High Temperature Membrane Working Group

Minutes of Meeting on September 14, 2006, in San Francisco

The meeting was held in San Francisco and was attended by 32 people. In addition, it was made available by teleconference and seven people participated, including a college class that listened in. The updated agenda for the meeting is posted online at http://www.eere.energy.gov/hydrogenandfuelcells/2006_htmwg_archives.html.

The meeting began with a welcome from Nancy Garland. Jim Fenton then reminded the working group about the discussion and the revision to the go/no-go decision point at the last meeting, held May 19, 2006, in Washington DC. Text from that meeting's minutes includes the words in italics:

> *Year two, at the third quarter, conductivity of 0.07 S/cm at 80% relative humidity at room temperature using alternate materials (not Nafion) will be demonstrated.*
>
> *Year three, at the third quarter, conductivity of >0.1 S/cm at 50% relative humidity at 120°C will be demonstrated as a go/no-go decision point.*
>
> *Revised go/no-go Decision Point: Discussions during and after the working group meeting generated some concern on the proper interpretation of the 3rd year go/no-go decision point. The current milestone could be read to mean operation at a relative humidity of 50% at 120°C while the intent is for the relative humidity to be based on a room temperature measurement. This latter interpretation is consistent with the HFCIT Multi-Year RD&D Plan 2010 membrane technical target (see Table 3.4.12) of an inlet water vapor partial pressure of 1.5 kPa*

The 2010 target listed below raises the question as to what is the appropriate water partial pressure at the membrane that should be used to measure the conductivity of the membrane, and what is the appropriate interpretation of the go/no-go decision point.

> The 2010 target for conductivity of >0.1 S/cm at 120°C and 1.5 kPa inlet water vapor partial pressure to the fuel cell stack (50% relative humidity measured at room temperature).

The agenda for this meeting was developed to provide information on membrane requirements and measuring membrane properties, and to help answer the question as to what the appropriate relative humidity to measure the conductivity of the membrane is. Copies of the presentations on "Membrane Performance and Durability Overview for Automotive Fuel Cell Applications," by Tom Greszler (GM); "Measuring Physical Properties of Polymer Electrolyte Membranes" by Cortney Mittelsteadt (Giner); "In-Plane Conductivity Testing" by Tim Bekkedahl (BekkTech); "Through-thickness Membrane Conductivity Measurement for HTM Program: Issues and Approach" by Kevin Cooper (Scribner); and "Temperature and RH Targets" by Vishal Mittal

(UCF/FSEC) are available online at http://www.eere.energy.gov/hydrogenandfuelcells/2006_htmwg_archives.html. The presentation by Tom Greszler provided an understanding of changes to the operating conditions on the performance of actual fuel cell automobile engines and the impact these conditions have on expectations of a membrane. Cortney's presentation provided insight into the many physical and chemical properties that membranes must have and how they may be measured. Tim (in-plane) and Kevin (through-plane) covered the various techniques that will be used in the program to measure conductivity. Vishal presented a discussion on the implications of the go/no-go decision point requirement of a 1.5 kPa inlet water vapor partial pressure to the fuel cell stack on what is the relative humidity at 120 ^{o}C that the membrane actually sees in the working stack.

Tom Grezler's summary slide which provides both membrane performance in terms of conductivity and also membrane durability requirements is copied below:

Summary

- Membrane Performance
  - High membrane conductivity at low RH (< 50%) required to enable an "auto-competitive" Fuel cell System
  - 120°C remains long term target, but 95°C enables initial commercialization
  - Low EW PFSAs have potential to meet performance requirements
  - HC benzene sulfonic acid membranes not expected to meet targets
- Membrane Durability
  - Humidity cycling durability must be considered when developing membrane materials
  - Humidity cycling durability strongly dependent on processing method
  - Mechanical reinforcement not sufficient to prevent RH cycling failures
  - Humidity cycling failure is accelerated by chemical degradation
  - Mitigations strategies must be incorporated to prevent radical attack on the membrane
- High Performance Membranes exist, Mechanically Robust membranes exist, and Chemically Stable Membranes exist

