

# ANALYSIS OF THE PHYSICAL CHARACTERISTICS OF BIODIESEL PRODUCTS MADE FROM USED COOKING OIL

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## ABSTRACT

Biodiesel is a very potential material used as a substitute for diesel fuel derived from petroleum. In manufacture of biodiesel was used waste cooking oil with FFA levels obtained which is 3.1%, so that the transesterification process is directly carried out. This study aims to find out the physical characteristics of biodiesel produced from waste cooking oil with a molar ratio of waste cooking oil to methanol 5:1 and 4:1. Method that used in this research is experiment and analytic of physical characteristics of biodiesel products made from used cooking oil. The results of the physical characteristic test of biodiesel with a ratio of 5:1 and 4:1 showed that the biodiesel density of waste cooking oil had met SNI 04-7182-2012. Viscosity test results showed that biodiesel from waste cooking oil has not met SNI 04-7182-2012. The results of flash point tests showed that biodiesel from waste cooking oil has not met SNI 04-7182-2012. Freezing point test results showed that biodiesel from waste cooking oil had met SNI 04-7182-2012. The results of the heat value test showed that biodiesel from waste cooking oil has not met SNI 04-7182-2012. And the yield shows that biodiesel from waste cooking oil has not produced a significant biodiesel yield.

**Keywords:** Cooking; Oil; Biodiesel; Transesterification

## Introduction

Most of the world's energy needs are supplied through sources of oil, coal and natural gas. Energy requirements that increase is not proportional to the availability of energy sources which is decreasing.<sup>1</sup> A number of countries began to develop nuclear, hydrogen, wind, and currently developing is biodiesel. Biodiesel production being developed because it is easy to manufacture, cheap and renewable.<sup>2</sup>

The need for diesel as one of the sources of energy in Indonesia currently reaches 170 million barrels/year. The fulfillment of national diesel is carried out by means of domestic supply and import activities. The type of diesel supplied is dominated by petroleum base materials, and not a few also domestic producer obtain this basic material through import activities. Since 2018 biodiesel made from palm oil is required by the government. Currently the implementation has reached B30 with a

mixture of FAME 30% and solar 70%. Based on research by the International Council on Clean Transportation (ICCT), Indonesia has a potential of 157 million liters of oil from restaurants, hotels, and schools in urban areas.

The fact, that explained above makes us think about how to replace petroleum energy sources, especially diesel with a cheaper and more precise energy source, named biofuels. which the one form of renewable energy source. cooked oil production that large enough, can be probability for Indonesia to use it into biodiesel as the newest energy source that is more environment friendly. Biodiesel is an alkyl ester made from biological sources such as vegetable oil, animal fats and even cooking oil. Biodiesel can also be synthesized through transesterification by eating a base catalyst.<sup>3</sup> One of the potential raw materials for the manufacture of biodiesel is cooking oil. This oil has almost the same characteristics as the

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characteristics possessed by petroleum. The usual use of cooking oil can be replaced with vacuum frying oil and contains less FFA (free fatty acids) with a relatively clearer color after being used to fry as many as 30 batches.<sup>4</sup>

Various researches on the manufacture and direct testing of biodiesel have been widely done as done by Mahreni and Setyoningrum<sup>5</sup> with the title "Biodiesel Production From cooking Oil" Using Solid Acid Catalyst (Nafion/SiO<sub>2</sub>) the results showed that biodiesel production of waste cooking oil (WCO) was carried out using a double catalyst, Nafion/SiO<sub>2</sub> as a esterification reaction catalyst and NaOH was used as a transesterification catalyst and the percentage of biodiesel produced using double catalysts was higher than using a single catalyst. Another research about biodiesel by Encinar<sup>6</sup> with the title "Biodiesel from Used Frying Oil. Variables Affecting the Yields and Characteristics of the Biodiesel". Results of this research showed that biodiesel with best properties can be obtained at 6:1 molar ratio (methanol/oil).

