SUPERVISOR DECLARATION

"I hereby declare that I have read this thesis and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Thermal-Fluid)"

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Date : 27/ JUNE /2016

BIODIESEL PRODUCTION USING WASTE COOKING OIL THROUGH THE MICROWAVE IRRADIATION AND CONVENTIONAL METHOD USING COCKLE AS CATALYST

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DECLARATION

"I hereby declare that the work in this report is my own except for summaries and quotations which have been duly acknowledged."

Signature : ....

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Date : 27 / June / 2016

DEDICATION

Dedicated to all my family:

Thank you for all your love

May Allah bless us.

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Bismillahirrahmanirrahim

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ABSTRACT

This study investigates the production of biodiesel through a reaction of transesterification process using two different method which are microwave (MW) irradiation method and conventional method. The waste cooking oil (WCO) is used as a biodiesel feedstock due to have low content of free fatty acid (FFA) meanwhile cockle catalyst is prepared through calcination process at 900^0C for 4 hours and obtained 93.98% of 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 MW irradiation are carried out at 300W power output and 5 minit reaction time while for conventional method are conducted at temperature 65^0C for 2 hours reaction time. The result shows that the highest yield of biodiesel between MW irradiation for 5 mins reaction time and conventional method for 2 hours reaction time are 83.76% and 80.2%. Therefore, MW irradiation could be employed as energy source due to its ability and efficient in accelerating the transesterification process.

ABSTRAK

Dalam kajian ini menyiasat cara pengeluaran biodiesel melalui tindak balas proses transesterifikasi menggunakan dua kaedah yang berbeza iaitu kaedah radiasi microwave MW dan kaedah konvensional. Sisa minyak masak (WCO) digunakan sebagai bahan mentah biodiesel itu kerana mempunyai kandungan rendah asid lemak bebas (FFA) pemangkin manakala cengkerang (kerang) disediakan melalui proses kalsinasi pada suhu 900^0C selama 4 jam dan memperoleh 93.98% kandungan CaO, tujuan pemangkin adalah digunakan untuk meningkatkan tindak balas transesterification dan hasil biodiesel. Seterusnya, kehadiran metanol dalam tindak balas untuk memutuskan emulsi lebih cepat untuk membentuk biodiesel dan lemak. Radiasi MW dijalankan pada 300W kuasa pengeluaran dan 5 minit masa tindak balas manakala bagi kaedah konvensional dijalankan pada suhu 65^0C masa 2 jam masa tindak balas. Hasil daripada kajian ini mendapati bahawa hasil yang paling tinggi biodiesel antara MW penyinaran untuk masa 5 minit tindak balas dan kaedah konvensional untuk 2 jam masa tindak balas adalah 83.76% dan 80.2%. Oleh itu, MW penyinaran boleh digunakan sebagai sumber tenaga kerana kemampuannya dan kecekapannya dalam mempercepatkan proses transesterifikasi itu untuk menghasilkan biodiesel.

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LIST OF ABREAVIATIONS

WCO	: Waste cooking oil
FFA	: Free Fatty Acid
°C	: Degree celcius
Hz	: Hertz
W	: Watt
ASTM	: American Society of Testing and Materials
AV	: Acid value
Kg	: kilo gram
g	: gram
ml	: mili litre
KOH	: Potassium Hydroxide
NaOH	: Sodium hydroxide
rpm	: rotation per minutes
ρ	: density
m	: mass
v	: volume
L	: Litre
FYP	: Final year project
CaO	: Calcium Oxide
$CaCO_3$	: Calcium carbonate
O_2	: Oxygen
CO_2	: Carbon dioxide
MW	: Microwave
SEM	: scanning electron microscopy
XRD	: X-ray diffraction
XRF	: X-ray fluorescence
CH_3OH	: Methanol
MEOH	: Methanol
ETOH	: Ethanol
Mole	: molacular

