EVALUATION OF FUEL PROPERTIES BEHAVIOUR OF BIODIESEL FROM DIFFERENT OIL STOCK

AMIR FARHAN BIN KAMALDEEN

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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AMIR FARHAN BIN KAMALDEEN

A report submitted
in fulfilment of the requirements for the degree of
Bachelor of Mechanical Engineering (Thermal-Fluid)

Faculty of Mechanical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2017

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DECLARATION

I declare that this project report entitled "Evaluation of fuel properties behaviour of biodiesel from different oil stock" is the result of my own work excepts as cited in the references.

Signature :…….

Name : AMIR FARHAN BIN KAMALDEEN

Date :…….

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APPROVAL

I hereby declare that I have read this project report 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 :…….

Name : DR. MD ISA BIN ALI

Date :…….

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DEDICATION

To my beloved father and mother.

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ABSTRACT

Biodiesel is an alternative to the petroleum diesel that is getting much attention from the consumers currently. There is a variety of sources in forms of vegetable oil and animal fats that can be used to produce biodiesel. Many types of vegetable oil and animal fats that have been used to produced biodiesel from previous studies. The sources of biodiesel produced from previous studies are based on the availability of the sources locally and researches on the particular sources. Since there are many sources can be used to produce biodiesel, the properties of the biodiesel produced can be different. Many studies and tests have been conducted in order to determine the properties of biodiesel from different sources and to know whether the biodiesel is suitable to be used by the consumers and commercialization purpose. In this project, the biodiesel is produced from three types of vegetable oil that is coconut oil, corn oil, and olive oil that are available locally. Several tests are then conducted to determine the properties of the biodiesel produced such as density, flash point, and viscosity. The results from tests and experiments conducted show that the density of coconut oil and corn oil biodiesel have the same value while density of olive oil biodiesel is slightly lower. Flash point of coconut oil biodiesel is the highest among the three biodiesels while corn oil and olive oil biodiesel show only a slight difference between them with corn oil biodiesel has the higher value of flash point. The viscosity of coconut oil biodiesel is slightly higher than corn oil biodiesel, while olive oil biodiesel has the lowest viscosity.

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ABSTRAK

Biodiesel merupakan alternatif kepada penggunaan diesel petroleum. Penggunaan biodiesel semakin mendapat tempat dalam kalangan pengguna pada masa kini. Terdapat pelbagai sumber yang terdiri daripada minyak sayuran dan lemak haiwan yang boleh digunakan untuk menghasilkan biodiesel. Banyak minyak sayuran dan lemak haiwan yang telah digunakan untuk menghasilkan biodiesel dalam kajian yang telah dijalankan sebelum ini. Pemilihan sumber untuk menghasilkan biodiesel dalam kajian-kajian sebelum ini adalah berdasarkan keberadaan sesuatu sumber tersebut di sesuatu tempat itu sendiri. Disebabkan terdapat banyaknya sumber yang boleh digunakan untuk menghasilkan biodiesel, maka sifat-sifat biodiesel yang dihasilkan juga berbeza. Banyak kajian dan ujikaji yang telah dijalankan untuk menentukan sifat-sifat biodiesel dan juga untuk mengetahui sama ada biodiesel ini sesuai untuk digunakan oleh pengguna dan tujuan pengkomersilan. Dalam projek ini, biodiesel dihasilkan menggunakan tiga minyak sayuran yang berbeza iaitu minyak kelapa, minyak jagung, dan minyak zaitun yang boleh didapati di pasaran tempatan. Beberapa ujian kemudiannya dijalankan untuk menentukan sifat-sifat biodiesel yang dihasilkan seperti ketumpatan, takat kilat, dan kelikatan. Keputusan dari beberapa ujian dan eksperimen yang dijalankankan menunjukkan bahawa ketumpatan biodiesel minyak kelapa dan minyak jagung mempunyai nilai yang sama manakala ketumpatan biodiesel minyak zaitun adalah sedikit lebih rendah. Takat kilat biodiesel minyak kelapa adalah yang tertinggi antara tiga minyak tersebut, manakala minyak jagung dan biodiesel minyak zaitun menunjukkan hanya sedikit perbezaan antara mereka dengan biodiesel minyak jagung mempunyai nilai takat kilat yang lebih tinggi. Kelikatan biodiesel minyak kelapa adalah lebih tinggi sedikit daripada biodiesel minyak jagung, sementara biodiesel minyak zaitun mempunyai kelikatan terendah.

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ACKNOWLEDGEMENT

First and foremost, I would like to thank my Final Year Project supervisor Dr. Md Isa bin Ali for his guidance and support. I also would like to thank him for his contributions of time throughout this project. Without his guidance and dedication throughout the process, this final year project would have never been accomplished.

