TRANSESTERIFICATION OF USED FRYING OIL AND OPTIMIZATION FOR BIODIESEL PRODUCTION

FADRAH HANIM BINTI AD SUHADAK

A thesis is submitted in fulfillment

of the requirements for the award of the degree of

Bachelor of Mechanical Engineering (Thermal-Fluid) (Honours)

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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)"

Signature : .....
Supervisor : MD ISA BIN ALI
Date : .....

DECLARATION

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

Signature : .....
Author : FADRAH HANIM BINTI AD SUHADAK
Date : .....

Dedicated to

My beloved parent Ad. Suhadak bin Nordin and Haslinda Hanim binti Jalil and family members for being supportive and always there through my thick and thin.

Alhamdulillah.

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ABSTRACT

Used Frying Oil (UFO) has significant potential as the raw material or starting substance for biodiesel production. As known to public the amount of petroleum is decreasing each day. Therefore, there are many research is being conducted to introduce a new alternative fuel to be used in diesel engine. The objective of this research is to compare the characteristics and performance of sodium hydroxide (NaOH) and potassium hydroxide (KOH) used for alkaline-catalyzed transesterification. The variables selected to be optimized are concentration of catalyst, reaction of time and temperature in transesterification. The respond variables to be determined are the performance of yields and density of biodiesel from UFO as the starting. Moreover, this research studies on the effect of variables and type of catalyst on transesterification process. The transesterification process is conducted on a mixing stirrer, to give out consistency of temperature and stir towards the mixture of UFO, catalyst and methanol. The density of biodiesel produced will be measures using a S.G bottle. Moreover, design of experiment is determine by Taguchi's Method to optimize the yield product and density of biodiesel. On top of that, the optimum value of KOH catalyst is at 0.63 wt.% concentration of catalyst, 60 ℃ reaction temperature and at 20 min reaction time produces yield production of 97.1648 g and 0.8755 g/cm^3. Meanwhile for NaOH, the optimum value is at 0.45 wt.% concentration of catalyst, 60 ℃ reaction temperature and 30 min reaction time generates yield production of 95.6810 g and density of 0.8720 g/cm^3. Thus, it shows that KOH is the better catalyst compared to NaOH in biodiesel production.

ABSTRAK

Minyak Masak Terpakai (MMT) mempunyai potensi sebagai bahan mentah dalam penghasilan biodiesel. Objektif kajian adalah untuk membandingkan sifat dan prestasi pemangkin natrium hidroksida (NaOH) dan kalium hidroksida (KOH) yang digunakan dalam proses transeseterifikasi katalis-alkali. Sebagaimana diketahui umum, jumlah kandungan petroleum makin berkurang dari semasa ke semasa. Pelbagai kajian dilaksanakan untuk memperkenalkan minyak alternatif untuk digunakan dalam enjin diesel. Pemboleh ubah yang akan dioptimumkan adalah kepekatan katalis, suhu dan jangka masa reaksi. Pemboleh ubah bergerak balas adalah jumlah hasil dan ketumpatan biodiesel yang dihasilkan. Kajian ini turut merangkumi kesan pemboleh ubah dan katalis terhadap proses transesterifikasi. Ketumpatan biodiesel akan diukur menggunakan radas S.G. botol. Reka bentuk kajian akan dijalankan berdasarkan kaedah Taguchi untuk menghasilkan kadar hasil dan ketumpatan yang optimum. KOH mempunyai nilai optimum pada kepekatan pemangkin 0.63 wt.%, suhu reaksi yang bernilai 60℃ dan jangka masa reaksi selama 20 minit yang berjaya menghasilkan biodiesel sebanyak 97.1648 g dan ketumpuatan 0.8755 g/cm^3. Manakala, NaOH mempunyai nilai optimum pada kepekatan pemangkin 0.45 wt.%, suhu reaksi yang bernilai 60℃ dan jangka masa reaksi selama 30 minit yang berjaya menghasilkan biodiesel sebanyak 95.6810 g dan ketumpuatan 0.8720 g/cm^3. Hasil kajian menunjukkan KOH adalah katalis terbaik jika dibandingkan dengan NaOH daripada segi penghasilan biodiesel.

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ANOVA	=	Analysis of Variance
CH_3 ONa	=	Sodium Methoxide
CO	=	Carbon Monoxide
CO_2	=	Carbon Dioxide
DOE	=	Design of Experiment
FFA	=	Free Fatty Acid
Fp	=	Flash Point
H_2S	=	Hydrogen Sulfide
HC	=	Hydrocarbon
HG	=	Heat Gross of Combustion
k	=	Number of factors
KOH	=	Potassium Hydroxide
L	=	Number of Level
LCD	=	Liquid Crystal Display
LTB	=	Larger the Better
N	=	Least Number of Experiment
NaOH	=	Sodium Hydroxide

