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

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.

General information
Publication status: Published
Organisations: Center for Electron Nanoscopy, Department of Physics, Experimental Surface and Nanomaterials Physics, Karlsruhe Institute of Technology, Friedrich-Alexander University Erlangen-Nürnberg, German Electron Synchrotron, Universität Hamburg
Number of pages: 12
Pages: 501-512
Publication date: 2017
Peer-reviewed: Yes

Publication information
Journal: Microscopy and Microanalysis
Volume: 23
Issue number: 3
ISSN (Print): 1431-9276
Ratings:
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 0.49 SJR 0.292 SNIP 0.273
Web of Science (2017): Impact factor 2.124
Web of Science (2017): Indexed yes
Original language: English
Keywords: ETEM, X-ray microscopy, Core–shell catalyst, Correlative imaging, Dimethyl ether
DOI:
10.1017/S1431927617000332
Source: FindIt
Source ID: 2355986781
Research output: Contribution to journal › Journal article – Annual report year: 2017 › Research › peer-review