At this time, the utilization of cooking oil in Indonesia is still not developed. The potential of cooking oil will increase along with the increasing production and consumption of cooking oil. Research to overcome the accumulation of waste from cooking oil has been widely tried, including by refining methods back or processed into biodiesel. Therefore, in this study will be done manufacturing and analysis to find out the physical characteristics of biodiesel products made from cooking oil. It is hoped that through this research can increase the useful value of cooking oil so that it can be processed to produce alternative sources of raw materials for the manufacture of biodiesel that does not damage the environment and endanger human health.

This study used a transesterification reaction which is a relatively slow counter-reaction and uses NaOH base catalysts, to speed up the course of the reaction then this process is done with good stirring, the

addition of catalyst.<sup>7</sup> At the transesterification reaction stage using NaOH base catalysts and methanol so that biodiesel is formed. Biodiesel resulting from the transesterification process must be analyzed to determine the quality of biodiesel products obtained. The manufacture of biodiesel from the raw materials of cooking oil and NaOH catalyst is basically shown to obtain the optimum biodiesel yield.<sup>8</sup>

## Methods

This research is experimental while analyzing the physical characteristics of products for biodiesel as a diesel replacement fuel and was tested at PT Sucofindo Laboratory using ASTM and SNI methods. Objects in this study used the cooking oil of former household fryers.

### A. Tools and Materials

The tools used are a pot, 1liter aqua bottle, 10ml measuring glass, 200ml beaker glass, 1000ml beaker glass, thermometer, filter paper, Erlenmeyer. Ingredients used: cooking oil, 99% methanol, NaOH, aquadest, indicator of phenolphthalein.

### B. Experiment

Tools and materials have been prepared in advance before the research is carried out. The main ingredient of this study uses the oil of the former household fryer. The prepared cooking oil is filtered using laboratory filter paper. Then the cooking oil is heated at 60°C and while stirring for 1 hour. The heated cooking oil is then left in the open pan lid until the condition about 30°C or 35°C.

Next mix 99% methanol as much as 200ml with NaOH as much as 3.5ml for a ratio of 5:1 and methanol 99% as much as 400ml with NaOH 3.5ml for a ratio of 4:1 in a 1 liter bottle. Then the cooking oil is poured into methanol and NaOH bottles that have been mixed. Then shake the bottle and then let stand for 24 hours. After glycerol is seen settling under then the dirty methyl ester is separated with glycerol.

The next stage is to heat the aquadest which is then used to wash dirty methyl ester

by mixing the aquadest in a bottle and then silenced for 24 hours which aims to produce biodiesel that is pure and free from impurities. This stage of washing produces methyl ester and glycerol  $H_2O$ . It then separates glycerol  $H_2O$  from methyl ester. Methyl esters that have been separated will be tested for characteristics.

## Result and Discussion

### a. Determination of the level cooking oil FFA

Determination of FFA (Free Fatty Acid) levels aims to find out the levels of free fatty acids found in the oil of household waste by using the standardized NaOH titration

$$\%FFA \text{ Content} = \frac{\text{mL NaOH} \times N \text{ NaOH} \times \text{BM Cooking Oil}}{\text{gram sample}} \times 100\% \quad (1)$$

From the calculation obtained the amount of FFA levels from cooking oil to be used is 3.1%, so that biodiesel manufacturing only passes the transesterification reaction and FFA levels are allowed to form biodiesel with a maximum transesterification reaction of 3%.<sup>9</sup>

### b. Biodiesel yield

The research yielded a biodiesel yield of 4:1 ratio of 10% and a 5:1 ratio of 28%. Based on these results there is a difference between a ratio of 4:1 and 5:1 of 18%. Because the use of catalysts in the manufacture of biodiesel will increase the yield of biodiesel produced.<sup>10</sup> The higher the concentration of the catalyst, the greater the conversion of the reaction. The low biodiesel yield value is also caused by washing that is not maximal, so that cake is formed in the membrane layer that makes the number of products accommodated decreases.<sup>11</sup> To maximize washing by using aquadest at 40°C to remove the remaining catalyst and the biodiesel is then put in the oven at 100°C for an hour.<sup>12</sup> It can also be in the washing process, dirty biodiesel is mixed with 0.01% acetic acid and rinsing with warm water to a neutral pH of waste water.<sup>13</sup>

