New Concepts in Nano-Electrochemistry – From Large Ensembles to Single Particle Studies

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Nanomaterials have been in the focus of major research interest for more than two decades. The great potential of electrochemistry to characterise these particles in terms of both, their physical properties and chemical reactivity make it a useful complement method, like SEM or TEM, but has hardly been explored up until now. The number of particles that can be analysed at once, ranges from individual particles to ensembles comprising >10^7 particles, depending on the techniques used.

Here, the beneficial use of ensemble studies to distinguish between core-shell and alloy nanoparticles and to measure the shell thickness of core-shell nanoparticles will be demonstrated.[1] To get size information, however, single nano-particle studies are required. A convenient method to do this, is via transformative nano-impact analysis.[2] This methodology uses the Brownian motion-based sporadic impact of dispersed nanoparticles at a potentiostated electrode to electrochemically convert one particle at a time. The charge transferred during this conversion can, for instance, be used to size the particle or to determine its composition.

Valuable information may also be gained from the shape of the current response of the electrochemical transformation at different applied potentials. This can be used to gain information on reaction kinetics of individual nanoparticles, for instance during their electrochemical oxidation in different solutions.[3] It can also provide insights in reaction mechanism and mass transport properties of the involved reactants, such that diffusion coefficients of anions in different solutions can be determined from the duration of such single particle impact experiments.

Measuring the electrocatalytic activity may also be realized at the single particle level, however quantitative assessment of catalysts, remains a challenge to be tackled in the future.

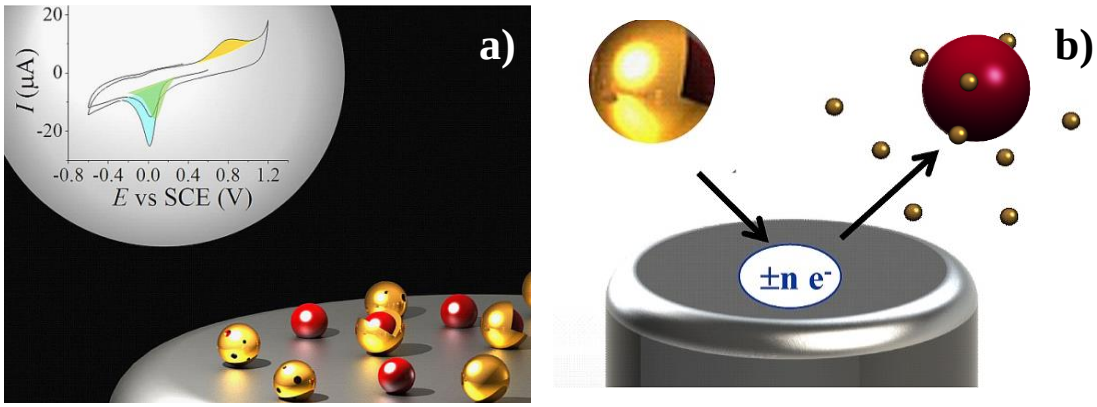

Figure 1. Schematic drawing of (a) nanoparticle ensemble studies of core-shell nanoparticles and (b) single nano-impact studies.

References

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