Synthesis of bimetallic and hybrid platinum-tin nanocrystals

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Nanotechnology and catalysis belong to today's key technologies for many applications like synthesis of chemicals or fuel cells. Catalytic nanoparticles are known for their increased activity and selectivity due to their small size and thus improved surface-to-volume ratio compared to microcrystalline or bulk materials. Certain particle shapes and compositions also affect catalytic properties. However, the catalytic activity is also influenced by so-called *strong metal-substrate interactions* (SMSI). [1], [2] This occurs when a metallic nanoparticle is supported on an transition-metal oxide for example Pt/TiO_2 [1], [2] as well as Pt/Fe_3O_4 [3]. The interaction between the catalyst and its support will either enhance or diminish the catalytic activity by coating the reactive sites with an oxidic film. To study this effect in more detail, well-defined materials, which can be used as models, are necessary, such as hybrid nanoparticles consisting of a metallic and an oxidic part.

The combination of two or more metals within one catalyst particle promises many advantages. For example, nanoparticles made from an alloy of platinum and tin show an increased catalytic activity compared to monometallic platinum nanoparticles. [4] Finding appropriate conditions for the synthesis of such particles is a challenging task, that is why tailor-made, bimetallic nanoparticles are far less extensively studied than monometallic platinum particles. [5], [6], [7]

Here we will show bimetallic platinum-tin nanoparticles obtained in a sequential reduction pathway. First monometallic platinum particles are prepared by reduction of platinum(IV)chloride with tetrabutylammonium borohydride. The reaction takes place at room temperature in toluene with dodecylamine as a stabilizer. [8], [9] Then we reduce bis[bis(trimethylsilyl)amino]tin(II) with diisobutylaluminium hydride in the presence of the previously produced platinum particles. [10] Depending on reaction conditions we obtain different intermetallic Pt-Sn phases, as well as hybrid nanocrystals containing not only Pt-Sn alloys but also Sn and SnO_x (see Fig. 1). The particles are characterized by transmission electron microscopy (TEM), high resolution transmission electron microscopy (HRTEM), energy-dispersive X-ray spectroscopy EDX and powder X-ray diffraction (XRD).

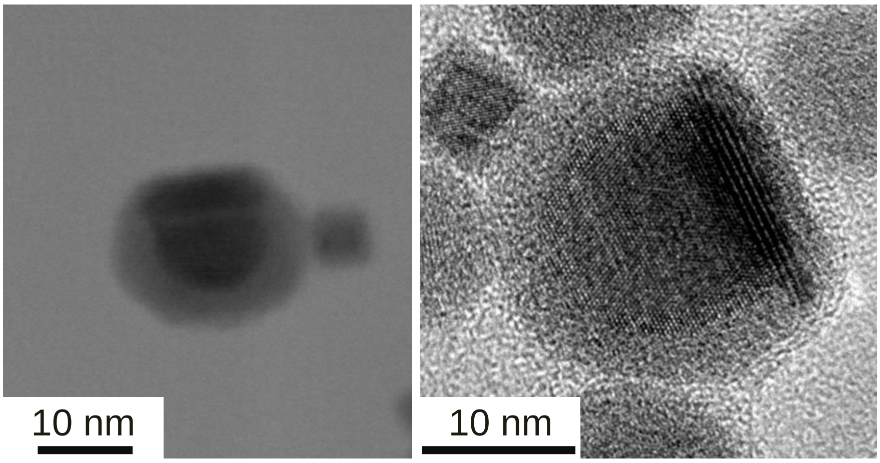

Fig. 1 a) STEM and b) HRTEM images of hybrid particles. The crystalline $PtSn_4$ and Sn regions and the amorphous SnO_2 shell are clearly visible.

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