UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BIODIESEL PRODUCTION FROM WASTE COOKING OIL (WCO) USING POTASSIUM HYDROXIDE ALKALINE CATALYST

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A thesis submitted
in fulfillment of the requirements for the degree of
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DECLARATION

I declare that this Choose an item. entitled " Biodiesel Production from Waste Cooking Oil (WCO) Using Potassium Hydroxide Alkaline Catalyst" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ISMAIL

Name : *TUAN ISMAIL BIN TUAN ZAKARIA*

Date : 18/1/2022

APPROVAL

I hereby declare that I have checked this thesis and, in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Mechanical Engineering Technology (Maintenance Technology) with Honours.

Signature : .....

Supervisor Name : *MAHANUM BINTI MOHD ZAMBERI*

Date : 18/1/2022

DEDICATION

From the bottom of my heart a gratitude to my beloved parents, Encik Tuan Zakaria bin Tuan Abdullah and Puan Maizatul Akma binti Abd. Ghani, for her encouragements and who have been the pillar of strength in all my endeavors. My utmost appreciation goes to my main supervisor, Puan Mahanum binti Mohd Zamberi, for all her support, advice and inspiration. Her constant patience for guiding and providing priceless insights will forever be remembered. My eternal love also to all my siblings, Tuan Nurul Husna binti Tuan Zakaria, Tuan Yusuf bin Tuan Zakaria and Tuan Nur Syuhada binti Tuan Zakaria for their endless support, love and prayers. Also, to my teammates, Muhammad Ariff bin Noor Salleh, Anis binti Mohamad Taib, Aizuddin Husaini bin Baharen and Nik Muhammad Amin bin Nik Amran constantly supported my journey and for all the help and support I received from them. Despite the entire memories of bittersweet research and studies, the memory that we endure together remains in our minds forever.

ABSTRACT

Oil prices have risen due to increased energy demand and the depletion of petroleum supplies throughout the world. Petroleum reserves depletion is an issue inherent with this form of fossil energy. Biodiesel is an alternative energy source that has the potential to be developed. The production of biodiesel from cheap and unwanted sources which is waste cooking oil (WCO). Methanol is frequently utilised in the preparing of biodiesel production due to its low cost, availability and easily acquire. Normally, the reaction that requires to produce biodiesel was strong base catalyst such as potassium hydroxide that can form methyl esters. The reaction that mentioned above is called transesterification. Transesterification has been found to be dependent on characteristics including the effect of alcohol, catalyst, reaction time, reaction temperature and alcohol molar ratio. A few steps that require to produces the biodiesel which is buy the raw feedstock oil that is waste cooking oil. After that, determination of acid value for raw waste cooking oil, prepare the solution of potassium hydroxide for the titration process. Next, base catalysed transesterification is done by heat the mix solvent of catalyst and waste cooking oil. After 24 hours, washing the oil in separation funnel using distilled water to remove impurities, including unfiltered particulates, methanol, and glycerine. Drying process is the next step to evaporate the residual water in the product. After all the process are done, find the acid value, density and flash point of biodiesel product. The best molar ratio to oil was 15:1 with 1.5% of potassium hydroxide (KOH), which is value of the percentage of yield is 81.50%, value of acid value is 0.3366, value of FFA is 0.1683%, value of density is 845.03 kg/m^3 and value of flash point is at 182 °C. All the variables involved such as molar ratio of methanol to oil, catalyst concentration, reaction time, reaction temperature and stirring effect will be emphasis in order to obtain high production yield according to ASTM D6571 and EN 14214 standards.

