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Production Biodiesel from Vegetable Oils Using Duck Egg Shell Catalyst

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ABSTRACT: Population growth causes energy needs to increase. Energy needs in Indonesia currently still depend on petroleum fuel. This research aims to determine the effect of the concentration of adding catalyst from egg shells on the production of biodiesel and determine the quality of biodiesel produced using egg shell catalyst. This research was carried out in 2 stages, namely catalyst preparation and the biodiesel manufacturing process. In catalyst preparation, egg shells that have been washed clean are then dried and crushed, then calcined using a furnace at a temperature of 1000°C for 7 hours. Next is the stage of making biodiesel using the conventional method which is carried out with variations in catalyst concentration of 1%, 2%, 3%, 4% and 5% (w/w). The research results showed that the best product yield was 78% at a concentration of 3% in 2 hours with a specific gravity of 0.889 gr/cm3 and a viscosity of 5.74 cSt.

KEYWORDS: biodiesel, catalyst, eggshell.

I. INTRODUCTION

Indonesia is a country that is in 4th place in the world with a large population. The large population causes energy needs to increase. Energy needs in Indonesia currently still depend on petroleum fuel. The availability of petroleum fuel is decreasing day by day, because petroleum energy sources cannot be renewed and sustainable [1]. To meet the needs of this energy source, it is necessary to have an alternative method, namely by using biodiesel. Biodiesel is an alternative diesel fuel produced from renewable sources such as vegetable and animal fats. As a diesel engine fuel, biodiesel has a high cetane number, has good lubricating properties and is environmentally friendly [2].

This interest in biodiesel means that research on biodiesel is growing rapidly. The target is to increase the rate of biodiesel production in accordance with SNI 04-7182-2006 standards. One of the test parameters that determines the quality of biodiesel is an ester content of at least 96.5% (% mass). Various methods have been used to increase the ester content in biodiesel, one of which is using a catalyst to speed up the reaction [3].

A catalyst is a compound that can speed up a reaction. In making a compound, homogeneous catalysts and heterogeneous catalysts are generally used [4]. So far, biodiesel synthesis has mostly used a homogeneous catalyst in the form of NaOH. The use of a homogeneous NaOH catalyst in making biodiesel has several disadvantages, including the formation of by-products in the form of soap, and the complexity of separating the biodiesel product produced using the catalyst. To overcome these weaknesses, the use of heterogeneous (solid) catalysts has begun to be developed to replace homogeneous (base) catalysts. Heterogeneous catalysts are very easily separated from the system at the end of the process or reaction and can be reused, with the use of heterogeneous catalysts, there will be no soap formation through neutralization of free fatty acids or saponification of triglycerides [5]. In the process of making biodiesel, it can be done using a catalyst such as CaO. This biodiesel uses a duck egg shell catalyst which is often found and is often considered waste [6]. Based on the existing mineral composition, egg shells are composed of the mineral CaCO3 (98.43%); MgCO3 (0.84%) and Ca3(PO4)2 (0.75%). CaCO3 can be converted into CaO through the calcination process. Therefore, it can be hoped that egg shells can be used as a source of CaO which has high purity so that it can act as a catalyst [4].

II. MATERIALS AND METODS

2.1. Materials

The raw material used in this research is coconut oil as a source of vegetable oil (Barco Co) in making biodiesel. Duck Egg Shell Waste taken from home industry, Methanol (purity: 96%), aquades and filter paper.

2.2. Equipment

The tools used in this research are: stirrer, pycnometer, ostwald viscometer, condenser, separating funnel, flat bottom reactor, erlenmeyer, measuring cup, beaker, funnel, dropper, thermometer, filter paper, burette, heater and socket.

2.2.1 Equipment Design

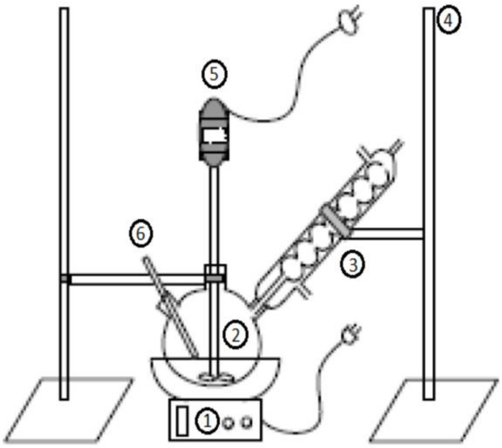

Figure 1. Series of biodiesel manufacturing equipment (1. heating mantel, 2. Reactor 3. condensor, 4. statif, 5. mixer, 6. thermometer)

