Operando characterization of carbon-supported metal nanoparticle fuel cell catalysts

Rebecca Pittkowski,[a] *Kirsten M. Ø. Jensen,*[a] *Matthias Arenz*[b]

[a]*University of Copenhagen, Copenhagen/Denmark,*

[b]*Universität Bern, Bern/Switzerland*

rebecca.pittkowski@chem.ku.dk

Electrocatalysis plays a major role in energy conversion technologies for the storage of renewable electricity, such as electrolyzers and fuel cells. Small metal nanoparticles, e.g. of platinum, immobilized on carbon support (Pt/C) are state-of-the-art catalysts for commercial fuel cell applications. The stability of catalysts with low Pt loadings is, however, still insufficient, and the degradation mechanisms at play are not fully understood. Here, X-ray scattering techniques such as small angle X-ray scattering (SAXS) can provide valuable information in *operando* experiments[1]. SAXS allows us to follow the particle size evolution during the operation of the catalyst. This can provide valuable information on the mechanisms that dominate catalyst degradation and can help to devise new strategies for catalyst optimization. By combining SAXS analysis with X-ray diffraction,[2] further information on changes in the atomic structure of the particles during catalysis can be obtained, e.g. on the alloying behavior of a bimetallic system with Pt and Au nanoparticles on carbon.[3]

This contribution focuses on the strengths and drawbacks of the different *operando* scattering techniques and how they can be combined, also with X-ray absorption spectroscopy (XANES and EXAFS), to obtain a complete characterization of the catalyst structure at applied potentials in an electrochemical cell. Understanding the structure of the catalysts under reaction conditions is crucial for any structure-property relations.

Bibliography

(1) Schröder, J.; Pittkowski, R. K.; Du, J.; Kirkensgaard, J. J. K.; Arenz, M. *J. Electrochem. Soc.* **2022**, *169* (10), 104504.

(2) Schröder, J.; Pittkowski, R. K.; Martens, I.; Chattot, R.; Drnec, J.; Quinson, J.; Kirkensgaard, J. J. K.; Arenz, M.. *ACS Catal.* **2022**, *12* (3), 2077–2085.

(3) Du, J.; Quinson, J.; Zhang, D.; Wang, B.; Wiberg, G. K. H.; Pittkowski, R. K.; Schröder, J.; Simonsen, S. B.; Kirkensgaard, J. J. K.; Li, Y.; Reichenberger, S.; Barcikowski, S.; Jensen, K. M. Ø.; Arenz, M. *JACS Au* **2022**, *2* (7), 1757–1768.