Katharina Hengge et al., J Fundam Renewable Energy Appl 2018, Volume 8
DOI: 10.4172/2090-4541-C5-062

Insight into the degradation of polymer based fuel cells

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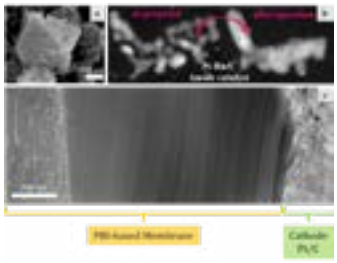
The impact of greenhouse gases on the environment and the scarcity of natural resources demand for sustainable solutions to maintain our steadily increasing demand for energy supply; one possibility are fuel cells. In particular for the transportation and stationary sector, polymer-electrolyte-membrane fuel cells are used. Their centerpiece is the membrane-electrode assembly which is composed of several functional layers: the polybenzimidazole-based membrane and two electrodes. Generally the lifetime of fuel cells is limited due to harsh operation conditions leading to several degradation mechanisms that affect all functional layers. In our studies, we focused on alternative materials for the fuel cells´ electrodes. We combined new catalyst or support materials with standardly used material systems and investigated the catalyst´s growth behavior during preparation and its aging properties in various operation conditions. In one study, octahedral shaped, high-surface-area platinum networks were grown on a tungsten suboxide support layer via a template-free synthesis route. Using various transmission electron microscopy (TEM) based techniques, we were able to explain their growth mechanism and evaluate their higher stability and lower degradation rate during fuel cell operation. In another study we investigated the structural characteristics and the stability of Pt/Ru catalyst nanoparticles on a high-surface-area carbon support material. Dynamic fuel cell operation was simulated using cyclic voltammetry experiments and site specific degradation mechanisms of single nanoparticles were evaluated by performing intermitted TEM studies on identical locations. Our results reveal dissolution and agglomeration to be the main degradation mechanisms. Continuous fuel cell operation gives rise to a further degradation mechanism: dissolution of the Pt and Ru catalyst particles promote the diffusion of the concomitantly formed ions into the membrane where they precipitate with different crystal structure and composition. Finally a band of nanoparticles was observed in the membrane adjacent to the cathode catalyst layer.



Recent Publications:

1. K Hengge, C Heinzl, M Perchthaler, S Geiger, K J J Mayrhofer, C Scheu, Crystal Growth & Design 2017, 17, 1661.
2. C. Heinzl, K. Hengge, M. Perchthaler, V. Hacker, C. Scheu, Journal of The Electrochemical Society 2015, 162, F280.
3. K. Hengge, T. Gänsler, E. Pizzutilo, C. Heinzl, M. Beetz, K. J. J. Mayhofer, C. Scheu, International Journal of Hydrogen Energy 2017, 42 (40), 25359.
4. K. Hengge, C. Heinzl, M. Perchthaler, D. Varley, T. Lochner, C. Scheu, Journal of Power Sources 2017, 364, 437.

Biography

Katharina Hengge studied Chemistry at the Ludwig-Maximilians-University in Munich. After finishing her Master degree in 2013, she started her PhD work at the Max-Planck-Institut für Eisenforschung GmbH in Düsseldorf. The scope of her PhD work is the degradation analysis of polymer-based fuel cells. Knowledge of the parameters that influence different operation related degradation mechanisms helps improve the fuel cells´ overall performance and elongate their lifetime. She completed her PhD in September 2017.

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