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Production Of Biodiesel Out Of Crude Palm Oil By Using NaOH Catalyst

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Abstract

The increasing consumption of diesel oil results in depletion of petroleum supply so that biodiesel is made out of crude palm oil. The purpose of this study was to determine the effect of the production of biodiesel by using NaOH catalysts. First, crude palm oil is analyzed for its free fatty acid content. If the free fatty acid is less than 5%, the transesterification process can be carried out immediately, if it's more than 5%, the esterification process is carried out first. The esterification process lasts for 60 minutes temperature of 60°C with an acid catalyst H_2SO_4 *then separated and washed. After the washing process, the transesterification process is continued with NaOH catalyst for 30 minutes at 60°C and then the washing process proceeds in order to purify the results. From the research that has been done, the result of biodiesel has a yield of 87.2866%, kinematic viscosity 4.655* mm^2/s*, flash point 110°C, pour point 12°C, and density at 15°C of 0.875 g/ml.*

Keywords: biodiesel, crude palm oil, NaOH

I. INTRODUCTION

The continuous use of petroleum results in depleting supply. In Indonesia, the consumption of petroleum, especially diesel oil is increasing. With the increasing need for diesel oil so the produced emissions are increasing as well. To overcome this problem, a new renewable energy form of biodiesel is created. The use of biodiesel is believed to be more environmentally friendly and improves environmental quality because it's easily biodegradable and the released emissions are lower than the emissions from burning fossil fuels (Kementerian ESDM Republik Indonesia, 2018).

Crude palm oil is used because of its abundance in Indonesia so that it's possible to be used as a mixture of fuel or a substitute for diesel fuel. Biodiesel can be made with an alkaline catalyst or an acid catalyst. In this case, an alkaline catalyst was chosen in the form of NaOH rather than KOH because NaOH is more reactive. In order to determine the quality of biodiesel, a sample test was carried out, including density, kinematic viscosity, flash point, and pour point

II. LITERATURE REVIEW

Crude palm oil is a vegetable oil obtained from the extraction process of the fruit of the plant *Elaeis guineensis*. To obtain crude palm oil with good quality, crude palm oil must be further processed by a refining process first so that there is no deterioration in quality due to hydrolysis and oxidation reactions. Crude palm oil contains triglycerides that are later reacted with an alcohol to produce biodiesel (Malasari, 2016). The manufacture of biodiesel can be used from several raw materials, such as crude palm oil, *sampling* oil, jatropha oil, sunflower oil, and others. According to (Ramos et al., 2009) crude palm oil has the advantage of high cetane numbers, iodine number, and good reaction stability.

Biodiesel is a biofuel for diesel engine/ motorbike applications in the form of Fatty Acid Methyl Esters (FAME) which is made from vegetable oil or animal fat through an esterification/transesterification process (Kementerian ESDM Republik Indonesia, 2018). The level of free fatty acids in biodiesel must be maintained to obtain a better quality of the biodiesel. The less free fatty acid content in biodiesel, the better the quality. If the amount of free fatty acids is not controlled, soap will form in the transesterification process (Atmojo, 2010).

Biodiesel has an advantage over diesel fuel, namely that biodiesel is generally more environmentally friendly. The use of 100% of biodiesel reduces CO emissions by 10%-50% then reduces SO_2 emission by 100% and reduces HC between 10%-50% oxides. Biodiesel is a fuel that is non-toxic, safe in transportation, and can be degraded naturally, which is more easily extracted by microorganisms (biodegradable). Also, biodiesel has a low smoke number and can eliminate the greenhouse effect, and has a high cetane number value, ranging from 57-62 so that its combustion efficiency is better (Havendri, 2007).

Biodiesel production can be done in two stages, namely the esterification and transesterification reaction. The esterification reaction is carried out when the Free Fatty Acids (FFA) content is more than 5%. This reaction aims to reduce levels of FFA. Esterification is a reaction of free fatty acids and methanol to produce fatty acid methyl esters or biodiesel with water impurities. Esterification reactions usually use acid catalysts, including sulfuric acid, phosphoric acid, and hydrochloric acid. Based on previous research literature studies, the esterification process that has been carried out by (Laila and Oktavia, 2017), (Wahyuni et al., 2011), (Devi et al., 2015), and (Hastuti et al., 2015) used an acid catalyst in the form of H_2SO_4 with a temperature between 50º-65ºC and a decrease in free fatty acids ranging from 2.45%-11.3%.

