OPTIMIZING BIODIESEL PRODUCTION FROM RUBBER SEED OIL USING CONVENTIONAL METHOD

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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)"

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STUDENT'S DECLARATION

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

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Dedicated to my beloved Father and Mother

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ABSTRACT

The rapid increase in the use of the world's crude oil reserve and diminishing of the natural source has accelerated the hunt for renewable energy. Biodiesel has proven to be able to provide energy as per the requirement of various sectors and will required in a large scale. This study focuses on the optimization of biodiesel production using rubber seed oil (RSO) via transesterification process which is proven to be the easiest and most productive method for biodiesel production in large scale with the aid of cockle as catalyst. The optimization of analytical procedures has been carried out by using Minitab software where the chosen multivariate statistic technique is Response Surface Methodology (RSM) in order to determine the optimum parameters values so that optimum yield can be achieved. The parameters involved are methanol to oil ratio, catalyst weight percentage, and reaction time. From the analysis done using Minitab software, the result obtained for optimum yield is 99.63 % by using parameter values of 18:1 methanol to oil ratio, 5 % catalyst weight percentage, and 2 hours reaction time. This study proves that production of biodiesel in a large scale is achievable and a step into a greener future where power generation solely depends on renewable sources.

ABSTRAK

Peningkatan pesat dalam penggunaan minyak mentah dunia yang diperolehi daripada sumber semula jadi yang semakin berkurangan telah mempercepatkan pemburuan untuk tenaga boleh diperbaharui. Biodiesel terbukti dapat membekalkan tenaga kepada pelbagai sektor dan akan diperlukan dalam skala yang besar. Kajian ini memberi tumpuan kepada pengoptimuman pengeluaran biodiesel menggunakan minyak daripada biji getah melalui proses transesterifikasi yang terbukti menjadi kaedah yang paling mudah dan paling produktif untuk pengeluaran biodiesel dalam skala besar dengan bantuan kulit kerang sebagai pemangkin. Analisis prosedur pengoptimuman telah dijalankan dengan menggunakan perisian Minitab di mana teknik statistik multivariat yang dipilih adalah kaedah 'Response Surface Methodology' (RSM) untuk menentukan nilai parameter optimum yang mampu menghasilkan isi padu biodiesel yang tinggi. Parameter-parameter yang terlibat adalah nisbah molar metanol terhadap minyak, peratusan berat pemangkin, dan masa tindak balas. Dari analisis yang dilakukan dengan menggunakan perisian Minitab, keputusan yang diperolehi untuk penghasilan biodiesel yang optimum adalah kadar penukaran sebanyak 99.63% dengan menggunakan nilai-nilai parameter, nisbah metanol terhadap minyak sebanyak 18:1, 5% berat pemangkin, dan masa tindak balas selama 2 jam. Kajian ini membuktikan bahawa pengeluaran biodiesel dalam skala yang besar boleh dicapai dan langkah ke masa depan yang lebih hijau di mana penjanaan kuasa hanya bergantung kepada sumber-sumber yang boleh diperbaharui.

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LIST OF SYMBOLS

^{O}C	=	degree Celsius
g	=	grams
ml	=	milliliter
N	=	Normality
cm	=	centimeter
ρ	=	density
mg	=	milligram
g/mol	=	gram per mol
m^2/s	=	meter squared per second
mm^2/s	=	millimeter squared per second
mgKOH/g	=	milligram KOH per gram
kg/L	=	kilogram per liter
g Iodine/100g	=	gram Iodine per 100 gram
%	=	percent
mm/s^2	=	millimeter per second squared

LIST OF ABBREVIATIONS

FAME	=	Fatty Acid Methyl Esters
TAG	=	Triacylglycerol
RSO	=	Rubber Seed Oil
CaO	=	Calcium Oxide
FFAs	=	Free Fatty Acids
wt.%	=	Weight Percentage
RSM	=	Response Surface Methodology
AV	=	Acid Value
GC	=	Gas Chromatography
N_2	=	Nitrogen
H_2	=	Hydrogen
He	=	Helium
KOH	=	Potassium Hydroxide
IV	=	Iodine Value
I_2	=	Iodine
cST	=	Centistokes
RCOOR’	=	Ester
H_2SO_4	=	Sulphuric Acid
ASTM	=	American Society and Testing and Material
DMAIC	=	Define, Measure, Analyze, Improve, and Control
DOE	=	Design of Application
CCD	=	Central Composite Design
ATM	=	Atmospheric

