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Separation of Glycerol from Biodiesel Oil Products Using High Voltage Electrolysis Method

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Abstract

This study aims to separate glycerol from used cooking oil biodiesel products. This research is done by main process by analyzing free fatty acid level (FFA) to know the fat content of the oil to determine the next process. This research is done by electrolysis process using high voltage. We did transesterification process by using methanol and NaOH as catalyst before performing the process of electrolysis with high voltage. Biodiesel is manufactured using a mini-scale stirred tank reactor (RATB) laboratory. This process is heated at temperature (35-60)°C, the ratio of used cooking oil and methanol (5:1, 6:1, 7:1, 8:1, 9:1) using a 0.1 N NaOH catalyst. The research obtained optimum reaction temperature yield highest percentage of yield at temperature 60°C and ratio of used cooking oil and methanol 5:1 with percentage of yield equal to 88.88, cetane number 48.4, kinematic viscosity 2.560, pour point 37.4°F, flash point 131°F, Conradson Carbon Residue (CCR) 0.09, and ASTM Color 1.5. This shows that the manufacture of biodiesel with high microwave and high voltage utilization yields a high percentage of 88.88 and the product is biosolar-48.

Keywords: biodiesel, used cooking oil, microwaves, high voltage, electrolysis

Abstrak (Indonesian)

Penelitian ini bertujuan untuk memisahkan gliserol dari produk biodiesel minyak jelantah. Penelitian ini dilakukan dengan proses utama yaitu dengan menganalisa kadar asam lemak bebas (FFA) untuk mengetahui kadar lemak pada minyak tersebut agar bisa mengetahui proses yang dilakukan untuk selanjutnya. Penelitian ini dilakukan dengan proses elektrolisa menggunakan tegangan tinggi. Sebelum melakukan proses elektrolisa dengan tegangan tinggi terlebih dahulu dilakukan proses transesterifikasi dengan menggunakan metanol dan NaOH sebagai katalis. Biodiesel diproduksi menggunakan reaktor tangki alir berpengaduk (RATB) skala mini laboratorium. Proses ini dilakukan pemanasan pada suhu (35-60)°C, rasio minyak jelantah dan metanol (5:1, 6:1, 7:1, 8:1, 9:1) dengan menggunakan katalis NaOH 0,1 N. Dari hasil penelitian didapatkan temperatur reaksi optimum menghasilkan persen rendemen tertinggi yaitu pada temperatur 60°C dan rasio minyak jelantah dan metanol 6:1 dengan persen rendemen sebesar 88,88, bilangan setana 48,4, viskositas kinematic 2,560, titik tuang 37,4°F, Titik nyala 131°F, CCR 0,09, Warna ASTM 1,5. Hal ini menunjukkan bahwa pembuatan biodiesel dengan pemanfaatan gelombang mikro dan tegangan tinggi menghasilkan persen rendemen yang tinggi yaitu sebesar 88,88 dan produk berupa biosolar-48.

Kata kunci: biodiesel, minyak jelantah, gelombang mikro, voltase tinggi, elektrolisa

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INTRODUCTION

The main energy source used in many countries today is petroleum. With so much exploitation being done, its existence is increasingly threatened, and its price will increase sharply. This is because petroleum is a non-renewable natural resource. Some various types of petroleum processed products used as fuel, the most widely used is diesel fuel. This is because most transportation, agricultural, heavy equipment and power plant generators use this fuel.

Various efforts have been made to seek alternative energy for diesel fuel. Biodiesel is a very potential material used as a replacement. This is because the raw materials derived from vegetable oils can be renewed, can be produced periodically and easily obtained. In addition, the price is relatively stable, and the production is easily adjusted to the needs. In terms of environmental biodiesel is also a material of biodegradability and the emission of pollutants is relatively small, because the unburned hydrocarbon content and its CO is lower, and SO_2-emission free when its burned [1].

One of the most common sources of biodiesel feedstock is used cooking oil. Cooking oil can be converted into biodiesel through the trans esterification stage by react the oil molecules with alcohol and catalyst to obtain methyl esters. To convert the molecules into biodiesel oil is required method that can convert oil in high quantities. The method often used to convert oil into biodiesel is conventional method. Unfortunately, however, the use of this method is less efficient because of its very slow heating resulting from the transfer of energy to materials that depend on the convection currents and the thermal conductivity of the reaction mixture [2].

