Physical Properties of Nyamplung Oil (*Calophyllum inophyllum L*) for Biodiesel Production

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Abstract. Worldwide energy crisis due to the too high of energy consumption causes the people trying to find alternative energy to support energy requirements. The use of energy from environmentally friendly plant-based materials into an effort to assist communities in sufficient national energy needs. Some processing of Nyamplung (*Calophyllum inophyllum L*) oil production is drying and pressing to produce crude oil. Degumming process is then performed to remove the sap contained in the oil. The next process is to remove free fatty acids (FFA) below 2% that can cause corrosion on the machine when in use. The results performed of the density properties quality to produce oil that appropriate with the international standards by time variation of catalyst. The result was obtained the density value of 0.92108 gr/cm³ at the time of 3 hours by trans-esterification process, and the best yield value was measured at 98.2% in 2 hours stirring of transesterification.

1. Introduction

The use of oil energy has become a huge need, which is could a trigger of global crisis. Most of oil energies are generally derived from petroleum of fossil material, that causes environmental pollution. Attempts to produce alternative energy derived from plants or vegetable, it is able to develope domestic energy oil especially for environmentally friendly. The contribution of renewable energy to total energy usage is still below 1%[1,2]. Therefore, there should be increased by using renewable energy from plant materials. In Indonesia, the plant of Nyamplung (*Calophyllum inophyllum L*) is one alternative biodiesel feedstock potentially quite large. Biodiesel is commonly produced by triglycerides from the vegetable oils or animal fats. In this research biodiesel is produced from *Calophyllum inophyllum* oil. The advantages of this biodiesel as an alternative fuel to substitute the diesel oil which is high cetane number, environmentally friendly because it contains little of SOx gas, which is a good lubricating power, exhaust emissions are few and relatively clean burning character. In addition to these advantages, the use of biodiesel also provides benefits to machine maintenance [3].

This research observed the biodiesel derived from Nyamplung material. This plant is easy to grow in tropical area especially in Indonesia [4]. The issues faced of vegetable oil research are: How to generate a high yield of oil, reducing the levels of free fatty acids that could produce lathering and inflict the corrosion in machine. Increase the caloric value of fuel or the vegetable oil, and measurement of physical properties such as viscosity, and density, and yield by time variations of catalyst to obtain results in accordance with the standards that have been established nationally and internationally [5]. In this research, the quality of oil will be improved to meet the international standards by varying of catalyst during processing.
2. Material and Method

The process of producing Nyamplung seeds into oil biodiesel in this study conducted in several stages, namely: the process of drying and pressing using a pressing machine with strong of 10 tons pressure to remove oil. Furthermore, the screening process or degumming process is to separate the oil from the sap (gum) contained in nyamplung oil consisting of phosphatides, protein, carbohydrate residues, water and resin, and to reduce the free fatty acid.

2.1. Degumming Process

A 500 ml Nyamplung oil is heated on a hot plate to a temperature of 65°C, then added 85% of phosphoric acid by amount of 5% (v/v) from the total of Nyamplung oil, and stirred for one hour. Subsequently, the mixture is allowed to stand for one night, then decanted. Oil obtained from the degumming, then washed with hot water at a temperature of 70°C until the pH of the waste water from the washing process is neutral. The neutralization of oil was heated at 100°C for 15 minutes, then calculated the weight and the levels of free fatty acids (FFA).

2.2 Esterification Process

A number of 50 ml of Nyamplung oil is inserted to a double-mouthed 500 ml of Erlenmeyer flask. Methanol is added with a mole ratio of 20: 1 (w/w) and 10% HCl for oil. Double-mouthed pumpkin mounted to condense the methanol vapor to enter back into the Erlenmeyer. The reaction was performed at 60°C with stirring 300 rpm for 1 hour. After the esterification process is complete, the mixture is put in a test tube, deposited for 8 hours and then measured the levels of FFA on the bottom layer by titrating using NaOH with a concentration of 0.1 N, the indicators used in this titration is PP 0.1%, the indicator as much as 3 drops and titration stopped after the entire color of solution was pink.

2.3 Trans-Esterification Process

A total of 200 ml of oil nyamplung esterification results is poured to the double-mouthed and added methanol at mole ratio of 6: 1 and dissolved by 0.5% NaOH in double mouth flask mounted on the condenser to condense the methanol vapor in order to back into the Erlenmeyer. The reaction is conducted at a temperature of 60° C with stirring 400 rpm for 1, 2 and 3 hours. After the transesterification process is complete, the mixture is inserted in the separating funnel, then deposited for 12 hours. After that the glycerol will settle on the bottom of the separating funnel, so it is easy to be separated. Biodiesel that is formed, then washed with hot water until pH neutral and dried by heating at a temperature of 80° C with vacuum for 20 minutes followed by vacuum drying at a temperature of 90° for 10 minutes.

