Platinum and Non-Platinum-Metal Tin Oxide Supported Catalysts for PEMFC Cathodes

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A primary challenge for the development of economically viable proton-exchange membrane (PEM) fuel cells is to lower the catalyst-associated costs. To decrease the Pt-content catalysts, we have developed a series of metal-oxide-supported noble-metal catalysts with high activity for the oxygen reduction reaction (ORR). Our previous studies of carbon-supported Pt-iron phosphate catalysts showed enhanced activity for the ORR relative to standard 20 wt% Pt/Vulcan carbon, despite lower Pt loading.[1] The enhanced catalysis is associated with three key characteristics of the metal-oxide structure including (1) activity for oxygen dissociation, (2) an open microporous structure, and (3) the presence of proton-conducting hydrous-oxide surface functionalities. While the Pt-FeOx material suffers from slow corrosion-related degradation under cathodic operating conditions of PEMFCs, the results demonstrate the potential of metal-oxide supports to reduce noble-metal loading in fuel cells.

In this paper, tin-oxide supported noble-metal catalysts will be detailed. Hydrous SnO_x is precipitated from aqueous solutions by the addition of NH_4OH, and then impregnated with Au, Pd, and Pt.[2] The physical and structural properties of the Au-SnO_2, Pd-SnO_2, and Pt-SnO_2 are characterized via X-ray photoelectron spectroscopy (XPS), scanning electron microscopy (SEM), thermal gravimetric analysis (TGA), surface-area measurements (BET), powder X-ray diffraction (XRD), and X-ray absorption near-edge (XANES) spectroscopy.

The SnO_2 and noble metal/SnO_2 catalysts are electrochemically evaluated by rotating disk electrode (RDE) voltammetry for ORR activity by adhering Nafion-impregnated carbon-supported catalyst inks on a glassy carbon electrode using an established electrode preparation method.[3] The ORR activity of selected Pt-SnO_2, Pd-SnO_2, and Au-SnO_2 catalysts are shown in Figure 1. These Tafel plots show that all catalyst powders are active for oxygen reduction and reveal particularly surprising level of activity for tin oxide-supported Au catalyst. The ORR activity of Au is typically low in acidic conditions, but the SnO_x appears to lower its overpotential for the electrocatalysis.

These results demonstrate the potential use of metal oxide supports for the successful preparation of ORR-active Pt-free catalysts. Additional strategies will be exploited, such as the use of mixed noble metals, and In and Sb doping of the SnO_x.

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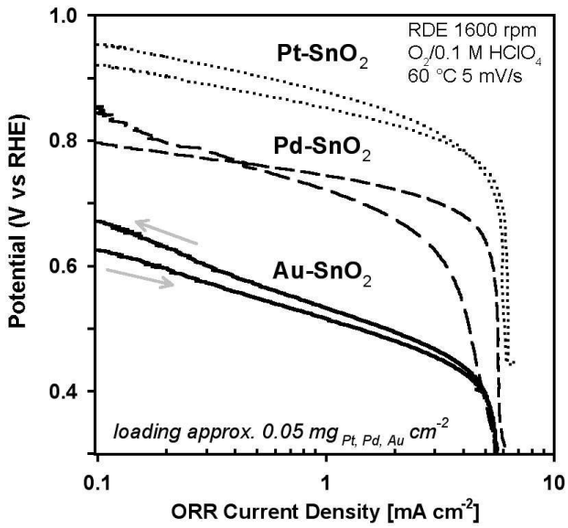

Figure 1: Tafel plots depicting the current/voltage response of the various noble metal/SnO_2 catalysts for oxygen reduction.