R-sq	=	Regression squared

CHAPTER 1

INTRODUCTION

1.1 PROJECT BACKGROUND

The rapid increase in the use of the world's crude oil reserve and diminishing of the natural source has accelerated the hunt for renewable energy. Renewable energy is energy source that use natural resources which have the potential to produce energy with minimum or zero emissions of both air pollutants and greenhouse gases. The predicted shortage of the crude oil encouraged the search for substitutes for petroleum derivatives which lead to an alternative fuel called "biodiesel". Biodiesel has proven to be able to provide energy as per the requirement of the sectors such as agriculture, transportation, commercial and industrial sectors of the economy (Shafiee and Topal. 2009).

Biodiesel consists of long chain of fatty acid methyl esters (FAME) which is obtained from renewable lipids such as those in vegetable oil. The major element of vegetable oil is triacylglycerol (TAG) and also known as triglycerides. Edible oils for example sunflower and corn oil are considered to be used for biodiesel production but the unstable prices of edible oils and high demands for alimentary needs caused research opted to non-edible oil as the raw material of choice (Yusup and Khan. 2010). Using vegetable oil as feedstock for the production of biodiesel causes a major worry over the struggle in the food supply for the future. So to avoid the issue, biodiesel production must be done using non-edible oil as raw material and not to mention the reduction of energy required during transesterification process by using catalyst. The non-edible vegetable oil used in this study is rubberseed oil (RSO)

The RSO has high free fatty acids (FFAs) content, which means that cockle based heterogeneous catalyst is desirable for usage. Heterogeneous base catalysts have pluses of being recycled, noncorrosive, have better tolerance to water and FFAs in feedstock, improve biodiesel yield and purity, a simpler purification process for glycerol and are easy to separate from the biodiesel product (Kawashima et al. 2008). The cockle is processed so the calcium oxide (CaO) can be extracted and used as catalyst. The use of biodiesel replacing the conventional diesel would slow the development of global warming by reducing the emissions of sulphur, hydrocarbon and carbon oxides. Because of economic benefits and more power output, biodiesel is often blended with diesel fuel in ratios of 2, 5 and 20% (Vasudevan and Briggs. 2008). In Malaysia B7 biodiesel was implemented where 7% of biodiesel is blended with 97% of pure diesel. The carbon dioxide emission can be minimized by increasing the ratio of biodiesel compared to diesel (Fukuda et al. 2001).

Optimizing is improvement on the performance of a system, a process, or a product so that the maximum value from the source can be obtained. The term optimization has been commonly used in analytical chemistry as a method of finding out circumstances at which to apply a practice that provides the best possible outcome (Bezerra et al. 2008). The optimization of analytical procedures has been carried out by using multivariate statistic technique which is response surface methodology (RSM). Response surface methodology is a collection of mathematical and statistical methods that depends on the fit of a polynomial equation to the experimental data, which must describe the behaviour of a data set with the objective of making statistical previsions. RSM can be well utilized when a response or a set of responses of interest are inclined by several variables.

Biodiesel production is gaining more and more relevance due to its environmental benefits and its ability to blend in with regular diesel and it is produced from renewable and its sustainability. In future, biodiesel will be one of the leading energy sources for all sectors of the industry.

1.2 PROBLEM STATEMENT

As the usage of innovation such as in diesel engine, power plant etc. grows rapidly, the demand for diesel has increased. The resource for diesel is from petroleum and it is not a renewable energy. The real problem lies on the production of the biodiesel where the yield of biodiesel achieved is low which results in the requirement of more raw materials which is rubber seed oil and more time. Biodiesel production models that have been designed previously vary a lot. So to obtain the optimum productivity of biodiesel, a standardized model with optimized process parameters is a minimum requirement so that raw material requirement and time consumption can be minimized. This study is done to optimize the biodiesel production process so that the yield can be increased. Moreover the existing biodiesel plant is complex, high in price and requires high work rate. Hence the small capacity biodiesel production is essential, so that the optimization process of biodiesel can be done effectively. Catalyst preparation is critical process parameters because catalyst plays an important role in biodiesel production where different catalyst preparation will result in different effects on biodiesel yield and alter the physical properties of the end product.