2.4 Density and Yield Measurement

Measurement of density is using 5ml Pycnometer. The procedure for measuring the density is weighed the empty pycnometer and then filled with biodiesel, if its density is just right volume, pycnometer is closed, and weighing the mass of pycnometer was contained biodiesel. Furthermore, calculate the mass of the fluid that is inserted by subtracting the mass of biodiesel in pycnometer with the mass of empty pycnometer, then count the density of biodiesel by using formulation of $\rho = m / v$. Where $\rho$ is the density of biodiesel in (gr/Cm$^3$), mass (m) in gram, and volume (v) in cm$^3$. Furthermore, the Yield (%) measurement is done by value of biodisel (gr) devided by cude oil mass (gr). The value of density and Yield are the two of important physical parameters of biodiesel.

3. Results and Discussion

Nyamplung oil obtained by using the trans-esterification processes to reduce the FFA content until below 2%. If the first esterification process has not FFA less than 2%, then the esterification process repeat again until meet FFA< 2 %. The results of these processes in this experiment can be seen in Table 1.

Table 1. FFA content of Nyamplung oil after Degumming and esterification process.

| No  | Processing     | FFA   |
|-----|----------------|-------|
| 1   | Degumming      | 4.08% |
| 2   | Esterification 1| 2.18% |
| 3   | Esterification 2| 1.17% |
After second esterification process, we can found that FFA of Nyamplung oil is 1.17%. This is meet the criteria for producing biodiesel.

Table 2 shows the measurement results of mass biodiesel of Nyamplung oil. In this case, the empty pycnometer was adjusted to 11.4439 gram with volume solution of 5 mL.

| No | Biodiesel Solutions | Mass of Pycnometer and Biodiesel (gr) | Mass of Biodiesel (gr) |
|----|---------------------|---------------------------------------|------------------------|
| 1  | Aquades as control  | 16.4807                               | 5.0308                 |
| 2  | Sample 1            | 16.0394                               | 4.5955                 |
| 3  | Sample 2            | 16.0413                               | 4.5974                 |
| 4  | Sample 3            | 16.0493                               | 4.6054                 |

Sample 1 is biodiesel at trans-esterification processing time of 1 hour
Sample 2 is biodiesel at trans-esterification processing time of 2 hours
Sample 3 is biodiesel at trans-esterification processing time of 3 hours

The density \( \rho \) is calculate by using equation,

\[
\rho = \frac{m}{v}
\]  \hspace{1cm} (1)

where \( m \) is mass, \( v \) is volume and aquades as a control. The aquades density is \( \rho_{\text{aquades}} = \frac{5.0308}{5} = 1.00736 \text{ gr/cm}^3 \). While, density of biodiesel from trans-esterification processing time of 1 hour is calculated as follow:

\[
\rho_1 = \frac{4.5955}{5} = 0.9191 \text{ gr/cm}^3
\]  \hspace{1cm} (2)

The density of biodiesel resulted from trans-esterification processing time of 2 and 3 hours is shown in Figure 1.

![Density of biodiesel with variation time of trans-esterification process.](image)

From Figure 1 above we can see that the highest density was 0.92108 gr/cm³ (trans-esterification time of 3 hours). For trans-esterification time of 1 and 2 hours, the density obtained almost same. This reveals that time of transesterification process can affect the properties of biodiesel. However, the density biodiesel obtained in this research exceed than the standard for biodiesel (ISO standards) which has density from 0.85 to 0.89 g / cm³.
The results also suggest that time of trans-esterification process should not exceed than one hour to meet the standard. Furthermore yield of trans-esterification process was measured. It found that the highest yield obtained at trans-esterification time of 2 hours which is 98.2%. The yield for 1 and 3 hour are 94.8% and 97.7% respectively. This result suggests that the most effective time of transesterification processing of Nyamplung biodiesel is 2 hours.

4. Conclusion

Experiment for produce biodiesel from biooil of Namplung was successfully performed. The free fatty acid (FFA) can be reduced to 1.17% after two step esterification. This biooil was used in transesterification process to measure the density of Nyamplung biodiesel. There found that the highest yield is 98.2% from 2 hours in transesterification. These results indicate the most effective time to produce biodiesel at the condition. It suggests that Nyamplung is good for biodiesel raw material.

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