The Analysis of The Use Calcium Oxide (Anadara Granosa) and Sodium Hydroxide Catalyst Reviewed on Yield of Biodiesel

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Abstract. The energy crisis in Indonesia is caused by an increase in the need for fuel oil which has increased in the replacement of fossil energy reserves. It's the time to dependency of the petroleum by developing an alternative energy sources that can be renewable. One of the way to overcome this matter is developing the fuel production such as biodiesel which is made by waste cooking oil. The level of FFA is contained the waste cooking oil is used below 5%, namely 1.945% so that the transesterification process can be directly carried out. This research was conducted to determine the effect and the type of catalysts concentration (NaOH and CaO), ((0.5-2.5%) with 3000 ml of waste cooking oil) on the quality of biodiesel. The results of the study shows the effect and the type of catalysts concentration is affected of the quality of biodiesel is produced. The optimum point is using of NaOH catalyst with the amount of catalyst 1% w/w waste cooking oil is yield 84.65%, density 0.8540 gr/ml, viscosity 5.65 cSt, acid number 0.447 mgKOH/gr, water content 0.048%, point flame 167°C, and calorific value 9757.7096 cal/gr, these values have fulfilled the biodiesel quality standards in accordance with SNI-04-7182-2015, while the optimum point is used of CaO catalyst and the amount of catalyst is 2.5% w/w waste cooking oil is yield 58.57%, density 0.8740 gr/ml, viscosity 5.66 cSt, acid number 0.447 mgKOH / gr, water content 0.040 %, flash point 179.6°C, and heating value 9543.5214 cal/gr.

Keywords: Biodiesel, Waste Cooking Oil, Transesterification, Catalysts, Yield.

1. Introduction

The energy crisis in Indonesia is caused by an increase in the consumption of petroleum in daily life. This increase was due to the increasing number of vehicles and industrial companies. In addition, the amount of petroleum is decreasing. Other energy sources must be found and empowered to solve this problem [1].

It's the time to dependency of the petroleum by developing an alternative energy sources that can be renewable. One of the way is changing vegetable oil become biodiesel. From the several types of biodiesel raw materials, one of which that biodiesel raw materials is waste cooking oil that is easily found and affordable. Waste cooking oil is the oil from cooking, based on the observations made at the Gadang Salero restaurant and the Arista Hotel Palembang, it is obtained the data that 40 liters of waste cooking oil is produced per each day which is a food frying oil, this matter if it is not processed and discarded carelessly it will become waste that can damage the environment.

Waste Cooking oil contains compounds that have carcinogenic properties that occur during the frying process. Continuous using of wasted cooking oil can damage human health, especially it causing a
cancer. So it needs a program to make waste cooking oil is more beneficial and does not cause harm for body health and the environmental aspects [2].

Using of waste cooking oil which is processed into biodiesel is also a way to reduce cesspool (waste cooking oil) which produces economic value and creates alternative fuels to replace diesel fuel. Biodiesel is a monoalkyl ester from long chain fatty acids contained in vegetable oils or animal fats to be used as diesel engine fuel.

Biodiesel can be obtained through triglyceride transesterification. Transesterification is an ester reaction to produce new esters that have exchanged fatty acid positions. Transesterification aims to break down and eliminate glycerides, reduce boiling, pour, flash point, and oil viscosity [3]. Transesterification reaction is influenced by internal factors and external factors. Internal factors are conditions derived from oil, such as water content, free fatty acids, and solutes / insoluble substances. External factors are conditions that are not derived from oil and can affect reactions, namely the molar ratio between triglycerides and alcohol, catalyst type, reaction temperature, water content, free fatty acids and stirring speed.

In the reaction of making biodiesel a catalyst is needed because in the absence of a catalyst the reaction tends to run slowly [4]. The catalyst has the function of reducing the activation energy of the reaction so that the reaction is faster. With a base catalyst the reaction can take place at room temperature but with an acid catalyst the reaction will work well at around 100°C. If without a catalyst, the reaction requires a minimum temperature of 250°C [5]. The grouping of catalysts based on the catalyst phase, reactants and reaction products are:

a. Homogeneous catalysts are catalysts that have the same phase as reactants and products. Homogeneous catalysts that are widely used in transesterification reactions are alkaline / alkaline catalysts such as potassium hydroxide (KOH) and sodium hydroxide (NaOH).

b. Heterogeneous catalysts are catalysts that have phases that are not the same as reactants and production. Types of heterogeneous catalysts that can be used in transesterification reactions are CaO and MgO.

The use of homogeneous catalysts such as NaOH and KOH has a higher catalyst ability compared to other catalysts. However, the use of this catalyst has the disadvantage that it is difficult to repair mixtures that can be reused and will eventually be wasted as waste that can pollute the environment. To overcome this, making biodiesel can be done using heterogeneous base catalysts such as CaO which can be produced from the Shells of Blood Clams. Calcium oxide (CaO) is a strong base oxide which has high catalytic activity so that it can be used as a catalyst for making biodiesel [6]. Therefore, in this research a comparison of the use of the CaO catalyst from the shell of a blood clam as a heterogeneous catalyst and also the use of the NaOH catalyst as a homogeneous catalyst against the yield of biodiesel produced.

