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Conversion of Used Cooking Oil into Biodiesel Using Lignite Coal Catalyst with the Assistance of Chemical Ultrasonography

Mustafa[1], Muh. Irwan[2]
[1,2]Department of Chemical Engineering, Politeknik Negeri Samarinda, Samarinda, Kalimantan Timur, Indonesia, 75131
Email address: mustafa@polnes.ac.id

***Abstract*— *Repeated use of cooking oil can produce used cooking oil or waste that can hurt consumers and have a negative impact on the environment. Therefore, to overcome this, a study was conducted to convert used cooking oil into biodiesel using low-grade coal catalysts with the help of ultrasonic waves. The purpose of this study was to determine the quality of biodiesel produced from the conversion of used cooking oil using low-grade coal catalysts with the help of ultrasonic waves. Biodiesel was obtained by reacting oil: methanol (1: 3) with a transesterification process for 35 minutes with temperature variations of 40, 45, 50, 55, and 60℃ by adding 6 grams of low-grade coal catalyst with the help of ultrasonic waves that have a frequency of 40kHz. The results of this study obtained biodiesel with the highest yield of 91.38% at a temperature variation of 50℃ with characteristics of a density of 40℃ of 877.2 kg/m3, a kinematic viscosity of 40℃ of 5.35 cSt, a water content of 0.040% and an acid number of 0.45 mg KOH/g and a meth ester content of 99.36%. In general, the biodiesel produced has met SNI 7182:2015.*

***Keywords*— *Low-rank coal, biodiesel, ultrasonic waves, used cooking oil*.

I. INTRODUCTION

Cooking oil is one of the basic needs of Indonesian people to process food to get a savory and crispy taste. Some people use cooking oil only for one use, and some use cooking oil many times [1]. People who cook and consume fried food using used cooking oil are at higher risk of developing high blood pressure compared to people who often change their cooking oil for cooking [2]. In addition, some people dispose of used cooking oil waste directly which results in environmental damage. Therefore, efforts are needed to convert used cooking oil waste into something useful, one of which is converting used cooking oil into biodiesel. Biodiesel is an alternative fuel to replace diesel from renewable sources such as vegetable oil and animal fat [3]. Biodiesel is produced from the transesterification process with raw materials of vegetable oil or animal fat which is reacted with alcohol compounds such as methanol and a catalyst is added to increase its conversion. In producing biodiesel, one aspect that plays an important role is the use of catalysts in the triglyceride transesterification reaction. In general, biodiesel is produced using homogeneous catalysts such as NaOH, but the use of this homogeneous catalyst has the disadvantage that it is difficult to separate from products that are sensitive to free fatty acids and water contained in the oil and can easily form soap that can interfere with biodiesel processing compared to heterogeneous phase catalysts, so the use of heterogeneous catalysts is one solution that can be used to overcome the shortcomings of homogeneous catalysts [4]. One example of a heterogeneous catalyst is low-rank coal (lignite). Coal is one of Indonesia's natural resources. Coal has a complex combination of carbon, oxygen, and other organic compounds containing hydrogen. According to the Ministry of Energy and Mineral Resources (2021), Indonesia's coal reserves reach 36 billion tons, especially in the Kalimantan region, which is 23.76 billion tons of the total coal in Indonesia. However, the quality of Indonesian coal is generally dominated by low-rank coal (lignite) which has a value of around 33.93% of the total available resources. In the biodiesel production process in general, it can be made more efficient by using production technology that is currently being widely studied, namely the use of ultrasonic wave assistance. The use of ultrasonic waves can reduce the energy used for the heating and stirring process [5]. The help of ultrasonic waves is one way that can be done to speed up the reaction time and increase the yield of biodiesel [6].

II. RESEARCH METHODS

Research Tools and Materials

The tools used in this study were: aluminum foil, 200 mesh sieve, 100 mm buchner, blender, bulb, burette, petri dish, porcelain cup, glass funnel, separating funnel, plastic funnel, crusher, Erlenmeyer, furnace, GC-MS, beaker, hot plate, digital scale, oven, pycnometer, dropper pipette, measuring pipette, vacuum pump, cloth filter, one set of ultrasonic tools, spatula, Stand & clamp, thermometer, tray, 1000 mL vacuum filter flask, and Ostwald viscometer. The materials used in this study were: distilled water, lignite coal, 96% p.a. ethanol, PP indicator, 0.1 N NaOH solution, 96% technical methanol, used cooking oil.

