Correlating the Structural and Catalytic Properties of Bimetallic Au-Pd Nanoparticles

J.E.S. van der Hoeven, Debye Institute for Nanomaterials Science, Utrecht University
L.A. Olthof, G. Totarella, A. van Blaaderen, P.E. de Jongh, Debye Institute for Nanomaterials Science, Utrecht University

By combining two metals in a bimetallic nanoparticle new and enhanced catalytic and optical properties can arise. The physicochemical properties of such bimetallic particles depend on the particle size, shape, metal composition and the atomic distribution of the two metals within the nanoparticles. The exact metal surface composition is particularly important in catalysis, where the atoms at and close to the surface determine the catalytic performance. However, a systematic study on the direct influence of the metal surface composition on the catalytic behaviour is challenging, as it is difficult to vary the surface composition without changing any other parameters in the system.

In this work, we make use of a well-defined model system consisting of colloidally synthesized mesoporous silica coated Au-core Pd-shell nanorods of which not only the size, shape and overall composition can be controlled, but also the distribution of the metals within the nanoparticles.[1] Via thermal treatment the nanorods can controllably be transformed from core-shell to alloyed Au-Pd nanorods.[2,3] In this process, the mesoporous silica shell ensures full retention of the particle shape and prevents the nanorods from sintering, meaning that solely the metal surface composition changes upon thermal treatment while all other parameters are kept the same.

We used this model system to correlate the catalytic behaviour of the Au-Pd nanoparticles to their surface composition. First, we performed *ex situ* measurements to investigate the change in atomic Au-Pd distribution from core-shell to alloy upon thermal treatment at different reduction temperatures in hydrogen. We used Au-core Pd-shell NRs with a relatively low Pd content (8 at%), such that the metal surface composition changed from pure Pd to predominately Au upon alloying. The atomic Au-Pd distribution was characterized in detail with scanning transmission electron microscopy combined with energy-dispersive X-ray spectroscopy (STEM-EDX). Thereafter, the differently structured Au-Pd NRs were tested in the selective hydrogenation of butadiene to butene in the presence of excess propene. In Figure 1 the catalytic performance of the Au-Pd NRs as a function of the reduction temperature is shown. We found that both the activity could be tuned by varying the atomic distribution of the Au and Pd atoms, where the activity increased with an increasing Pd surface fraction while maintaining a high selectivity.

The EDX maps show a core-shell and alloyed AuPd nanorod. The graph shows the turn over frequency of the AuPd nanorods in the selective hydrogenation of butadiene versus the pretreatment temperature.


E-mail j.e.s.vanderhoeven@uu.nl