Transmission electron microscopy on live catalysts

Bremmer, G.M.

Propositions

Associated with the PhD thesis 'Transmission Electron Microscopy on live catalysts'

I. In order to fully investigate a catalytic process in all its aspects, it is essential to combine multiple approaches and apply a variety of techniques.
Chapter 1 of this thesis

II. Our observation that the oxidation of (Ni/Co)MoS_2, supported on γ-Al_2O_3, occurs from the edges of the slabs towards the center at a progressively lower rate, seems to indicate that the outer oxide forms a protective, ring-like barrier that hinders further oxidation.
Chapter 2 of this thesis

III. The fact that the slabs grow back to their original sizes when sulfidation conditions are applied to oxidized (Ni/Co)MoS_2 catalyst samples, while the catalytic activity increases significantly, might be caused by the growth of the smaller, catalytically inactive slabs (<~1.6 nm) to sizes at which they contribute significantly to the catalytic process.
Chapter 3 of this thesis

IV. Complete coverage of a Co nanoparticle by graphene, formed via the Boudouard reaction at 500 °C and 1 bar CO/N_2, inhibits further facilitation of this reaction by blocking the supply of CO to the Co surface.
Chapter 5 of this thesis

V. The material that supports MoS_2 slabs must be of great influence on the oxidation stability of the catalyst, as HRTEM inspection by Kisielowski *et al.* of carbon-supported MoS_2 that was transported through air did not show any indication of oxide formation, whereas our observations of MoS_2 supported on γ-Al_2O_3 showed significant oxidation.
C.F. Kisielowski *et al.* Angew. Chem. Int. Ed. **2010**, *49*, 2708

VI. *In situ* catalytic experiments carried out in an environmental TEM are often performed at irrelevantly high temperatures and low pressures, as is illustrated by the sulfidation experiments of MoS_2 at 720 °C and 1 mbar, carried out by Hansen *et al.* (who thereby still sacrificed their ETEM to sulfur-only experiments), which shows the importance of the development of dedicated *in situ* TEM hardware.
L.P. Hansen *et al.* JPCC **2014**, *118*, 22768

VII. The greatest challenge during *in situ* TEM catalysis experiments at lower temperatures, as Liu *et al*. encountered during their ETEM experiments, is controlling carbon contamination due to electron irradiation.
X. Liu *et al.* ACS Catal. **2017**, *7*, 4867

VIII. Automated image analysis to process series of images as proposed by Vendelbo *et al.* might seem a powerful and widely applicable tool, however, it requires high levels of image quality and stability that are not often obtained during *in situ* TEM experiments.
S.B. Vendelbo *et al.* Nat. Mater. **2014**, *13*, 884

Marien Bremmer
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