method, so that it can be determined the feasibility of the cooking oil as a basic material for producing biodiesel. As much as 10 grams of cooking oil is dissolved into 50 mL of alcohol in Erlenmeyer to dissolve the free fatty acids found in the oil without changing the pH of the cooking oil itself. Then, the solution is added indicator (phenolphthalein) and then titration with NaOH. In this case phenolphthalein is used as an indicator to show the equivalent point of titration by marked color change from yellowish to pink. The average NaOH volume used for titration is 1.1 ml. The calculation of FFA levels is done by using equation:

### c. Analysis of biodiesel characteristics

Data from the character test of biodiesel made from cooking oil with Indonesian national standards. Biodiesel character test results include determination of viscosity, density, flash point, freezing point, and caloric value.

*The viscosity of biodiesel* research results at a temperature of 40°C with a 1% NaOH catalyst ratio of oil volume cooking oil: methanol 5:1 which is 9.223 mm<sup>2</sup>/s, and at the ratio of oil volume cooking: methanol 4:1 obtained viscosity value of 7.653 mm<sup>2</sup>/s. From these results it is known that both compositions of biodiesel produced have each viscosity value greater than the quality standards of Indonesian biodiesel. The quality requirement for biodiesel viscosity based on SNI is 2.3 to 6.0 mm<sup>2</sup>/s. This happens because the use of the number of NaOH catalysts used in biodiesel manufacturing is too much. So the more catalysts used in biodiesel manufacturing, the greater the viscosity of biodiesel products produced. Viscosity that is too high will cause dirty smoke because the fuel becomes slow to flow and complicates the fuel misting process.<sup>14</sup>

*The biodiesel of density* resulting from this research at a temperature of 40°C with a 1% NaOH catalyst 1% ratio of oil volume

cooking: methanol 5:1 has a density value of 872.9 kg/m<sup>3</sup>, and at the ratio of oil volume cooking: methanol 4:1 which is 870.0 kg/m<sup>3</sup>. From these results it can be known that the value of biodiesel density produced in this study is in accordance with the international biodiesel quality standard range of 850-890 kg/m<sup>3</sup>. The factor that affects the density of this type is the use of base catalysts. If the use of an excess base catalyst will cause a

saponification reaction.<sup>15</sup> Glycerol factors found in methyl esters will affect density.<sup>16</sup> The process of washing and refining less perfectly will cause greater density levels. The greater the density will affect the increase in fuel consumption. This is because more fuel is need to be injected into the combustion chamber to get the same engine power.<sup>17</sup>

**Table 1.** Comparison of cooking oil test results with national standard ratio of 5:1

parameters	Biodiesel Results	SNI 7182-2012
Viscosity 40°C	9.223 mm <sup>2</sup> /s	2.3-6.0 mm <sup>2</sup> /s
Density 40°C	872.9 Kg/m <sup>3</sup>	850-890 Kg/m <sup>3</sup>
Flash Point	64°C	Min 100°C
Freezing Point	5°C	Max 18°C
Caloric Value	9515.1 cal/g	10160-11000 call/g

**Table 2.** Comparison of cooking oil test results with national standard ratio of 4:1

parameters	Biodiesel Results	SNI 7182-2012
Viscosity 40°C	7.653 mm <sup>2</sup> /s	2.3-6.0 mm <sup>2</sup> /s
Density 40°C	870.0 Kg/m <sup>3</sup>	850-890 Kg/m <sup>3</sup>
Flash Point	58.0°C	Min 100°C
Freezing Point	6°C	Max 18°C
Caloric Value	9445.1 cal/g	10160-11000 cal/g

The flash point of biodiesel produced with a 1% NaOH catalyst in this study with a 5:1 methanol volume ratio of 64.0°C and at a 58°C ratio of oil volume of 58°C. The results obtained from this test are far below the minimum biodiesel flash point standard based on SNI 04-7182-2012 which is min 100°C. A low flash point indicates an excess of methanol that has reacted perfectly, as excess methanol can lower the flash point.<sup>18</sup> The flash point is associated with the remained methanol (alcohol), the rest of the

alcohol can weaken the flame point of biodiesel, if flash point of the fuel is low, the fuel is flammable in its storage.<sup>19</sup>

