FINAL YEAR PROJECT 2

A STUDY ON THE EFFECTS OF PARAMETERS FOR OPTIMIZING BIODIESEL PRODUCTION

NAME	**: NUR SABRINA BINTI BASHARUDDIN**
MATRIX NO	**: B041010253**
COURSE	**: BMCT**
SUPERVISOR	**: MS. SITI NOR HABIBAH BINTI HASSAN**
SECOND SUPERVISOR	**: IR. DR. TAN CHEE FAI**

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-Fluids) with Honours”

Singnature: ....

Supervisor: MS. SITI NOR HABIBAH BINTI HASSAN

Date : JUNE 2013

A STUDY ON THE EFFECTS OF PARAMETERS FOR OPTIMIZING BIODIESEL PRODUCTION

NUR SABRINA BINTI BASHARUDDIN

This report is submitted in partial fulfilment of requirements
in order to be awarded with
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Faculty of Mechanical Engineering
Universiti Teknikal Malaysia Melaka

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DECLARATION

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

Signature: ....

Author: NUR SABRINA BINTI BASHARUDDIN

Date: JUNE 2013

Specially dedicated to my beloved parent

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In the Name of Allah the Most Gracious Most Merciful

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ABSTRAK

Transesterifiksi sisa minyak sayuran (WVO) di antara metanol dengan kehadiran kalium hidroksida (KOH) dikaji untuk menghasilkan biodiesel. Proses penghasilan biodiesel dijalankan di bawah parameter transesterifikasi proses. Parameter yang memberi kesan kepada penghasilan biodiesel dikaji dan dioptimumkan oleh penggunaan metodologi permukaan sambutan (RSM) dan faktorial reka bentuk. Tujuh belas bilangan eksperimen direplikasikan di bawah julat tipikal keadaan parameter yang dikodkan sebagai x_1 nisbah molar antara alkohol kepada minyak (*MR*), x_2 sebagai kepekatan pemangkin (*W*) dan x_3 sebagai masa tindak balas (*T*). Data eksperimen hasil biodiesel yang diperolehi dalam eksperimen akan dibandingkan dengan data ramalan hasil biodiesel menggunakan metodologi permukaan sambutan (RSM). Optimum transesterifikasi parameter dalam dalam kajian ini diramalkan pada 98% bagi hasil pengeluaran biodiesel. Ia dinyatakan di bawah keadaan molar nisbah 3.1:1 mol/ mol, 0.6 wt% kepekatan pemangkin dan masa 15 minit masa tindak balas.

ABSTRACT

The transesterification of waste vegetable oil (WVO) between methanol in the presence of potassium hydroxide (KOH) is studied in order to produce biodiesel. The biodiesel production process is carried out under the transesterification process parameters. The parameters effecting the biodiesel production are investigated and optimized by utilization of response surface methodology (RSM) and the factorial design. Seventeen number of experiments were replicated under the typical range of parameter conditions which coded as x_1 molar ratio between alcohols to oil (*MR*), x_2 as catalyst concentration (*W*) dan x_3 as reaction time (*T*). The experimental data of biodiesel yield that obtained in experiment will be compared with the prediction data of biodiesel yield using the response surface methodology (RSM). The optimal transesterification parameters in this study was predicted at 98% for biodiesel production yield. It is specified under conditions of molar ratio 3.1:1 mol/ mol, 0.6 wt% catalyst concentration and reaction time of 15 minutes.

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LIST OF ABBREVIATIONS AND SYMBOLS

KOH	=	Potassium Hydroxide
NaOH	=	Sodium Hydroxide
ASTM	=	American Society for Testing and Materials
EN	=	Europen Nation
C_2H_5OH	=	Etanol
CH_3OH	=	Methanol
TLC	=	Thin Layer Chromatography

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Depletion of world petroleum reserves with support on environmental issues concerned, lead researchers to find the new option sources as alternatives to replace dependency of petroleum based fuel. It is a renewable source that offers the replacement of petroleum based fuel demands. The production of biodiesel is sourced from vegetable oil or an animal fat that is formed by reaction of triglycerides in the vegetable oils or animal fats with alcohol such as methanol in the presence of the alkaline catalyst. The common types of alkaline catalyst have been used in the reaction are sodium hydroxide (NaOH) and potassium hydroxide (KOH). The reaction will result in producing a new chemical mixture identified as methyl esters. This methyl ester is known as biodiesel. The process is a process where a biodiesel is produced from a chemical reaction between vegetable oils or animal fats and alcohol, which requires the presence of a catalyst.

