X-ray photoelectron spectroscopy characterization of surfaces and interfaces in polymer electrolyte membrane devices

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The success of a hydrogen-based infrastructure relies on the advancement of electrochemical energy conversion devices like polymer electrolyte membrane fuel cells and water electrolyzers (PEMFCs and PEMWEs). Over time, there have been notable improvements in the development of catalysts and electrodes for PEM systems, boosting their performance and durability, and also reducing the usage of precious metals. The properties of the electrodes used in these devices are influenced by multiple parameters; the chemical identity of the catalyst and the ionomer, the morphological properties of the catalyst and support, ink formulation, and the various processing and fabrication parameters used to prepare the electrode. Due to the breadth of possible variable combinations and the inherent complexity of electrode materials, it is unsurprising that PEM electrodes are both morphologically and chemically heterogeneous, and significant gaps in understanding of surfaces and interfaces in these devices remain.

Understanding and analyzing the surfaces and interfaces in devices is a challenging task that requires a multi-technique approach to evaluate all relevant properties at different scales. It is also important to understand how these properties evolve under realistic operating conditions. In this presentation, I will discuss effective strategies for characterizing catalysts and catalyst layers using X-ray Photoelectron Spectroscopy (XPS). The talk will cover the opportunities for studying catalyst-gas interactions and highlight the challenges and progress made in understanding the catalyst-ionomer interface. I will focus on the results obtained with ultra-high vacuum and in-situ studies conducted with near-ambient pressure XPS. Additionally, XPS and electron microscopy will be highlighted as complementary techniques for comprehensive analysis, especially when exploring a large processing and fabrication parameter space. This work provides valuable insights that enable a feedback loop between synthesis, fabrication efforts, and electrochemical analysis.

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