wt% : weight percentage

% : percentage

mg : mili gram

FAME : fatty acid methyl ester

FAEE : fatty acid ethyl ester

PAHs : polycyclic aromatic hydrocarbons

HC : hydrocarbons

NOx : nitrogen oxide

max : maximum

min : minimum

Vol. : volume

mm^2 : mili meter square

mm : mili meter

TAG : triacylglyceride

DAG : diglycerides

MAG : monoglycerides

mins : minutes

h : hour

CH_3ONa : sodium methoxide

HCl : hydrochloric acid

H_2SO_4 : sulphuric acid

$NaOCH_3$: Alkaline methoxide

$RS(=O)_2$-OH : Sulfonic acid

NaOMe : sodium methoxide

WFO : waste frying oil

RSO : rubber seed oil

UTeM : Universiti Teknikal Malaysia Melaka

TeO_2 : tellurium dioxide

Na_2O : sodium oxide

SrO : strontium oxide

MgO : magnesium oxide

SO_3 : sulphur trioxide

SiO_2 : sillicon dioxide

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

In recent years, study focuses on alternative to traditional petroleum-derived fuel has been increased due to environmental concern and sustainability issue. Therefore, many researches has been directed to explore and study the plant-based fuels, plants oils and fats as they have promising future as fuels. Now, one of the best available resources that have come to forefront is biodiesel. Besides, biodiesel fuel is eco-friendly alternative fuel compared to fossil fuel because of non-toxic, renewable, biodegradable, and aromatic free that can reduce impact of greenhouse gases (Ullah et al. 2015) ‘and’ (Gupta et al. 2015).

Biodiesel fuel or in scientific name fatty acid methyl ester FAME is one of biofuel types derived from biomass or waste matter. It generates excess oxygen O_2 that leads to complete combustion hence reduces the emission. Since the major contributor of total gas emissions comes from the transport sector, the advantage of biodiesel could be a key solution to reduce the air pollution in urban area. Estimated that using each kg pure biodiesel blended with fossil fuel could reduce 3.2 kg of carbon dioxide CO_2 production compared to the fully using of fossil fuel. In fact, there is little or no modification requirement in compression to ignitions diesel engine (Mahesh et al. 2015).

Biodiesel can be made through the transesterification reaction using novel techniques such as supercritical, ultrasonic and microwave (Gupta et al. 2015) or also using conventional method. The production of biodiesel comes from reaction of vegetable oil or animal fat with alcohol such as methanol MEOH or ethanol ETOH in the presence of acid or alkali catalyst (Sirisomboonchai et al. 2015). In addition, the properties of 100 percent pure biodiesel must comply the specific standards given by the American Society of Testing and Material (ASTM) international D6751.

An alternative diesel fuel are made from natural and renewable sources, either edible oil or non-edible oil. The use of edible oil such as soybean, sunflower, cottonseed, rapeseed and animal fat to make biodiesel are not suitable in terms of competition with food materials as they can be high cost production. Biodiesel should be low cost as raw material and can be obtained easily around us. Total cost of biodiesel fuel production depends much on the raw material cost which is about 70-95% of total cost. Hence, non-edible oil such as waste cooking oil (WCO) is chosen as a feedstock for biodiesel is an effective way to reduce the production cost because it is available at a reasonable price or even free and it also help the disposal problem (Ullah et al. 2015).

Catalyst usually is used to raise the reaction rate and yield in the transesterification reaction for biodiesel production where it can be homogeneous or heterogeneous. Homogeneous catalyst are in liquid form such as sodium hydroxide NaOH and potassium hydroxide KOH are widely used in biodiesel production due to good catalytic activity and the easiest method. However, they are difficult in term of separation process. This increases the production cost for the purification process due to a lot of wastewater generated and unrestored catalyst (Gupta et al. 2015). Hence, heterogeneous base catalyst is used because of its green process which are non-corrosive, recyclable, simple catalyst separation and less energy consumption. Commonly heterogeneous base catalyst are in solid form used is calcium oxide CaO catalyst that can be prepared from natural sources such as waste egg shell, waste animal bone and waste seashell (Gupta et al. 2015). Waste seashell commonly can be found at the beach coastal areas at east side of Peninsular Malaysia and also Sabah and Sarawak. Utilization of waste seashell as raw materials for catalyst helps to solve the environment problems and reduces cost for biodiesel production. Those waste seashell consist of calcium carbonate $CaCO_3$ can be converted into calcium oxide CaO through calcination process and it can be recycled and used as catalyst (Lee et al. 2015).

The main aim of this study is to use an alternative catalyst which is green, low cost and reusable. The catalyst is derived from waste seashell and is used to convert effectively a waste cooking oil WCO with the present of methanol to produce biodiesel using microwave process.

