The Effect of Methanol Concentration on Membrane Conductivity and Interfacial Resistance in DMFCs

Yu Seung Kim and Bryan S. Pivovar

Electronic and Electrochemical Materials and Devices,
MST-11, MS-D429, Los Alamos National Laboratory,
Los Alamos, NM 87545

Increased methanol feed concentrations could be advantageous for direct methanol fuel cells (DMFCs) from a system perspective due to increased energy density, increased freeze tolerance and improved ability to respond to dynamic loads. However, methanol crossover scales with methanol concentration, and increased crossover in DMFCs leads to lower cell performance and decreased fuel efficiency. These effects are magnified when a poor methanol barrier membrane such as Nafion™, the standard DMFC membrane, is used, limiting operation to concentrations below 1M. Still, higher methanol concentrations are of interest for membranes that are better methanol barriers. Here, we investigate the impact of methanol concentration on membrane and membrane-electrode interfacial resistance for Nafion and fully aromatic copolymer (BPSH) MEAs.

We have reported previously that increased membrane-electrode interfacial resistance not only caused higher ohmic losses but also accelerated deterioration of long-term stability.[1,2] Figure 1 shows high frequency resistance (HFR) of the Nafion and BPSH MEAs as a function of membrane thickness at 80°C. In the HFR plot, the slope of the linear regression represents the resistivity of the bulk membrane, the inverse of this value is the membrane conductivity.[3] The interfacial resistance is estimated by subtraction of the electronic resistances of cell components from the non-membrane resistance (y-intercept). Figure 1 clearly shows both membrane resistivity (slope) and non-membrane resistance (y-intercept) increased with methanol concentration for Nafion 1100 equivalent weight. The BPSH-35 MEA showed a similar increase in interfacial resistance,, but a smaller change in resistivity, suggesting similar interfacial effects but a smaller dependence of bulk membrane conductivity on methanol concentration.

Figure 2 shows DMFC performance of BPSH-35 and Nafion as a function of methanol feed composition. At low methanol concentration, performance is very similar, but at high methanol concentrations, (i.e. > 2 M), the Nafion MEA suffers significant performance losses due to the increased methanol crossover rates. Long-term performance data and data on the effects of methanol concentration in free-standing films will also be provided at the time of presentation.

References

1. Y. S. Kim, M. J. Sumner, W. L. Harrison, J. S. Riffle, J. E. McGrath, B. S. Pivovar, 204th Meeting of the Electrochemical Society, Orlando, Oct. 12-16, (2003).
2. Y. S. Kim, William L. Harrison, James, E. McGrath, B. S. Pivovar, 205th Meeting of the Electrochemical Society, May 9-14, San Antonio, (2004).
3. Y. S. Kim, B. S. Pivovar, 204nd Meeting of the Electrochemical Society, Orlando, Oct. 12-16, (2003).

Acknowledgment
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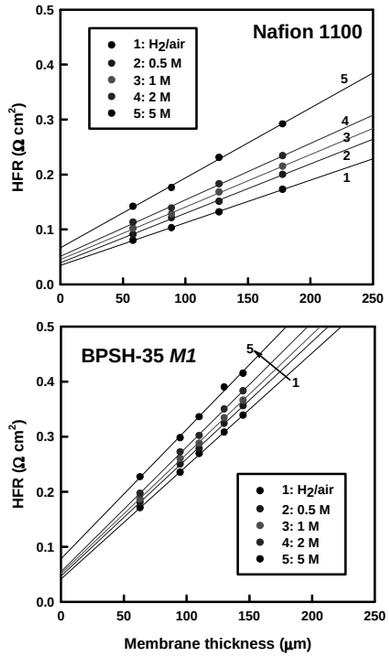

Figure 1. Effect of methanol concentration on high frequency resistance (HFR) vs. membrane thickness.

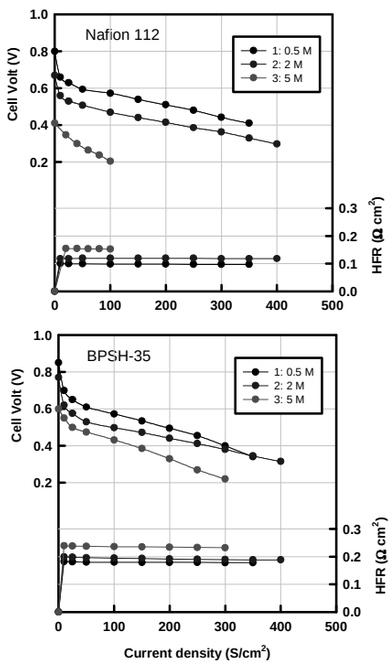

Figure 2. Effect of methanol concentration on DMFC performance of Nafion and BPSH at 80°C.