Synchrotron-based X-ray methodologies to determine the operando structure of the catalytic active site

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Recent developments in synchrotron radiation facilities and X-ray optics have further expanded the X-ray analytical toolbox for operando studies. These X-ray tools allow to follow the structure of the catalytic active site in action and include X-ray absorption and emission spectroscopy, diffraction and total scattering. One of these tools, quick scanning X-ray absorption spectroscopy (with sub second time-resolution) in combination with transient experimentation provides a unique platform for determining the nature of the catalytic active site and the rate limiting steps of a reaction.

In this talk, I will give an overview of the X-ray toolbox for catalysis research available at the Swiss Light Source, introduce our plans for a Swiss center for operando studies and focus on one technique, quick scanning X-ray absorption spectroscopy (XAS) and how this was leveraged to provide new insights into relevant catalytic processes under operating conditions: heterogeneous Wacker oxidation of ethylene, selective catalytic reduction of nitrous oxides and the oxygen evolution reaction.

Maarten Nachtegaal is heading the operando spectroscopy group at the Paul Scherrer Institut (Switzerland) which operates the SuperXAS beamline at the Swiss Light Source for X-ray absorption and emission spectroscopy and currently constructs the Debye beamline for combined X-ray absorption, diffraction and total scattering experiments. He earned his M.Sc. degree in geochemistry from Utrecht University (the Netherlands) a Ph.D. in environmental chemistry at the University of Delaware (USA) followed by a postdoctoral position at the ETH in Zürich (Switzerland) before taking up his current position. The focus of his research moved from environmental chemistry to heterogeneous/photo/electro-catalysis, primarily employing novel spectroscopic techniques under operando conditions. Recurrent themes are a strong interest in cross-disciplinary research and the development of new operando experimental methods.