ABSTRAK

Harga minyak yang semakin meningkat disebabkan oleh permintaan tenaga yang tinggi dan kekurangan bekalan petroleum di seluruh dunia. Pengurangan bekalan minyak dalam bentuk tenaga fosil ini adalah satu masalah yang timbul ketika ini. Biodiesel adalah salah satu sumber tenaga alternatif yang berpotensi untuk dikembangkan. Penghasilan biodiesel dari sumber yang murah dan tidak lagi terpakai dengan menggunakan minyak masak terpakai. Metanol sering kali digunakan didalam penyediaan pengeluaran biodiesel kerana kosnya yang rendah dan mudah diperoleh. Kebiasaannya, tindak balas yang diperlukan untuk menghasilkan biodiesel adalah kalium hidroksida yang boleh membentuk metil ester. Tindak balas yang dinyatakan di atas dipanggil transesterifikasi. Transesterifikasi didapati bergantung kepada beberapa ciri termasuk kesan alkohol, mangkin, tindak balas masa, tindak balas suhu, dan nisbah molar alkohol. Beberapa langkah yang diperlukan untuk menghasilkan biodiesel iaitu dengan membeli minyak mentah tersisa seperti minyak masak terpakai. Selepas itu, tentukan nilai asid minyak masak terpakai dan sediakan larutan kalium hidroksida untuk proses pentitratan. Seterusnya, proses transesterifikasi dilakukan dengan memanaskan pelarut campuran mangkin dan minyak masak terpakai. Selepas 24 jam, basuh minyak di dalam corong pemisah menggunakan air suling untuk membuang kekotoran, termasuk zarah yang tidak ditapis, metanol dan gliserin. Proses pengeringan adalah langkah seterusnya untuk menyejat sisa air yang masih ada di dalam produk. Selepas semua proses selesai, cari nilai asid, ketumpatan dan takat kilat produk biodiesel. Nisbah molar terbaik kepada minyak ialah 15:1 dengan 1.5% kalium hidroksida (KOH), iaitu nilai peratusan hasil ialah 81.50%, nilai asid ialah 0.3366, nilai FFA ialah 0.1683%, nilai ketumpatan ialah 845.03 kg/m3 dan nilai takat kilat ialah pada 182 °C. Beberapa pembolehubah yang akan terlibat dalam penghasilan biodiesel ini seperti nisbah molar metanol bersama minyak, kepekatan pemangkin, tindak balas masa, tindak balas suhu dan kesan kepada pengacauan akan diberi penekanan untuk menghasilkan pengeluaran biodiesel yang terbaik mengikut piawaian ASTM D6571 dan EN 14214.

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Last but not least, from the bottom of my heart a gratitude to my beloved parents, YM Tuan Zakaria bin Tuan Abdullah and Puan Maizatul Akma binti Abd. Ghani, for her encouragements and who have been the pillar of strength in all my endeavors. My eternal love also to all my siblings, Tuan Nurul Husna binti Tuan Zakaria, Tuan Yusuf bin Tuan Zakaria and Tuan Nur Syuhada binti Tuan Zakaria for their endless support, love and prayers. Finally, thank you to all the individual(s) who had provided me the assistance, support and inspiration to embark on my study.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

ASTM	-	American Society for Testing and Materials
EN	-	European Standard
WCO	-	Waste Cooking Oil
KOH	-	Potassium Hydroxide
IUPAC	-	The International Union of Pure and Applied Chemistry
FFA	-	Free Fatty Acid
H_2SO_4	-	Sulfuric Acid
HCI	-	Hydrochloric Acid
ml	-	Millilitre
GCMS	-	Gas Chromatography-Mass Spectrometry
OH^-	-	Hydroxide
FAME	-	Fatty Acid Methyl Ester
CO_2	-	Carbon Dioxide
SO_2	-	Sulphur Dioxide
CO	-	Carbon Monoxide
SDG	-	Sustainable Development Goals
SFA	-	Saturated Fatty Acid
MUFA	-	Monounsaturated Fatty Acid
PUFA	-	Polyunsaturated Fatty Acid
USFA	-	Unsaturated Fatty Acid
FP	-	Flash Point
UNCT	-	United Nation Resident Coordinator
RC	-	Resident Coordinator
ρ	-	Density

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

Due to the high price of petroleum product, decreasing non-renewable fuel sources reserves, and air pollution produced by petroleum-based fuels, other energy sources were explored. Biodiesel, created from a renewable indigenous resource, hence alleviating dependency on imported petroleum fuel, is a new answer to the rapidly expanding energy issue. Biodiesel fuels also release lower quantities of carbon monoxide, particulate matter and unburned hydrocarbons than diesel petroleum (Park et al., 2019).