NO_x	=	Nitrogen Oxides
NTB	=	Nominal the Better
OA	=	Orthogonal Array
O&G	=	Oil and Gas
P	=	Parameter
PM	=	Particulate Matter
S.G	=	Specific Gravity
SNR	=	Signal to Noise Ratio
STB	=	Smaller the Better
TE	=	Trial and Error
UFO	=	Used Frying Oil
USD	=	United States Dollar
USDA	=	United States Department of Agriculture
VO	=	Vegetable Oil

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CHAPTER 1

INTRODUCTION

1.1. Background Study

Biodiesel fuel is defined as long chain fatty acid methyl or ethyl esters produced by the transesterification of vegetable oils or animal fats used as frying oils. Biodiesel is derived from vegetable oil or animal fats via transesterification with alcohol such as methanol and ethanol. It is also recommended to be used as a substitute of petroleum. It is due to biodiesel characteristics of an oxygenated, renewable, biodegradable and an environmental friendly biofuel with similar flow and combustion properties and also low emission profile. Moreover, with introduction of biodiesel it has help in reducing global warming gas emission like carbon dioxide, sulfur and carbon monoxide.

The benefits of biodiesel have garnered attention of many countries to conduct research and development in biodiesel industry. Unfortunately, the feedstock contains a tremendous amount of free fatty acids (FFA). The FFA is reacted with alkaline catalyst to produce soap, soap can exhibit the separation of methyl ester and glycerol and produce formation of emulsion during the washing procedure is conducted.

Optimization is selected to produce the highest rate of transesterification based on the several factors such as, catalyst concentration, reaction time and reaction temperature of transesterification. It is used to cut down time and cost production of biodiesel as optimal point is determine for further research or production of large scale biodiesel.

1.2. Objectives

The objectives of this study are to conduct test on used frying oil (UFO), in order producing an alternatives biodiesel to be used in automotive industries. The test is conduct in laboratory scales using transesterification process to reduce the viscosity of the UFO. However, the transesterification process will be optimized to achieve the following objectives:

i. Compare the characteristic and performance of two commonly used catalyst used for alkaline– catalyzed transesterification.
ii. Optimize the variables that influence the transesterification. The variables involved will be reaction time, concentration of catalyst and reaction temperature

1.3. Problem Statement

Vegetable oil is being used extensively in food industry as frying oil. Mostly, the UFO will be discharged to pipe or thrown away without proper way of managing the UFO. This situation has lead to many environmental problems. For example, fat, oil and grease cause major problems to drains. When they are disposed down through the kitchen sinks or drains they cause blockages; when they enter rainwater pipes they cause pollution in streams and rivers.

Instead of throwing away the UFO, it can be transform to engine fuel. However, since the UFO contains higher viscosity compared to normal engine fuel, transesterification process is used to lower the viscosity indirectly producing biodiesel. Biodiesel is made from vegetable oil or animal fats through transesterification process, is recommended to be used as a substitute fuel for petroleum based diesel mainly because biodiesel comes from a renewable source, has a characteristics of biodegradable and environmentally friendly fuel, with an alike flow properties, combustion properties and low emission profile (Lotero E. et al., 2004). Indirectly, it helps to reduces global warming gas emissions such as carbon dioxide. Moreover, when biodiesel has no aromatics characteristics, it will reduce the

harmful carbon monoxide and hydrocarbon emission in the exhaust gas compared to petroleum based diesel fuels (Peterson & Hustrulid, 1998).

Moreover, biodiesel can be used as an alternative fuel in transportation industry. All of natural sources such as petrochemical sources, coal and natural gas, are finite and at current usage rates will be consumed in the future (Meher et al, 2006). The depletion of world petroleum reserves and increased environmental concerns has gather recent interest in alternative sources for petroleum based fuels (Fukuda et al, 2001).

On top of that, the effect on type of catalyst, concentration of catalyst, reaction time and reaction temperature towards the performance of transesterification process is study. The performance of transesterification process refering to yield production of biodiesel. The density of optimum combination of variables to produce the highest and lowest amount of yield production is analyse whether it is in the standards of EN 14214:2003, MS 2008: 2008 and EN 590:1999 (Petroleum Diesel).

1.4. Scope of Study

Based on problem statement, this report will approach through the following scope:

1. The process variables that influence the transesterification of triglycerides such as catalyst concentration, reaction time and reaction temperature will be investigated and optimised.
2. Types of catalyst to be used are potassium hydroxide (KOH) and sodium hydroxide (NaOH).

1.5. Importance of Study

The importance of this study is to optimize the important variables and to compare the characteristic and performance of two commonly used catalyst used for alkaline –catalyzed transesterification process. With the important variables such as concentration of catalyst, reaction time and reaction temperature, being optimized only then, a high quality of biodiesel can be produce.

The high energy demand in the industrialized world and domestic sector, had caused pollution problems due to the widespread use of fossil fuels make it increasingly necessary to develop the renewable energy sources of smaller environmental impact than the fossil fuels such diesel fuels. The alternative fuel must be feasible, competitive in terms of economic, acceptable to the environment and readily available, and biodiesel fulfilled those properties. Moreover, biodiesel also has characteristics of biodegradability, non-toxic and contains low emission profiles as compare to diesel fuel.