (FFA), the acid value, the density, the kinematic viscosity and the flash point composition that may influence the final properties of the biodiesel.

1.4 Scopes

i. The effects of process variables, production yield and apparatus embodiment will be studied by analysing and investigating the wanted biodiesel properties in the results of the product produced.

ii. The biodiesel studied is produced by using extracted Jatropha curcas oil prepared in the laboratory with the help of cleaned mussel shells as the natural heterogeneous catalyst.

iii. The feedstock characteristics such as the FFA composition were studied by using some calculations through the acid values of the feedstock and how the characteristics such as flash point, kinematic viscosity and density may influence the final yield product.

CHAPTER 2

LITERATURE REVIEW

2.1 Biodiesel

Biodiesel or bio fuels exist in the internal of combustion engines since the year (1920 to 1930) and the World War II all over the globe, (Amin Talebian-Kiakalaieh et al., 2013). There are many types of biodiesel that have been tested and used until now. At that time, the productions of petroleum fuel costs were cheaper than the other alternative fuels that caused to slow down manufacture of biodiesel infrastructures. On the other hand, concerns about recent fossil fuel reduction and environmental degradation have again jumpstarted the production of biodiesel; it was found out to be the most possible solution for the condition.

Biodiesel are produced to battle the threats of global warming and high cost of fossil fuel, (Urvi patel et al., 2013). The release of greenhouse gases is increasing everyday with rapid reduction of oil resources. Thus, biodiesel provides many benefits; environmental protection, economic development and national security.

Awareness about the fuels that was obtained from a lot of renewable sources, such as biodiesel, has amplified drastically recently because of the instability of political and economic of the oil market and the environmental benefits related to the gaseous emissions decreasing levels from the fuels combustion from non-renewable sources, (Kamila Colombo et al., 2017). Biodiesel is a way to be a conventional diesel fuel because of its renewable nature and the linked decrease in the emission of particles and greenhouse gases.

It was defined by the American Society for Testing and Materials (ASTM) that biodiesel act as a mono alkyl ester of fatty acids or fatty acid methyl ester derived from renewable feed stocks like the vegetable oils. The term 'bio' point out the biological source of the biodiesel, in contrast with conventional diesel. By the study of Zahira Yaakob et al., (2013), biodiesel product features is likely a clear liquid with a light to dark-yellow colour. Biodiesel has a boiling point of over than 200 ˚C, a flash point that is in between 145 ˚C to 175 ˚C and a distillation range of 195 ˚C to 325 ˚C and it is also insoluble in the water, light musty or soapy odour, biodegradable, and stable in reactivity. However, strong oxidising agents have to be avoided.

First generation biodiesel are directly produced from the food crops, (Syed Hasnain Shah et al., 2018). The biodiesel is eventually derived from the sugar, animal fats, vegetable oil and starch that these crops provide. It is significant to take note that the production of the biodiesel itself will not be changed between generations, but the source from which the fuel is derived will be changes. The most commonly used first generation biodiesel feed stock are like corns, wheats, and sugar canes. Biodiesel production from the first generation feed stocks are easier as they were obtained by using simple pressing of oil-bearing biomass.

Second generation biodiesel are known as more advanced biodiesel, (Syed Hasnain Shah et al., 2018). The feedstock used in producing the second generation biodiesel is basically not food crops. All of the food crops exist can only act as the second generation biodiesel if they have already accomplished on their food purposes. Waste vegetable oil is a type of second generation biodiesel due to the condition that it has already been used and it cannot be used for human consumption anymore. The second generation feedstock is mostly extra in efficiency and more extra environmentally friendly. Animal fat methyl esters are one of the examples that have some advantages such as higher in octane numbers, non-corrosiveness, cleaner and renewable properties. They can get rid of the competition for food and feed.

Third generation biodiesel refers to biodiesel that is derived from algae, (Syed Hasnain Shah et al., 2018). Algae were not categorized as the second generation biodiesel. When it has become obvious that algae are further capable of higher yields with lower resources input than the other feed stocks, there are many suggestions that they need to be moved into another category. Algae also offer a lot of benefits. Microalgae are very eco-friendly, demand less area to grow, rich in oil contents. Microalgae do not require huge land area if compared to the growing food crops and similar products.

2.2 Raw Material preparation

Most of biodiesel production project begins with the findings and the pre-treatment for all of the raw materials. This is important to the biodiesel production processes because; ensuring the feedstock's quality so that it is always in the required values will make it easier for the production process. The quality of the feedstock brings major effects to the biodiesel yields at the end. So, it is important to always aware to the amount and properties of the raw materials that needs to be mixed in the mixtures based on the standards.

There are many types and kinds of materials that can be used in the production of biodiesel. For example, some of the raw materials used for this biodiesel production process are like the raw oil itself which is the crude Jatropha curcas oil, the alcohol that are needed to be mixed and react with the oil which is methanol (MeOH) and the catalyst that are used to enhance or changes some of the oil's properties during the reaction process of the mixtures which is the potassium hydroxide (KOH) as the alkali catalyst, sulphuric acid (H_2SO_4) as the acid catalyst and mussel shells/ calcium oxide (CaO) as the heterogeneous catalyst. There are many more raw materials that can be used but all of it is needed to be calculated and tested to know about their properties whether it is suitable for the biodiesel production.