The freezing point of biodiesel in this research with a ratio of 5:1 is 5°C and the freezing point value at a ratio of 4:1 is 6°C. From the results of the tests obtained it can be known that the freezing point of biodiesel produced from this study has a good freezing point quality because the freezing point is smaller than the standard biodiesel SNI 04-7182-2012. If the higher the value of the

freezing point of fuel, exceeding the quality standard of biodiesel Indonesia eats will be faster the time it takes fuel to freeze. Freezing that occurs inside the machine can result in damage and congestion of the engine.<sup>20</sup> Freezing point is very important to cool the engine in the cold and to handle the oil in the machine and storage.<sup>21</sup> So from the research biodiesel made from cooking oil has met the quality standards of Indonesian biodiesel and can be used for areas with low temperatures or cold as in European countries and remains safe to use in the tropics.<sup>22</sup>

*The caloric value of biodiesel* in this research with a ratio of 5:1 is 9516.1 Kcal / kg and at a ratio of 4:1 of 9445.1 Kcal / kg. From the test results obtained it can be known that the heat value of biodiesel produced is below the quality standard of Indonesian biodiesel which is 10160-11000 cal/g. The heat value of biodiesel is influenced by the constituent compounds that depend on the basic constituent ingredients. The increase in the concentration of catalysts causes the speed at which a reaction increases and also increases the number of collisions between molecules, so that more and more carbon chains will be cut off, then the termination of this carbon chain affects its molecular weight which will decrease and cause the heat value of combustion to be greater.<sup>23</sup> Then the caloric value of this research has not met the quality standards of Indonesians biodiesel. The heat value must also be adjusted to the capacity of the machine used, because if the heat value is low, it will cause damage to the machine it self.<sup>24</sup>

Comparison between the results of this study and research that has results approaching this research, namely by Erni Dwi Cahyati and Lestari Pujaningtyas<sup>25</sup> about "Making Biodiesel from Used Cooking Oil with the Transesterification Process Using KOH Catalyst", which results in almost the same density, namely 872.9 kg /m<sup>3</sup> (5:1 ratio); 870.0 kg/m<sup>3</sup> (4:1 ratio) and 890 kg/m<sup>3</sup>. Then the viscosity ratio is 9,223 mm<sup>2</sup>/s (5:1 ratio); 7,653 mm<sup>2</sup>/s (4:1 ratio)

and 2.80 mm<sup>2</sup>/s. Then the flash point is 64°C (5:1 ratio); 58.0°C (4:1 ratio) and 148°C. The difference in the results of this study is caused by different types of catalysts.

The main contribution of this research is as a reference for further research on renewable energy, especially biodiesel production.

## Conclusion

Based on the research that has been carried out, it can be concluded that the results of biodiesel characteristic testing of oil and parameter variations of 5:1 and 4:1 are as follows:

1. Viscosity comparison behind biodiesel 5:1 and SNI, the result showed that SNI better than biodiesel 5:1. Biodiesel 4:1 has the same case with biodiesel 5:1 in viscosity comparison.
2. Density comparison behind biodiesel 5:1 and SNI, the result showed that SNI and biodiesel 5:1 has similar result. Biodiesel 4:1 has the same case with biodiesel 5:1 in density comparison.
3. Flash Point comparison behind biodiesel 5:1 and SNI, the result showed that SNI better than biodiesel 5:1. Biodiesel 4:1 has the same case with biodiesel 5:1 in flash point comparison.
4. Freezing Point comparison behind biodiesel 5:1 and SNI, the result showed that SNI and biodiesel 5:1 has similar result. Biodiesel 4:1 has the same case with biodiesel 5:1 in freezing point comparison.
5. Caloric Value comparison behind biodiesel 5:1 and SNI, the result showed that SNI better than biodiesel 5:1. Biodiesel 4:1 has the same case with biodiesel 5:1 in caloric value comparison.

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