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High Stability, High Activity Pt/ITO Oxygen Reduction Electrocatalysts

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Proton exchange membrane fuel cells (PEMFCs) have drawn significant attention as a 21st century alternative to environmentally unfriendly power sources, for example, fossil fuel power plants and internal combustion engines. However, to make PEMFCs economically viable, one of the main problems to be solved is to find catalysts with sufficient activity and stability for the oxygen reduction reaction (ORR) [1-2].

To address this problem, a number of methods have been proposed for developing an electrocatalyst with improved performance, including alloying Pt with secondary transition metals or depositing monolayers of Pt onto other fine metal particles to create core-shell structures [3-4].

Although Pt supported on carbon is still the most widely used catalyst, oxide supports as alternatives to carbon have shown improved corrosion resistance and reduced electrochemically active area (ECA) degradation rates [5]. In addition, oxide supports are also able to affect the electrocatalytic activity of the supported noble metals due to metal-support interactions. These interactions manifest in several ways including: (i) modification of the electronic states or Fermi level of Pt that pushes the formation of Pt-OH groups to higher potentials [6]; (ii) spillover of OH groups onto the oxide support; and (iii) reduction of OH coverage by lateral repulsion between Pt-OH and oxide surfaces [7].

In this study, tin-doped indium oxide (ITO) particles with high conductivity are used as supports for Pt. The ORR activity and stability of Pt/ITO are explored to understand the enhancement of the ORR on Pt due to the interaction between Pt and surface Sn. Figure 1 shows the tight attachment of a characteristic Pt nanoparticle to the ITO surface with the diameter of ~4 nm. In addition, the surface of the Pt nanoparticle is dominated by {111} facets, and reveals continuous lattice fringes from the ITO substrate to supported Pt particles. It is found that the Pt/ITO exhibited a specific activity of ~0.75 mA/cm^2 at 0.9 V, which was 3 times greater than Pt/C (~0.235 mA/cm^2); And a mass activity of (~621 mA/mg$_{Pt}$), which was 4 times greater than Pt/C (~156 mA/mg$_{Pt}$). The stability test was conducted by applying potential sweeps to a thin-film rotating disk electrode in O_2-saturated 0.1 M $HClO_4$ solution at room temperature. As shown in Figure 2, after 1000 cycles, for Pt/ITO, there was no recordable loss in the Pt ECSA and electrocatalytic activity of the ORR. Thus, high stability has been achieved in this Pt/ITO design.

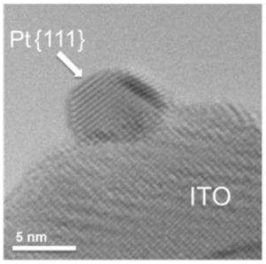

Figure 1. Pt nanoparticle supported on ITO particles prepared by heating to 500°C, 5 at%.

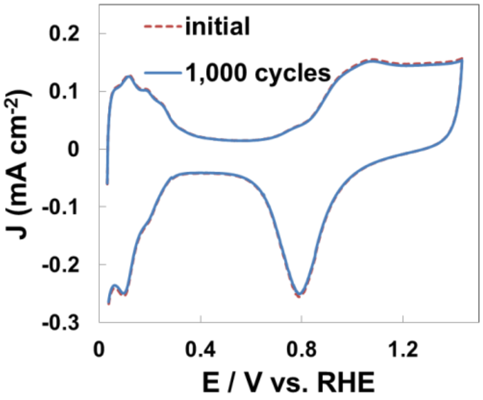

Figure 2. Voltammetry curves for Pt/ITO before and after 1,000 cycles. Sweep rate, 10 mV/s

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