The effect of catalyst loading on the biodiesel production from lard

L Buchori, DD Anggoro, F Tsaniya, MB Elyasa and E Noviariyono

Department of Chemical Engineering, Faculty of Engineering, Diponegoro University, Jl. Prof. Sudharto, SH, Tembalang, Semarang, Indonesia 5075

E-mail: luqman.buchori@che.undip.ac.id

Abstract. Biodiesel is one of the renewable alternative fuels as a substitute for fossil fuels. This research aims to study the effect of catalyst loading on the synthesis of biodiesel from lard. The transesterification reaction is carried out using a CaO catalyst prepared from an eggshell. Esterification is carried out by using an HCl acid catalyst to lower the free fatty acid (FFA) of lard. The catalyst loading is varied on 1, 3, 5, and 7% w/w of lard. The molar ratio of methanol to oil is 6:1 with a reaction time is 1 h, while operating conditions were kept at a reaction temperature of 65°C and atmospheric pressure. The results showed that the yield of biodiesel decreased with the increase of catalyst loading. The optimum biodiesel yield was obtained at 1% w/w catalyst loading of 92.69%.

Keywords: biodiesel; catalyst loading; lard; transesterification reaction

1. Introduction

Biodiesel is a renewable alternative fuels. It can be made from vegetable oils or animal fats which is reacted with alcohol to produce esters and glycerol. The most commonly used alcohol is methanol. The reaction between alcohol and vegetable oils or animal fats is called transesterification [1]. The most widely used virgin vegetable oil as raw material for biodiesel production such as rapeseed, soybean and sunflower oils [2]. The animal fats were researched for biodiesel production including beef tallow, lard and fish oil [3].

Biodiesel from animal fats has the advantages compared biodiesel from vegetable oil. These advantages are a higher caloric value and cetane number. However, biodiesel from animal fats is less stable for oxidation [2,4]. In addition, animal fat has the high saturated fatty acid content so that causes problems in winter operations [3].

Some researchers use lard as a raw material for biodiesel production [2,3,5,6]. However, researchers are using homogeneous and enzyme catalysts to produce this biodiesel. The use of heterogeneous catalysts has not been widely developed in the synthesis of biodiesel from lard.

The aim of this study was production of biodiesel from lard using heterogeneous catalyst. The solid catalyst used is CaO made from eggshell. The effect catalyst loading is investigated to determine the amount of catalyst needed for biodiesel production in order to obtain maximum biodiesel yield.
2. Materials and Methods

2.1. Materials
As raw materials were methanol and lard. Methanol (99.9%) was purchased from Merck and lard was purchased from local market. Eggshells were obtained from food waste around Tembalang, Semarang. Hycrochloric acid (37%) was used for esterification process purchased from Merck.

2.2. Catalyst Preparation
The eggshells waste were washed and cleaned by tap water from dust and attached impurities. Clean eggshell were dried in an oven at 105°C overnight. Then followed calcinations at 900°C for 4 h in Ney Vulcan furnace. The product obtained was white powder.

2.3. Esterification Process
The esterification process was carried out to reduce FFA of lard. Esterification process was performed using HCl acid catalyst. The molar ratio of methanol to oil is 6:1. The HCl acid catalyst was added as much as 0.75% w/w of oil. The reaction time of esterification process was 2 h.

2.4. Transesterification Reaction
The esterified lard is reacted with methanol with a molar ratio of 6:1. CaO catalyst is inserted into the reactor. The mixed of reactant and catalyst are stirred at a speed of 400 rpm. Transesterification reaction was carried out at 65°C. The product is then separated from the catalyst. The products is put into a separating funnel and allowed to sit overnight to be separated between biodiesel products from glycerol and methanol excess. Yield of biodiesel is calculated by the equation (1).

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Yield(\%) = \frac{\text{weight of biodiesel (g)}}{\text{weight of lard (g)}} \times 100\%
\] (1)

3. Results and Discussions

3.1. Analysis of Raw Material
Lard has FFA content higher 10% [5]. Feedstocks with FFA more than 1% require two step process that are esterification and transesterification [7,8]. Based on the analysis of the raw material, the FFA content of lard was 10%. After the esterification process, the FFA content of lard decreased to 1.36%. Therefore, biodiesel synthesis can proceed to the next step, that is transesterification process.

3.2. Effect of Catalyst Loading to Yield of Biodiesel
The transesterification process is carried out by varying catalyst loading which are 1, 3, 5, and 7% w/w of lard. The yield of biodiesel is depicted in Figure 1.
Figure 1 shows that the highest biodiesel yield is obtained at 1% catalyst loading. The more catalyst added, the yield of biodiesel obtained decreases. This shows that in the transesterification process with heterogeneous catalyst, 1% w/w catalyst loading is sufficient for the transesterification process using lard. The use of excessive catalyst (>1% w/w) will cause the formation of slurry so that inhibit the formation of biodiesel. As a result, the yield of biodiesel produced decreases. Research conducted by Berrios et al. [3] and Ezekannagha et al. [6] also showed that the catalyst needed for the transesterification process was 0.9% and 1.25% with the optimum reaction time ranging from 45-60 minutes.

The results of density and viscosity tests are shown in Table 1.

| Catalyst loading (% w/w) | Density (g/cm³) | Viscosity (cp) |
|--------------------------|----------------|--------------|
| 1                        | 0.86           | 4.48         |
| 3                        | 0.87           | 4.02         |
| 5                        | 0.86           | 4.01         |
| 7                        | 0.89           | 6.52         |

According to SNI standard [9], the density of biodiesel at 40°C is permitted between 0.85-0.89 g/cm³ and kinematic viscosity between 2.3-6.0 cp. Table 1 presents that the biodiesel density and kinematic viscosity fulfill SNI standard except for 7% catalyst loading which is kinematic viscosity slightly higher than SNI. Based on Figure 1, an increase in catalyst loading will reduce the yield of biodiesel obtained. Biodiesel yield decreases due to the formation of other compounds which are not categorized as methyl esters. As a result, the biodiesel density and viscosity increases.

4. Conclusion
Catalyst loading which produces high yield of biodiesel is obtained at 1% catalyst loading. Yield biodiesel attain 92.69%. Biodiesel produced in this condition fulfill SNI standards on density and kinematic viscosity parameters. To produce high yield biodiesel, research needs to be done by studying the effect of other parameters such as reaction time, reaction temperature and molar ratio of methanol:oil.

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