Transesterification is a process that reacts triglycerides with alcohol, usually in the form of methanol, by using an alkaline catalyst to produce FAME (biodiesel) and glycerol. An alkaline catalyst is used because the transesterification reaction rate will proceed way faster than the acid catalyst. The alkaline catalyst is chosen because of the ability to catalyze reactions at low temperature and atmospheric pressure, high conversion with minimal time, and it's widely available and economical. Based on previous research literature studies, the process of produce biodiesel that has been carried out using crude palm oil as raw materials by (Ristianingsih et al., 2015) with 1% NaOH catalyst and a ratio of oil and alcohol (1:3) reacted for 1 hour at a temperature of 65ºC obtained a yield of 65.38%, the kinematic viscosity of 4.459 mm^2/s, a flashpoint of 81.5°C, and pour point of 15°C. as well as research conducted by (Hamid and Yusuf, 2002) using 3.5 grams of NaOH catalyst with a ratio of oil and alcohol (1:5) reacted for 1 hour at 60ºC obtained a yield of 82.46%, the kinematic viscosity of 6 mm^2/s, the flashpoint of 160°C, and pour point of 9°C. Also, the transesterification process to produce FAME with raw materials other than crude palm oil such as used cooking oil was carried out by (Leung and Guo, 2006) using 1.1% NaOH catalyst with a ratio of oil and alcohol (1:7) reacted for 19 minutes at 60^{o}C obtained a yield of 88.8%, (Demirbas, 2009) using a KOH catalyst as much as 6% with a ratio 1:9 for 2 hours at 87^{o}C obtained a yield of 87%, meanwhile (Zheng et al., 2006) used a 41,8% H_2SO_4 catalyst with a ratio 1:245 for 4 hours at 70^{o}C, the yield was 99%.