In other circumstances, several countries have struggle to represent the commitments for biofuel programs and biodiesel productions. Malaysian authorities have issued around 34 industrial permits for biodiesel production to date. However, only around one-fifth of them indicated that they were constantly active. In 2018, global biodiesel output totalled 32.3 billion litres, with Malaysia accounting for approximately 3% of the total. Despite the fact that the installed capacity represents 9% of worldwide output, the majority of these biorefineries have been operating at or near capacity due to a lack of demand for local consumption. As a result, Malaysia's capacity increase has been halted since 2008 (Farid et al., 2020).

Biodiesel is a liquid alternative fuel for diesel engines that is produced chemically by waste cooking oil (WCO) reacting with an alcohol such as methanol. It is used in diesel engines to replace fuel. Methanol is frequently utilised in the preparing of biodiesel production due to its low cost, availability and easily obtained. The reaction that requires to

produce the biodiesel is a strong base catalyst such as potassium hydroxide (KOH) that can form a new chemical compounds that is call methyl esters (Vedha Lakshmi et al., 2019).

The reaction described above is called transesterification, and it produces two products that is glycerine & esters. During the transesterification reaction, the alcohol reacts with the triglyceride component of WCO in the presence of potassium hydroxide (KOH). Methanol is frequently used because of its higher efficiency. Transesterification has been found to be dependent on a number of characteristics, including the effect of alcohol, catalyst, reaction time, reaction temperature, and alcohol molar ratio (Saini, 2017). The physical and chemical properties of the feedstock oil are mostly dictated for the best values of biodiesel.

In terms of exhaust emissions, cetane number, lubricity qualities, exhaustible resources are deficiency due to conventional and greenhouse gas pollutant emissions, biodiesel has advantages over fossil diesel fuel, yet there is no substantial difference in the heat of combustion between biodiesel and fossil diesel fuel. Additionally, biodiesel generates around 90% more energy than it consumes (Sarno & Iuliano, 2019). Biodiesel that blended with standard diesel in certain quantities can be utilized to power any current conventional compression ignition engine without necessitating engine modification. Biodiesel is becoming increasingly popular all over the world due to its renewable nature, low cost, and potential for greenhouse gas emission reductions.

The results point out that recycling WCO into biodiesel that fulfils with the international fuel standard ASTM D6751 and EN 14214 is practicable that can use in engine (Degfie et al., 2019). WCO biodiesel could be used as a diesel fuel since it was deemed renewable energy and an environmentally friendly recycling process. Due to all these reasons, the goal of this study is to develop a more rigorous understanding on cheap,

effective and green biodiesel production and at the same time aiming to fulfil the Sustainable Development Goals (SDG).

The Sustainable Development Goals (SDG), also known as the Global Goals, were adopted by all United Nations Member States in 2015 as a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity by 2030. The 17 SDGs are integrated - that is, they recognize that action in one area will affect outcomes in others, and that development must balance social, economic and environmental sustainability. Through the pledge to Leave No One Behind, countries have committed to fast-track progress for those furthest behind first. That is why the SDGs are designed to bring the world to several life-changing zeroes.

The mandate of the United Nations in Malaysia is to help the country in its vision of achieving developed nation status via the 2030 Agenda, which charts a development path that balances economic growth with social inclusion and environmental sustainability, based on solid institutional foundations, conditions for peaceful societies and the realization of human rights. In Malaysia, the United Nations Country Team (UNCT) comprises 21 agencies, led by the UN Resident Coordinator (RC), to deliver greater impact together on the 2030 Agenda and SDGs in line with national priorities, plans and needs

1.2 Problem Statement

Every year, the population is increasing in this world, the technology and advancing industry, people seem to be more concerned about a better standard of living, physical health and living conditions. Moreover, industrial development especially in advancing industry and manufacturing industry that require high energy consumption and contributes to environmental pollution. This project is focusing on how to prepare a good and quality biodiesel to overcome this problem.

WCO is a vegetable oil that has been applied in the preparation and cooking of food and it cannot be used for others food production because of the health concern. Waste cooking oil is collected and derived from a variety of sources such as household, commercial and industrial. Waste cooking oil is a possibly hazardous waste stream when waste cooking oil is discarded irresponsibly so it is must be managed properly. A biodiesel fuel can be produced from any type of material that contains fatty acids, even if they are connective to other molecules or exist as free fatty acids.