A microwave is an alternative source of energy that can be used to supply energy in chemical reactions. Through dielectric heating, the reaction mixture can be mixed homogeneously without contact with the wall. The time required for the overall reaction can be significantly reduced [3].

Microwave radiation is a non-ionizing radiation that can break a bond to produce energy manifested in heat through interaction between substances or mediums. The energy can be reflected, transmitted, or absorbed [4].

Microwave heating has different characteristics than conventional heating, because heat is generated internally due to the vibrations of molecules the material wants to be heated by microwaves. This will save energy for warming microwave energy provided or delivered directly to molecules that react through chemical reactions. Move heat using a microwave is more effective than conventional heating where heat is removed from the environment [5].

The microwave heating process uses a shorter time to heat up raw materials without preheating [5]. In addition, microwave use showed a more efficient reaction, with short reaction times and short separation processes, decreased the number of byproducts, and could decrease energy consumption [6]. The efficiency of microwave trans esterification is derived from the dielectric properties of polar mixtures and ionic components of oils, solvents, and catalysts [7]. Rapid and efficient warming of microwave radiation because microwave waves interact with samples at the molecular level produces an intermolecular and agitation mixture that increases the chances of an alcohol molecule meeting an oil molecule [8].

The process of separation with the help of a voltage electric current can provide good results because it can accelerate the process of separation between biodiesel from glycerol and other substances that are not desirable [8,9]. Biodiesel separation by electrical voltage separation method can be a promising technology for the synthesis of biodiesel from plant oils because reaction time is relatively short, no soap formation occurs, and does not form glycerol as a by-product. But the disadvantage is that it is still difficult to control the reaction mechanism due to the presence of high-energy electrons, control which bonds to be excited or ionized and prevent further reactions due to the action of high-energy electrons [9].

From the above weaknesses, the authors undertake the research of the design of the tools of making biodiesel with the utilization of microwaves and utilizing high voltage for the process of separation of biodiesel and glycerol. In this study used cooking oil and is expected to produce biodiesel with a quality that meets applicable standards.

MATERIALS AND METHODS

Materials

The materials used are used cooking oil, methanol, zeolite, and NaOH 0.1 N. The medium used is a microwave equipped with two feed tanks, one full emulsifier tank with propeller, one portable pump, and one separation tank with 3 pairs of electrodes.

Methods

Laboratory Scale

This laboratory-scale research process is aimed at obtaining validation of operating conditions, process variables, prior research data, and hypotheses conducted by researchers. The next stage is named the design of the prototype of the tool can be adjusted with optimum production of laboratory scale biodiesel to obtain an efficient tool.

Design Prototype

The prototype of this biodiesel making apparatus uses a microwave heater and is designed to approach the phases of the stages performed on laboratory scale testing as shown in Figure 1.

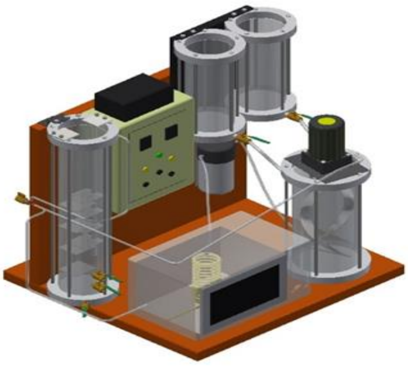

Figure 1. Prototype of biodiesel production equipment with high voltage electrostatic product separation (Source: Personal Document)

Trial Procedure

1. Free Fatty Acid Analysis (FFA)
2. Preparation of Sodium Methoxide Catalyst 1%
3. Making Biodiesel
4. Product Quality Testing

RESULT AND DISCUSSION

The Effect of Reaction Temperature on Percentage of Biodiesel Yield

The relation between temperature and yield is listed in Figure 1. Based on the Figure 1, it is known that there is an increase in the percentage of biodiesel yield along with the increase of reaction temperature. This high yield percentage is due to the faster movement of reagent molecules. This is in line with Wahyuni [10], i.e. the higher the temperature causes the molecular movement to accelerate or the kinetic energy of the reactant molecules gets larger so that the collisions between the reagent molecules also increase. The increase in temperature will increase the rate of reaction resulting from the increase of the kinetic energy of the system [11].

