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Effect of calcination temperature on the activity of solid Ca/Al composite oxide-based alkaline catalyst for biodiesel production

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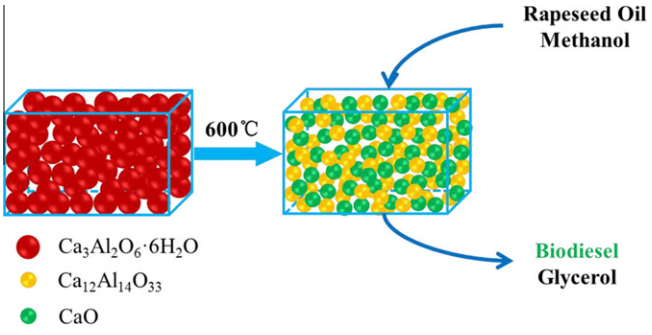
HIGHLIGHTS

- A solid base catalyst based on $Ca_{12}Al_{14}O_{33}$ and CaO was developed.
- The catalyst showed excellent catalytic activity with biodiesel yields >94%.
- The effect of calcination temperature on the catalytic activity was investigated and optimal temperature was determined.
- Structure and properties of the catalyst were studied.
- The synergistic mechanism between crystalline $Ca_{12}Al_{14}O_{33}$ and CaO of the catalyst was revealed.

GRAPHICAL ABSTRACT

The Ca/Al composite oxide which contains $Ca_{12}Al_{14}O_{33}$ and CaO was prepared successfully by a simple method and used as an environmentally benign solid catalyst in the transesterification of rapeseed oil with methanol. The effect of the calcination temperature ranging from 120 °C to 1000 °C on the catalytic activity was investigated. The catalyst calcined at 600 °C showed the highest activity with >94% yield of biodiesel. The activity of the catalyst was closely related to its specific surface area and crystalline structure. In particular, the generation of crystalline $Ca_{12}Al_{14}O_{33}$ vastly improved the catalytic activity due to the synergistic effect between $Ca_{12}Al_{14}O_{33}$ and CaO.



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ABSTRACT

A solid Ca/Al composite oxide-based alkaline catalyst containing $Ca_{12}Al_{14}O_{33}$ and CaO was prepared by chemical synthesis and thermal activation from sodium aluminate solution and calcium hydroxide emulsion. The effect of calcination temperatures ranging from 120 °C to 1000 °C on activity of the catalyst was investigated. The catalyst calcined at 600 °C showed the highest activity with >94% yield of fatty acid methyl esters (i.e. biodiesel) when applied to the transesterification of rapeseed oil at a methanol:oil molar ratio of 15:1 at 65 °C for 3 h. Structure and properties of the catalyst were studied and the characterizations with XRD, TGA, FTIR, BET, and SEM demonstrated that the performance of the catalyst was closely related to its specific surface area and crystalline structure. In particular, the generation of crystalline $Ca_{12}Al_{14}O_{33}$ improved the catalytic activity due its synergistic effect with CaO.

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