Stability of a Bifunctional Cu-Based Core@Zeolite Shell Catalyst for Dimethyl Ether Synthesis Under Redox Conditions Studied by Environmental Transmission Electron Microscopy and In Situ X-Ray Ptychography - DTU Orbit (29/12/2018)

When using bifunctional core@shell catalysts, the stability of both the shell and core-shell interface is crucial for catalytic applications. In the present study, we elucidate the stability of a CuO/ZnO/Al₂O₃@ZSM-5 core@shell material, used for one-stage synthesis of dimethyl ether from synthesis gas. The catalyst stability was studied in a hierarchical manner by complementary environmental transmission electron microscopy (ETEM), scanning electron microscopy (SEM) and in situ hard X-ray ptychography with a specially designed in situ cell. Both reductive activation and reoxidation were applied. The core-shell interface was found to be stable during reducing and oxidizing treatment at 250°C as observed by ETEM and in situ X-ray ptychography, although strong changes occurred in the core on a 10 nm scale due to the reduction of copper oxide to metallic copper particles. At 350°C, in situ X-ray ptychography indicated the occurrence of structural changes also on the µm scale, i.e. the core material and parts of the shell undergo restructuring. Nevertheless, the crucial core-shell interface required for full bifunctionality appeared to remain stable. This study demonstrates the potential of these correlative in situ microscopy techniques for hierarchically designed catalysts.

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