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Biodiesel production from used cooking oil by two-step heterogeneous catalyzed process

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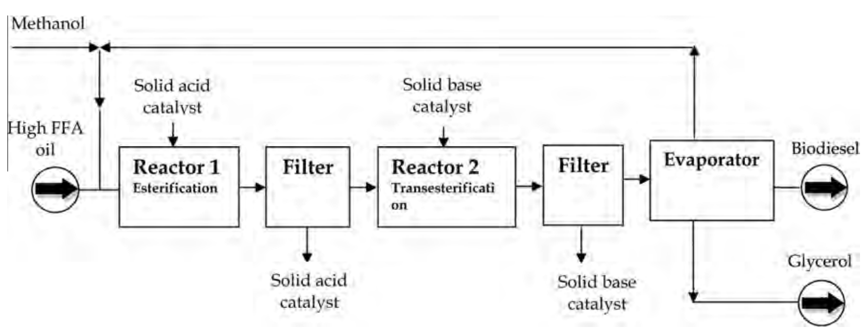
HIGHLIGHTS

- An economical and eco-friendly two-step heterogeneously catalyzed process for biodiesel production is presented.
- The process is applicable to oil feedstocks containing high free fatty acids.
- Very cheap used cooking oil is taken as feedstock and high yields of biodiesel are achieved.
- The solid catalysts used are highly active and reusable for both esterification and transesterification reactions.

GRAPHICAL ABSTRACT



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ABSTRACT

The present study demonstrates the production of biodiesel from used cooking oil containing high free fatty acid by a two-step heterogeneously catalyzed process. The free fatty acids were first esterified with methanol using a 25 wt.% TPA/Nb_2O_5 catalyst followed by transesterification of the oil with methanol over ZnO/Na-Y zeolite catalyst. The catalysts were characterized by XRD, FT-IR, BET surface area and CO_2-TPD. In the case of transesterification the effect of reaction parameters, such as catalyst concentration, methanol to oil molar ratio and reaction temperature, on the yield of ester were investigated. The catalyst with 20 wt.% ZnO loading on Na-Y exhibited the highest activity among the others. Both the solid acid and base catalysts were found to be reusable for several times indicating their efficacy in the two-step process.

1. Introduction

Recently, biodiesel has gained widespread acceptance as a renewable, eco-friendly and sustainable fuel (Ma and Hanna, 1999; Kiss et al., 2008). It consists of monoalkyl esters of fatty acids derived from renewable lipid sources such as vegetable oil or animal fat (Zhang et al., 2003). The most common commercial process for biodiesel production is by homogeneous alkali-catalyzed transesterification of a vegetable oil with methanol. As the economics of biodiesel production greatly depends on the cost of feedstock (Knothe et al., 2005), the use of cheaper oils such as yellow greases and non-edible oils has received immense interest (Birla et al., 2012). However, such low-cost materials contain high amounts of free fatty acids (FFAs) that are not compatible with the alkali catalyst used in transesterification, causing problems like incomplete recovery of the catalysts, increased purification costs and reduced yield (Veljkovic et al., 2006).

To deal with such feedstocks, a few methods have been adopted (Canacki and Gerpen, 2003; Hayyan et al., 2010). One method is the acid-catalyzed transesterification. Though it is insensitive to the

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