Transport characteristics at Reaction Layer Proton Exchange Membrane Interfaces Designed for Elevated Temperature Operation

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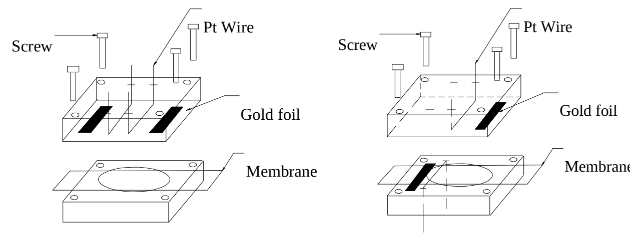
Proton exchange membranes operating at elevated temperatures (<100-130°C) are expected to diminish problems of system integration and water management in the current state of the art PEMFCs stacks. Since the current state of the art low temperature proton conductor (Nafion, from Dupont) requires greater than 80 percent relative humidity for maintaining proton conductivity, alternative approaches for elevated temperature are required. One approach under active consideration is the use of Nafion membrane composites containing inorganic oxide gels. This approach relies on the ability of the composite on maintaining higher levels of hydration within the membrane structure at lower relative humidities. The other approach is to use alternative membrane chemistry to enable sufficient proton conductivity at lower relative humidity such as at 50% level. These alternative polymer membranes under active consideration include (a) poly(arylene-ether-sulfone), (b) Poly(sulfide sulfone). Ongoing studies at our laboratory has shown promising results with conductivity at low relative humidity.

For viable fuel cell operation at elevated temperatures mass transport characteristics at the reaction layer interface have to be tailored for lower relative humidity. An understanding of the proton and reactant gas transport characteristics in reaction layer is therefore critical. This investigation therefore examines these parameters by measuring the effect of different relative humidity at the reaction layer in terms of proton conductivity and the reactant (O_2) solubility & diffusion coefficient. The objective therefore is to be able to quantify the mass transport losses in a membrane electrode assembly using alternative membranes designed for elevated temperature operation.

Experimental

The alternative proton transport membranes under investigation were (a) sulfonated poly(arylene-ether-sulfone)[BPSH-40], (b) sulfonated poly phenyl sulfone [Radel R] and (c) sulfonated Poly(sulfide sulfone). These membranes were procured as a part of a collaborative effort from Virginia Polytechnic Institute (Professor Mcgrath's research group, for poly (arylene ether sulfone) and from Foster Miller Inc., (Waltham, MA, for sulfonated poly sulfide sulfone and poly phenyl sulfone).

A specially designed four-probe conductivity cell was used (figure 1). This cell allowed for both in-plane and through plane measurements. In addition, the membrane contained in this cell was humidified akin to normal fuel cell operation. The gas inlet was designed for humidity control using an in-house humidity control setup. This setup incorporated a constant temperature oven, which housed the conductivity cell. The humidity was controlled by a feed back loop setup using mass flow meters and proportioning valves, mixing wet and dry gas. This arrangement was controlled via a computer using labview software. Reaction layers used for this study were specially made so that the measured conductivity was limited by proton conduction of the ionomer alone, without interference for other parameters. In order to enable this the reaction layer comprising of an ink containing ionomer blend and catalyst was deposited on to a hydrophilic Nylon membrane support. The catalyst in the ink composition in this case was γ-Al_2O_3 instead of the normal Pt/C. Care was taken to use exactly the same methodology as used with conventional reaction layer ink formulations. The choice of the alternative support was



necessitated by the need to avoid any interference from other conductive substrates.

Results and Discussions

Effect of different ionomers in terms of their proton conductivity in the reaction layer is shown in Figure 2. Very different proton transport characteristics is

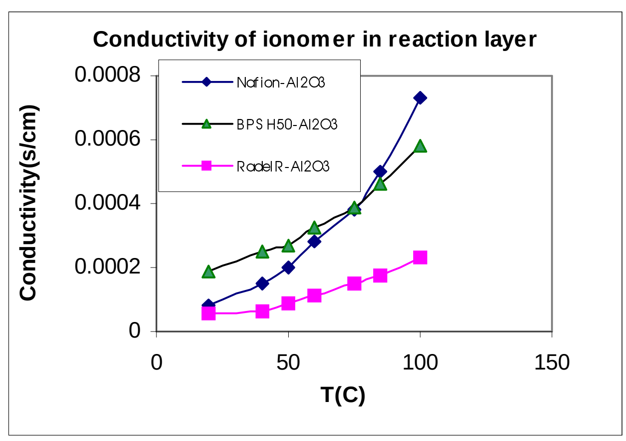


Figure 2. Comparison of reaction layer proton conductivity for Nafion 117 relative to sulfonated poly (arylene ether) sulfone [BPSH-40] and sulfonatyed ploy (pheny sulfone) [Radel R]

exhibited by sulfonated poly (phenyl sulfones) [Radel R] and the sulfonated poly (arylene ether) sulfones [BPSH-40] as compared to Nafion 117. This presentation will provide a well rounded picture of possible strategies for reaction layers with alternative membranes designed for elevated temperature operation.

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