2.3 Research Variables

2.3.1 Fixed Variables

a. Molar ratio 1:9 (mol)
b. Magnetic stirrer speed
c. Sample volume (25 ml)
d. Reaction Temperature 60 ºC
e. Atmospheric pressure atmosferic

2.2.2 Variables are not fixed

a. Catalyst concentration: 1; 2; 3; 4 and 5 (% gr/ml)
b. Reaction Time: 1; 1.5; 2; 2.5 and 3 (hr)

2.4 Methods

2.4.1 Preparation of CaO Catalyst from Egg Shells.

Wash the duck egg shells using water until clean and dry in the sun for 12 hours. then dried using an oven at 110 ºC for 10 hours. Next, the dried duck egg shells are blended until they become powder and filtered using a 200 mess sieve. Then calcined using a furnace at a temperature of 1000 ºC for 7 hours until a solid is formed.

2.4.2 Biodiesel Manufacturing Process

50 ml of coconut oil was heated in a three-neck flask for 30 minutes using a temperature of 60 ºC. Then 1% catalyst and 24 ml methanol were added and stirred using a magnetic stirrer for 1 hour. Then the product formed was transferred to a separating funnel and left for 6 hours. After separating the glycerol and biodiesel, the biodiesel is washed until there is no more glycerol. The biodiesel was then transferred into a petri dish and placed in the oven at 120 ºC for 1 hour. The above treatment was repeated for a catalyst concentration of 1%; 2%; 3%; 4% and 5%. Next, testing is carried out on the biodiesel product including density and viscosity.

III. RESULT AND DISCUSSION

3.1 Preparation of Egg Shells as a Catalyst

The physical characteristics of eggshells resulting from calcination at a temperature of 1000 ºC for 7 hours produce a slightly fine eggshell powder that is light white in color. Characterization of duck egg shell as a catalyst was carried out using a scanning electron microscopy (SEM) instrument. SEM is a type of electron microscope that is capable of producing high resolution images of a sample surface. Therefore, the images produced by SEM have qualitative characteristics in two dimensions because they use electrons as a substitute for light waves and are useful for determining the surface structure (morphology) of a sample [5](Mulder, 1996). The results of SEM analysis can be seen in the following Figure 2 :

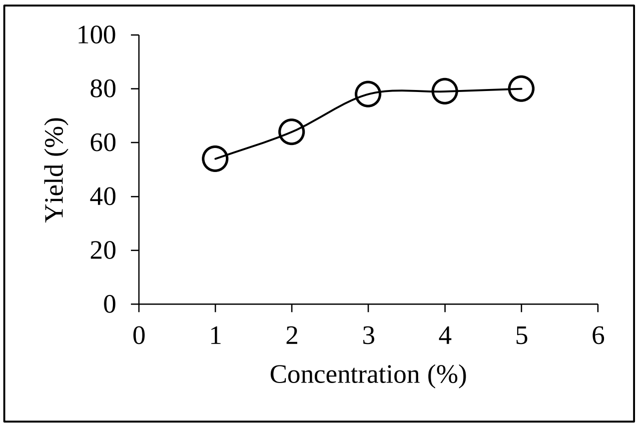

Figure 2. SEM test results with 5000 times magnification

From Figure 2 above, it can be seen that the calcined egg shells that are formed have sizes that reach the micrometer scale, have a non-uniform shape and are also partially aggregated. In this research, it was also carried out using the Brunauer Emmett Teller (BET) instrument. This BET analysis aims to determine the active surface area of the calcined eggshell catalyst. The results of the BET analysis can be seen in Figure 4 regarding the relationship between volume at standard conditions (STP) and relative pressure. The volume under these conditions determines the number of gas molecules adsorbed by the solid catalyst, in this case the gas used is 26.06 g nitrogen. The gas used is nitrogen because nitrogen gas is inert so it does not disturb the condition of the catalyst. Based on the results of the analysis carried out, the surface area of the calcined egg shell was 90,970 m²/g.

3.2 Effect of Catalyst Addition Concentration

Biodiesel is made through a transesterification reaction by mixing coconut oil with the help of a catalyst [1]. The use of a homogeneous base catalyst is still found to be a weakness due to the mixing of the biodiesel product and the catalyst after the reaction process is complete [2]. In this research, a process for making biodiesel was developed using egg shell waste as a catalyst. The eggshell catalyst activity test was carried out with eggshell catalyst concentrations of 1%, 2%, 3%, 4% and 5%, resulting in a % yield which can be seen in Figure 3.

