Steering Deoxygenation Reaction Pathway Towards Biofuel Production Using Oleic Acid: Unveil the Role of Transition Metal Promoters on Ni-supported Zeolite Beta Catalysts

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The urgency to discover a more sustainable approach for the society has become vital with alarming trends, on a global scale, in the energy demand, the depletion of fossil fuel reserves, the need to mitigate emissions of greenhouse gases (GHG) and hence their devastating consequences. Given the fact that oil prices fluctuate on a timely basis, a clean, cost-competitive and stable solution is required, particularly with the foresees of 15% increase in energy demand by transportation sector by 2030 (compared to 2018) across Middle East, and emerging economies of China and India [1]. Fast pyrolysis of biomass is rather a viable technology that results in higher yield of liquid bio-oil (50-75wt.%) at mild temperatures (400-650 °C) with high heating rates (>103 °C/min) under atmospheric pressure, and short vapor residence time (<2 s) [2]. However, the biomass-derived bio-oil is practically unsuitable for direct implementation as transportation fuel due to its lower heating value as a result of high water (12-30wt.%) and oxygen contents (19.40-50.30wt.%), compared to heavy fuel oil.

In this study, zeolite-based catalysts promoted with transition metals are synthesized to be evaluated for the hydrodeoxygenation (HDO) of oleic acid, with emphasis on the role of different promoters (i.e. Mn^{+2}, Fe^{+2}, Co^{+2}, Cu^{+2}) on steering the HDO reaction pathway. The outstanding catalytic activity of zeolites is centered through their pore system, framework dimensions, chemical compositions and acidic properties that ultimately define the active sites. Many analytical techniques were used so to understand the fundamentals of the structure/microstructure/surface science of the catalysts. In particular, the crystallography of all catalysts was studied by x-ray diffraction (XRD) technique. the crystallite size and inter-planar d-spacing were estimated accordingly. Porosimetry (pore size) measurements were conducted based on N2-adsorption-desorption isotherms to estimate the specific surface area and pore size distribution. The surface morphology, chemical composition, particle size, crystal structure and elemental mapping were analyzed using scanning electron microscopy (SEM) and high-resolution transmission electron microscopy (HR-TEM). The surface elemental concentrations and chemical states were analyzed by x-ray photoelectron spectroscopy (XPS). The catalysts reducibility was evaluated through H2-temperature programmed reduction experiments. Besides, the basicity and acidity of the catalysts were investigated using the two probe molecules, CO2 and NH3, respectively. Hydrodeoxygenation of oleic acid, which is model compound extracted from palm oil, is being conducted on the prepared catalysts. The experiment is being carried out in a BTRS-Jr Autoclave Engineers (Pennsylvania, USA) testing system with a maximum operating pressure and temperature of 40 bar and 800 °C, respectively.

References
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