Research Path

If you are using This research was conducted in the basic laboratory of the Chemical Engineering Department of Samarinda State Polytechnic the Analytical Chemistry Laboratory of the Plantation Product Processing Technology Department of Samarinda Agricultural Polytechnic and the Instrument Laboratory of Alauddin State Islamic University Makassar. Testing the characteristics of lignite coal catalysts was carried out in the basic laboratory of the Chemical

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Engineering Department of Samarinda State Polytechnic and the Analytical Chemistry Laboratory of the Plantation Product Processing Technology Department of Samarinda Agricultural Polytechnic. The coal catalyst was first activated and then its characteristics were tested. For testing, used cooking oil and biodiesel were analyzed in the Instrument Laboratory of Alauddin State Islamic University Makassar.

III. Results and Discussion

TABLE 1. Analysis of Used Cooking Oil

No	Parameters	Analysis Results
1.	Free Fatty Acid Content	0.5865
2.	Density 40°C	923.9
3.	Viscosity 40°C	16.91
4.	Water Content	0.7393
5.	Acid Number	1.0975
6.	Color Analysis	Yellow Brown

TABLE 2. Analysis of Biodiesel Characteristics Variation in Temperature

No	Parameter	Biodiesel Analysis Results					SNI 7182 :2015
		Temperature 40°C	Temperature 45°C	Temperature 50°C	Temperature 55°C	Temperature 60°C	
1	Density 40°C, kg/m3	892.7	885.6	877.2	883.1	878.0	850-890
2	Kinematic Viscosity 40°C, cSt	7.83	6.78	5.35	8.34	7.27	2.3-6.0
3	Water Content, % (v/v)	1.62	1.65	0.040	0.60	0.72	0.05
4	Acid Number, mg KOH/g	0.56	0.65	0.45	0.90	1.10	0.5
5	Yield, %	89.52	81.95	91.38	73.45	87.82	-
6	Color Analysis	Normal	Normal	Normal	Normal	Normal	Sample Color Yellow

Table 2 shows the results of the analysis of the characteristics of used cooking oil on the parameter of the free fatty acid content of 0.53% where the free fatty acid content is less than 1%, so the manufacture of biodiesel is carried out in one stage of the process, namely transesterification. The transesterification reaction is a reaction known as an alcoholic reaction. In addition to producing alkyl esters as the main product, the transesterification reaction also produces a by-product of glycerol [7]. In this reaction, an oil: methanol ratio of 1: 3 is used which refers to research [8] by adding a catalyst in the form of low-rank coal that has been activated at a temperature of 900 °C for 2 hours. The activated catalyst is then used in the transesterification reaction which lasts for 35 minutes with varying temperatures, namely 40, 45, 50, 55, and 60 °C.

Effect of Transesterification Temperature on Biodiesel Yield

The variation of transesterification temperature, namely 40, 45, 50, 55, and 60°C in the transesterification reaction, affects the amount of oil produced as shown in Figure 1:

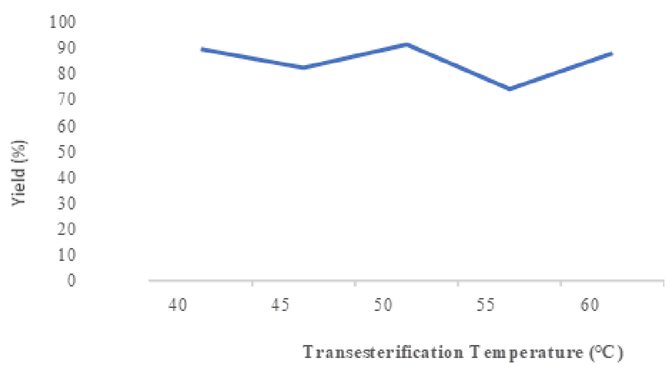

Figure 1.

Based on Figure 1, temperature variations in the transesterification reaction show an increase in the yield produced, where the highest yield was obtained at a temperature of 50°C, which was 91.38%. According to [9], increasing the temperature in the transesterification reaction will increase the kinetic energy of the reactants so that it will increase the amount of oil. which is converted into biodiesel.

The greater the oil converted into biodiesel, the yield of biodiesel also increases. However, at temperatures of 55 and 60°C the yield of biodiesel produced decreases which may occur due to the type of catalyst used, reaction time, water content, free fatty acid content, soap content [10] and according to [11], a decrease in yield can occur due to the formation of an emulsion which increases viscosity and causes gel to form.

Effect of Transesterification Temperature on The Characteristics of The Biodiesel Produced

The quality of the biodiesel produced can be seen in table 2 with analysis parameters including density 40°C, kinematic viscosity 40°C, water content, acid number, and color. For variations in transesterification temperature with the highest yield at 50°C, additional analysis was carried out in methyl ester content to determine the biodiesel methyl ester produced.

Based on table 2, the biodiesel density obtained ranges from 877.2-892.7 kg/m3. These results have met the density standards in SNI 7182:2015, namely between 850-890 kg/m3, except at a temperature of 40°C the resulting density exceeds SNI 7182:2015 which is possibly caused by used cooking oil which has not been converted perfectly. According to [2], biodiesel with appropriate density SNI is able to produce perfect combustion.

