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Comparative durability study of Pt-based PEM fuel cell catalysts using EIS

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With the increasing environmental requirements on reducing automobile emissions and energy production problem, proton exchange membrane (PEM) fuel cells have been considered as one of the best candidates for realizing hydrogen economy not only for zero emissions, but also for higher energy efficiency. However, the development of PEM fuel cell is still in its early stages, long-term durability is a major concern for their commercial success. Among other fuel cell components, the degradation of catalyst layer (CL) is often found to be a significant cause of cell death.

Accordingly, there remains a need to understand the degradation of CL to mitigate or eliminate such degradation. The extent of degradation is normally assessed by cyclic voltammetry (CV) measurements to determine changes in the electrochemically active surface area (ECSA), though this assessment is limited by the fact that it cannot conclusively diagnose ionomer degradation and carbon corrosion. This often can only be determined through post mortem analysis. Our strategy for testing of fuel cell CL degradation combines accelerated aging and ECSA monitoring by CV with the monitoring of the electrochemical impedance (EIS) response over time [1].

A simple but effective EIS test protocol is proposed in order to accelerate the lifetime testing of PEM fuel cells. To do this, we have selected several commercially available carbon-supported Pt catalysts with different compositions, to serve as models and compare their degradation mechanisms using our durability test protocols. Various carbon supports were chosen as standard support materials due to their high surface area, high corrosion resistance and wide application in PEM fuel cell catalysts. Figure 1 demonstrates how changes in the CV responses are indicative of stability of the CLs measured at various aging times. Using these model catalysts, we have also shown that the changes with EIS response over time can be used to clearly identify the degradation mechanism related to conductivity that is occurring on carbon-supported Pt electrocatalysts even if the carbon materials possess similar characteristics. Thus, the addition of EIS testing to accelerated durability protocols is highly recommended for in situ diagnostic measurements of catalyst layer health.

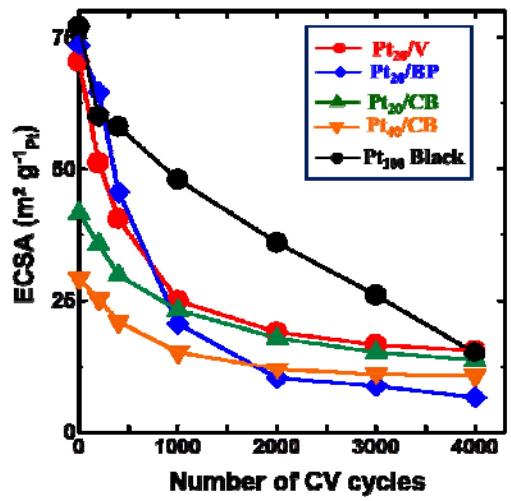

Figure 1. Comparison of loss of ECSA of various supported and non-supported Pt electrocatalysts as a function of the number of CV cycles. Catalysts are: 20 wt% Pt on Vulcan (Pt_{20}/V), 20 wt% Pt on Black Pearls 2000 (Pt_{20}/BP), 20 wt% Pt on Carbon Black (Pt_{20}/CB), 40 wt% Pt on Carbon Black (Pt_{40}/CB) and 100% Pt Black (Pt_{100} Black).

References

1. Farhana S. Saleh and E. Bradley Easton, *J. Electrochem. Soc.*, **159**, B546 (2012).