Mechanical syntheses of Al$_2$O$_3$/TiO$_2$ ceramics for the biodiesel production by heterogeneous catalysis

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Due to the predicted shortness of conventional fuels and also to environmental concerns, a search for alternative fuels has gained recent significant attention. As the calorific value of vegetable oils is comparable to that of petrodiesel, they could be used as fuels in compression ignition engines. However, their direct use in injection diesel engines is problematic mainly because of their high viscosity and low volatility. Indeed, the viscosity of vegetable oils is about ten times higher than that of diesel. As a result, the vegetable oils could cause poor fuel atomization, incomplete combustion and carbon deposition on the injector and valve seats resulting in serious engine fouling. The commonly employed methods for reducing the viscosity of vegetable oils are blending with diesel, emulsification, pyrolysis, cracking and transesterification. Among these, transesterification of vegetable oils to methyl or ethyl esters appears to be the best method. The transesterification of vegetable oils is a catalytic transesterification reaction where a triglyceride reacts with methanol producing glycerine and a mixture of fatty acid esters. The result is that triglyceride molecules, which are long and branched, are transformed into smaller esters whose size and properties are similar to those of diesel oils. These esters have significant potential as an alternative diesel fuel both in neat forms or blended with conventional petrodiesel fuels. Biodiesel is characterized by excellent properties as diesel engine fuels and thus can be used in compression-ignition (diesel) engines with little or no modifications. In this work, we used nanostructured ceramic powders as heterogeneous catalysts for transesterification of vegetable oils. Alumina ($\alpha$-Al$_2$O$_3$) and Rutile (TiO$_2$) composites were processed by mechanical alloying. Thermal treatment in different controlled temperatures and atmospheres promoted the activation of the catalytic centers in ceramics. The structural characterizations of the processed powders were carried out with a Shimadzu XRD-7000 diffractometer, with Cu K$_{\alpha}$ radiation, and indicate the formation of the non-stoichiometric composite samples. The microstructures were examined in a Shimadzu SuperScan SS-550 scanning electron microscope, and reveal porous structures composed by agglomerates with a much broadened distribution of grain sizes, ranging from micro to nano scales. The values of specific superficial area and porosity had been determined from isotherms adsorption of the N$_2$ at 77 K. The results for the transesterification reaction of vegetable oils with these ceramic powders, obtained by magnetic nuclear resonance, indicate that with increasing grinding time the rate of the conversion of vegetable oils also increased.

Keywords: catalyst, biodiesel, high-energy ball milled.

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