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Dynamical Changes in the Cu–ZnO_x Interaction Observed in a Model Methanol Synthesis Catalyst

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Abstract A systematic series of model methanol synthesis catalysts was prepared by sequential impregnation of a mesoporous silica material (5 nm average pore size) with an organometallic ZnO precursor which is liquid at room temperature, followed by the infiltration with an aqueous Cu nitrate solution. These catalysts, which contained 14–20 wt.% Cu and 1–5 wt.% Zn, were characterized by N_2O reactive chemisorption, by EXAFS and by measuring their methanol synthesis activities. It was observed that the formation of confined, nanocrystalline ZnO prior to copper infiltration is of major importance for the development of catalyst activity. Severe reduction of properly prepared catalysts (10% CO/H_2, 673 K, 15 min) leads to the emergence of a new feature in the ZnK EXAFS spectrum which was assigned to a Cu neighbour by combined evidence from the ZnK EXAFS and XANES regions. The zinc oxide component was partially reduced as well, but Zn(0) was not formed to any significant extent. Catalysts which developed this Cu–Zn^{2+} interaction under severe reduction were superior in terms of methanol synthesis rate per m^2 Cu surface area to a sample which did not exhibit this feature.

Keywords Methanol synthesis · Copper · Zinc oxide · Metal-support interaction · Model catalyst · Mesoporous silica · XAFS

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