

Exploring the Activity and Stability Limits for Pt/ITO ORR Electrocatalysts

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Electrochemical energy conversion devices, fuel cells, have received considerable attention over the past few decades, because they have the potential to provide high efficiency power since electrochemical processes are not limited by traditional Carnot or Rankine heat cycles [1]. Over the past two decades, one of the most widely investigated fuel cell is the proton exchange membrane fuel cell (PEMFC).

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) [2]. The most common electrocatalysts for ORR are nanometer-sized clusters of platinum and Pt alloys dispersed on high surface area carbon (Pt/C); however, they are plagued by rapid performance loss with time. One of main sources of the performance loss is the electrochemical oxidation of surface carbon atoms at potentials higher than 0.207 V vs. NHE where the activated carbon species reacts with nearby water molecules, eventually yielding CO₂ [3].

It has been shown that oxide supports can provide improved corrosion resistance and reduced electrochemically active area (ECA) degradation rates [4] compared to Pt/C. In addition, oxide supports can affect the electrocatalytic activity of 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 [5]; (ii) spillover of OH groups onto the oxide support; and (iii) reduction of OH coverage by lateral repulsion between Pt-OH and oxide surfaces [6].

In our previous work on ~20 wt % Pt/ITO electrocatalyst, we found that the interaction between Pt and the ITO led to a modification of the shape of the Pt particles compared to Pt/C, which can be seen in Figure 1. Here, the surface of the Pt nanoparticles was dominated by {111} facets and possesses reveals continuous lattice fringes from the ITO substrate to supported Pt particles. It was found that the Pt/ITO exhibited a specific activity of ~0.75 mA/cm² at 0.9 V and a mass activity of (~621 mA/mg_{Pt}). The stability test was conducted by applying potential

sweeps to a thin-film rotating disk electrode in O₂-saturated 0.1 M HClO₄ solution at room temperature. After 1000 voltammetric cycles between 0.0 and 1.4 V vs. NHE, there was no recordable loss in the Pt ECSA and electrocatalytic activity of the ORR [7]. However, it is well known that commercial applications require high platinum loadings, around 50 wt% Pt, and it remains unclear whether the high activity and stability for Pt/ITO will be translated at high Pt loadings.

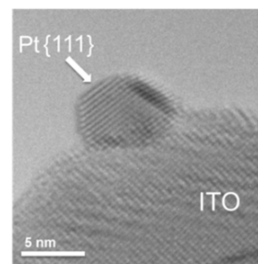


Figure 1. Pt nanoparticle supported on ITO particles prepared by heating to 500°C, 5 at%.

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 over a wide range to understand the ORR enhancement on Pt due to the interaction between Pt and surface Sn, and the Pt loading effect on the performance of Pt/ITO.

References:

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