I also would like to send my gratitude to my family members who have been very lovely, supportive and encouraging. Special thanks to both of my parents who raised me with much love and for believing me in my life. Lastly, I am very thankful to my friends and anyone who have been involved in the process of finishing this project.

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LIST OF ABBEREVATIONS

ASTM	American Society for Testing and Materials Standard
EN	European Standard
NaOH	Sodium Hydroxide
KOH	Potassium Hydroxide
CP	Cloud Point
PP	Pour Point

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND STUDY

Biodiesel is mono-alkyl esters of long chain fatty acids derived from vegetable oils or animal fats. Biodiesel can be produced through a chemically reversible reaction called transesterification which has been widely used. In this reaction, vegetable oil or animal fat reacts with alcohol such as methanol in the presence of catalyst. The product of the reaction is a mixture of methyl esters and its by-product which is glycerol or glycerin. The properties of resulting biodiesel are quite similar to the petroleum diesel fuel.

There are varieties of oils that are edible and non-edible which can be used to produce biodiesel. However, most of the biodiesel that have been produced originated from edible oils such as palm oil, soybean oil, corn oil, and many more. However, since the price of edible vegetable oils are quite expensive, the less raw materials containing free fatty acids such as waste cooking oil and animal fats are preferred (Nakpong et al, 2009).

Since biodiesel can be produced from a variety of sources, the biodiesel produced also can have a wide range of fuel properties value and behaviour. Properties of biodiesel depends on the concentration of fatty acids and other chemical composition of its source. Therefore, the properties of biodiesel produced from different sources must be evaluated in order to commercialize it and convince the consumers that biodiesel is an alternative way to petroleum diesel.

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1.2 PROBLEM STATEMENT

In a world of increasingly advanced and high-tech, energy generation and consumption are also in high demand. Ever since the days of the Industrial Revolution, fossil fuels such as natural gas and petroleum is used to generate energy. As this source is a non-renewable energy, the world is now experiencing problems as the fossil fuel reserves are diminishing and thus causing fossil fuel prices higher. According to statistics, the world's fossil fuel reserves are expected to be exhausted by 2112 (Singh et al.,2012).

Burning of fossil fuel also causes a negative effect to the environment which is global warming. Burning of fossil fuel contributes to the emission of greenhouse gases that causes the Earth climate to increase. The most gases emission comes from transportation where fossil fuel is the source of energy. As a result of these problems, various alternatives are being explored to reduce the dependency on the use of fossil fuel and increase the dependency on green energy resources. One of the alternatives is to use biodiesel fuel. Biodiesel is a fuel that can be derived from natural oils such as vegetable oils and animal fats.

However, to produce biodiesel fuel, the sources should be identified based on the environmental conditions and the availability of the oil stocks. Since there are many sources can be used for biodiesel production, the properties of the biodiesel produced can also be different. The properties of the biodiesel produced must be determined and evaluated in order to identify whether it is suitable to be used in engine or for commercialization purpose.

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1.3 OBJECTIVES

Below are the main objectives which would be:

1. To produce biodiesel oil from different oil stocks.

2. To study and evaluate the fuel properties behaviour of biodiesel oil.

1.4 SCOPE OF PROJECT

Throughout this project, first of all, the suitable oil stocks to be used for biodiesel production must be identified. Since there are varieties of fuel properties for biodiesel, a few suitable parameters of the properties need to be identified for evaluation. After the identification of fuel properties of biodiesel, appropriate experiments and test methods for the evaluation of the properties must be determined. Next step is to conduct the experiment of biodiesel production process and fuel properties testing. Final step in this project is to compare and evaluate the properties of biodiesel from the chosen oil stock and write a final report.

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CHAPTER 2

LITERATURE REVIEW

2.1 OVERVIEW

The second chapter is referencing what could be used by the readers to understand the theory and detail about the scope of this project. This literature review will be focusing on the type of oil stocks, fuel properties, fuel sampling process, and analysis.

2.2 TYPE OF OIL STOCKS

Biodiesel can be produced by using vegetable oil or animal fats but commonly used for biodiesel production is vegetable oil. Vegetable oil is comprised of the five most common fatty acids which are palmitic, stearic, oleic, linoleic, and linolenic. The amount of these acids varies among the oil stocks and because their methyl esters have different properties, the biodiesel derived from these oils also show varying properties. Table 2.1 shows the properties of chosen vegetable oil which is coconut oil, olive oil, and corn oil.

Table 2.1: Several properties of chosen vegetable oils.

