Measurement and Manipulation of Ionic Conductivity in Fuel Cell Catalyst Layers

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The proton conductivity of the cathode catalyst layer of a Proton Exchange Membrane Fuel Cell (PMFC) is one of the key parameters that determine its performance. The addition of a proton conductor (usually Nafion) to the catalyst layer[1, 2] is now routine and together with improvements in methods for preparing the catalyst layer[3-9] it has led to tremendous improvements in fuel cell performance. In view of the potential for further improvements in performance, it is crucial that reliable methods for measuring proton conductivity in fuel cell electrodes be available, and that other methods for improving this conductivity be explored.

Boyer et al[10] have described a method in which the ionic resistance of a non-operational catalyst layer, sandwiched between two membranes in a fuel cell, is measured from the slope of a polarization curve. We[11] have used electrochemical impedance spectroscopy to investigate ionic conductivity in operational catalyst layers. Results from these two approaches will be compared, and some of the issues that complicate these measurements will be discussed.

We have increased the proton conductivity of fuel cell catalyst layers by surface modification of the catalyst surface by silanization[12] and by treatment with nitric acid.[13] Treatment of the carbon support with 2(4-chlorosulfonylphenyl)ethyl trichlorosilane was found to improve the performance of a H_2/air fuel cell when low Nafion loadings (<30%) were used in the cathode catalyst layer. Optimum performance was obtained at lower Nafion loadings when the silane modified catalysts were used. Treatment of a carbon supported catalyst with nitric acid was found to greatly improve its performance for oxygen reduction in a half-cell.[13]

Investigations of proton-transport in layers of these modified catalysts by impedance spectroscopy will be presented.

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