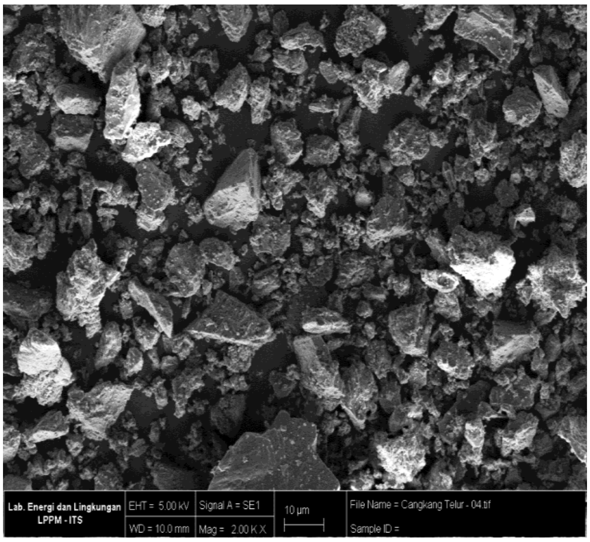

Figure 3. Effect of Catalyst Addition Concentration on Yield

Figure 3 above shows that by adding 1% catalyst the resulting biodiesel yield was 54%, 2% catalyst was 64%, 3% catalyst was 78%, 4% catalyst was 79% and 5% catalyst was 80%. This shows that variations in catalyst addition greatly influence the increase in yield of biodiesel because more catalyst will increase the activation energy, thereby increasing the number of activated molecules which causes the reaction speed to increase [6]. It can be seen that the smallest yield is at an addition concentration of 1% eggshell catalyst and the largest is at an addition concentration of 3%.

3.3 Effect of Reaction Time on Biodiesel Yield

Figure 4 shows the relationship between heating time and product yield. From this figure it can be seen that the yield of biodiesel products increases with increasing heating time. The range of yield values in this research for catalysts is 76% - 92%. The increase in biodiesel yield obtained based on the specified time variation indicates that the specified time range is still within the limits where there has been no decrease in yield as the reaction time increases. When biodiesel is made with a longer reaction time, the biodiesel conversion results obtained decrease, this is because the transesterification reaction is a reversible reaction, where after reaching the optimum point the reaction will shift towards the reactants [7].

When viewed from the reaction time, the method used in this research is much more effective with reaction times in minutes, compared to conventional processes which still require reaction times in hours. In terms of catalysts, heterogeneous catalysts provide relatively good results compared to homogeneous catalysts. Apart from being cheaper, heterogeneous catalysts are also easier to separate and can be reused for subsequent processes [8,9].

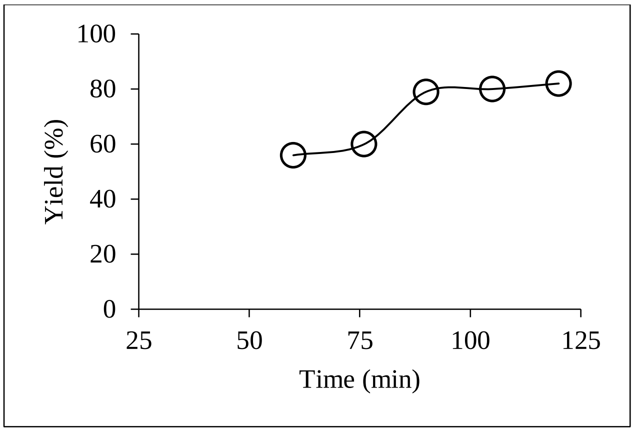

Figure 4. Effect of time on obtaining biodiesel yield

Figure 4 shows the relationship between heating time and product yield. From this figure it can be seen that the yield of biodiesel products increases with increasing heating time. The range of yield values in this research for eggshell catalysts is 56% - 82%. The increase in biodiesel yield obtained based on the specified time variation indicates that the specified time range is still within the limits where there has been no decrease in yield as the reaction time increases. When biodiesel is made with a longer reaction time, the biodiesel conversion yield obtained decreases, this is because the transesterification reaction is a reversible reaction, where after reaching the optimum point the reaction will shift towards the reactants [10].