Meanwhile, based on table 2, the kinematic viscosity of biodiesel obtained ranges from 6.85 to 12.34 CST. These results do not meet the kinematic viscosity standards in SNI 7182:2015, namely between 2.3-6.0 cSt. According to [12], high viscosity is caused by the fact that optimal conditions for converting used cooking oil into biodiesel have not been achieved and the refining process has not been completed, in addition, according to [13], high viscosity is because used cooking oil has not undergone a refining process, where the higher the viscosity, the thicker and more difficult it is for the material to flow.

Furthermore, in table 2 the biodiesel water content obtained ranges from 0.60-1.65%. These results do not meet the water content standard in SNI 7182:2015, namely 0.05%. High water content can be caused by an incomplete evaporation process. According to [14], the water content does not meet SNI due to a lack of purification process by heating and when washing the biodiesel there is quite a long contact with water, causing the water content to be high.

Meanwhile, based on Table 4.2 the acid number obtained ranges from 0.44-1.90 mg KOH/g. These results do not meet the acid number standard in SNI7182:2015, namely 0.5mgKOH/g, except at a temperature of 50℃ which meets SNI7182:2015. According to [15], the high acid number in biodiesel indicates the presence of free fatty acids remaining. High acid numbers can cause corrosion in diesel engine fuel tanks [16].

From the discussion above, it can be concluded that the reaction in the transesterification process produces a biodiesel product whose characteristics and yield have been tested. Therefore, optimal biodiesel product analysis results were obtained at a temperature of 50℃. Then, the biodiesel product is tested for methyl ester content at a temperature of 50℃ using a GC-MS instrument.

Methyl Ester Content at Transesterification Temperature 50℃

The biodiesel produced is then analyzed using a GC-MS instrument. The aim is to determine the components contained in the biodiesel and the quantity of each component by producing spectrometer peaks, each of which indicates the type of methyl ester shown in Figure 2.

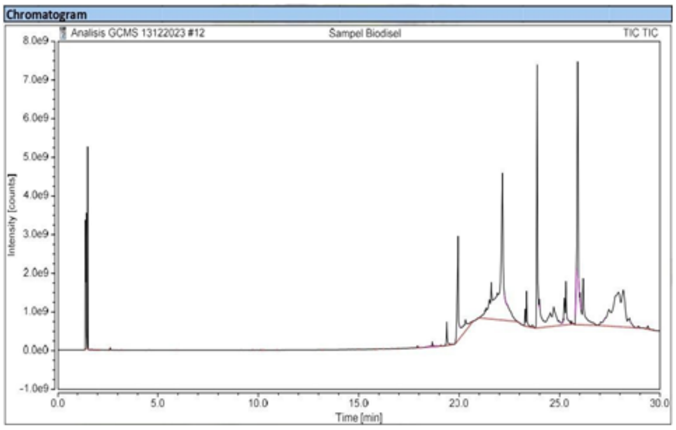

Figure 2 Chromatogram of Methyl Ester at 50℃

Next, each peak in Figure 2 further identified with a mass spectrometer, in which each compound has a specific peak. The highest result was obtained at a retention time of 25,899, methyl ester was obtained at 19.75%. Then at a retention time of 22,158, methyl ester was obtained at 5.49%. Furthermore, at a retention time of 19,947, the methyl ester yield was 2.88% and at a retention time of 19,379, the methyl ester yield was 0.78%. Meanwhile, at a retention time of 23,886, the highest results were obtained for impurities in the form of glycerol esters at 9.62%.

Based on GC-MS analysis, the resulting biodiesel has 99.63% methyl ester. This means that the methyl ester meets SNI 7182:2015, namely a minimum of 96.5%. The results obtained show that almost all triglycerides are converted into methyl esters. As is known, glycerol is a by-product resulting from the transesterification process, so glycerol must be separated from methyl ester to improve the purity of the methyl ester obtained.

IV. Conclusion

The results obtained in this study were biodiesel with a temperature of 50 ℃ where the yield obtained was 91.38%. The quality of the biodiesel produced was: density 40 ° C: 877.2 kg / m3, kinematic viscosity 40 ° C: 5.35 cSt, water content: 0.040%, acid number 0.45 mg KOH / g, and methyl ester content: 99.63% At a temperature variation of 50 ℃, the quality of biodiesel was produced with test parameters of density 40 ℃, -Kinematic viscosity 40 ° C, Water content, acid number and methyl ester content met SNI 7182: 2015. Therefore, at temperature variations of 40, 45, 55, and 60 ℃, the quality of biodiesel was produced with test parameters that met the SNI 7182: 2015 standard.

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