Biodiesel is generally considered as renewable sources as its primary feedstock is from natural resources which either a vegetable oil or animal fat. The use of biodiesel able to preserve the environment since the carbon content in the oil itself originates from carbon dioxide in the air. As a result, it contributed less to global warming compared with fossil fuels. Thus, the vast application of biodiesel in industrialization and mobilization are preferred based on its advantages. Basically, the properties of biodiesel are similar to the petroleum based, but it is more environmental preservation since it is biodegradability and low emission of carbon monoxide profile.

The viable standard specification when dealing with the biodiesel in the United State country is ASTM 6751 while in the European Union is EN 14214. The ASTM 6751 defined as the mono alkyl ester of long chain fatty acids acquiring in renewable sources. This standard provides the specification for the remaining total glycerol in biodiesel, which is an undesirable product in biodiesel. Besides that, it is a standard comprise of B100 and blended biodiesel with any proportion of petroleum based. Blended biodiesel can be represented as B*x* where *x* is significant for the percentage of biodiesel in the blend. The B100 is denoted as a pure biodiesel and consequently B5 is indicates 5% of biodiesel and the other 95% is petroleum based fuel.

However, the biodiesel developer has a great concern in terms of cost. Usually the production of biodiesel is more expensive than the petroleum based fuel. The restriction is comprised of the cost of oil feedstock where it contributed the overall cost operating power plant as reported by Predojevic Z.J., (2008). Thus, the waste vegetable oil (WVO) which is less expensive provides a wise feasible solution instead of using the virgin oil to encounter this restriction. In economic and environment point of view, it is appealing to use WVO as oil feedstock in biodiesel production. The WVO can be found in restaurant and fast food processing industry. It is can be recycled to be an alternative source feedstock in producing biodiesel. Nevertheless, WVO contains high contaminants and free fatty acid (FFA) which inhibit the chemical reaction. As a result, the FFA gives a huge effect to reduce the quality and quantity of biodiesel product. The content of free fatty acid in WVO made the biodiesel is difficult to produce. Furthermore, adequate amount of alcohol should be certain in producing the high biodiesel production, as alcohol requires more than 1.6 times the stoichiometric of oils in order to complete the reaction as presented by Garpen, J.V., (2005).

However, the cost of producing biodiesel can be reduced by remedied the production process. Consequently, the further study to obtain the most optimize parameters involved in this transesterification should be conducted. The optimizations of parameters are needed to shorten the experimental time and cost consuming in extracting the biodiesel. Hence, the trusted tool that proficient to determine the best optimum condition in transesterification process is response surface methodology (RSM). The parameters influencing the biodiesel yield concentrated on the molar ratio between methanols, the amount of catalyst to oil and reaction time. This kind of experimental design has benefited to reduce the number of experiments to be conducted and provide the knowledge of interactions between variables within the fixed range.

1.2 OBJECTIVES

There are several objectives as listed below in assisting the clearest overview of achievements in this study.

i. To compare the experimental and prediction data for biodiesel yield.
ii. To evaluate the effect of parameters towards biodiesel yield using transesterification process.
iii. To optimize the reaction condition parameters to produce the maximum biodiesel yield.

1.3 SCOPE

The scopes of this research embody the optimization of biodiesel production is from the waste vegetable oil. The source of waste vegetable oil is collected from the fried bananas stall. The parameters affecting the optimization of biodiesel production in this study only concentrated on three parameters, which are molar ratio methanol to oil, the amount of catalyst and reaction time. The range of parameters specified is 3:1 to 7:1 mol/mol for molar ratio between alcohols to oil (*MR*), 0.3 to 1.1 wt% for catalyst concentration (*W*) and 15 to 75 minutes for reaction time (*T*). Afterward, the data collected will be analyzed by using Statistical Package for Social Sciences (SPSS). A mathematical model then will be expressed for the effect of parameters towards biodiesel yield and Analysis of Variance (ANOVA) in SPSS will be used to examine the relationship between the parameters.

