Mesoscopic Effects in Electrocatalysis: from Concept to Catalyst Synthesis and Performance Evaluation

Matthias Arenz
University of Bern
Freiestrasse 3, 3012 Bern, Switzerland
matthias.arenz@dcb.unibe.ch

In the last decade the interest in electrocatalyst design has been boosted by the increasing availability of regenerative energy in the form of electricity. The intermittent nature of energy sources such as photovoltaic power and wind energy requires suitable energy storage technology to be able to align the *"production"* with the *"demand"* of energy. While battery technology for mobile applications shows continuous progress, the storage and re-conversion of electricity in the form of energy carriers such as hydrogen gas still faces significant challenges. Complementing strategies to utilize renewable energy for the production of gases, liquids or chemicals of interest, summarized under the *"Power to value"* or *"Power2X"* label, are even more in their technological infancy. However, for an efficient regenerative energy management on a global scale such technologies are indispensable.

For all these technologies a fundamental understanding and rational design of (electro-)catalysts, on which many surface reactions of interest take place, play an essential role. In state-of-the-art academic electrocatalyst design, the focus is on optimizing the surface structure of the catalyst on a nanometer scale. This design principle, however, only takes kinetic factors into account – which are important, but not sufficient for catalytic applications. Furthermore, the electrocatalyst performance is determined at significant lower reaction rates than required for applications.

I will present our research concept that focuses on a different, complementary design approach for supported electrocatalysts in order to optimize their properties. In supported electrocatalysts, the active phase consists of metal or alloy nanoparticles distributed over a conducting support, mostly carbon based. Our aim is to elucidate *the role of mesoscopic properties* – such as the interparticle distance on the support – for their performance in a comprehensive and systematic manner by combining electrochemical measurements with (ex-situ and in operando) spectroscopy and microscopy. Mesoscopic properties have so far received only little attention in academic electrocatalyst design, yet some few studies demonstrate that they bear significant potential for improving the electrocatalyst performance. A proof of concept has been our pioneering work on the particle proximity effect on size-selected Pt clusters. Different colloidal catalyst synthesis strategies developed allow the investigation of mesoscopic effects with a significantly broader perspective.