Revealing the Formation of Copper Nanoparticles from a Homogeneous Solid Precursor by Electron Microscopy - DTU Orbit (09/11/2017)

Revealing the Formation of Copper Nanoparticles from a Homogeneous Solid Precursor by Electron Microscopy

The understanding of processes leading to the formation of nanometer-sized particles is important for tailoring of their size, shape and location. The growth mechanisms and kinetics of nanoparticles from solid precursors are, however, often poorly described. Here we employ transmission electron microscopy (TEM) to examine the formation of copper nanoparticles on a silica support during the reduction by H_2 of homogeneous copper phyllosilicate platelets, as a prototype precursor for a coprecipitated catalyst. Specifically, time-lapsed TEM image series acquired of the material during the reduction process provide a direct visualization of the growth dynamics of an ensemble of individual nanoparticles and enable a quantitative evaluation of the nucleation and growth of the nanoparticles. This quantitative information is compared with kinetic models and found to be best described by a nucleation-and-growth scenario involving autocatalytic reduction of the copper phyllosilicate followed by diffusion-limited or reaction-limited growth of the copper nanoparticles. The plate-like structure of the precursor restricted the diffusion of copper and the autocatalytic reduction limited the probability for secondary nucleation. The combination of a uniform size of precursor particles and the autocatalytic reduction thus offers means to synthesize nanoparticles with well-defined sizes in large amounts. In this way, in situ observations made by electron microscopy provide mechanistic and kinetic insights into the formation of supported nanoparticles, essential for the rational design of nanomaterials.

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