Minutes of the High Temperature Membrane Working Group Meeting
Monday, May 18, 2009

The semi-annual meeting of the HTMWG was held at the Crystal City Marriott in conjunction with the DOE Annual Merit Review Meeting. Participants were welcomed by Donna Ho, representing the Department of Energy.

Following the welcome, Dr. John Kopasz gave a brief overview of the talks to be presented during the AMR that were related to fuel cell membranes. These talks included several given at two poster sessions, as well as talks all day Tuesday and on Wednesday morning.

Dr. Kopasz then proceeded to give an update on the Membrane Classification Scheme that was developed three years ago. This scheme uses a two-dimensional scheme to relate morphology and conduction mechanism. The conductivity results from the program at 80 °C and 80% RH indicated that rigid rods, poly POMs and structured ionomers gave conductivities of >200 mS/cm. According to Dr. Kopasz, at the Go/No-Go decision point of 120 °C and 50% RH, PolyPOMS, phosphates, rigid rods, structured supports, structured ionomers and the additive approach using "other" all gave conductivities of ≥ 0.1 S/cm (some of which were measured in-house, rather than by BekkTech).

Additionally, Dr. Kopasz reviewed the DOE membrane targets, emphasizing that it has been updated to use area-specific resistance (ASR) instead of conductivity. He also reviewed the importance of, and metrics for, mechanical and chemical durability of membrane electrode assemblies (MEAs).

The next speaker was Dr. Yu Seung Kim from Los Alamos National Lab, who gave a talk on the Integration of Non-Traditional Membranes into MEAs. The talk was broken down into two major parts: Membrane-Electrode Interface and Non-PFSA Ionomers. For the binder for non-traditional membranes, Dr. Kim emphasized that while a membrane must have low reactant permeability, the ionomer binder must have high reactant permeability. Therefore, the ionomer binder having a dissimilar structure with the membrane may be desirable.

Dr. Kim reviewed various reports from the literature regarding the difficulty in preparing an MEA and the problems associated with the membrane-electrode interface. He pointed out that MEAs can be prepared by either direct membrane painting or by decal transfer using hot pressing. He reported that the direct method is a simple process, but it is difficult to control the catalyst loading, and difficult to process a highly-water-swollen membrane. In contrast, the decal transfer method is a more complex procedure but one that leads to precise control of catalyst loading. This process also works better for the highly-water-swollen membranes. Following the description of the processes, performance data was presented for electrodes prepared using each method.

The second part of Dr. Kim's talk -- non-PFSA ionomers -- discussed electrode formulation and testing conditions for electrode studies. An electrode bonded by a hydrocarbon ionomer gave inferior performance when compared to an electrode bonded by Nafion® ionomer. Next, he presented data that illustrated the differences in electrodes made with the ionomer dispersion in NMP versus glycerol or water/2-propanol. Additional data was presented to show that the dispersed and solid ionomers have different structures and mechanical properties, depending on the dispersing agent. Dr. Kim completed his talk with a discussion on side chain mobility and the influence on electrode performance.

The third speaker of the day was Dr. James Fenton from the University of Central Florida's Florida Solar Energy Center (FSEC). Dr. Fenton distributed copies of the Procedure for Performing PEM Single Cell Testing that was prepared by FSEC. This document will be used for the MEA manufacture and testing that will be done with membranes supplied by the DOE-funded membrane projects.

Dr. Fenton outlined FSEC's responsibilities with regard to preparing and testing these MEAs. He said that FSEC's goal is to make good MEAs by working closely with the membrane developer to apply an appropriate electrode for the specific membrane. After a brief review on the components of an MEA, he emphasized that there is a complex interplay amount the key elements. Dr. Fenton presented a variety of data to illustrate possible problems that FSEC has identified as being relevant in MEA manufacture, including: drying steps that can result in a brittle membrane; solvent selection that can impact swelling; and the rate of spraying the catalyst. The standard process that FSEC uses for preparing an MEA was then outlined, followed by the cell assembly process and, finally, the steps used in testing. The data and materials that FSEC will furnish to the membrane provider were also discussed. Dr. Fenton finished by outlining how the membrane providers can assist FSEC in having all of the information possible to fabricate the best MEA possible.

The final talk of the meeting was presented by Dr. Craig Gittleman from General Motors (GM), who spoke regarding the Automotive Perspective on PEM Evaluation. Dr. Gittleman began with an overview of FC operating conditions from the OEM perspective. He stressed that the OEMs are currently focusing on 95 °C, where the RH could be from 40 - >100%. He then discussed the performance durability trade-offs, where a number of pathways can lead to lower proton transport resistance, but these might not be the best pathways for improved durability. Next, Dr. Gittleman discussed various tests that GM uses for testing PEMs, both *ex situ* and *in situ* tests. He also stressed the importance of not focusing solely on conductivity. He said that fuel cell testing is the best indicator of membrane performance and that actual membrane RH is extremely sensitive to in-cell water transport.

With respect to membrane mechanical durability, Dr. Gittleman said that any test results are very sensitive to cell design and specific operation. He recommended that membrane testing should be benchmarked against NRE-211 with a specific set-

up, and that if the setup is proper, the NRE-211 should fail at ~5000 cycles. He said that humidity cycling accelerates mechanical failures in the absence of electrochemical degradation and that different processing methods for the same polymer can dramatically affect durability to humidity cycling. He said that mechanical reinforcement can help prevent crossover leaks that are induced by humidity cycling.

Dr. Gittleman went on to say that tensile tests cannot be used as a predictor for mechanical stability. He explained the blister test used at GM, but said that if facilities aren't available for the blister test or for RH cycling, swelling and elongation to break should be measured at a minimum.

In closing, Dr. Gittleman said that failure modes of mechanical degradation, chemical degradation and shorting must all be considered when developing materials for automotive fuel cell systems.

The presentations were followed by a brief period of discussion and adjourned shortly before noon.