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Effect of Interfacial Resistance on Long Term Performance of Direct Methanol Fuel Cells

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In earlier work, it was found that the interfacial incompatibility between proton exchange membranes (PEM) and Nafion®-bonded catalyst layers can result in an initial performance loss in direct methanol fuel cells (DMFCs).[1,2] In this research, the effect of interfacial incompatibility of membrane electrode assemblies (MEAs) on long term DMFC performance is presented.

When a DMFC is operated for extended periods of time, performance decreases continuously. A major source of performance loss, especially in the short term and at high operating potential, is due to platinum surface oxidation in the cathode catalyst layer. While platinum oxidation is known to be recoverable by lowering the cathode potential,[3,4] irreversible performance losses will ultimately limit DMFC lifetimes. Here, we focus on the irreversible DMFC performance degradation due to interfacial incompatability between the membrane and electrode.

DMFC performance loss due to interfacial incompatibility can be readily observed in lifetime data such as that shown in Figures 1 and 2. Figure 1 compares lifetime performance and resistance of two representative MEAs, i.e. disulfonated polysulfone copolymer (BPSH-35) and Nafion control MEAs, under 80°C DMFC conditions. While in previous work we showed that BPSH-35 MEAs had relatively higher interfacial resistances compared to Nafion MEAs,[5] Figure 1 shows that BPSH-35 MEA is less stable than the Nafion MEA and exhibits an increase in cell resistance along with a more pronounced performance drop. These observations are supported in Figure 2, polarization curves performed before and after the 200 h life test. The Nafion MEA shows very little change in performance, however the BPSH-35 MEA shows a significant decrease in performance, suggesting this performance drop is not related to catalyst oxidation and represents an irrecoverable performance loss.

Table 1 shows a number of other novel membranes that have also been tested for DMFC lifetime. The results in Table 1 show a qualitative dependence between water uptake and resistance gain. This suggests that swelling of the test membrane (leading to a dimensional mismatch between the PEM and the catalyst layer) is an important parameter for interfacial compatibility.

References

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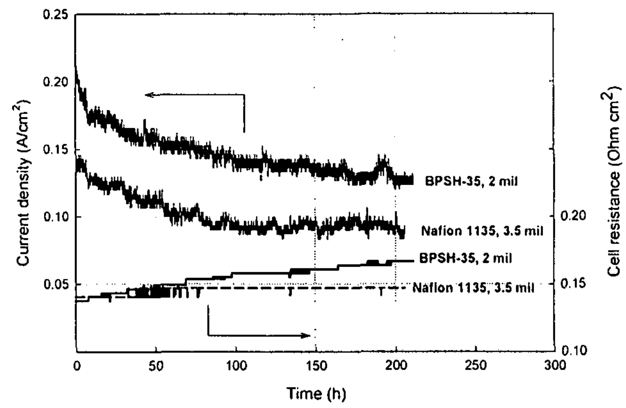

Figure 1. Current density and cell resistance changes over time for BPSH-35 and Nafion MEAs at 0.5 V.

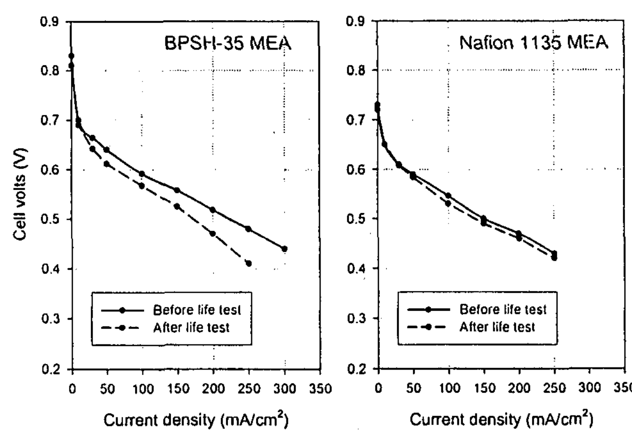

Figure 2. Comparison of polarization curves for the BPSH-35 and Nafion MEAs before and after 200 h life test.

Table 1. High frequency resistance (HFR) gain for various PEMs with Nafion bonded electrode.

PEM[a]	H_2O uptake (vol. %)	HFR gain for 100 h (mA/cm^2)
Nafion 1135	38	4.3
Recast Nafion	46	14.2
BPSH-30	40	7.5
BPSH-35	49	17.5
BPSH-40	75	30.3
6F10BPS-35[b]	47	13.9
6F30BPS-35[b]	42	9.6
6FCN-35[c]	31	-2.9

[a] numbers in abbreviation after dash refers to the sulfonation percentage of a disulfonated monomer
[b] hexafluoro bisphenol A and biphenol copolymerized poly(arylene ether sulfone)s
[c] disulfonated poly(arylene ether benzonitrile)s[1]

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