2. Research Methods

The raw materials is used in this research are waste cooking oil obtained from hotels around the city of Palembang, methanol, NaOH, CaO, activated carbon, aquadest, and phenolphthalein indicators. The process of making biodiesel has been done of using a prototype of making biodiesel tools at the Energy Engineering Laboratory and biodiesel quality testing is carried out at the Sriwijaya State Polytechnic Chemical Engineering Laboratory. This research was conducted in March-July 2019.
The block diagram for making biodiesel can be seen in Figure 1.

![Block Diagram for Making Biodiesel](image)

**Figure 1.** The Block Diagram for Making Biodiesel

Prototype Biodiesel Processors can be seen in figure 2.

![Prototype Biodiesel Processors](image)

**Figure 2.** Prototype Biodiesel Processors
Biodiesel Analysis is carried out, that is:
1) Density testing
   Density testing was carried out using a pycnometer with the ASTM D 1298 method
2) Viscosity testing
   Viscosity testing was carried out using a Gilmont viscometer with the ASTM D 445 method
3) Flash point testing
   Flash point testing was carried out using a Pensky-Martens flash point tester with ASTM D 93 method
4) Testing the moisture content
   Water content testing is done using an oven with ASTM D 2709 method
5) Determination of acid numbers
   Acid number testing was performed using a biuret with ASTM D 664 method
6) Testing the heating value
   The heating value test was carried out using the Parr 6400 model calorimeter bomb

3. Result and Discussion

The results of the study the effect of the type and amount of NaOH and CaO catalysts from blood shells on biodiesel yield can be seen in Figure 3.

![Figure 3. The Effect of Type and Number of Catalysts on Yield of Biodiesel](image)

The optimum yield of biodiesel of 84.65% was obtained for the NaOH catalyst type with a catalyst amount of 1% w/w (3000 ml of waste cooking oil), while the lowest biodiesel yield of 31.31% was obtained for the CaO catalyst type with a catalyst amount of 0.5% w/w waste cooking oil. The effect of NaOH catalyst on the conversion of oil into biodiesel will decrease when the amount of NaOH catalyst is above 1% w/w of waste cooking oil because it can form a saponification reaction that can reduce the amount of waste cooking oil that is converted to biodiesel. But it is different from the use of CaO catalyst where the higher the amount of catalyst used, the higher the yield, this is because not all parts of CaO have been active as catalysts.

The effect of type and amount of catalyst on biodiesel density can be seen in Figure 4.
Density on the use of NaOH catalyst with an amount of 1% w/w 3000 ml of waste cooking oil with a value of 0.8540 gr / ml, this value is still within the standard range of SNI-04-7182-2015 biodiesel density which is 0.85-0.89 gr/ml and optimum density obtained on the use of CaO catalyst with an amount of 0.5% w/w 3000 ml waste cooking oil with a value of 0.8879 gr / ml. From the research data it can also be seen that if the amount of NaOH catalyst used exceeds 1%, the density value will increase while the use of CaO catalyst if the amount of catalyst used is more and more the density value will decrease. This is because NaOH and CaO are both alkaline strong but NaOH is included in a type of homogeneous catalyst that has a greater basicity effect on the working capacity of the catalysis, but the excess catalyst is easier to form soap as a byproduct of the reaction. This allows the presence of impurities such as glycerol as a reaction reaction, fatty acids that are not converted to methyl esters, water, potassium methoxide residual or residual methanol which causes biodiesel densities to be greater. Biodiesel with high density should not be used because it will increase engine wear, and cause damage to the engine.

The effect of type and amount of catalyst on the viscosity of biodiesel can be seen in Figure 5.

The viscosity value is influenced by the type of catalyst and the amount of catalyst used, where the lowest viscosity is obtained from the use of NaOH catalyst with an amount of 1% w / w 3000 ml of waste cooking oil with a value of 5.65 cSt, this value is still within the standard range of the viscosity of biodiesel SNI-04- 7182-2015 which is 2.3-6 cSt. and the highest viscosity was obtained with the use of CaO catalyst with an amount of 0.5% w / w 3000 ml of waste cooking oil with a value of 39.76 cSt. From the research data it can also be seen that if the amount of NaOH catalyst used exceeds 1%, the
viscosity value will increase. This is in accordance with the opinion of Dhiastama (2018), who said that the longer the carbon chain, the greater the viscosity value, therefore theoretically biodiesel which has a greater conversion value of methyl ester will have a smaller viscosity value. In the use of biodiesel, viscosity affects the transfer of fluid by pumps and atomization.

The effect of type and amount of catalyst on biodiesel acid number can be seen in Figure 6.

