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Catalysis and Electrocatalysis by Clusters: Size, Composition and Support Effects

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The elucidation of the size, composition, shape, structure and function relationship, of the effect of support along with the determination and control of the nature of the catalytic particles under reaction conditions are instrumental for addressing fundamental aspects of catalysis on the way to the design and understanding the function of existing and new classes of cluster-based catalytic materials. Highly uniform particles on technologically relevant supports are prerequisites for such studies, hand-in-hand with the characterization of the working particles under realistic reaction conditions of pressure and temperature.

Our experimental studies are based on 1) the use of technologically relevant oxide and carbon based supports, 2) size- selected cluster deposition with atomic precision control of cluster size as well as composition and 3) in situ and ex situ synchrotron X-ray characterization of cluster size, shape and oxidation state under realistic working conditions, combined with mass spectroscopy analysis of the reaction products. The synchrotron-based studies are complemented with in situ and ex situ microscopies and DFT calculations.

The first part of the lecture will focus on the size-and support dependent catalytic properties of clusters and their assemblies in selective oxidative reactions such as the dehydrogenation of propane and cyclohexene, or in the selective partial oxidation of propylene.

In the second part of the presentation the strongly size-dependent performance of sub-nanometer clusters in water splitting and batteries will be discussed.

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