UNIVERSITI TEKNIKAL MALAYSIA MELAKA

MICROWAVE ASSISTED TRANSESTERIFICATION OF JATROPHA OIL OVER WASTE COCKLES CATALYST OF BIODIESEL PRODUCTION

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

by

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2018

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

Tajuk: Microwave Assisted Transesterification of Jatropha Oil over Waste Cockles Catalyst of Biodiesel Production

Sesi Pengajian: 2019

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Date:

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) with Honours. The member of the supervisory is as follow:

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ABSTRAK

Kajian ini menyiasat pengeluaran biodiesel melalui tindak balas proses transesterifikasi dengan menggunakan kaedah radiasi gelombang mikro. Minyak jatropha (JCO) digunakan sebagai bahan mentah biodiesel kerana sumbernya sebagai minyak tidak boleh dimakan dan mudah diperolehi tanpa merosakkan sumber pengeluaran makanan. Minyak jatropha mempunyai kandungan asid lemak bebas (FFA) yang tinggi, oleh itu ia perlu menjalani proses pengesteran asid sebelum proses tranesterifikasi menggunakan kaedah radiasi gelombang mikro. Sementara itu, sisa kulit kerang yang dibersihkan disediakan melalui proses penyambungan dalam relau pada 900 ° C dengan kadar pemanasan 10 ° C/min selama 4 jam untuk menukar kalsium karbonat, CaCO3 menjadi kalsium oksida, CaO. Tujuan pemangkin digunakan untuk menaikkan tindak balas transesterifikasi dan hasil biodiesel. Seterusnya, kehadiran metanol dalam reaksi untuk pecahan emulsi lebih cepat membentuk biodiesel dan gliserol. Radiasi gelombang mikro dilakukan pada output kuasa 400 W dan masa reaksi 7 minit. Keputusan menunjukkan bahawa hasil optimum yang dihasilkan ialah 83.6 % dan nilai asid 0.56 berlaku pada 9:1 nisbah methanol keatas minyak dengan kepekatan pemangkin sebanyak 5 wt %. Oleh itu, penyinaran gelombang mikro boleh digunakan sebagai sumber tenaga kerana keupayaannya dan efisien dalam mempercepatkan proses transesterifikasi.

ABSTRACT

This study investigate the production of biodiesel through a reaction of transesterification process by using microwave irradiation method. The jatropha oil (JCO) is used as the biodiesel feedstock due to its source as the non-edible oil and easy to obtain without undermining the food production. The jatropha oil have high content of free fatty acid (FFA), thus it need to undergo an acid esterification process before proceed with transesterification process via microwave irradiation. Meanwhile, the waste cockles is prepared through a calcination process in a furnace at 900°C with a heating rate of 5 °C/min for 4 hours to convert calcium carbonate, $CaCO_3$ into calcium oxide, CaO. The purpose of catalyst is used to raise the transesterification reaction and biodiesel yield. Next, the presence of methanol in the reaction to breakdown the emulsion faster to form of biodiesel and glycerol. The microwave irradiation are carried out at 400 W power output and 7 minute reaction time. The results shows that that the maximum yield produced occur at 9:1 methanol to oil molar ratio with 5 wt % catalyst concentration which is 83.6% and acid value after transesterification process of 0.56. Thus, microwave irradiation could be employed as energy source due to its ability and efficient in accelerating the transesterification process according to the ASTM D6751 and EN 14214.

DEDICATION

Dedicated to all my family, thank you for your love.

ACKNOWLEDGEMENTS

Alhamdulillah, praised to Almighty Allah for the guts and strength given to me in completing this report. Without His Guidance, I would not be able to complete this report. Apart from that, I want to thank my beloved family for their support whether it is financially or morally. I also would like to express my gratitude to Mdm. Mahanum Mohd Zamberi as my supervisor who's helping me in stimulating suggestions and information in completing this report. A million thanks to my fellow course-mate who are always encouraging each other and sharing their knowledge with me. Lastly, I would like to thank the authority of Universiti Teknikal Malaysia Melaka (UTeM) for providing me with a good environment and facilities to complete half of this project, especially Faculty of Engineering Technology (FTK) which giving me the opportunity to use the materials, apparatus and instrument provided in the laboratory.