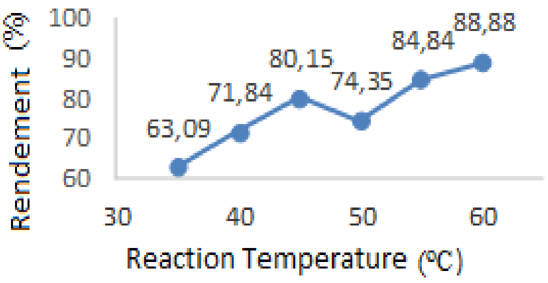

Figure 2. Reaction temperature vs. yield

Effect of Methanol Oil Ratio Vs. Yield

The smaller the mass ratio of used cooking oil and methanol then the percentage of yield will be smaller. This is because the amount of methanol is greater in the ratio of small ratio. Using excess methanol, the reaction can be shifted to the right to produce maximum conversion. The relation between oil ratio and yield is listed in Table 1.

Table 1. The methanol ratio versus yield.

Methanol Oil Ratio	Yield (%)
5:1	85,91
6:1	84,84
7:1	82,70
8:1	81,07
9:1	79,12

Viscosity

Based on the observation and analysis of the characteristics of biodiesel products, the reaction temperature influences the biodiesel viscosity. The result of characteristic analysis of biodiesel shows that the higher the reaction temperature used, the lower the viscosity of the biodiesel product. The decreasing in the viscosity value is caused by the movement of molecules of the substance faster due to the rise in temperature. This rapid movement will increase the pressure so that the molecule will expand and widen the distance between molecules. The viscosity value of the product will affect the fuel injection process on the machine. The viscosity of the research biodiesel product is 2.560 and it still in the category of bio solar. The complete product quality is shown in Table 2.

Table 2. Product quality data temperature 60°C and methanol oil ratio (5:1)

No	Analysis	Method	Viscosity	Remarks
1	Cetane Number	D 613	48.4	Min 48
2	Viscosity kinematic	D 445	2.560	2.0 – 4.5
3	Pour Point (°C)	D 97	3	2.0 – 4.5
4	Flash Point (°C)	D 93	55	Min 52
5	CCR (%/m/m)	D 4530	0.09	Max 0.1
6	Color ASTM	D 1500	1.5	Max 3.0

Source: Personal Document Result of Analysis at PT PERTAMINA RU III Laboratory

Flash Point

The flash point value will affect the treatment on storage of biodiesel products. The results of the analysis show that the higher the reaction temperature used, the flash point will be lower. Flash point is too low will complicate the storage process because of its flammability, but the flash point is too high is also not good because it will complicate the process of fuel ignition. High reaction temperatures will accelerate the triglyceride molecules to convert to methyl esters so that the breaking process gets faster and the reaction is complete. The perfect reaction result in other compounds become less when it mixed with biodiesel.

Pour Point

The pour point is the lowest temperature where the fuel can still flow because of its own weight. Pour point is one of the most important properties especially in the subtropical region. In the specification of biodiesel products in the research is still within the range of 3°C.

Conradson Carbon Residues (CCR)

CCR or residual carbon produced by biodiesel meet the standard of diesel and diesel fuel. The CCR value of the product in the study was 0.09.

Color

The color of biodiesel produced is lighter than the solar available on the market. Biodiesel has a color value of 1.5 while the existing diesel color market value 2. The higher the color value indicates the darker the color of the fuel. In addition, if the color of a fuel passes a predetermined standard value, it indicates the occurrence of thermal or subsequent decomposition of dark matter into fuel [12].

CONCLUSION

The maximum reaction temperature for producing biodiesel using microwave and high voltage with high yield percentage and in accordance with SNI quality standard is 60°C with yield of 88.88%. The result showed that the optimum reaction temperature yielded the highest percentage of yield at 60°C and the ratio of used cooking oil and methanol 5:1 with yield of 88.88%, cetane number 484, kinematic viscosity 2.560, pour point 37.4°F, flash point 131°F (55°C), CCR 0.09, and color (color ASTM) 1.5. This shows that the manufacture of biodiesel with high microwave and high voltage utilization gives high yield percentage (88.88%) and after analysis in PT PERTAMINA RU III laboratory is solar-48.

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