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Role of NaOH in the Synthesis of Waste-derived Solid Hydroxy Sodalite Catalyst for the Transesterification of Waste Animal Fat to Biodiesel

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Abstract : A sustainable NaOH integrated hydrothermal protocol was developed for the synthesis of waste-derived hydroxy sodalite catalysts for transesterification of waste animal fat (WAF) with a high per cent free fatty acid (FFA) to biodiesel. In this work, hydroxy sodalite catalyst was synthesized from two complex waste materials namely coal fly ash (CFA) and waste industrial brine (WIB). Measured amounts of South African CFA and WIB obtained from a coal mine field were mixed with NaOH solution at different concentrations contained in secured glass vessels equipped with magnetic stirrers and formed consistent slurries after aging condition at 47 oC for 48 h. The slurries were then subjected to hydrothermal treatments at 140 oC for 48 h, washed thoroughly and separated by the action of a centrifuge on the mixture. The resulting catalysts were calcined in a muffle furnace for 2 h at 200 oC and subsequently characterized for different effects using X-ray diffraction (XRD), scanning electron microscopy (SEM), Fourier transform infrared (FT-IR), and Bennett Emmet Teller (BET) adsorption-desorption techniques. The produced animal fat methyl ester (AFME) was analyzed using the gas chromatography-mass spectrometry (GC-MS) method. Results of the investigation indicate profoundly an enhanced catalyst purity, textural property and desired morphology due to the action of NaOH. Similarly, the performance evaluation with respect to catalyst activity reveals a high catalytic conversion efficiency of 98 % of the high FFA WAF to biodiesel under the following reaction conditions; a methanol-to-WAF ratio of 15:1, amount of SOD catalyst of 3 wt % with a stirring speed of 300-500 rpm, a reaction temperature of 60 oC and a reaction time of 8 h. There was a recovered 96 % stable catalyst after reactions and potentially recyclable, thus contributing to the economic savings to the process that had been a major bottleneck to the production of biodiesel. This NaOH route for synthesizing waste-derived hydroxy sodalite (SOD) catalyst is a sustainable and eco-friendly technology that speaks directly to the global quest for renewable-fossil fuel controversy enforcing sustainable development goal 7.

Keywords : coal fly ash, waste industrial brine, waste-derived hydroxy sodalite catalyst, sodium hydroxide, biodiesel, transesterification, biomass conversion
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