Spatially-resolved small-angle X-ray scattering and electrochemistry mapping of humidity-driven PtCo/C degradation in polymer electrolyte fuel cells.

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Polymer electrolyte fuel cells (PEFCs) are essential for sustainable energy, but catalyst degradation, especially of carbon supported Pt alloys, limits their durability. Our study [1] employs in operando electrochemistry, ex situ small-angle X-ray scattering (SAXS), and scanning electron microscopy (SEM) to investigate humidity-driven degradation of carbon supported Pt and Pt_3Co catalysts. Accelerated stress tests (ASTs) under uniform humidity (AST1) and with a humidity gradient (AST2) show that Pt_3Co is more affected by humidity, losing 77% of its performance under AST2 compared to 30% for Pt. Impedance spectroscopy indicates increased resistance in Pt_3Co when exposed to humidity gradients. Spatially resolved current mapping shows uneven degradation in Pt_3Co, linked to dealloying and cobalt leaching, while Pt remains stable. SAXS data indicate distinct structural changes: individual Pt_3Co nanoparticles grow, whereas their clusters shrink (the cut-off distance drops from about 10 nm to 7 nm), suggesting fragmentation from cobalt dissolution. Conversely, Pt nanoparticles double in size (from 1.38 nm to about 2.76 nm), and clusters grow (the cut-off distance increases to approximately 7 nm near the outlets). Both catalysts transition from mass to surface fractal aggregation, reducing their electrochemically active surface area. SEM shows the Pt_3Co catalyst layer becomes thinner (from 4.81 to 3.08 µm), with membrane heterogeneity caused by cobalt leaching (0.28 µg L^{-1} Co) and radical formation that induces oxidation. This spatially resolved SAXS–electrochemistry approach enhances understanding of structure–function relationships, supporting the development of durable Pt-alloy catalysts.

Reference:

[1] J.M. Edjokola, M. Bogar, M. Grandi, R. Taccani, H. Amenitsch, M. Marinšek, V. Hacker, M. Bodner, Humidity-Induced Degradation Mapping of Pt_3Co ORR Catalyst for PEFC by In-Operando Electrochemistry and Ex Situ SAXS, *Small* 20 (2024) e2407591. https://doi.org/10.1002/smll.202407591

Short bio:

Since 2011, the research of Ass.Prof. Priv.-Doz. Dr.techn. Merit Bodner focuses on electrochemical engineering, with particular emphasis on the

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She completed her PhD in Chemical and Process Engineering in 2017 and held leading positions in European fuel cell companies. Since May 2021, she is a professor at Graz University of Technology, where she is leading the “electrochemical engineering” group. Merit Bodner has more than 35 peer reviewed publications and received the Hydrogen Europe Research Young Scientist Award in 2022.