→ Now we need to combine these properties into a single material

Fuel Cell Activities
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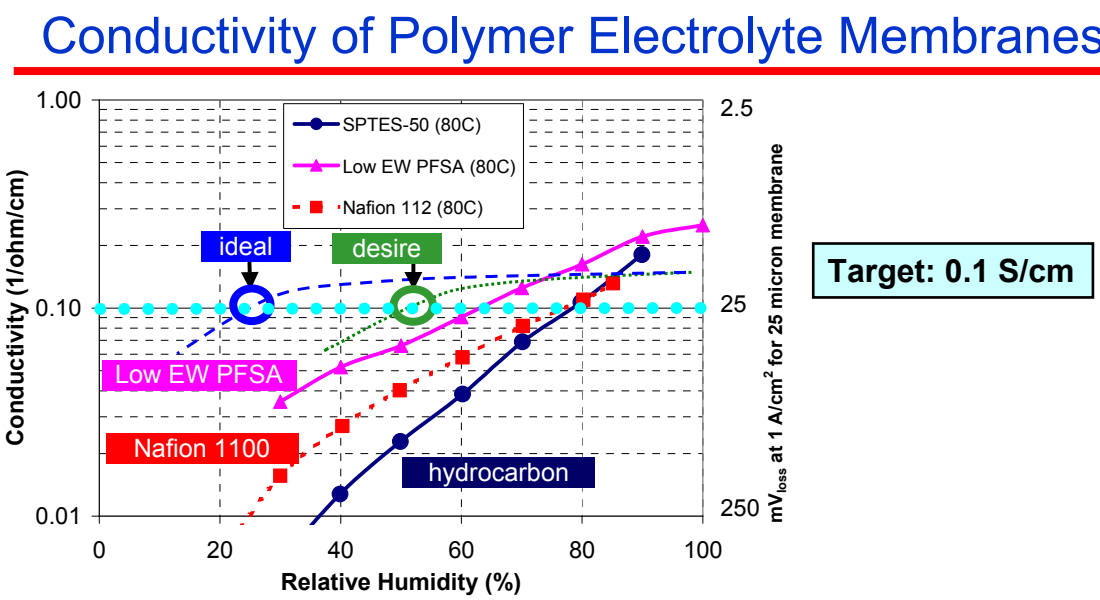
General Motors

The following figure of conductivity as a function of relative humidity was taken from slide 8 of Tom Grezler's presentation. The light blue circles represent the required target of 0.1 S/cm. The Nafion® 1100 curve and the Low EW PFSA curve have similar parallel shapes with the Low EW PFSA meeting the 0.1 S/cm target at >65% RH and the Nafion® 1100 not until >80% RH. It is this reason that the low EW PFSAs have the potential to meet near term performance targets. While Nafion® 1100 EW should not be considered the benchmark because of the superior performance of the low EW PFSAs, it will be used as a standard in making conductivity measurements for comparison with new developmental membranes. The green dotted curve represents a desired conductivity curve for initial fuel cell commercialization while the dark blue dashed line represents the ideal conductivity curve for 120 ^{o}C long term targets. The desired curve meets the 0.1 S/cm target at ~ 50% RH (95 ^{o}C) and the ideal curve meets the 0.1 S/cm target at ~ 25%

RH (120 °C). While both of these curves are similar in shape, their conductivity at low RH is substantially more than the PFSA and Nafion® curves at low RH.



A version of the above figure of conductivity as a function of relative humidity taken from slide 8 of Tom Grezler's presentation as well as discussion about membrane performance can be found in "Two Fuel Cell Cars In Every Garage?" by Mark F. Mathias, Rohit Makharia, Hubert A. Gasteiger, Jason J. Conley, Timothy J Fuller, Craig J. Gittleman, Shyam S. Kocha, Daniel P. Miller, Corky K. Mittelsteadt, Tao Xie, Susan G. Yan and Paul T. Yu. The Electrochemical Society *Interface*, pages 25-35, Fall 2005. http://www.electrochem.org/dl/interface/fal/fal05/IF8-05_Pg24-35.pdf

Until further clarification is obtained, to satisfy the requirement of the year three, third quarter go/no-go decision point conductivity measurements will be made at 120 °C over the range of relative humidity from 20 to 100% RH. The University of Central Florida's Florida Solar Energy Center, proposes to interpret the go/no-go decision point as the membrane will be expected to demonstrate conductivity of >0.1 S/cm at 120°C and **25%RH.**

The next meeting of the group is planned for May after the DOE Hydrogen Program program review meeting in Washington, D.C.