ABSTRACT

Nowadays the need of energy depends heavily on petroleum (crude fossil oil). However, oil fossil reserves are dwindling because of its non-renewable character. Moreover, the continuous usage of fossil fuels has lowered the quality of the environment. Therefore, it is necessary to find alternative fuels that are environmentally friendly and comes from renewable sources. Biodiesel is one of the strategic alternative energy that can be developed as an effort to overcome the deficit of diesel oil.

Biodiesel has been produced by a conventional method using homogeneous base or acid catalyst. However, this process has many flaws which resulted in production costs become more expensive than petroleum diesel. This problem can be overcome by using heterogeneous catalysts. This study used γ-alumina supported solid base catalyst with a single promoter CaO (CaO/γ-Al₂O₃) and dual promoter CaO and KI (CaO/KI/γ-Al₂O₃). Basic catalyst used because it requires relatively lower reaction temperatures than the acid catalyst. The general objective of the research is to study the performance of the CaO/γ-Al₂O₃ and CaO/KI/γ-Al₂O₃ catalyst on transesterification reaction of palm oil into biodiesel. This study consists of five stages: the first stage is catalyst preparation, second stage catalyst characterization, third stage testing catalyst activity, fourth stage transesterification process in a continuous fixed bed reactor and the fifth stage determining kinetics models for transesterification reaction of palm oil.

Catalyst preparation was done by precipitation and impregnation method followed by drying over night at 100-110°C in an oven and calcined at high temperatures (718°C for CaO/γ-Al₂O₃ and 650°C for CaO/KI/γ-Al₂O₃). The catalyst was characterized by X-ray Diffraction (XRD), Brunauer Emmett Teller (BET), and Scanning Electron Microscopic (SEM) methods. Catalyst activity test was carried out in batch reactor both on refluxed methanol along with sub and supercritical methanol. The transesterification process of palm oil into biodiesel was performed in a continuous fixed bed reactor by varying the reaction temperature and feed rate of methanol-palm oil blend. Biodiesel products formed were analyzed by gas chromatography (GC) method.

The results showed that the CaO/γ-Al₂O₃ catalyst was successfully synthesized by the precipitation method, while the CaO/KI/γ-Al₂O₃ catalyst by precipitation and impregnation methods. Characterization results indicate that the surface area of the CaO/KI/γ-Al₂O₃ catalyst (30% loading CaO) = 16, 51 m²/g is smaller than of CaO/γ-Al₂O₃ catalyst (83.77 m²/g), however the peaks of active site is much more and higher in intensity, leading to higher basic strength and basicity thus increasing its activity. From experiments it is known that the catalytic activity of the CaO/KI/γ-Al₂O₃ catalyst is higher than CaO/γ-Al₂O₃ catalyst. Evident from the acquisition of yield and conversion for both catalysts have a very significant difference. Palm oil transesterification with CaO/γ-Al₂O₃ catalyst in a batch reactor at refluxed methanol (75 °C), 7 h of reaction time, 6% of the amount of catalyst and methanol-oil molar ratio of 1:42 acquired relatively low of biodiesel yield and conversion of palm oil ( around 65% and 66%). Maximum yield and conversion (approaching 95% and 97%) for CaO/KI/γ-Al₂O₃ catalyst were obtained at 65°C, 5 h of reaction time, and other conditions are the
same. While the condition of supercritical methanol (290 °C, 60 minutes, 3% catalyst weight and the molar ratio of oil-methanol 1:24) CaO/KI/γ-Al2O3 catalysts obtained similar results (yield and conversion were almost 95% and 97%). For continuous fixed bed reactor, the highest yield obtained at of 60 ml/h and 200 °C of temperature by 62% using pellets catalyst of CaO/KI/γ-Al2O3.

Kinetics model transesterification reaction of vegetable oils can be expressed as follows:

Kinetics model of palm oil for CaO/γ-Al2O3 catalyst in a batch reactor with refluxed methanol was expressed by: $$-r_{TG} = 2.29 \times 10^4 \, e^{-35.014/RT} C_{TG}$$, for CaO/KI/γ-Al2O3 catalysts was $$-r_{TG} = 1.22 \times 10^2 \, e^{-15.47/RT} C_{TG}$$. In sub and supercritical methanol without catalyst kinetics model soybean oil and palm oil were given by: $$-r_{TG} = 7.25 \times 10^6 \, e^{-89.32/RT} C_{TG}$$ and $$-r_{TG} = 3.91 \times 10^5 \, e^{-79.05/RT} C_{TG}$$. Kinetics model for palm oil with CaO/KI/γ-Al2O3 catalyst was: $$-r_{TG} = 67.67 \, e^{-15.85/RT} C_{TG}$$. Meanwhile, the kinetics model of palm oil in continuous fixed bed reactor with CaO/KI/γ-Al2O3 catalyst can be expressed by: $$-r_{TG} = 63.78 \, e^{-26.4/RT} C_{TG}$$

Characteristics of biodiesel produced is in accordance with Indonesian biodiesel quality standard (RSNI EB 020 551).

Key-words: biodiesel, solid catalyst, transesterification, γ-alumina