2.2.1 Jatropha curcas oil

Jatropha curcas is basically a plant that comes from the genus Euphorbiaceous habitats located in the tropical of American but mostly spread in the tropical and in the subtropical regions from all through South East Asia, Africa and India. From the study of Amonrat Samniang et al., (2014), it is one of the tropical plants that can grow in low until high rainfall places either in farms or on the borders of fields. Jatropha oil has gained popularity as biodiesel feedstock because of the ease of planting at minimum cost.

The likelihood of non-edible oil like the Jatropha curcas oil is compared to all the edible oil feed stocks, (A.S. Silitonga et al., 2013). Jatropha curcas oil is a second generation feed stock has been capable to be the replacement to petrol or diesel regarding to the accessibility, maintainability and lower cost in the market.

The use of Jatropha curcas oil as a feedstock for the production of biodiesel is increasing in the nowadays, (Jar-Jin Lin et al., 2017). The produced oils by this crop can be simply changed to biodiesels that meet the American standard and European standard. It can also be produced in tropical countries in an environmentally and sustainable way.

Jatropha is among the best nominees for the future biodiesel production, (M. Mofijur et al., 2012). Any country that has enough area of land and good climatic condition which can help the development of Jatropha plants for being one of the main foundations of production of biodiesel. It is likely that biodiesel productions will grow up drastically in the following years because of the availability of mass biodiesel feed stocks like the palm oils and JCO.

Based on the study of Ignacio R. Huerga et al., (2014), the use of alternative technologies has also been explored in order to obtain biodiesel from Jatropha curcas oil, for example ultrasound assisted transesterification and supercritical methanol reactive extraction. The properties of different samples of biodiesel obtained by using dissimilar acids (H_2SO_4 and HCl) and alkaline catalysts (NaOH and KOH) have been compared. Kinetics of the transesterification of Jatropha curcas oil has also been studied.

2.2.2 Alcohol

The most frequently used alcohols are like the methanol, ethanol and propanol, (Urvi patel et al., 2013). The deactivation of the enzymes with alcohol has been predicted to be inversely proportional to the number of carbon atoms in the alcohol. This means, methanol is the most deactivating alcohol.

Methanol is one of the petroleum-based alcohols. The use of methanol has been proposed for production of biodiesel due to its low cost, broad availability and high reactivity in comparing with ethanol, which will minimises the reaction rate, (Zahira Yaakob et al., 2013). While in the other hand, ethanol has the benefits of being derived from renewable agricultural sources. It is more soluble in oil than methanol and can enhance the mass transfer during the reaction of transesterification. Biodiesel produced by using ethanol will have lower pour and cloud points than the biodiesel produced by using methanol which can increases the storage ability of the biodiesel. Transesterification reaction is a reversible reaction. Excess alcohol is needed in order to change the reaction towards the forward direction. The methanol-to-oil molar ratio is a sensitive factor that can affect the final biodiesel yield.

Normally, a molar ratio of 1:6 for oil to methanol was used for biodiesel production through transesterification process. Excess methanol will deactivate the catalyst performance, (M. Kirubakaran et al., 2018). In general, acid catalyzed processes need high reaction rate, high reaction temperature and greater alcohol and oil molar ratios.

2.2.3 Catalyst

Catalysts are well known as a substance or materials that are needed to be used as to enhance the reaction processes of a solution or change the properties of some mixtures. There are actually a lot of catalyst exists in the world. All of them come in different forms and sizes. Plus, their types and conditions are also different as well as its properties. The catalysts are divided into some types which are like the alkali or base catalysts, acid catalysts and the heterogeneous catalyst. Each of the catalyst used in the biodiesel production has their own important criteria and functions. Their amounts are properties are also needed to be calculated and be treated first before mixing it into the biodiesel solutions.

2.2.3.1 Alkali/ Base Catalyst

Alkali catalysts have been used by researchers (NaOH, KOH) for biodiesel production because they are low in cost and are readily available, (Amin Talebian-

Kiakalaieh et al., 2013). However, there are some limitations occurs in this process such as high energy consumptions which will be causing the raise in the equipments cost and safety issues. This process is very sensitive if exposed to the water and free fatty acid (FFA) contents in the feed stocks. Greater water contents may transform the reaction into saponification, which will be causing decrease of ester yield, difficult separation of glycerol from methyl ester, increment in viscosity, and the formation of emulsion all of and will cause many problems to occur in the downstream purification and the methyl ester recovery.

The potassium hydroxide (KOH) and sodium hydroxide (NaOH) are most commonly used catalysts which have high sensitivity to the purity of the reaction being affected by the water and free fatty acids content, (Carlos Daniel Mandolesi de Araújo et al., 2013). The presence of water will be causing the ester saponification under the alkaline conditions. The free fatty acids might also respond to the alkaline catalysts that produce soaps and water. Saponification is not only use up the catalyst, but will also be causing formation of emulsions that will spoil the purification and separation of biodiesel. NaOH or KOH as base catalysts can be recommended for the process due to its better reactions in comparison with an acid catalysed transesterification, (Jilu Lizy Stephen et al., 2018).

2.2.3.2 Acid Catalyst

It was believed that solid acid catalysts have the strongest potential for the replacement of liquid acid catalysts. By the research of Man Kee Lam et al., (2012), solid acid catalyst have some advantages like they are not so sensitive to free fatty acids content, esterification process and transesterification process will occur simultaneously, remove the washing process of biodiesel, easy separation of the catalyst from medium, lower product contamination level, easy recycling of catalyst and lessen the corrosion problem.