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LIST OF ABBREVIATIONS

JCO	: Jatropha Oil
FFA	: Free Fatty Acid
°C	: Degree Celsius
ASTM	: American Society of Testing and Materials
AV	: Acid Value
KOH	: Potassium Hydroxide
NaOH	: Sodium Hydroxide
rpm	: Rotation per Minute
CaO	: Calcium Oxide
wt%	: Weight Percentage
TAG	: Triacylglyceride
DAG	: Diglycerides
MAG	: Monoglycerides
mins	: Minutes
h	: hour
MeOH	: Methanol

CHAPTER 1

INTRODUCTION

1.1 Background

Biodiesel is considered as one of the next step of other alternating fuel as any type of plant was used to be its oil or fuel based. Other terms also indicates that biodiesel as a renewable fuel that manufactured from methanol and vegetable oil, animal fats, and recycled cooking fats. Biodiesel also generalized as a liquid biofuel obtained by chemical processes from vegetable oils or animal fats and an alcohol that can be used in diesel engines, alone or blended with diesel oil. In this case, the benefits of biodiesel that can contributes to the enhancement of fuel energy is the biodiesel itself that can produce from renewable, domestic resources. Other than that, it is also an energy efficient and can be used directly in most diesel engine applications.

According to C.L.Yuan et.al, 2014, the primary focal points of biodiesel are inexhaustibility, low fumes gas discharges, and biodegradability. Past examinations have illustrated that, when biodiesel is utilized as an elective fuel in diesel motors, it can lessen discharges of hydrocarbons (HC), carbon monoxide (CO), sulphur oxide (SO2), molecule matter (PM), polycyclic fragrant hydrocarbons (PAH), and polychlorinated dibenzo-pdioxin also, dibenzofuran (PCDD/F).

ASTM International (initially known as the American Society for Testing and Materials) characterizes biodiesel as a blend of long-chain monoalkylic esters from unsaturated fats got from sustainable assets to be utilized as a part of diesel motors. Mixes with diesel fuel are shown as "Bx", where "x" is the level of biodiesel in the mix. For example, "B5" shows a mix with 5% biodiesel and 95% diesel fuel; in outcome, B100 indicating pure biodiesel. In addition, the properties of 100% of pure biodiesel must follow the specified standards given by the American Society of Testing and Material (ASTM) International D6751.

The production of biodiesel fuel from natural and renewable sources, either it is edible or non-edible oil is crucial. The biofuels that derived from these type of oil can be a realistic substitute for petroleum-based fuels. The usage of edible oil such as sunflower seed, soybean and animal fats are not suitable as it requires high cost in productions and competition in food industry was high due to the severity of food crisis (Y.Yan et.al, 2014). Ullah et.al, 2015, indicates that in the biodiesel production almost 70-95% of total cost depending on the raw material used either it is edible oil or non-edible oil. Thus, to reduce the production cost of biodiesel, the usage of non-edible oil is suitable due to the availability of the source itself.

Increasing in biodiesel yields proving the good grade of biodiesel oil. Main things that considered in the biodiesel production were the reaction temperature, reaction time, catalyst amount and molar ratio as their important parameters. Thus, comparing with others method catalytic reactions, alkali-catalysed transesterification gives an optimum results as it can produce at low temperature despite having a requirement of high temperature and longer reaction time (C.L.Yuan et.al, 2014).

In producing biodiesel, a transesterification process must be done as the process itself explains the reactions enhance from a lipid with an alcohol to form esters and by product, glycerol (Gashaw et.al, 2014). In general, biodiesel was generated from the vegetable oils or animal fats. Thus, from this process the chemical reactions converts the esters indicating vegetable oils or animal fats into a mixture of esters of the fatty acids that makes up the oil (or fat). Biodiesel is obtained from the purification of the mixture of fatty acid methyl esters (FAME). A catalyst is used to accelerate the reaction and type of catalyst used can be vary. In this experiment, waste cockles was used as the main catalyst.

The aim of this research is to investigate the performance of the biodiesel after going through transesterification process by using a waste cockles as a heterogeneous catalyst and heating process through microwave irradiation.

1.2 Problem Statement

1. Due to the costing of biodiesel compared to the conventional diesel oil which is expensive, a proper method of preparation was developed by using available sources from the waste to be used as a raw material.
2. The biodiesel production preparations depends on the usage of the edible/virgin oil as a raw material.
3. The usage of material catalyst as the reinforcement in the oil reducing the cost of using acidic type of catalyst.