1.3 PROJECT OBJECTIVE

This report is obliged according to the title of the project which is Optimizing Biodiesel Production from Rubberseed Oil using conventional method. Before conducting the project study, objectives of this study have to be defined clearly and specifically. This is very essential in order to carry out this study successfully. The objectives of this study are:

1. To produce biodiesel from rubber seed oil using waste heterogeneous catalyst (cockle) and conventional method.
2. To statically evaluate and optimize the yield of the biodiesel production using Response Surface Method (RSM).
3. To study the feedstock characteristics such as FFAs and fatty acid composition that may influence the final properties of the biodiesel.

1.4 PROJECT SCOPE

The scope of the study is defined so that a specified study can be conducted and the study does not go off the track of the study. Scope also ensures that the study is parallel with the objective. The scope of this study is:

1. The raw material used to produce biodiesel is Rubber seed oil.
2. The biodiesel production involves only Acid Esterification and Base Catalysed Transesterification process.
3. Heating equipment used for Acid Esterification and Base Catalysed Transesterification process is Constant temperature electric heater with magnetic stirrer.
4. The type of base catalyst used in Base Catalysed Transesterification process is Cockle.

CHAPTER 2

LITERATURE REVIEW

2.1 RUBBER SEED OIL

Rubber seed is another source that nature has to offer where it can be obtained from rubber tree. From the rubber seeds, rubber seed oil can be extracted. Rubber seed doesn't involve in the latex manufacturing process and usually the rubber seed is not fully utilized even though the processed oil has the potential that can be utilized in various applications. In Malaysia, rubber plantation is vast hence it is an abundant source in our country. According to Association of Natural Rubber Producing Countries, it is estimated rubber seed production in Malaysia to be 1.2 million metric tons (Ng et al. 2013). The advantages of using rubber seed as the raw material to produce biodiesel is that the rubber seed is a poisonous seed and the oil produced is non-edible. This means that the usage of rubber seed for biodiesel production can be large and will no cause problem such as supply shortage unlike the edible oil. Besides that, by choosing rubber seed oil as the raw source for biodiesel production, there is no requirement for cultivation of new rubber plantation because there is large plantation existing in Asia and Africa due to the demand for latex production. At the same time, the production of biodiesel will help the farmers to be able to make extra income by collecting and selling the rubber seed which previously has less function.

2.2 BASIC CHEMICAL REACTIONS

Vegetable oils are esters. Esters which are called as triglycerides are composed of unsaturated and saturated monocarboxylic acids with the trihydric alcohol glyceride (Leung et al. 2010). With the presence of a catalyst these esters are able to act in response with alcohol. This process is called transesterification. The simplified form of its chemical reaction is presented in equation where R1, R2, R3 as shown in Figure 2.1 (at the end of section 2.2) are long-chain hydrocarbons, sometimes called fatty acid chains. A study revealed that rubber seed comprises of 38.9% oil. The oil contains 80.5% unsaturated fatty acids and 18.9% saturated fatty acids. The unsaturated fatty acids are mainly comprised of three acids which are Linoleic acid with a content of 39.6%, second is Oleic acid with content of 24.6% and finally Linolenic acid with 16.3% of content. As for saturated fatty the major acids are Palmitic acid with 10.2% of content and Stearic acid with a content of 8.7% (Ramadhas et al. 2005). During transesterification the triglyceride will breakdown gradually to diglyceride, and then to monoglyceride, and finally to glycerol where at each breakdown step 1 mol of fatty ester is released (Hanna and Ma. 1999). The preferable alcohol for producing biodiesel is methanol due to its low cost. Vegetable oils may contain small amounts of water and FFAs. The FFAs can react with alcohol to form ester which is the biodiesel by a reaction called acid-catalysed esterification which very useful for handling oils with high FFAs. For an alkali-catalysed transesterification, the alkali catalyst that is used which in this study is methanol (CH_3OH) will react with the FFAs to form soap and water.

