Self-Combustion Synthesis of Nanocrystalline CuO and CuMn$_2$O$_4$
Powders Used as Methanol Synthesis Catalyst for Direct Dimethyl Ether Synthesis from Syngas

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Abstract:
In this study, nanocrystalline powders consisting of CuO and CuMn$_2$O$_4$ have been synthesized by means of a simple combustion synthesis technique using sorbitol as fuel and cupric nitrate and manganese (II) nitrate as oxidant. The starting materials were mixed thoroughly with adding a small amount of ammonia solution and then ignited in the air at 250 °C. It underwent a self-combustion process with a large amount of smoke. The as-synthesized powders were characterized by X-ray diffraction (XRD) analysis, transmission electron microscope (TEM), scanning electron microscope (SEM), surface area measurements, and sinterability. Experimental results revealed that the nanocrystalline powders show high specific surface area and possess small primary crystallite size. Specific surface area and primary crystallite particle size of the powders were ~60 m/g and 10-25 nm, respectively, through the stoichiometric fuel/oxidizer ratio reaction. In addition, the thermal decomposition and combustion process of the reactant mixture were investigated using thermogravimetry (TG) and differential scanning calorimetry (DSC). Nanocrystalline CuO and CuMn$_2$O$_4$ Powders were physically admixed with Y-type zeolite methanol dehydration catalyst to form hybrid catalysts. The one-step synthesis of dimethyl ether (DME) from syngas was carried out over the hybrid catalyst under pressurized fixed-bed continuous flow conditions. About 62% CO per-pass conversion and 63% DME selectivity could be achieved under the pressure of 2.0 MPa, the temperature of 260 °C, the ratio H$_2$/CO of 3/2 and the space velocity of 1800 h$^{-1}$.

Keywords: self-combustion; dimethyl ether synthesis; nanocrystalline powder