1.2 Problem Statement

Currently, the biodiesel cost is much expensive compare to the conventional diesel oil. This might be happen because most of biodiesel production depends on the usage of edible oil or virgin oil as raw material. Therefore, the available solution to reduce the cost is by using a low cost of feedstock such as waste cooking oil (WCO). The feedstock cost is almost 70-95% of the overall production of biodiesel. In contrast, the biodiesel production cost is stepped down by 60-70% when waste cooking oil is used (Gupta et al. 2015). Thus, it makes the biodiesel a promising low cost feedstock. Additionally, natural catalyst is used due to recyclability and easy to earn in beach areas (Mahesh et al. 2015).

1.3 Objective

The objectives of this study are as follows:

1. To identify the properties of waste cooking oil WCO.
2. To prepare and characterize cockle as a heterogeneous catalyst.
3. To prepare high quality biodiesel from waste cooking oil (WCO) through transesterification process via mivrowave and conventional method.
4. To measure the fuel characteristics and properties based on the ASTM D6751 and EN14214 european standard method

1.4 Scope of Study

The scopes of this study are as follows:

1. To pre-treatment a waste cooking oil WCO which is palm oil as a feedstock in-term of density, saponification value, kinematic viscosity, acid value, water content and iodine value
2. To converts a calcium carbonate $CaCO_3$ cockle to heterogeneous calcium oxide CaO via calcination process as a catalyst preparation.
3. To characterize the calcined heterogeneous catalyst using SEM, XRD and XRF.
4. To conduct transesterification process through the microwave irradiation technique and conventional method for a quality biodiesel production.
5. To study the affected variable parameter involve such as reaction temperature and catalyst concentration in both method.
6. To prepare biodiesel property that comply the specific standards given by the American Society of Testing and Material ASTM and EN14214 european standard method which are acid value, free fatty acid, density and flash point.

CHAPTER 2

LITERATURE REVIEW

In this chapter, the summarization from previous researchers related to biodiesel study is presented. The theory of biodiesel as well as the background of the significance and the effect on transesterification process to produce biodiesel will also be explained in this chapter.

2.1 Biodiesel Background

Energy has becomes one of the important factors for humanity to maintain high standard of living and continues the economic growth. Recently, the petroleum-based fuels are one form of energy that is crucial. This source is limited and it is in the verge of getting extinct. Rudolf Diesel's prime model ran on its own power for the first time in Germany in 1893 on biodiesel (Pacific Biodiesel 2012). The peanut oil as fuel is used in diesel engine and it found that the fuel can become useful in the future (Pacific Biodiesel 2012).

The term “bio” in biodiesel represents a nature-based and renewable source derivation; while the “diesel” refers to the usage in the diesel engine. In short, biodiesel is a renewable fuel based on vegetable oil. The name was given by National Soy Diesel Development Board, now known as National Biodiesel Board. Biodiesel is defined as the mono-alkyl esters of long chain of fatty acids synthesized from vegetable oils or animal fats using an alcohol with the presence or without a catalyst (Atabani et al. 2012).

Biodiesel appeared to be a clear liquid with a light yellow to dark yellow colour. A pure biodiesel consist of 100% biodiesel fuel. It is referred to B100 or sometimes called “neat” fuel. Next, the mixture of petro diesel and pure biodiesel is known as biodiesel blend. Biodiesel blends are referred to Bxx. The xx here indicates amount of biodiesel blend. As an example, for a B20 blend, it consists of 20% biodiesel and 80% petro diesel fraction. The interesting part of biodiesel is it can be used directly in the diesel engine with little or no modification to the engine (Demirbas 2009). Other than that, it has almost identical properties to those traditional fossil diesel fuel and thus may substitutes diesel fuel (Yaakob et al. 2013).

There are lots of available sources of biodiesel that is already being processed and used around the world such as corn, palm, soybean, sunflower, rapeseed and others. However, these pure vegetable oils feedstock cost is relatively high that makes cost to be expensive. Therefore, the use of cheap inedible vegetable or non-edible oil can be a way to overcome and improve the production of biodiesel.

Today's, biodiesel have been used in many countries such as United States of America, Brazil, Malaysia, Germany, France and other European countries (Atabani et al. 2012). **Table 2.1** shows the list of top 10 countries producing biodiesel in the world.

Table 2.1 Top 10 countries with biodiesel potential (Atabani et al. 2012).

Rank	**Country**	**Biodiesel potential (ML)**	**Production ($/L)**
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