# Problems with Membrane Electrode Assemblies for non-Nafion based Membranes

B.S. Pivovar, M. Hickner, J.E. McGrath, P. Zelenay, and T.A. Zawodzinski

MST-11 Fuel Cells and Electrochemistry
Los Alamos National Laboratory
Los Alamos, NM 87544

Department of Chemistry
Virginia Polytechnic Institute and State University
Blacksburg, VA 24061

Nafion or other perfluorinated sulfonic acid ionomers have been the standard upon which polymer electrolyte fuel cell technology has been based. However, for application high temperature applications or in direct methanol fuel cells (DMFC), Nafion membranes often suffer from insufficient performance. In the case of high temperature membranes, Nafion is limited due to its dependence on free water for adequate conductivity and long-term stability. For DMFCs, Nafion suffers from excessive methanol permeability leading to high crossover rates. Additionally, Nafion has a very high electro-osomotic drag coefficient that can lead to problems with water management in a cell. Ideally, new polymers with improved properties would be found to replace Nafion in fuel cell systems.

Still an additional hurdle exists because Nafion has been made into high performance membrane electrode assemblies (MEAs), while in many situations making high performance MEAs from other polymers may not be possible. The problem centers around the application of the catalyst layer. In most situations the catalyst layer is applied to the membrane as ink or hot-pressed onto the membrane from a film of dried ink by a decal method. In almost every case this ink contains Nafion as a binder and porous ionic pathway for the catalyst particles. For Nafion-based MEAs, the interface between the porous catalyst layers and the polymer electrolyte show only a small increase in resistance between the free standing film and the MEA. For example, at 60 C a Nafion-based MEA showed only a 30% increase in resistance in fuel cell tests when compared to ac impedance measurements made on a free standing film. While other polymers show much greater decreases in conductivity when made into MEAs from Nafion-based inks. For example, BPSH 40, a poly(arylene ether) sulfone synthesized at Virginia Tech, showed a 150% increase in resistance when comparing the free standing film to the MEA.

The properties of free standing films will be compared to those of Nafion-based MEAs for a system of poly(arylene ether) sulfones of various sulfonation levels, two Ion Clad membranes (Pall), and several other proprietary membranes. The influence of the catalyst layer on the performance of these cells will be discussed, along with possible solutions to making higher performance MEAs.