PROPERTIES	Coconut Oil	Olive Oil	Corn Oil
Density (kg/m3)	800	881.5	886
Flash Point (^oC)	100	182	108
Cloud Point (^oC)	0	7	N/A

(Source: Kostik et al, 2012)

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The cost of biodiesel production is largely determined by the cost of the oil stocks; therefore, less expensive oil stocks have been of interest for a considerable length of time (Knothe, 2013). In order to promote the use of biodiesel, various low priced vegetable oil must be explored and commercialized into biodiesel. In this project, there are three different oil stocks have been chosen. They are coconut oil, corn oil, and olive oil. The reason for the selection of the three oil stocks will be explained in the next section.

2.2.1 Coconut Oil

For decades, coconut has been preferred as the raw material for the production of soap and cosmetics. In term of edibility, coconut oil provides many health benefits as being anti-viral, anti-bacterial, anti-fungal, and many more (Bello et al, 2015). Coconut oil is created through a process similar to that used to create olive oil. The main difference is that coconut oil is derived from the meat of the coconut rather than the olive. Coconut oil can be produced through a variety of different processes where there is some that relying on pre-dried coconut and some other use raw coconut. Coconut oil will take the form of solid below 24^{o}C and takes on a creamy white appearance but will easily melt into a liquid form at higher temperatures.

Coconut oil is used in this project because it is one of the main crops and easily available in Malaysia. Coconut oil is also chosen as its price in the local market is cheaper as coconut tree is widely planted in the country. As for the people in the rural area, they also have easier access to coconut oil to produce biodiesel. According to the statistics in IndexMundi (2016), Malaysia is placed in 9th position of the largest production of coconut oil by country.

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Coconut oil contains high concentration of saturated fatty acids such as lauric, myristic, palmitic, caproic, caprylic, capric, arachidic, and stearic acid. The concentration of saturated fatty acid in coconut oil can be as high as 90%. Table 2.2 shows the concentration of saturated and unsaturated fatty acid in coconut oil.

Table 2.2: Concentration of fatty acids in coconut oil.

ACID	CARBON	Concentration (%)	Molar mass (g/mol)
Caproic	C6:0	0.04	116
Palmitic	C16:0	9.2	256
Caprylic	C8:0	7.0	144
Capric	C10:0	8.0	172
Lauric	C12:0	48.0	200
Myristic	C14:0	16.0	228
Arachidic	C20:0	0.25	312
Stearic	C18:0	2.0	284
Oleic	C18:1	8.8	282
Linoleic	C18:2	0.5	280

(Source: Kostik et al, 2012)

2.2.2 Corn Oil

Corn oil is one of the product of corn. Corn oil was first extracted in 1898 and initially meant for cooking purposes. It was first extracted by Benjamin and Theodore Hudnut by using machinery that they created themselves. It is initially called as mazoil. Corn oil contains triglyceride that can be broken down further into monounsaturated fatty acid, polyunsaturated fatty acid, and saturated fatty acid (Davis, 2016). Table 2.3 shows the concentration of fatty acid in corn oil.

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Table 2.3: Concentration of fatty acids in corn oil.

ACID	CARBON	%	g/mol
Caprylic	C8:0	4.0	144
Capric	C10:0	7.0	172
Myristic	C14:0	0.6	228
Palmitic	C16:0	10.0	256
Stearic	C18:0	3.5	284
Oleic	C18:1	26.8	282
Linoleic	C18:2	48.0	280

(Kostik et al, 2012)

Corn oil is very popular as cooking oil as it has a very high smoke temperature. High smoke temperature means that it will not smoke easily, allowing it to heated at higher temperature compared to other vegetable oils. Other than for cooking purposes, corn oil is also can be used in soaps and textiles manufacturing. Besides that, it also can be used in nitro-glycerine, paints, and insecticides. Recently, corn oil is also one of the preferable oil stock for the production of biodiesel.

Corn oil can be extracted from the germ of corn, which is the small germinating part that will grow into new maize plant. These germs are rich in nutrients and oils. There are various method to extract oil from the seed germs. However, the best oil in terms of health benefits is the cold pressed oil. Although crude corn oil contains almost 99% of triglycerides, it also contains other minor compounds such as free fatty acids, waxes, phospholipids, pigments, and odorous compounds. Therefore, these compounds should be removed from the crude oil through a refining process for it to be accepted (Davis, 2016).

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2.2.3 Olive Oil

Olive oil is the product of olive tree (*Olea europaea*). Olive tree has been cultivated for thousands of years. They are highly appreciated and commonly known for their taste and aroma. They also known for their healthy and nutritional properties (López-Cortés et al, 2013). Originally, scientists thought the primary benefit of olive oil was its monounsaturated fat. This is because, almost 75 percent of the fatty acids concentration in olive oil come from monounsaturated fat and only 15 percent of them is saturated fat. That is why blood cholesterol goes down when butter and high-fat meat are replaced with olive oil as the source of fat (Rubio, 2008). Table 2.4 shows fatty acid concentration of olive oil.

