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-relation 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 SnO2 is precipitated from aqueous solutions by the addition of NH4OH, and then impregnated with Au, Pd, and Pt.2 The physical and structural properties of the Au-SnO2, Pd-SnO2, and Pt-SnO2 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 SnO2 and noble metal/SnO2 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. The ORR activity of selected Pt-SnO2, Pd-SnO2, and Au-SnO2 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 SnO2 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 SnO2.

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References


Figure 1: Tafel plots depicting the current/voltage response of the various noble metal/SnO2 catalysts for oxygen reduction.