UNIVERSITI TEKNIKAL MALAYSIA MELAKA

MICROWAVE TRANSESTERIFICATION OF WASTE COOKING OIL (WCO) USING WASTE COCKLES

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

by

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I hereby, declared this report entitled Microwave Transesterification of Waste Cooking Oil (WCO) Using Waste Cocklesis 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 UniversitiTeknikal 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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ABSTRAK

Kajian ini menyiasat pengeluaran biodiesel melalui reaksi proses transesterifikasi menggunakan kaedahpenyinaran gelombang mikro (MW). Minyak masak sisa (WCO) digunakan sebagai bahan mentah biodiesel kerana mempunyai kandungan asid lemak bebas (FFA) yang rendah manakala pemangkin dari kulit kerang disediakan melalui proses kalsinasi pada suhu 900℃ selama 4 jam dan memperoleh 93.98% 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. Penyinaran MW dijalankan pada output kuasa 100,200 dan 300W dan masa reaksi 3,5,7 minit berbanding konvensional memerlukan lebih banyak masa reaksi. Hasilnya menunjukkan bahawa hasil biodiesel tertinggi antara penyinaran MW untuk masa tindak balas 3 minit dan output kuasa pada 200 W ialah 84.578%. Oleh itu, penyinaran MW boleh digunakan sebagai sumber tenaga kerana keupayaannya dan efisien dalam mempercepatkan proses transesterifikasi.

ABSTRACT

This study investigates the production of biodiesel through a reaction of transesterification process using a microwave (MW) irradiation 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 $900^{0}C$ for 4 hours and obtained 93.98% of CaO.The purpose of catalyst is used to speed up 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 is carried out at 100,200,300W power output and 3, 5, 7 minutes reaction time compared to conventional requires more reaction time. The result shows that the highest yield of biodiesel obtain at 3 minutes reaction time and 200 watt power output is 84.578%. Therefore, MW irradiation could be employed as energy source due to its ability and efficient in accelerating the transesterification process.

DEDICATION

To my beloved parents

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m	**Mass**
v	**Volume**
L	**Litre**
g	**gram**
kg	**Kilogram**
N	**Normality of standard alkali**

LIST OF ABBREVIATIONS

WCO	Waste cooking oil
FFA	Free fatty acid
ASTM	American Society of Testing and Materials
Hz	Hertz
AV	Acid Value
KOH	Potassium Hydroxide
NaOH	Sodium Hydroxide
CaO	Calcium Oxide
H_2O	Water
rpm	Rotation per minutes
XRF	X-ray fluorescence
CH_3OH	Methanol
%wt	Weight percentage
FAME	Fatty Acid Methyl Ester
TAG	Triacylglyceride
DAG	Diglyceride
MAG	Monoglycerides
H_2SO_4	Sulphuric acid
CO_2	Carbon dioxide
$CaCO_3$	Calcium carbonate
PAH	Polycyclic aromatic hydrocarbons

CHAPTER 1

INTRODUCTION

1.1 Background

In recent years, study focuses on alternative to traditional petroleum-derived fuel have 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 bio fuel types derived from biomass or waste matter. It generates excess oxygen O_2 that leads to complete combustion hence reduce 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 or ethanol in the presence of acid or alkali catalyst (Sirisomboonchai et al. 2015). In addition, the properties of 100 percent pure biodiesel must according to the specific standards given by the American Society of Testing and Material (ASTM) international D6751.

An alternative diesel fuel is 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 their green processes 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 cockles 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 cockles and is used to convert effectively waste cooking oil WCO with the present of methanol to produce biodiesel using microwave process.

1.2 Objectives

The objectives of this study are as follows:

1. To identify the properties of waste cooking oil WCO based on ASTM D6751 Standard.
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 microwave.

1.3 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).

1.4 Scope of Study

1. To pre-treatment a waste cooking oil WCO which is palm oil as a feedstock in-term of density, kinematic viscosity, and acid value.
2. To converts a calcium carbonate $CaCO_3$ cockle to heterogeneous calcium oxide CaO via calcination process as a catalyst preparation.
3. To conduct transesterification process through the microwave irradiation technique for a quality biodiesel production.

CHAPTER 2

LITERATURE REVIEW

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 the percentage of the diesel and petrol for example 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 substitute's 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: The list of 10 countries producing biodiesel in world (Atabani et.al. 2012)

Rank	Country	Biodiesel potential (ML)	Production
1	Malaysia	14540	0.53
2	Indonesia	7595	0.49
3	Argentina	5255	0.62
4	USA	3212	0.70

5	Brazil	2567	0.62
6	Netherland	2496	0.75
7	Germany	2024	0.79
8	Philippine	1234	0.53
9	Belgium	1213	0.78
10	Spain	1073	171

2.2 Source of biodiesel feedstock

Nowadays, there are more than 350 oil-bearing potential crops can be used for biodiesel production. This is the significant factor of producing biodiesel because there are many choices of feedstock that can be selected to produce biodiesel. Table 2.2 shows the various type of biodiesel feedstock.

Table 2.2: Type of Biodiesel Feedstock

Edible oil	**Non–edible oil**
Soybean	Jatrophacurcas
Canola oil	Croton mangolopus
Sunflower seed	Waste cooking oil

The biodiesel feedstock can also be classified into first, second and third generation (Nur Syazwani et al. 2015). The first generation feedstock refers to the edible oils. It is because the soybeans, coconut, palm oil, rapeseed, peanut and sunflower are the first crops that have been used to produce biodiesel. Next, the inedible oils such as animal fats, waste oils and grease are considered as the second generation feedstock. Meanwhile, the third generation of biodiesel feedstock that have been emerged was the microalgae.

The edible oils have become major contributor to more than 95% to world biodiesel production. However, the food versus fuel competition problem has risen when the food source or edible oils is used for biodiesel production. The edible vegetable oil is more preferable for food purposes rather than fuel because it can cause hunger and starvation especially for the developing countries (Lam et al. 2010). Furthermore, in order to produce more edible oils crops, many unnecessary land clearing need to do for plantation purpose to fulfil the demand for biodiesel production (Yaakob et al. 2013). Therefore, it will cause unbalance in animal and plant ecosystems.

Among of these sources, the non-edible oils are getting world attention to be exploited. The resources are easily available in many region of the world such as wastelands that are not suitable for food crops. Therefore, the cultivation cost for inedible oils is lower compared to the edible oils. Apart from that, the uses of this type of feedstock can eliminate the need to dispose them. According to (Banković-Ilić et al. 2012), oils from inedible oils contain no nutrition and fatal to human consumption due to the presence of toxic compound. Therefore, synthesis biodiesel from inedible oils can be a good advantage.

In addition, the third generation which is microalgae also have potential to be the biodiesel feedstock source in the future. It is a fast growing photosynthetic microorganism that converts sunlight, water and carbon dioxide CO_2 to algal biomass but they do it more efficiently than conventional crop plants (Atabani et al. 2012). This is because it can grow in bioreactor or farm. Furthermore, they are easier to harvest or cultivate compared to conventional crop plants.