1.4 PROBLEM STATEMENT

Biodiesel lately introduced as an alternative source of petroleum based diesel. Among the significant advantages of biodiesel are environmentally friendly, biodegradability, low emission profile and lower levels of combustion particulates. However, there are restrictions in terms of cost of broadly production biodiesel compared to the petroleum based diesel. The optimization of production biodiesel is crucial in order to acquire the highest biodiesel yield. Thus, the response surface methodology is believed to be the most appropriate approach to perform the optimal parameters affects the transesterification of WVO. The experimental and prediction data can be compared with the response methodology surface.

CHAPTER 2

LITERATURE REVIEWS

Searching the alternative fuels has been rapidly carried out nowadays as consequences of the escalating global price of petroleum based fuel. The awareness on the environmental issue leads people to struggle in order to discover the promising further renewable fuels, which not only rely towards the dependency on petroleum based fuel. Thus, the biodiesel is a perfect renewable fuel with its several advantages; biodegradable and harmless to the environment. Commonly, biodiesel is most widely used in compression ignition engine and it is unnecessary of any modification of the engine.

2.1 ALKALI CATALYZED TRANSESTERIFICATION PROCESS

Biodiesel produced commonly by the transesterification process. The fatty free methyl ester (FAME) which is biodiesel derived in the transesterification process by accomplished the catalyzed chemical reaction between the oil feed stock with alcohol in presence of based alkaline catalyst according to the statement Nelson L.A et al. (1996). The presence of the catalyst is to accelerate the triglycerides chemical reaction undergoing in the transesterification process as stated by Meher et al. (2004). An alcohol is needed in the transesterification process to transform triglyceride into fatty acid ester.

The soap has severe impact to biodiesel reduction yield due to difficulty to separate mixtures phase, which are biodiesel and glycerol as a co-product. On top of that, water content existing in oil feedstock itself has developed the saponification process, which decelerated the transesterification process as the hydrolysis reaction takes place. In the hydrolysis process, the triglyceride will react with water and formed diglyceride and FFA as represented in Figure 2.3.

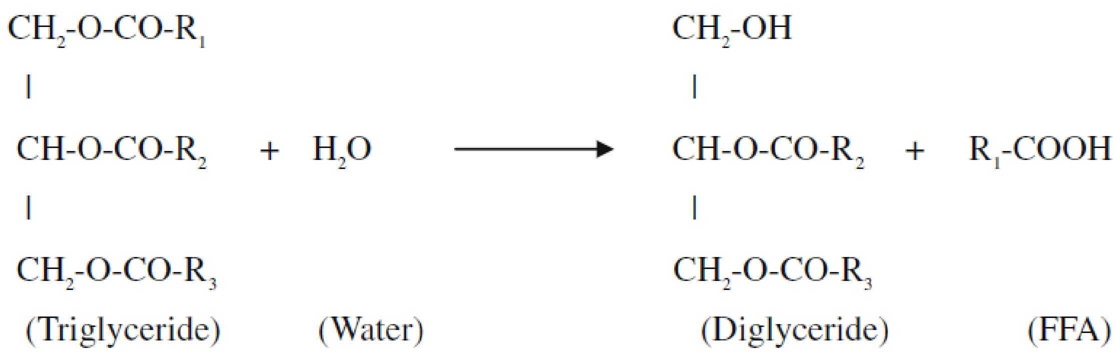

Figure 2.3: Hydrolysis Process of Triglyceride to Diglyceride
(Source: Garpen, J.V., 2005)

Once the chemical reaction is completed, the mixture is then separated into two phases. The biodiesel must undergo the treatment process to satisfy the permissible standard. At the final point, the contaminant concentration in biodiesel production will be reduced.

2.2 BIODIESEL PRODUCTION PROCESSES

2.2.1 Process Flow Chart

The transesterification process is the favored process in producing the biodiesel. Figure 2.4 shows a simplified flow chart of the transesterification process.