![Figure 6](image_url)

**Figure 6.** The Effect of Type and Number of Catalysts on Acid Number of Biodiesel

From the research data above it can be analyzed that only one sample that meets the Indonesian National Standard states that the minimum limit for acid numbers is 0.5 mgKOH / gr. The lowest acid number value is obtained at the amount of 1% w / w NaOH catalyst that is equal to 0.447 mgKOH / gr, this value has entered the Indonesian National Standard for acid number and the highest acid number value is obtained at the amount of 0.5% w / w CaO catalyst that is equal to 2.894 mgKOH / gr. From the above research data it can also be seen that if the use of NaOH catalyst exceeds 1%, the acid number will increase while the use of CaO catalyst if the amount of catalyst used is more, the acid number will decrease.

The Effect of type and amount of catalyst on biodiesel water content can be seen in Figure 7.

![Figure 7](image_url)

**Figure 7.** The Effect of Type and Number of Catalysts on Water Content of Biodiesel

Water content in NaOH catalyst with a catalyst amount of 1% w / w waste cooking oil is 0.048%, this value meets the Indonesian National Standard which states the maximum water content in biodiesel is 0.05%. Optimum water content is obtained in CaO catalyst with the amount of catalyst 1% w / w waste cooking oil is 0.604%. From the research data above it can also be seen that if the use of NaOH catalyst exceeds 1%, the water content will tend to increase while the use of CaO catalyst if the greater the amount of catalyst used, the water content tends to decrease. Basically the water content in waste cooking oil can trigger a hydrolysis reaction where the water will react with triglycerides in oil and form...
glycerol and free fatty acids. The phase of purification and washing of biodiesel that is imperfect can cause water to be bound or emulsified into biodiesel and can be difficult to separate or it can also be due to a lack of heating process so that not all washing water residual evaporates from biodiesel.

The effect of type and amount of catalyst on the flash point of biodiesel can be seen in Figure 8.

**Figure 8. The Effect of Type and Amount of Catalyst on The Flash Point of Biodiesel**

From the research data above it can be analyzed that all samples have met the Indonesian National Standard which states that the minimum flash point of biodiesel is at least 100°C. The lowest flash point was obtained on the use of NaOH catalyst type with the amount of catalyst 1% w / w waste cooking oil that is 167°C and the highest flash point was obtained on the use of CaO catalyst with the amount of catalyst 0.5% w / w waste cooking oil that is 220°C. From the research data above it can also be seen that if the use of NaOH catalyst exceeds 1%, the flash point will increase while the use of CaO catalyst if the catalyst is used with an increasing number, the flash point will decrease. This is because the flash point contained in biodiesel will decrease along with the transesterification reaction. When triglycerides react, they release bonds with glycerol and bind the alkyl from methanol.

The Effect of type and amount of catalyst on the Calorific Value of biodiesel can be seen in Figure 9.

**Figure 9. The Effect of Type and Amount of Catalyst on The Calorific Value of Biodiesel**

The Calorific value is a quantity or amount of heat both absorbed and released by an object. However, there is no specific standard set by SNI for the measurement of the biodiesel heating value. From the research data above it can be seen that the highest heating value is obtained on the use of NaOH catalyst with the amount of catalyst 1% w / w waste cooking oil which is 9757.7096 cal / gr while the lowest heating value is obtained on the use of CaO catalyst with the amount of catalyst 0.5% w / w waste...
cooking oil is 9087.579 cal / gr. From the research data above it can also be seen if the use of NaOH catalyst exceeds 1%, the heating value will decrease while the use of CaO catalyst if the catalyst is used more and more, the heating value will increase. This is inversely proportional to the density of the product, in other words the greater the density of the product, the calorific value will be lower, but conversely if the density of the product is smaller then the resulting heat value will be even greater. The heating value affects the rate of combustion. The higher the calorific value a fuel contains, the better the fuel is used for combustion. The effect is the power generated will be even greater. This heating value is determined in a standard test using a calorimeter bomb.

4. Conclusion and Suggestion

From the results of research on the means of making biodiesel made from waste cooking oil, it can be concluded that the optimum point of biodiesel that meets SNI 04-7182-2015 is the use of NaOH catalyst with the amount of catalyst 1% w / w 3000ml waste cooking oil that is with a yield value of 84.65%, density 0.8540 gr / ml, viscosity 5.65 cSt, acid number 0.447 mgKOH / gr, moisture content 0.048%, flash point 167°C, and calorific value 9757.7096 cal / gr. While the optimum point in the use of CaO catalyst is the amount of catalyst 2.5% w / w 3000ml waste cooking oil that is with a yield value of 58.57%, density 0.8740 gr / ml, viscosity 5.66 cSt, acid number 0.447 mgKOH / gr , moisture content 0.040%, flash point 179.6°C, and calorific value 9543.5214 cal / gr.

From the making of biodiesel that has been done, the researchers suggest that further biodiesel production is needed by adding variations in the type of catalyst and the amount of CaO catalyst.

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