Application of differential electrochemical mass spectrometry in electrocatalysis

Niusha Shakibi Nia(), Julia Kunze-Liebhäuser
Institute of Physical Chemistry, University Innsbruck

Abstract

Differential electrochemical mass spectrometry (DEMS) is a technique which allows the online detection of chemical products or intermediates during an electrochemical reaction. To detect the reaction products formed on an electrode, the employed electrochemical cell is coupled with a mass spectrometer. A hydrophobic Teflon membrane with specific porosity and permeable to volatile species is used as the interface between the electrolyte and the high vacuum [1].

DEMS is typically used to better understand pathways of electrocatalytic reactions. Two different electrochemical cell configurations are used in combination with a Hiden HPR-40 mass spectrometer.

As an example for fuel cell anode reactions, the ethanol oxidation reaction (EOR) was studied at titanium oxycarbide (TiOxCy) supported platinum nanopowders in acidic electrolytes in a hanging meniscus configuration optimized for the analysis of 'real' catalyst materials. We quantitatively showed that the TiOxCy material is a synergistic support for Pt nanoparticles and significantly enhances the CO2 conversion efficiency at room temperature [2].

As highly relevant system for electrolysis, molybdenum carbide flat films (Mo2C) were used for electrocatalytic water splitting and their activity towards the hydrogen evolution reaction (HER) was investigated [3] using the single flow DEMS cell. Complementary to our DEMS measurements which showed overpotentials comparable to literature values for Mo2C, ex situ emersion XPS studies supported the assumption that the electrode surface composition changes during the HER and contributes to the observed faradaic current changes.

As a third example for electrocatalysis applications for non-noble metal catalysts, the electrochemical stability and the electrocatalytic activity of zirconium oxycarbide nanopowders (ZrOxCy) is introduced [4]. At low pH, ZrOxCy is stable in an extremely wide potential range, which makes this material a highly interesting catalyst for electrochemical energy conversion.

References

[1] H. Baltruschat, J. Am. Soc. Mass Spectrom. 2004, 15, 1693.

[2] N. Shakibi Nia, A. Martucci, G. Granozzi, G. García, E. Pastor, S. Penner, J. Bernardi, N. Alonso-Vante, J. Kunze-Liebhäuser, Electrochim. Acta 2019, 304, 80.

[3] E. M. Wernig, C. Griesser, T. Götsch, T. Schachinger, A. Steiger-Thirsfeld, N. Shakibi Nia, D. Winkler, S. Penner, J. Kunze-Liebhäuser, Applied Materials and Interfaces 2019, submitted

[4] D. Hauser, A. Auer, J. Kunze-Liebhäuser, S. Schwarz, J. Bernardi, S. Penner, RSC Adv. 2019, 9, 3151–3156.