Activation of a Cu/ZnO catalyst for methanol synthesis

The structural changes during activation by temperature-programmed reduction of a Cu/ZnO catalyst for methanol synthesis have been studied by several in situ techniques. The catalyst is prepared by coprecipitation and contains 4.76 wt% Cu, which forms a substitutional solid solution with ZnO as determined by resonant X-ray diffraction. In situ resonant X-ray diffraction reveals that the Cu atoms are extracted from the solid solution by the reduction procedure, forming metallic Cu crystallites. Cu is redispersed in bulk or surface Zn lattice sites upon oxidation by heating in air. The results are confirmed by in situ electron energy loss spectroscopy and in situ resonant small-angle X-ray scattering. The average Cu particle size in the reduced catalyst as determined by the latter technique is ~27 Å. The observed structural behaviour may have important implications for catalyst design and operation. More than one type of Cu particle with different origins may be present in Cu/ZnO catalysts with Cu loadings higher than the solubility limit of Cu in ZnO: particles formed by extraction of Cu from the (Zn,Cu)O solid solution and particles formed by reduction of CuO primary particles. The former type is highly dispersed and in intimate contact with the surface of the host ZnO particles. The possibility of re-forming the (Zn,Cu)O solid solution by oxidation may provide a means of redispersing Cu in a deactivated catalyst.

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