The Production Of Biodiesel From A Traditional Coconut Oil Using NaOH/γ-Al2O3 Heterogeneous Catalyst

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Abstract : Biodiesel is an alternative energy fuel a substitute for diesel oil produced from vegetable oil or animal fat which has the advantage of being easy to use, because they are biodegradable, not toxic and sulfur free. This research aims to do a process of producing biodiesel using base catalysts (NaOH/γ-Al2O3) for a transesterification process with the variation of catalyst concentration (1%; 2%; 3%; 4% and 5%) and the time (60; 120; 180; 240 and 300). The production of biodiesel from coconut oil is making by the ratio of oil mass: ethanol = 1:2. Research of methodology started with the analysis of the material, the process of making the NaOH/γ-Al2O3 catalysts and transesterifications for biodiesel production. The product was analyzed by viscosity, density, and GC-MC to identify the fatty acid methyl esters composing the biodiesel. In conclusion, the best conversion of biodiesel from coconut oil using NaOH catalyst is 3% concentration with a 180 minutes reaction time.

Keywords : Biodiesel; Coconut oil; NaOH/γ-Al2O3; Transesterification

1. Introduction

Energy is a primary human need. This is an important key in economic sectors such as food, industry, transportation, agriculture, and power generation. Fuel and energy crisis and the concern of the society for the depleting world’s non-renewable energy resources led to a renewed interest in the quest for alternative fuels. Biodiesel is a liquid fuel similar to petroleum diesel in combustion properties, but essentially free of sulfur, making it a cleaner burning fuel than petroleum diesel. Biodiesel is derived from renewable energy sources, such as vegetable oils and animal fats. It has similar physical and chemical properties with petro-diesel fuel. However, biodiesel properties can sometimes be superior than that of petro-diesel fuel because the former has higher flash point, ultra-low sulfur concentration, better lubricating efficiency, and better cetane number.

Both, non-saturated fatty acids contents of vegetable oils, such as: coconut oil, palm, soybean, rape-seed, woody oils and the like, can be converted into fuels. Coconut oil as other vegetable oils are compounds consisting of various kinds of triglyceride fatty acids and about 90% are saturated fatty acid compounds. Coconut oil is rich in fatty acids are chain (C8-C12), especially lauric acid and myristic acid. Coconut oil as a raw material has advantages than other vegetable oils, it contains medium chain fatty acids about 70% making it possible to obtain other fuels such as kerosene or jet fuel. Coconut has industrial and domestic uses of its different parts. The oil and milk extracts from coconut are commonly used in cooking and frying. The oil is widely used in making soaps and cosmetics. In order to diversify the use of the oil on one hand and finds its suitability as alternative for diesel engine on the other hand, it is therefore characterized, which is the main aim of this research work.
The conventional catalysts for transesterification reaction are homogeneous acids (such as H₂SO₄) and homogeneous strong bases (such as alkali metal hydroxides and alkoxides). However, basic catalysts are generally corrosive to equipment and also react with free fatty acid to form unwanted soap as by-products that require expensive separation. Homogeneous acid catalysts are difficult to recycle and operate at high temperatures, and also give rise to serious environmental and corrosion problems. Enzymes or lipases are naturally occurring substances. They have excellent catalytic activity and stability in non-aqueous media, which facilitate the esterification and transesterification process during biodiesel production. Enzyme-based transesterification is carried out at moderate temperatures with high yields, but this method cannot be used in industry today due to high enzyme costs, and the problems related to its deactivation caused by feed impurities. Therefore, to overcome all these problems including cost, people are working on the development of economically viable as well as ecofriendly solid catalysts for biodiesel industries.

As mentioned above, the disadvantages of homogeneous base-catalyst transesterification are high energy-consumption, costly separation of the catalyst from the reaction mixture and the purification of crude BDF. Therefore, to reduce the cost of the purification process, heterogeneous solid catalysts such as metal oxides, γ-alumina, hydrotalcites, and zeolites, have been used recently, because these catalysts can be easily separated from the reaction mixture, and can be reused. Most of these catalysts are alkali or alkaline oxides supported on materials with a large surface area. Similar to homogeneous catalyst, solid base-catalysts are more active than solid acid-catalysts.

The catalyst support used γ-Al₂O₃. Gamma alumina (γ-Al₂O₃) is used as a catalyst support because it has a large surface area (150-300 m² / g) also has an amphoteric acid and base active side with different strengths depending on the method of making it. In addition, γ-Al₂O₃ has the main function of providing a surface area for the active component which aims to extend the contact between the active nucleus and the reactants without reducing the active phase activity of the active phase.