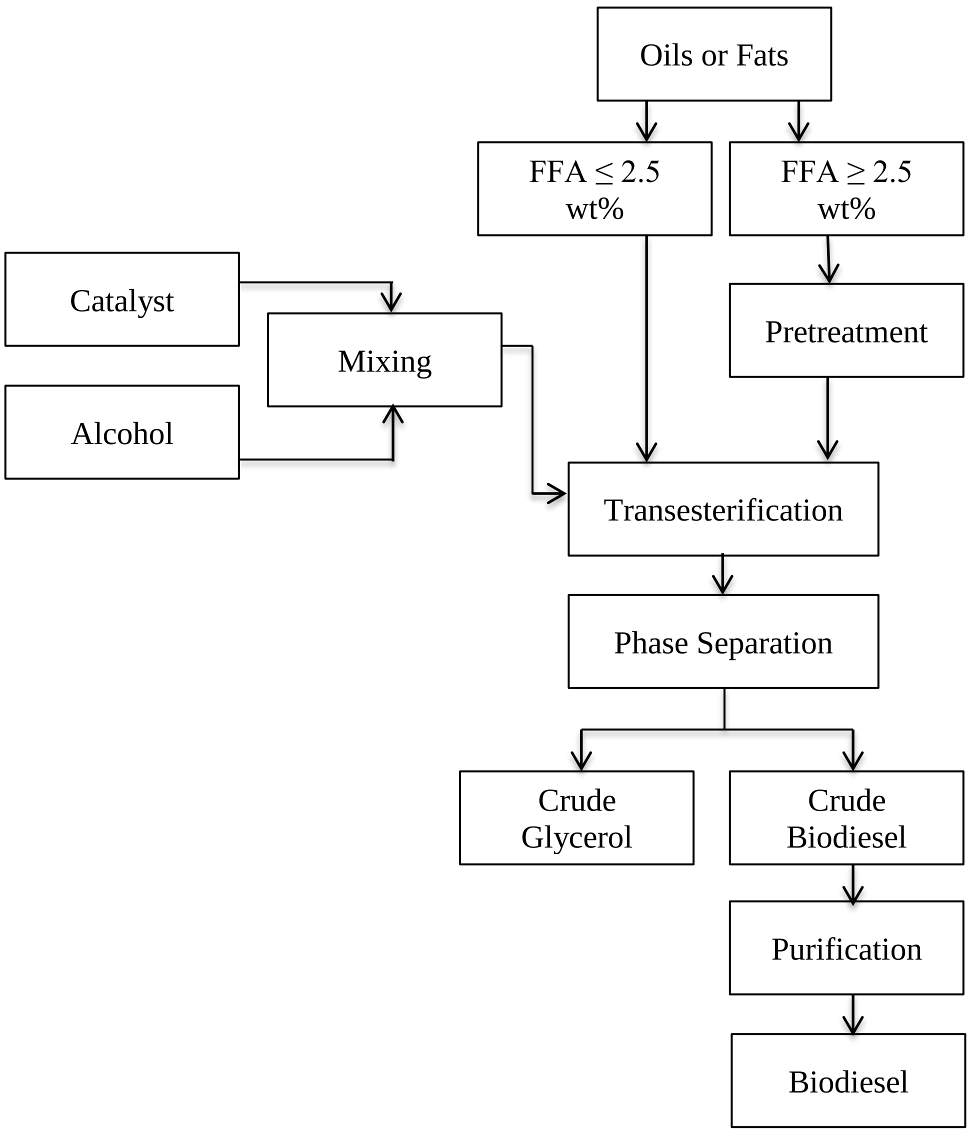

Figure 2.4: Process Flow Schematic for Biodiesel Production

(Source: Leung D.Y.C et al. 2010)

2.2.2 Process Details

2.2.2.1 Titration

The titration proses perform to reveal the percentage of FFA in oil feedstock. This process will determine whether the percentage of FFA is within or beyond the acceptable range where a yardstick of FFA is 2.5 wt%. If FFA exceeds 2.5 wt%, the pretreatment process should be carried out.

2.2.2.2 Pretreatment

Pretreatment process is intended to reduce the content of FFA in the oil feedstock to meet the acceptable range in order to proceed with the next processes of producing biodiesel. The wide spread of pretreatment process is esterification as stated by Kaieda M., et al. (1999) and Zhang Y., et al. (2003) since the raw materials contains a large value of FFA. The pretreatment process is necessary to conduct in order to reduce soap. Soap reduction is important to facilitate the separation of biodiesel and glycerol. Esterification is done with FFA and methanol in the existence of an acidic catalyst, which is commonly sulfuric acid.

2.2.2.3 Mixing Alcohol and Catalyst

The mixing of alcohol and catalyst will result to methoxide. The methoxide is a mixture between methanol and alkali catalyst either sodium hydroxide (NaOH) or potassium hydroxide (KOH) which typically types of catalyst used in biodiesel production. Based on Leung D.Y.C., et al. (2006), the methoxide is a better catalyst contrasted from hydroxide due to certainly no produce of water when methoxide dissolved in alcohol. Mostly, the catalysts stated previously both are in solid form and