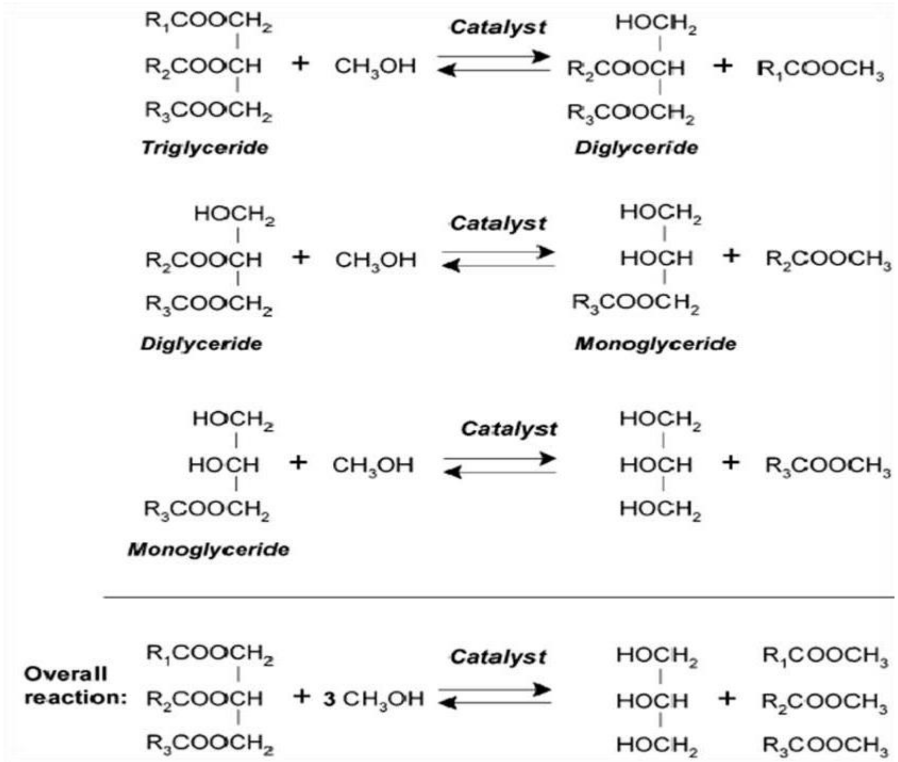

Figure 2.1: Schematic view of the chemical reaction during transesterification (Ngamcharussrivichai, C. et al., 2010)

2.3. BIODIESEL PRODUCTION PROCESSES

2.3.1 Raw Material properties

The rubber seed oil that will be used for production of biodiesel must be studied first so that the physical properties and chemical properties of the oil can be found out. These properties are important because it have influence in the quality of biodiesel that will be obtained. In this study, the physical properties that studied for the rubber seed oil are density and kinematic viscosity. As for the chemical properties, acid value (AV), saponification number, and iodine value is studied. This study also prioritizes the chemical properties of the rubber seed oil because it plays a larger role in the yield and properties of the produced biodiesel. Section 2.3.1.1 until 2.3.1.5 explains in detail regarding the chemical properties of the rubber seed oil.

2.3.1.1 Gas Chromatography (GC)

GC is a common analytic method used in many research fields as identification and quantitation equipment for compounds in a mixture. The reason that GC is more favourable technique is because the detection of compound with very small quantities is possible with GC. A small amount sample of the mixture that is being analysed will be injected into the GC machine via a syringe. The mixture usually brought into the GC machine in liquid form where at latter stage in the column oven the components of the mixture are heated and instantly vaporize. Before the mixture is heated, a carrier gas is injected to the mixture to be tested. The carrier gas only serves a sole purpose which is to help the gases in mixture to move through the column after heated and vaporized. The most common carrier gases are nitrogen gas (N_2), hydrogen gas (H_2), and helium gas (He). The carrier gases must be chemically inert and has very high purity whereas lack of the two criteria will result in column bleeding and destroy the column. The column is made up of thin glass or metal tube where the tube is filled with liquid that has high boiling point. The column is placed in a column oven that functions as an adjuster to the column temperature to a determined and reproducible value. The absorption and separation occurs as the mixture travels through the column where the components separate out. Each component emerges one by one at the end of the column and passes an electronic detector. The electronic detector identifies each component and a peak on a chart is printed for each component resulting in a final chart that has a series of peaks that represents to every substance that exists in the mixture. The process explained above is represented by the flow chart in Figure 2.2.