Transesterification of waste cooking oil using $K/Si/Fe_3O_4$ magnetic composite as a solid catalyst

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Abstract

Biodiesel has becoming brighter year by year [Boey et al., 2010]. In this work, transesterification of waste cooking oil to methyl ester is being studied with the aid of $K/Si/Fe_3O_4$ as a solid magnetic composite catalyst. This catalyst was formed by using boiler ash and rice husk ash which is waste source. By using heterogeneous catalyst, some environmental problem can be avoided since the catalyst can be reuse and the final product is easy to separate.

The objective of this study is to synthesize and characterize the catalyst and to utilize $K/Si/Fe_3O_4$ as a catalyst. It was tested at different parameters such as catalyst loading, methanol to oil molar ratio and reaction duration. $K/Si/Fe_3O_4$ was prepared by impregnation method and calcined at 500 °C for 2 hours and the catalyst was tested by Hammett indicator for its basicity. The catalyst was characterized by FTIR, BET, TGA, XRD and XRF.

The data from XRF in Table 1 shows that $K/SiFe_3O_4$ is suitable for transesterification reaction since it contain high amount of potassium which can act as base catalyst. Meanwhile silica act as the support for the catalyst.

Table 1: XRF data of $K/Si/Fe_3O_4$

Parameter	Result (%)
Potassium Oxide (K_2O)	40.40
Silicon dioxide (SiO_2)	30.31
Chlorine (Cl)	3.80
Iron oxide (Fe_2O_3)	2.15
Calcium oxide (CaO)	1.66

Methyl esters peaks from GC-FID were identified easily by comparing with standards and the following Formula 1 is used to quantify the conversion.

$$\text{Conversion (\%)} = \frac{A_{Total} - A_{ISTD}}{A_{ISTD}} \times \frac{C_{ISTD} - V_{ISTD}}{M_{Sample}} \times 100\% \quad (1)$$

Where

A_{total} = Total area of methyl ester peak from $C_{14:0}$ to $C_{18:3}$
A_{ISTD} = Area of internal standard
C_{ISTD} = Concentration of internal standard in mg/ml
V_{ISTD} = Volume of internal standard in ml
M_{sample} = Mass of sample in mg

conversion is at maximum at the reaction of 3 h which is 83.0603%. From that, we can concluded that the optimum time reaction for the catalyst is 3 h. The conversion drops after 3 h might be due to reverse reaction is taken place and difficulties in separation of final product.

The methanol to oil molar ratio was varied from 6-18:1 to find the optimum condition for biodiesel conversion. Methyl ester conversion increased from 6:1 at 3.3782% to 12:1 at 72.1072% but then decreased until 18:1 to 5.6209%. This shows the low amount of methanol did not enough to enhance the reaction while excessive amount of methanol proves to disturb the reaction [Rashid and Anwar, 2008].

K/Si/Fe_3O_4 show high activity under optimum condition of 3 hours of reaction time, 12:1 of methanol to oil molar ratio with 5 wt.% of catalyst. The transesterification yields 97.4823% methyl ester. Methyl ester was then analyzed using gas chromatography flame ionization detector (GC-FID). Therefore, magnetic composite catalyst is able to reuse and maintaining its activity at considerable ME content (53.15%).

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