In situ Transmission Electron Microscopy of catalyst sintering - DTU Orbit (09/11/2017)

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Recent advancements in the field of electron microscopy, such as aberration correctors, have now been integrated into Environmental Transmission Electron Microscopes (TEMs), making it possible to study the behavior of supported metal catalysts under operating conditions at atomic resolution. Here, we focus on in situ electron microscopy studies of catalysts that shed light on the mechanistic aspects of catalyst sintering. Catalyst sintering is an important mechanism for activity loss, especially for catalysts that operate at elevated temperatures. Literature from the past decade is reviewed along with our recent in situ TEM studies on the sintering of Ni/MgAl2O4 catalysts. These results suggest that the rapid loss of catalyst activity in the earliest stages of catalyst sintering could result from Ostwald ripening rather than through particle migration and coalescence. The smallest particles are found to disappear in a few seconds as soon as the catalyst reaches the operating temperature. While particle migration and coalescence is evident in some of these in situ studies, it does not follow the classical model where the smallest particles are most mobile. Deterministic models of Ostwald ripening as well as atomistic Monte Carlo simulations are both in good agreement with these experimental observations, predicting a steep loss in catalyst activity at short times on stream. The in situ studies show the importance of direct observations to deduce mechanisms and show the important role played by the support and the gas atmosphere (especially the presence of H2O) on the rates of catalyst sintering.

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