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Continuous Catalytic Ketonization of Water Extracted Fast Pyrolysis Oils Using Iron Oxides

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Abstract

Continuous processing of fast pyrolysis oil components was performed in a packed bed reactor using H_2 reduced red mud or RRM (waste product of bauxite processing). The mixed metal oxide catalyst composed primarily of magnetite doped with Ti (~4.8%) and other metals (Na 16%, K 1.7%, Mg 0.3%, V 0.3%) was synthesized from red mud via H_2 reduction at 300°C. Hydrogen reduction significantly increased surface area and generated new acid and base sites in the resultant material. NH_3 and CO_2 temperature programmed desorption analysis indicated the presence of both strong acid and base active sites. Continuous catalytic reaction studies were conducted with individual and mixtures of model compounds (acetic acid, formic acid, acetol, levoglucosan), and water extracted fast pyrolysis oil. Acetone was the primary product from acetic acid, and acetone and 2-butanone from acetol, clearly indicating a ketonization reaction. Levoglucosan entered the same pathway, since it was converted to acetic, formic, and acetol. Total conversion and yields approached 100% and 22 mol% ketones, respectively, at 400°C and a W/F of 6 h for a model mixture (4 wt. % each). Similar results were obtained using water extracted oil (15-20 mol% ketones, W/F 1.4-4 h, 400-425°C). The highest space time yields (STY) approached 60 g (acetone+2-butanone)/L-cat/h for the model mixture and 98 g/L-cat/h for the commercial oil, but could be higher if aliphatic and cyclic ketones are rigorously accounted for in the product yield. Results indicate the crude catalyst synthesized from the solid waste is capable of simultaneously reducing acidity, recovering carbon, and generating upgradable intermediates from the aqueous fraction of fast pyrolysis oil in a continuous process.

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