3.4 Effect of Concentration on Biodiesel Density

According to the Indonesian National Standard (SNI 7182-2015), the density of biodiesel at a temperature of 40oC which meets the standard is 0.887-0.896 gr/ml. Based on the data produced for the various variations in catalyst concentration that have been carried out, it can be concluded that the biodiesel produced meets the SNI 7182-2015 standard for biodiesel density standards. Figure 5 shows the effect of catalyst concentration on the density of the biodiesel produced which can be seen as follows:

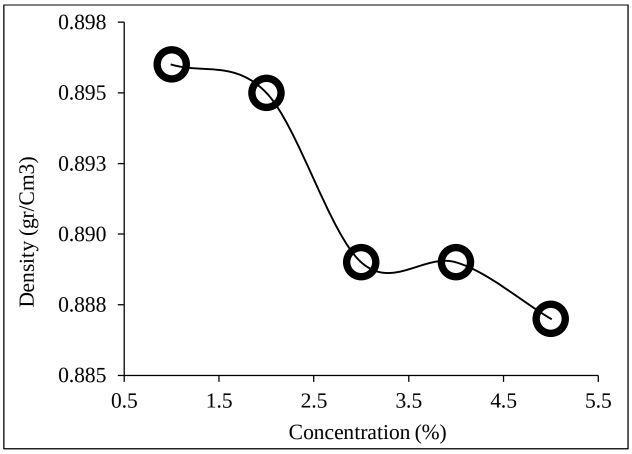

Figure 5. Effect of concentration on the density of biodiesel products

It can be seen in Figure 5 above that the density measurement is a measurement that shows the weight per unit volume. If biodiesel has a density that exceeds the provisions, an imperfect reaction will occur in the conversion of vegetable oil. In this study, the results of biodiesel density measurements for the addition of shell catalyst with a concentration of 1% were 0.896 gr/cm3, a 2% concentration was 0.895 gr/cm3, a 3% concentration was 0.889 gr/cm3, a 4% concentration was 0.889 gr/cm3 and a concentration of 5 %, namely 0.887gr/m3. It can be concluded that what meets the density and viscosity quality requirements according to SNI Biodiesel 04-7182-2006 is the shell catalyst addition concentration of 3%.

3.5 Effect of Concentration on Viscosity of Biodiesel Products

The viscosity of a fuel in a diesel engine also indicates the lubrication or lubrication properties of the fuel, where fuel with a relatively high viscosity will have good lubrication properties. Another influence of this characteristic is the ability of diesel fuel to atomize when injected into the combustion cylinder. Fuels with relatively lower viscosity will atomize easily. So diesel fuel should have a relatively low viscosity so that it flows more easily and atomizes more easily. However, a fuel also requires good lubrication properties to prevent engine wear so that there is a minimum limit for the viscosity value of the fuel [9,11,12]. Figure 6 shows the relationship between heating time and the viscosity of the resulting biodiesel product

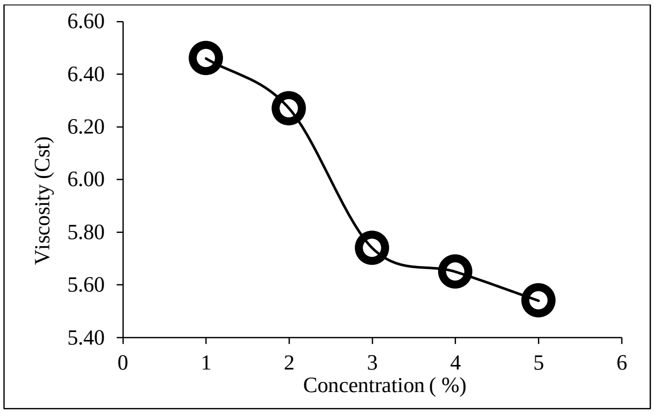

Figure 6. Effect of concentration on the viscosity of biodiesel products

From the Figure 6. It can be seen that the analysis data for the viscosity of biodiesel with egg shell catalyst ranges between 5.54-6.46 cSt. The viscosity of the biodiesel product was measured using an Ostwald viscometer at a temperature of 40oC according to SNI 7182-2015 standards. Indonesian National Standard (SNI 7182-2015) biodiesel viscosity at a temperature of 40 ºC which meets the standard is 2.3-6.0 cSt. Based on the data produced for the various time variations that have been carried out, it can be concluded that the biodiesel produced meets the SNI 7182-2015 standard for biodiesel viscosity standards at a concentration of 3%, namely 5.74 cSt. This biodiesel viscosity value can affect the performance of the engine and its emission characteristics. The higher the viscosity value causes the increased energy requirements required for the pump and fuel injection [13,14,15].

IV. CONCLUSION

Based on the results of the research that has been carried out, it can be concluded that duck egg shells can be used as raw materials in making catalysts and egg shell catalysts can be used in vegetable oil transesterification reactions, the effect of increasing the catalyst concentration in making biodiesel on obtaining increased biodiesel product yields and the best conditions at a concentration of 3% with a yield of 78%, while the characteristics of the biodiesel product yield as a quality requirement in accordance with SNI standards are a density of 0.889 gr/cm3 and a viscosity of 5.74 cSt.

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