Consumers dispose of discarded cooking oil in sinks, garbage cans, drainage systems, and toilets, as well as directly into neighbouring rivers and wetlands. Additionally, around 50,000 tonnes of WCO derived from vegetable oils and/or animal fats are reported to be thrown into the environment in Malaysia each year without being appropriately processed (Kabir et al., 2014). In the long run, this act adds to water and soil contamination, disrupts aquatic life, causes sewage system clogs and overflows, raises the expense of water treatment and waste management, and has a negative influence on the overall environmental system.

It is claimed that biodiesel can contribute significantly less to global warming than fossil fuels because the carbon in the oil comes mainly from carbon dioxide in the air. When diesel engines run on biodiesel instead of petroleum-based diesel fuel, they release less carbon monoxide (CO), nitrogen oxides (NOx), hydrocarbons, less particles of particulate matter and sulphur oxides in the air that can reduce pollution and slow down global warming. Transesterification of palm oils with an alcohol that is methanol and catalyst that is potassium hydroxide that use to develop the biodiesel production, which is remark as a desirable alternative fuel.

Due to this issue, production and preparation of biodiesel from WCO seems is the right choice to overcome some of the drawbacks. Except for the low cost associated with

their quantity and availability, using waste cooking oil as a biodiesel feedstock can contribute to the conversion of WCO, which is one of the many products consumed, into a profitable product. The production of biodiesel will be calibrated to meet the ASTM D6751 and EN 14214 standards.

1.3 Research Objective

The main purpose of this research is to produce the best of biodiesel that fulfils with the international biodiesel standard. Specifically, the objectives are as follows:

a) To study the biodiesel production by using alkali catalyst which is potassium hydroxide.

b) To produce the biodiesel by using current existing lab-scale and the important parameter such as catalyst loading, ratio of methanol and oil, reaction of time and reaction temperature.

c) To perform the biodiesel quality testing according to international standards that is ASTM D6751 and EN 14214.

1.4 Scope of Research

The scope of this research are as follows:

- To study the current existing procedure and the method in producing the biodiesel using waste cooking oil (WCO).
- Identifying all the variables involved in the experiment such as molar ratio of methanol to oil, catalyst concentration, reaction time and reaction temperature.
- Perform physical and chemical testing to check the properties of raw feedstock according to ASTM D6751 and EN 14214.
- To check the quality and purity of the produced biodiesel so that it can be use in the real diesel engine.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Biodiesel is a type of diesel fuel made from animal or vegetable fats. The main components of vegetable oil are triglyceride also known as fatty acid ester and change to glycerol. The biodiesel is boundless used as fuel in part of to eliminate greenhouse gas emissions such as carbon monoxide (CO), nitrogen oxides (NOx) and hydrocarbons. Waste cooking oil (WCO) is vegetable oil used in food processing, but no longer appropriate for its original function. Different sorts of waste cooking oil can be obtained from a variety of sources including domestic that is household and from both commercial and industrial sectors. Waste cooking oil is a probably hazardous source of waste that requires thoughtful management because it can be a problem when the improper disposal of waste cooking oil happen.

The most widely used procedure for producing biodiesel is transesterification of oils with short chain alcohols or esterification of fatty acids, as biodiesel can be used directly or in blends with diesel fuel in diesel engines. To make biodiesel possible, many technical limitations must be overcome. The high cost of virgin vegetable oil as a source of triglycerides is critical for process of production. To keep the production in low costs and make it competitive with oil diesel, a low cost feedstock such as waste cooking oil can be used as raw material (Mofijur et al., 2021).

The method applied, the procedure used, the raw feedstock of oil, the type of alcohol, catalyst, stirring effect, reaction time, and the reaction temperature were all factors to consider in this study. This research helped in the development of a more complete

understanding of the tasks and offered general insight into how to contribute to the successful completion of the current project.

An Ishikawa diagrams shows the causes of an event and is frequently used in manufacturing and product development to illustrate the steps in a process, identify potential quality control concerns, and determine which resources are necessary at important points. Figure 2.1 below shows the step and process of biodiesel production.