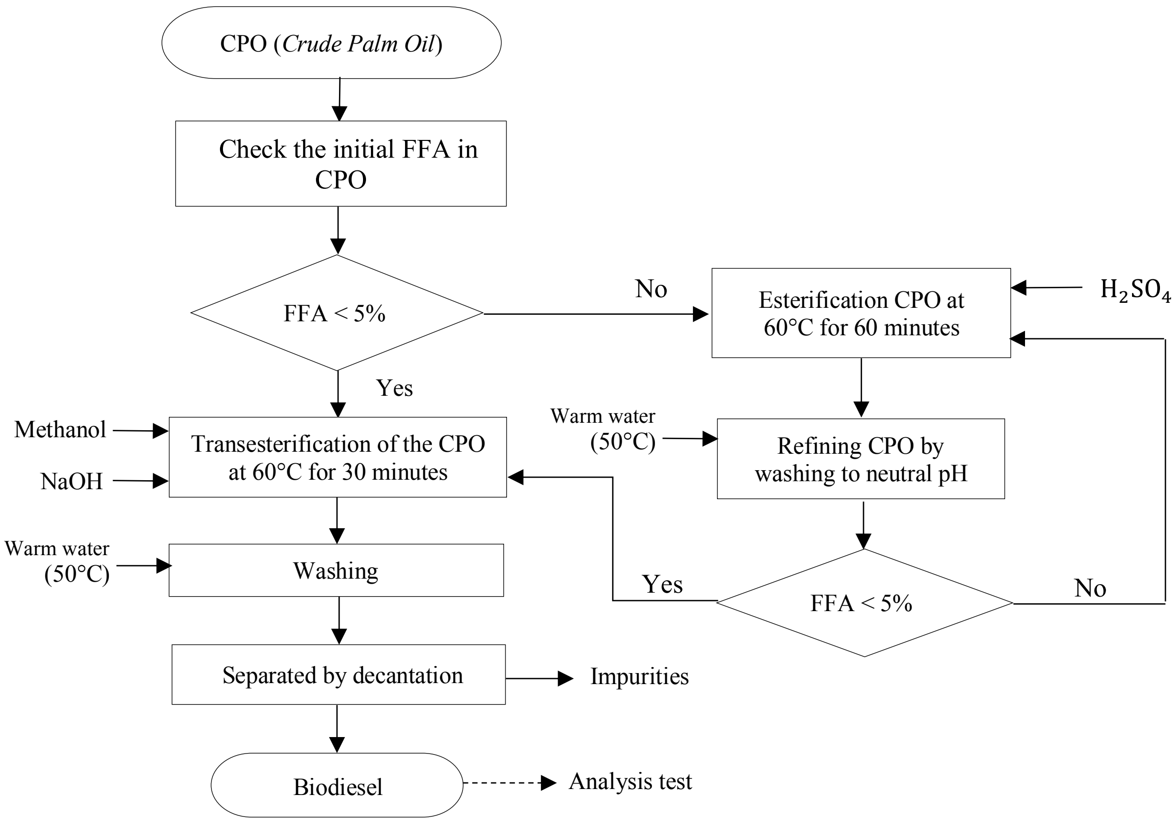

Figure 1 Process Flow Diagram of The Biodiesel Manufacturing

III. RESEARCH METHODOLOGY

III.1 Tools and Materials

The used tools in this study include three necks rounded flask, magnetic stirrer, stative, heater, thermometer, clamp, 250 ml Erlenmeyer, volume pipette, burette, measuring cup, dropper pipette, separating funnel, pH meter, beaker glass, pycnometer, and hydrometer. While the materials used are crude palm oil, H_2SO_4, NaOH, methanol, distilled water, indicator PP (phenolphthalein), and ethanol 96%.

III.2 Procedure

III.2.1 Analysis of Free Fatty Acid

The palm oil is weighed as much as 1 gram, then pour it into the Erlenmeyer and add 10 ml of alcohol. Then heated until boiling. After the sample has cool, 3 drops of PP indicator are added and titrated with 0.1 N NaOH solution until it turns pink.

III.2.2 Esterification of Crude Palm Oil

Palm oil is heated in the three-neck rounded flask until reaches a temperature of 50°C. Then as much as 1% w/w H_2SO_4 with methanol is added with the mole ratio of CPO: methanol is 1:4. Then the reaction is maintained at a fixed temperature of 60°C for 60 minutes under stirring. After the reaction is stopped the mixture is washed with warm water at 50°C.

III.2.3 Transesterification of Crude Palm Oil

The result of the esterification process that has been separated and washed from its impurities is then processed by transesterification using NaOH 1.1% w/w by weight of oil, mixed with methanol, then added the oil that has been weighed with a mole ratio of CPO: methanol is 1:7 and reflux for 30 minutes at 60°C.

III.2.4 Separation and Filtering Process

Washing is proceeded by adding warm water at a temperature of 50°C until the pH of the washing water is neutral. After that, cooled down until it is obtained a layer of biodiesel with impurities. The top layer is taken and followed by decantation to ensure the separation of methanol and water until biodiesel is reddish yellow.

III.3 Analysis of Biodiesel Characteristics

III.3.1 Yield

Yield is the ratio between the mass / the amount of biodiesel produced by the used mass of palm oil. Yield can be calculated using the following equation:

$$\text{Yield} = \frac{\text{the mass of biodiesel}}{\text{mass of crude palm oil}} \text{ x } 100\% \qquad (1)$$

III.3.2 Kinematic Viscosity

The kinematic viscosity analysis is carried out by the ASTM D7279-16 standard. This kinematic viscosity test method uses an automatic Houillon viscometer. The kinematic viscosity that can be measured by this method ranges from 2 mm^2/s to 2500 mm^2/s depends on the used constant tube.

III.3.3 Flashpoint

Flashpoint analysis is performed by using the ASTM D93-16a standard. This test method uses a Pensky-Martens *closed-cup* and includes a sample of the flashpoint between 40°-370°C. The sample is poured into a clean and dry bowl until the limit mark. After that, the bowl is covered with the lid. A thermometer is attached to the test bowl, then the stirring is performed. The ignition test starts when the sample reaches a certain temperature which is considered to be the flashpoint with the ignition flame brought near the surface of the sample. Repeat the test for every 1°-2°C rise in temperature. Then note the flashpoint.

