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Highly Efficient Iron Oxide-Sulfonated Graphene Oxide Catalyst for Esterification and Trans-Esterification Reactions

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Abstract : Esterification of free fatty acid (oleic acid) and transesterification of waste cooking oil (WCO) with ethanol over graphene oxide (GO), GO-Fe2O3, sulfonated GO (GO-SO3H), and Fe2O3/GO-SO3H catalysts were examined in the present study. Iron oxide supported graphene-based acid catalyst (Fe2O3/GO-SO3H) exhibited highest catalytic activity. GO was prepared by modified Hummer's process. The GO-Fe2O3 nanocomposites were prepared by the addition of NaOH to a solution containing GO and FeCl3. Sulfonation was done using concentrated sulfuric acid. Transmissionelectron microscopy (TEM) and atomic force microscopy (AFM) imaging revealed the presence of Fe2O3 particles having size in the range of 50-200 nm. Crystal structure was analyzed by XRD and defect states of graphene were characterized using Raman spectroscopy. The effects of the reaction variables such as catalyst loading, ethanol to acid ratio, reaction time and temperature on the conversion of fatty acids were studied. The optimum conditions for the esterification process were molar ratio of alcohol to oleic acid at 12:1 with 5 wt% of Fe2O3/GO-SO3H at 1000C with a reaction time of 4h yielding 99% of ethyl oleate. This is because metal oxide supported solid acid catalysts have advantages of having both strong Brønsted as well as Lewis acid properties. The biodiesel obtained by transesterification of WCO was characterized by 1H NMR and Gas Chromatography techniques. XRD patterns of the recycled catalyst evidenced that the catalyst structure was unchanged up to the 5th cycle, which indicated the long life of the catalyst.

Keywords : Fe_2O_3/GO-SO_3H, Graphene Oxide, GO-Fe_2O_3, GO-SO_3H, WCO
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