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Preparation of reduced graphene oxide-nickel oxide-zinc oxide nanocomposites with potential capacity for desulfurization of organic sulfur from gasification gases. Preliminary studies

The removal of sulfur species from the biomass-derived producer gas after gasification represents an operational and economic challenge in order to protect catalysts. Sulfur containing compounds is usually present in biomass gasification gas, since sulfur is typically found in the feedstock. The presence of organic sulfur compounds present in the gas streams is undesirable, because of its contaminating behavior. Even at concentrations as low as a few ppm they can poison catalysts causing significant technical difficulties to the production process.

Graphene, one of the most promising carbon-based materials, has gained immense attention in the field of nanomaterials research because of its excellent properties regarding electrical and thermal conductivity, mechanical strength and large specific area. Its large π-conjugated planar structure makes graphene as an attractive material to support catalysts. In addition, chemical functionalization of graphene by a solvothermal route is a facile approach to obtain large quantities of nanocomposites. Hence, graphene-metal oxide nanocomposites are being extensively investigated for a variety of heterogeneous catalytic reactions.

In this work, we study the synthesis of reduced graphene oxide rGO-NiO-ZnO nanocomposites in order to explore its possibilities as efficient catalysts for removing organic sulfur compound from gasification gases. The proposed procedure is based on a simple solvothermal process starting from graphene oxide (GO) prepared by the classical Hummers method and the improved Tour method. The morphology, microstructure and composition of the as obtained GOs and its corresponding rGO-NiO-ZnO nanocomposites have been systematically characterized by X-ray diffraction (XRD), scanning electron microscopy with EDS detector (SEM / EDS), Fourier transform infrared spectroscopy (FT-IR) and N_2 adsorption at -196°C. Results show that GO from Hummers method is slightly more oxidized than GO from Tour method, probably due to the relatively mild temperatures used in the last one. The formation of metal oxides particles, mainly ZnO, associated to rGO sheets, was observed for both nanocomposites. Obtained surface area of rGO-NiO-ZnO NiO by the Hummers method was 78.57 m^2/g, giving rise, a priori, to be the composite with the highest potential of catalytic activity.

This work is in the framework of the ECOSGAS project “Removal of Sulfur Organic Compounds from gasification gases by reactive adsorption”. The objective of this project is to make contribution to R&D in deep desulfurization technologies of biomass and waste gasification gases, at high temperature (300-500ºC), for integration in renewable fuels production (SNG, biofuels, DME) and thus reduce the use and dependence on fossil fuels. Specifically, the proposal focuses on the assessment of a commercial sorbent, based on zinc and nickel oxide, for the removal of organic sulphur species from gasification gases (thiophene, benzothiophene and dibenzothiophene) in a single stage, by means of reactive adsorption. The technology has been successfully proven for gasoline sulphur removal and for H_2S removal from syngas. Both facts mean a sound assumption for evaluating its feasibility for removal of organic sulphur compounds present in gasification gases. In order to improve the performance of sorbent for desulfurization process, an exploratory activity in preparation of novel Zn-Ni sorbents supported on graphene, is included as part of this initiative.

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