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A study on the structure and catalytic performance of $Zn_xCu_{1-x}Al_2O_4$ catalysts synthesized by the solution combustion method for the esterification reaction

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ABSTRACT

A $Zn_xCu_{1-x}Al_2O_4$ catalyst was prepared via the microwave-assisted solution combustion method (MSC). This method presents a fast procedure for industrial scale catalyst preparation. The physicochemical properties of the fabricated catalyst were characterized using XRD, FTIR, BET, SEM and TEM analyses. The catalytic performance through the esterification reaction was examined under the following conditions: reaction temperature = 180 °C, catalyst concentration = 3% (w/w), molar ratio of oleic acid to methanol = 9 and reaction time = 6 h. XRD results showed that loading both zinc and copper oxides on alumina at a ratio of amounts that were nearly the same resulted in decreased crystalline size and well-dispersed copper-alumina and zinc-alumina crystals. Moreover, the mean pore diameter of the sample was increased by simultaneous loading of zinc and copper oxides on alumina that enhanced permeation of the reactants within pores and increased the interaction of the reactant with the catalyst active sites. The catalyst showed minimum tendency towards adsorbing moisture from air, which was attributed to it having less atoms on the surface through which binding with H_2O molecules takes place. The highest level of activity in the esterification reaction (96.9%) was obtained at the optimum ratio of the Zn:Cu molar ratio, identified to be 2:3. The sample particles ranged from 10 to 30 nm in size, without agglomeration.

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1. Introduction

Energy consumption across the globe is currently escalating and this has brought about two important crises: firstly, the problem of carbon emissions in the form of greenhouse gases and secondly, the predicted termination of fossil fuel resources. Scholars have suggested that global temperature could be brought under control by 2100 if there is a sharp reduction of fossil fuel consumption but that a failure to take such an appropriate action could result in irreparable damage to earth. Accordingly, researchers have attempted to enhance renewable and less polluting energy resources to substitute existing systems [1–3]. Biodiesel has been nominated as an appropriate source of energy due to its obvious advantages such as low level pollution, renewable availability, and biological analyzability, and that it can be used in existing engines [4,5]. Biodiesel is generally fabricated from edible oil, inedible oil or animal fat. However, due to the high price of cooking oil for biodiesel production [6], inedible oils such as Jatropha [7], algae [8], and waste cooking oil [9] have often been nominated as suitable alternatives. Biodiesel is usually produced by trans esterification, using triglycerides with short chain alcohols by homogeneous base catalysts such as NaOH or KOH [10]. However, inedible oils contain large amounts of free fatty acids (FFAs) that tend to react with a homogeneous base catalyst to form soap. Subsequently,

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