1.3 Objective

1. To prepare and characterize waste cockles as a heterogeneous catalyst.
2. To prepare a biodiesel from Jatropha Oil through transesterification process via microwave assisted.
3. To analyse the parameter effect of biodiesel properties.
4. To measure the fuel characteristics and properties based on the ASTM D6751.

1.4 Scope

1. The pre-treatment of Jatropha Oil that came from non-edible oil as a feedstock for biodiesel production.
2. To convert a calcium carbonate, CaCO3, cockles to heterogeneous calcium oxide, CaO via calcination process in catalyst preparation.
3. To determine the effect of catalyst weight percentage, methanol concentration and microwave power on biodiesel yield.
4. To ensure that the biodiesel production meet its standard ASTM D6751 and EN14214.

CHAPTER 2

LITERATURE REVIEW

2.1 Biodiesel Background

Biodiesel is a substitute for an added substance to diesel fuel that is generated from the oils and fats of plants, similar to sunflower, canola or jatropha. It is an elective fuel that can be utilized as a part of diesel motors and gives control like customary diesel fuel. Biodiesel is a renewable locally created fluid fuel that can help in lessen the nation's reliance on remote oil imports. In 1991, the European Community, (EC) proposed a 90% assessment decrease for the utilization of biofuels, including biodiesel (The Global Authority of Non-Food Biodiesel Crops, 2013).

Biodiesel is defined as mono-alkyl esters of long chain fatty acids derived from vegetable oils or animal fats and alcohol with or without a catalyst (A.E.Atabani et.al, 2012). The term of "bio" explains on a nature-based and renewable source derivation. Meanwhile, the word "diesel" refers to the usage in the diesel engine. For short, biodiesel is a renewable fuel based on vegetable oil.

For the preparation of biodiesel feedstock production by using jatropha oil, there are several type that need to be done as for the preparations. Type of material used for the process, type of catalyst and clear definitions about every part of catalyst, the enhancing alcohol, a proper method of producing biodiesel and variable or parameters needed in the biodiesel production were the listed preparation for biodiesel production.

These days, a higher demand in petroleum fuel keep increasing as the accommodation usage in Malaysia is getting higher. Based on Z. Yaakob et.al, 2013, the traditional fossil diesel fuel may have an identical properties with biodiesel that can be a substitutes for diesel fuel. With the advancement of biodiesel fuel production, it will help in reducing the petroleum dependency as the main accommodation fuel and help in preserving the petroleum itself as well as reducing the expenses needed for the oil. The grade of this biodiesel usage was referred as *B100* in which one hundred is referred as the percentage required for the pure biodiesel content produce and appeared to be in a clear liquid with a light yellow to dark colour form.

Mainly, the idea of generating biodiesel from different type of feedstock were used based on the past researchers ideas. Currently, the production of biodiesel came from the edible oil type of feedstock through a transesterification process which almost 95% of the edible oil usage can create food problems in developing countries (J. Nisar et.al, 2017). Thus, the use of non-edible oil such as jatropha oil may be a good choice as it provide commercially good alternative oil compared to edible oil.

According to A.E. Atabani et.al, 2012, explains that the emergence of biodiesel usage as an energy sources brings other countries such as United States of America, Brazil, Malaysia, Germany, France and other European countries to the production of biodiesel. Table 2.1 shows the list of top 10 countries producing biodiesel in the world.

Table 2.1: Top 10 Countries with Biodiesel Potential (A.E. Atabani et.al, 2012).

Rank	Country	Biodiesel Potential	Production
1	Malaysia	14,540	0.53
2	Indonesia	7595	0.49
3	Argentina	5255	0.62
4	USA	3212	0.70
5	Brazil	2567	0.62
6	Netherlands	2496	0.75
7	Germany	2024	0.79
8	Philippines	1234	0.53
9	Belgium	1213	0.78
10	Spain	1073	1.71

2.1.1 Sources of Biodiesel

The production of biodiesel came from the various type of raw material which is algae oils, animal fats, vegetable oils and microbial oil sources as it is also gives different composition and purity based on different material (Indu Ambat et.al, 2018). In this part, the selection on feedstock for biodiesel production is crucial according to their availability and type of source by determining the cost, yield, composition, and purity of the produced biodiesel. Referring to the author, Indu Ambat et.al, 2018, an analyzation upon the selected raw material was summarize based on numerous parameter such as oil content, suitability, chemical composition and physical properties. Table 2.2 summarize the different raw oil material for biodiesel production.