Interaction between Ionomers and Ni nanostructures in Anion Exchange Membrane Water Electrolysis: A Cautionary Tale

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Anion exchange membrane water electrolysis (AEMWE) is a promising technology for sustainable hydrogen production. This emergin technology promises to combine the benefits of alkaline and proton exchange membrane (PEM) electrolyzers to produce hydrogen at high current densities, high efficiency using low-cost, non-platinum group metal (PGM) catalysts. However, the performance and durability of AEMWE systems can be significantly influenced by the choice and behavior of ionomers, particularly in conjunction with Ni nanostructures.[1,2] Ionomers play several critical roles in AEMWE systems. Firstly, they provide mechanical support and structural stability to the electrocatalyst layer, ensuring its integrity during electrolysis and facilitating anion transport at the interfaces. In the context of Ni nanostructures, which are commonly employed as electrocatalysts in AEMWE, the interaction between ionomers and Ni can significantly impact the performance and longevity of the electrolysis system.[3]

Nanostructured Ni-based catalysts are promising non-noble metal catalysts for both anodic (oxygen evolution reaction, OER) and cathodic (hydrogen evolution reaction, HER) reactions in AEM water electrolyzers due to their high activity, stability in alkaline media and low cost. In recent studies from our group, we focused on the development and implementation of several Ni-based nanoparticles (Ni, NiFe and NiFe/CeO_2) of various particle size and composition (Ni to Fe at. ratio), for AEMWE.[4-8] We studied the effect of nanoparticle synthesis method, addition of Fe to Ni, effect of CeO_2 and the electrochemical active surface area (ECSA) of the resulting nanostructures. Significant effort has been devoted to the studies of ionomer/catalyst interaction in a single-cell, zero-gap AEMWE electrolyser. We investigated Fumatech Fumion® FAA-3 ionomer for NiFe particles with and without ceria. Furthermore, the use of the commercial Aemion™ ionomer from Ionomr Innovations was evaluated in combination with the best performing $Ni_{90}Fe_{10}$ for OER.[7] Results indicated that in comparison to commonly used Nafion™ ionomer and the commercial Fumatech Fumion® ionomer, the Aemion™ ionomer suppressed the $Ni(OH)_2$/NiOOH redox couple, leading to lower OER current densities. In our recent work, commercial Aemion, Fumion, and Nafion ionomers were compared to the lab-synthesized ammonium-enriched anion exchange ionomer PPO-LC-TMA (poly(2,6-dimethyl-1,4-phenylene oxide) backbone with amine-functionalized by trimethyl amine)[8] that showed promising performance with $Ni_{90}Fe_{10}$ nanostructured catalyst.

This talk will discuss the Ni-based nanostructured electrocatalysts for AEM water electrolysis and the technical challenges related to electrode material, membrane and ionomer interaction that need to be solved to achieve the desired current densities and long-term system stability.

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