CH 6560: Studying fuel cell catalyst degradation mechanisms based on bimodal Pt/C catalysts

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1. Abstract

In this study, we followed the degradation of fuel cell catalysts comparable to 'real-life application' with the help of Accelerated Stress Tests (AST). We have employed the scattering techniques PDF/WAXS/SAXS to follow the degradation of a bimodal Pt/C catalyst and the respective monomodal smaller and larger Pt/C catalysts. An important part of this study is that we use a Monte Carlo approach for the SAXS analysis and compare the results for the different sizes, mixed catalysts. This grants valuable insights into the degradation mechanisms of the fuel cell catalysts.

2. Experimental details

The experiments were conducted in an electrochemical set-up that was developed at Bern. It is very similar to the set-up with the flow-through cell available at the beamline. The catalyst layer was prepared by vacuum filtration of the supported Pt nanoparticles (small size, larger and mixed) on a gas diffusion layer in Bern. They were used as working electrodes in the electrochemical cell, a Pt wire was used as counter and a Ag/AgCl was used as reference electrode. We used 0.1 M H_2SO_4 as electrolyte which was flowed through the cell. We measured the dry sample, the sample with electrolyte and measured two CVs. Afterwards, we conditioned the catalyst layer and measured at different potential holds. We moved on with an AST consisting of potential jumps between 0.6-1.0 V vs. RHE, 3s each. We measured after repetitions of each 50 cycles of 1, 1, 1, 1, 1, 1, 2, 2, 5, 5, 5, 5 and 10. We concluded with a measurement at a potential hold and then 20 CVs and then a final measurement at a potential hold.
For the measurements at a potential hold we measured scans in height with the Pilatus in PDF, WAXS and SAXS position. After the respective AST we measured with the detector in WAXS and SAXS positions. We performed each measurement at two different positions of our sample.
The height scan and the two different sample positions were necessary for background subtraction at averaging.

3. Results

Figure 1 and 2 both show the distinct differences between the bimodal and the small catalyst. The change in the smaller catalysts is more obvious than for the bimodal catalysts. This is as expected. Further analysis and refinement will help us to understand and follow the changes in morphology and crystallite size better.

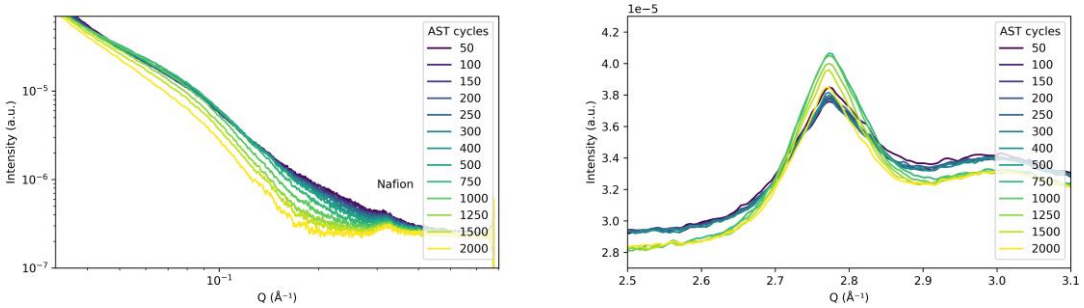

*Figure 1. **Left** The evolution of size for the bimodal catalyst followed with SAXS. **Right** Growth of crystallite size of the same catalyst.*

4. Conclusion and outlook

The beamtime went successfully. We measured scattering data of the small, the large and the mixed Pt/C. We are currently in the process of refining the XRD data and PDF. Further, we are in the process of analyzing the measured SAXS data with a Monte Carlo approach to gain insights into the change of size distribution during ASTs. Additional electrochemical characterization and TEM measurements will be conducted to compare to our obtained results from the beamtime.

Once all this has been done, we will compare the results for each, the small, large and mixed nanoparticles to hopefully gain further insights on the degradation.

5. Publications resulting from this work

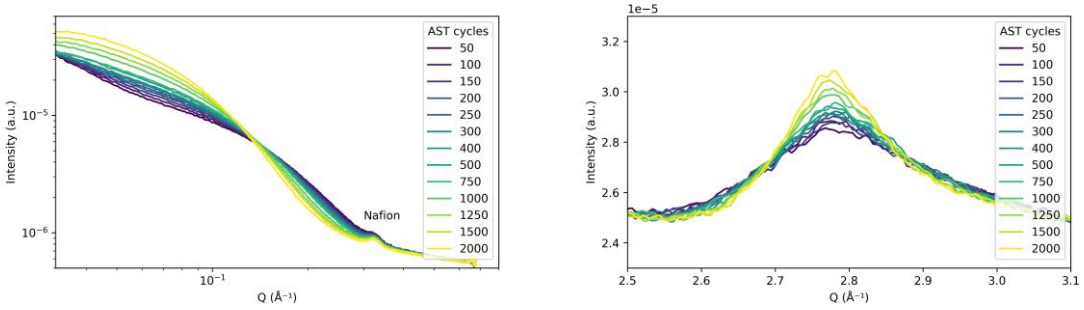

*Figure 2. **Left** The evolution of size for the small catalyst followed with SAXS. **Right** Growth of crystallite size of the same catalyst.*

Once the analysis is complete and we achieved a proper understanding, we are planning to publish the results.