V.B.19 Dimensionally Stable High Performance Membrane

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Contract Number: DE-FG02-05ER84322

Start Date: June 27, 2005
Phase I End Date: March 26, 2006 (currently undergoing consideration for a Phase II SBIR grant)

Objectives

- Develop membrane electrode assemblies (MEAs) based on dimensionally stable membrane (DSM™) with high freeze/thaw durability.
- Enhance MEA X-Y (in-plane) dimensional stability.
- Develop MEAs with high ionic conductivity and excellent mechanical properties.
- Demonstrate concept feasibility for membranes based on patterned support.

Technical Barriers

This project addresses the following technical barriers from the Fuel Cells section (3.4.4.2) of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan.

(A) Durability

(B) Cost

Technical Targets

The goal of this DOE SBIR project is the development of a DSM having excellent dimensional stability during freeze/thaw cycles and superior mechanical properties under wide range of temperatures and relative humidities (RH). The membrane should demonstrate better durability than Nafion® under accelerated operating conditions as well as better performance and mechanical properties against conventional perfluorinated sulfonic acid membranes.

Approach

Improved mechanical properties of the DSM are achieved by employing a high-strength support structure fabricated from high-performance engineering plastics. The pattern design of the support structure is completely customizable so that the weak areas, such as edges, can be specifically reinforced to further enhance the durability.

By employing the high-strength support structure, lower-equivalent-weight ionomers, which are too mechanically weak to be implemented in the fuel cells, can be used without sacrificing mechanical durability. Thus, higher performance, especially at lower RH levels, can be achieved.

Accomplishments

- DSMs demonstrate drastically improved freeze/thaw stability compared to Nafion® in *ex situ* tests.
- DSMs show 10x better in-plane swelling stability than Nafion®.
- DSMs show more than one order of magnitude less creep rate compared to Nafion® (Figure 1).
- A DSM-based MEA with EW700 ionomer demonstrates superior mechanical properties and 40% performance gain over Nafion® (Figure 2).

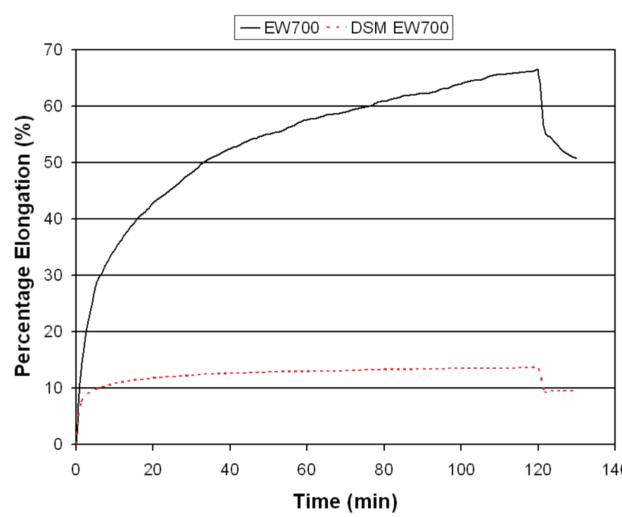

FIGURE 1. DSM demonstrates more than one order of magnitude improvement of creep stability compared to Nafion®.

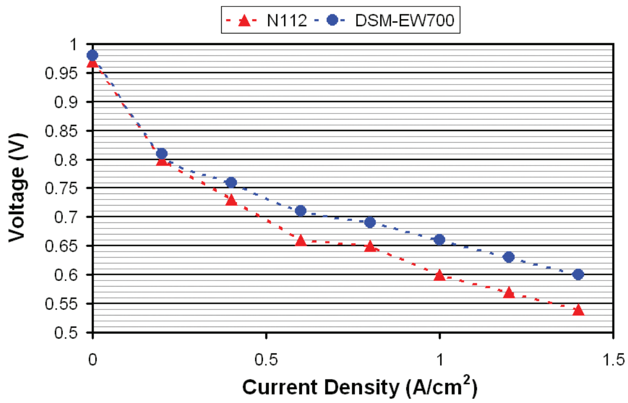

FIGURE 2. By employing EW700 ionomer, the DSM can outperform Nafion 112 by 40% at high current density. Test conducted at 80°C cell, 100% inlet RH anode and 50% inlet RH cathode.

Special Recognitions & Awards/Patents Issued

1. Liu, H., A.B. LaConti, C. Mittelsteadt and T.J. McCallum, "Solid Polymer Electrolyte Composite Membrane Comprising Laser Micromachined Porous Support," U.S. Patent Application 20060065521.

2. Liu, H. and A.B. LaConti, "Solid Polymer Electrolyte Composite Membrane Comprising Plasma Etched Porous Support," U.S. Patent Application 20060065522.

FY 2006 Publications/Presentations

1. Liu, H., 2006 DOE Hydrogen Program Review, Arlington, VA, 2006