III.3.4 Pour Point

Analysis of pour point is carried out by using ASTM D5950-14 standards. The pour point test method is carried out by tilting the test tube during the cooling process. The test can be determined at a temperature interval between 1°-3°C.

III.3.5 Density at 15°C

Density analysis at 15°C is performed by using the ASTM D1298 standard with a hydrometer. The sample is added into a measuring cup and placed on a flat place. The temperature is measured with a thermometer and then a suitable hydrometer is carefully inserted into the sample. After the hydrometer stops moving, note the number shown on the hydrometer

IV. FINDING AND DISCUSSION

Based on the research that has been done, performed of the characteristic analysis on the manufacture of biodiesel from palm oil using a NaOH catalyst includes kinematic viscosity, flash point, pour point, and density at 15°C.

IV.1 Yield

In making biodiesel by using a NaOH catalyst as much as 1.1% and a period of transesterification reaction for 30 minutes, the obtained yield is 87.2866%. This result is obtained because of the side result in the form of glycerol and the dissolution of biodiesel during the washing process. In this study, the use of a catalyst was 1.1% more effective than previous studies conducted in the literature review and a reaction time of 30 minutes was sufficient time to react triglycerides with alcohol because of the higher conversion.

IV.2 Kinematic Viscosity

The test result shows the kinematic viscosity at a temperature of 40°C with the ASTM D7279 standard, the obtained result is 4.664 mm^2/s based on the SNI 7182 standard regarding kinematic viscosity biodiesel in the range of 2,3-6 mm^2/s. Based on the SNI 7182 standard, the produced biodiesel is following the standards because it is in the value range and with a total of 1.1% NaOH catalyst and a ratio of oil and alcohol 1:7, reacted for 30 minutes at 60°C, the resulting kinematic viscosity is lower than previous research. The kinematic viscosity that is too high makes it difficult for biodiesel to flow on the fuel tank and it can cause the injector to work even harder. The viscosity number is also influenced by the soap content that is contained in biodiesel where the soap comes from the side result of the transesterification process, to reduce the produced of the soap formed, the NaOH content needs to be reduced as well.

IV.3 Flashpoint

Following the flashpoint test standard ASTM D93, the obtained result is 110°C. The flashpoint of biodiesel is higher compared to diesel oil is caused by more C atoms. The flashpoint relates to the fuel's ability to burn and safety in storage. If the test results are compared with the SNI standard, the flashpoint is 110°C in accordance with the standard, because the SNI 7182 standard of minimum flash point for biodiesel is 100°C.

IV.4 Pour Point

The result of the pour point value for biodiesel is 12°C. The test result is carried out in accordance with the ASTM D5950 standard. The pour point relates to the ease of fuel to flow from the tank into the combustion chamber or in the case of fuel storage for tropical countries where the average temperature is above 20°C the pour point with a maximum of 12°C is not a problem. However, if the pourpoint is too high then the fuel will be difficult to flow and the fuel tends to freeze and require more handling. Meanwhile, based on the SNI 7182 standard, the maximum pour point is 18°C so that the biodiesel meets the determined standards.

IV.5 Density at 15°C

From the test result that has been carried out, the density of biodiesel is 0.873 g/ml. For biodiesel density standards are between 0.82 to 0.86 g/ml, it can be concluded that the produced biodiesel is not in accordance with existing standards. The high density can cause low combustion of fuel. In addition, the high density is due to the presence of side result in the form of glycerol which is still left in the biodiesel. Another problem caused by high density is when biodiesel is blended with diesel fuel. The mixture of biodiesel and diesel will be difficult to be homogeneous because of the difference in density that occurs and two layers will be formed.

V. CONCLUSION AND FURTHER RESEARCH

From the results of tests and research that have been done, the obtained results are 87.2856% yield, kinematic viscosity at 40°C of 4.664 mm^2/s, a flashpoint of 110°C, pour point of 12°C, and density at 15°C of 0.873 g/ml. However, the obtained density of biodiesel from research that has been carried out is not following the determined standards. For suggestions, it is better to conduct further research to fix the problem of biodiesel density by studying the effect of the amount of catalyst, reaction time, and the addition of additives. With the result obtained from this study, further research will be carried out by mixing diesel oil into B50.

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