V.M.2 Membranes and MEAs for Dry, Hot Operating Conditions

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Subcontractors:
- Case Western Reserve University, Cleveland, OH
- Colorado School of Mines, Golden, CO
- University of Alabama, Huntsville, AL
- University of Detroit Mercy, Detroit, MI

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Objectives

To develop a new proton exchange membrane with higher proton conductivity and improved durability under hotter and dryer conditions, in order to meet DOE Hydrogen, Fuel Cells and Infrastructure Technologies Multi-Year Research, Development and Demonstration Plan 2010 commercialization targets for automotive fuel cells.

Technical Barriers

This project addresses the following technical barriers from the Fuel Cells section of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

(A) Durability

(C) Performance

Technical Targets

TABLE 1. Progress Towards Meeting Technical Targets for Membranes for Transportation Applications

Characteristic	Units	3M 2007 Status	2010	2015
Membrane Conductivity:				
120°C (50 % RH)	S/cm	0.05	0.10	0.10
120°C (25 % RH)	S/cm	0.02	0.07	0.07
20°C	S/cm	0.07	0.01	0.01
-20°C	S/cm	**		
Oxygen cross-over	mA/cm^2	**	2	2
Hydrogen cross-over (25 microns)	mA/cm^2	1.5	2	2
Area specific resistance (25 microns)	Ohm/cm^2	0.05	0.02	0.02
Durability with cycling				
At operating temp of ≤80°C	hours	>5,000	5,000	5,000
At operating temp of >80°C	hours	≤4,300	2,000	5,000
Unassisted start from	°C	**	-40	-40
Thermal cyclability in presence of condensed water		**	Yes	Yes

** Not measured yet - work still underway.

Approach

The focus of this project is to develop a new proton exchange membrane which can operate under hotter, dryer conditions than the state-of-the-art membranes today and integrate it into a membrane electrode assembly (MEA) and then finally into a fuel cell stack. These MEAs should meet the performance and durability requirements outlined in the solicitation, operating under low humidification conditions and at temperatures ranging from -20ºC to 120ºC, to meet 2010 DOE technical targets for membranes. Activities include:

- Synthesize and test new polymer membranes, including both fluorinated and non-fluorinated polymers as well as composite or hybrid systems, and evaluate their conductivity and chemical and mechanical stability.
- Evaluate new membrane manufacturing methods for increasing membrane mechanical properties and improving MEA lifetime.

- Develop new membrane additives aimed at increasing conductivity and improving membrane stability/durability under these dry conditions.
- Perform both experimental and theoretical studies of factors controlling proton transport and mechanisms of polymer degradation and factors affecting membrane durability in an MEA.
- Focus on materials which can be made using processes which will be scalable to commercial volumes using cost-effective methods.
- Integrate these new membranes into MEAs and test these for performance and durability. These tests will be performed in both single fuel cells and in a short stack using realistic automotive testing conditions and protocols.

Accomplishments

- New inorganic additives to perfluorosulfonic acid (PFSA)-based membranes have been identified which show improvements in conductivity and fuel cell performance (Figure 1). MEAs made from this membrane also had a lower fluoride release rate compared to the control.
- A new PFSA with an equivalent weight below 650 has been prepared.

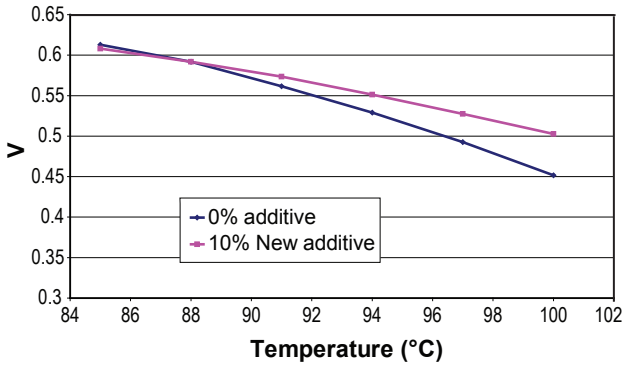

FIGURE 1. MEA Test (Constant Cell Voltage 0.5 A/cm^2, H_2/air, 50 cm^2 Cell, 70°C Dewpoint)

FY 2007 Publications/Presentations

1. Hamrock, S. J. "Membranes and MEA's for Dry, Hot Operating Conditions", DOE Hydrogen, Fuel Cells, and Infrastructure Technologies Program Review Meeting, May 15 - 18, **2007**, Arlington, VA, Presentation FCP 32.

2. Hamrock, S. J. "Membranes and MEA's for Dry, Hot Operating Conditions", 2007 DOE Fuel Cell Projects Kickoff Meeting, February 13, **2007**, Arlington, VA.

References

1. Hamrock, S. J. "The Development of New Membranes for PEM Fuel Cells," Advances in Materials for Proton Exchange Membrane Fuel Cell Systems, Asilomar Conference Grounds, Pacific Grove, CA, February 21, **2005**.

2. Debe, M. K. "Advanced MEA's for Enhanced Operating Conditions" DOE Hydrogen, Fuel Cells, and Infrastructure, Technologies Program Review Meeting, May 23 – 26, **2005**, Arlington, VA, Presentation FC-3.

3. Yandrasits, M. A. "MEA and Stack Durability for PEM Fuel Cells", DE-FC36-03GO13098, Fiscal Year **2007** Progress Report.