In this study, transesterification was used to produce biodiesel. The conventional method, process where all the vegetables oil, solvent and catalyst are mixed in one phase to get a higher yield of methyl ester. In this process, alcohol reacts as a reagent for transesterification.

2. Material and Method

Vegetable oils used are coconut oil traditionally produced. The ethanol used is technical ethanol (96%) was purchased from a local chemical supplier (Makassar). NaOH, p.a MERCK, (in purity: 99 %) and Alumina, p.a MERCK, (in purity: 99 %) was obtained from a local chemical supplier.

2.1. Preparation of Catalyst

Preparation of the catalyst was prepared by making 10% NaOH solution with aquadest. 5 ml of solution is poured into 5 gr of γ-Al₂O₃ acting as a catalyst support. The mixture is stirred for 30 minutes. The solid was dried overnight in the oven at 100°C and calcined in air at 550°C for 3 hours.

2.2. Transesterification and Reaction

Coconut oil is fed into the reactor and a mixture of ethanol and NaOH/γ-Al₂O₃ is added. The mass ratio of oil to ethanol is 1: 2 and the basic catalysts used for the reaction are 1%, 2%, 3%, 4%, and 5%. The coconut oil of seventy-five milliliters (with 0.913 gr / ml) is fed to the reactor and mixed with 150 milliliters of ethanol. The solution was reacted in a 1000 ml reaction flask with a reflux set. The reaction starts at a temperature of 60°C. The process is repeated for 60, 120, 180, 240 and 300 minutes. After completion, the product is stored in a channel separator for 24 hours to separate ethyl ester, glycerol, and catalyst. The product is dried at 110°C for 1 hour.
3. Result

3.1. Characterization of Coconut Oil

Table 1. Fatty Acid Profile Of Feed Stock

| No | Name of fatty acid    | Composition (wt.%) |
|----|----------------------|--------------------|
| 1  | Caprylic acid        | 0.27               |
| 2  | Capric acid         | 3.91               |
| 3  | Lauric acid         | 41.21              |
| 4  | Myristic acid       | 23.90              |
| 5  | Palmitic acid       | 16.50              |
| 6  | Stearic acid        | 3.14               |
| 7  | Oleic acid          | 9.47               |
| 8  | Linoleic acid       | 1.61               |

3.2. Effect of Catalyst Concentration toward Viscosity, Density, and Conversion of Biodiesel

![Figure 1](image1.png) Effect of catalyst concentration toward viscosity

![Figure 2](image2.png) Effect of catalyst concentration toward density

![Figure 3](image3.png) Effect of catalyst concentration toward conversion
3.3. Effect of Reaction Time toward Viscosity, Density, and Conversion of Biodiesel

**Figure 4.** Effect of reaction time toward viscosity

**Figure 5.** Effect of reaction time toward density

**Figure 6.** Effect of reaction time toward conversion

4. Discussion

4.1. Coconut Oil

Table 1 describes the types and compositions of fatty acid characterized by gas chromatography. The highest contents were 41.2% lauric acid and 23.9% myristic acid, which were suitable to previous studies.
4.2. Viscosity

Fig. 1 describes the higher of catalyst concentration used will result in lower kinematic viscosity and Fig. 4 describes that all variables of reaction time in the standard range. Indonesian National Standard (SNI 04-7182-2012) [9] the kinematic viscosity of biodiesel at 40°C is 2.3-6.0 mm²/s (cst). Based on the experiment, only samples with 1% catalyst concentration not meet the SNI standard. Higher viscosity of biodiesel in other combinations is influenced by unreacted triglyceride content with methanol, fatty acid composition of methyl ester compound, and intermediate compounds such as monoglyceride and diglyceride having high polarity and high molecular weight.

4.3. Density

Indonesian National Standard (SNI 04-7182-2012) [9] biodiesel density at 40°C is 0.85-0.89 gr / ml. Fig. 2 shows the concentration of 3% catalysts in the range and Fig. 5 shows all variables in range.

4.4. Conversion

Literature [6] mentions that when the number of catalysts is increased the number of collapsed molecules will increase and the reaction rate will increase. The best catalyst concentration of 3% with 90% conversion will be used in research with variable reaction time (Fig. 3) and Fig. 6 shows an increase of biodiesel conversion at 180 minutes with 90% conversion. The product was analyzed by GC-MS and the result 97% contain methyl esters.

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