Table 2.4: Concentration of fatty acids in olive oil.

ACID	CARBON	%	g/mol
Palmitic	C16:0	11.6	256
Palmitoleic	C16:1	1.0	254
Stearic	C18:0	3.1	284
Oleic	C18:1	75.0	282
Linoleic	C18:2	7.8	280
Linolenic	C18:3	0.6	278
Arachidic	C20:0	0.3	312
Behenic	C22:0	0.1	340
Lignoceric	C24:0	0.5	368

(Kostik et al, 2012)

However, olive oil has become one of the vegetable oil that can be used to produced biodiesel other than its benefits as health and nutrition product. Many studies have been conducted to produce biodiesel from olive oil.

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2.3 BIODIESEL PRODUCTION

In order to produce biodiesel, those three oil stocks will undergo transesterification process. Transesterification process is the most common process used to convert triglycerides from vegetable oils to ester or biodiesel. Vegetables oil is made up of triglycerides that contains glycerine. The process of transesterification will convert the oil into esters, and thus separating out the glycerine and biodiesel as shown in Figure 2.1. When separated, the glycerine will sink to the bottom leaving the biodiesel on top.

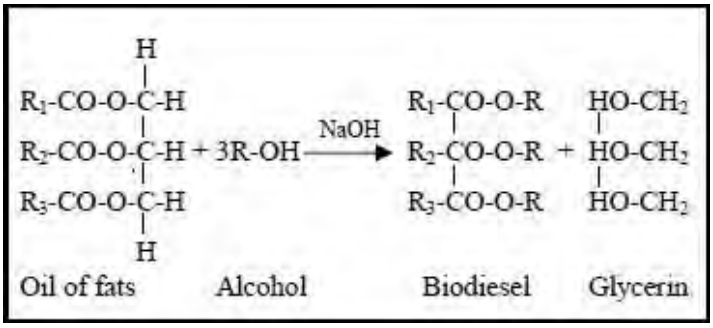

Figure 2.1**:** Reaction of transesterification.
(Source: Hossain et al, 2012)

The methodology or procedures for the transesterification process will be explained in other section. There are a few parameters need to be considered in transesterification process. They are molar ratio of alcohol to oil, type of alcohol used, type and amount of catalyst, reaction temperature, pressure and time.

2.3.1 Molar Ratio

Molar ratio of alcohol to oil is one of the main factor of biodiesel production. It can affect the conversion efficiency, yield of biodiesel and also the biodiesel production cost. The stoichiometric molar ratio of alcohol to oil for transesterification process is 3:1. Therefore, in order to increase the miscibility and to enhance the contact between alcohol

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molecule and triglyceride, higher molar ratio is required. Higher alcohol to oil molar ratio also give rise to greater alkyl ester conversion in shorter time.

Previous study by Balat et al (2008) shows that alcohol to oil molar ratio of 6:1 gives better yields of biodiesel compared to 4:1 and 5:1 as shown in Table 2.5. Musa (2016) noted that generally accepted molar ratio of alcohol to oil is 6:1 - 30:1. Therefore, in this project, molar ratio of alcohol to oil is to be 6:1 as it is the mostly applied molar ratio in the biodiesel production from vegetable oil.

Table 2.5: Effect of reaction time and methanol-to-oil molar ratio.

No.	**Reaction Time (min)**	**Percent Conversion at Molar Ratio**			**Percent Yield at Molar Ratio**		
		4:1	**5:1**	**6:1**	**4:1**	**5:1**	**6:1**
1	15	85	89	93	45	46	62
2	30	86	89	94	53	54	66
3	45	88	91	94	57	59	72
4	60	90	92	94	61	67	77
5	120	91	93	94	66	67	72
6	240	92	94	95	66	67	82
7	360	92	95	97	83	82	83

(Source: Balat et al, 2008)

Vegetable oils contain triglycerides that is a combination of glycerol and fatty acids. If 6:1 molar ratio of alcohol to oil is going to be used, 2 mol of alcohol must be allowed to react with each chain of triglycerides since there are three chains of glycerides. Each vegetable oil used in this project such as coconut oil, corn oil, and olive oil have different type of fatty acids. Molar mass of each fatty acid must be determined. Then, the concentration of each fatty acid must be divided with the molar mass of fatty acid. Result of the division must be multiplied with two since two mol of alcohol is needed for each chain of glyceride. The total of the multiplication shows the number of mol for alcohol needed.

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