# V.B.21 Dimensionally Stable High Temperature Membranes

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Israel Cabasso, SUNY-Syracuse, NY

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## Objectives

- Generate low equivalent weight (EW) perfluorinated sulfonic acids (PFSAs) having enhanced dimensional stability through the utilization of two and three dimensional structural supports.
- Understand the relationship between ionomer EW, support geometry and mechanical and conductive properties of the resulting composite polymer electrolyte membrane (PEM).
- Demonstrate that the improved mechanical properties of the composite PEM lead to improved fuel cell lifetimes.
- Demonstrate DOE targets for PEM performance, durability.

## 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

(D) Thermal, air management

Specifically:

- Cost of the micro-supports
  - Current laser machining exceeds DOE targets for membrane cost.
- Membrane swelling
  - Absence of membrane swelling in x-y plane will lead to greater durability.
  - Some freeze-thaw and relative humidity (RH) cycling already accomplished.
- Bulk polymerization of PFSA not yet demonstrated
  - Oligomers generated during first attempt.

## Technical Targets

- This project is directed at reaching the DOE 2010 targets for PEMs including;
- Cost: $40/m$^2$
- Conductivity: 0.10 S/cm at 120°C and 1.5 kPa water vapor pressure
- 5,000 hour lifetime with cycling
- <2 mA/cm$^2$ loss of hydrogen and oxygen
- Survivability of cycling through -40°C

## Approach

The overall approach of this project is to lower the EW of perfluorosulfonic acid ionomers to increase low RH conductivity and support the ionomer with two and three dimension non-ionic materials.

Ionomers that are stable in two dimensions will be generated by incorporation of the ionomer in a 2-dimension micro-scale honeycomb matrix. The matrix will be generated by laser machining. The effect of ionomer EW and support geometry/composition on the PEM composite will then be explored.

Membranes with enhanced stability in three dimensions will be generated by the direct polymerization of low EW PFSA into a nano-scaled porous support. Initially, methods of conducting bulk polymerization will be explored, followed by carrying out these methods within the support. Variables to be explored are synthetic pathways, support material and support geometry.

## Accomplishments

Two Dimension Stable Membranes

- Obtained support material in second polymer
  - Polysulfone and polyimide both available now.
- Ordered first set of different sized supports to explore the effect of support geometry
- Improved spray booth for incorporation of ionomer into support
- Fabricated 50 $cm^2$ MEAs into baseline material with new spray booth

Three Dimension Stable Membranes

- Completed first matrix of polymerization pathways
  - Redox and azobisisobutyl nitrile (AIBN) appear to be possible initiation pathways.
- Sending samples out for nuclear magnetic resonance (NMR) analysis
  - Previously using SUNY-Environmental Science and Forestry, elected (with DOE approval) to fund fellowship to assist with synthesis, and especially characterization.

## Special Recognitions & Awards/Patents Issued

**1.** U.S. 2006-065521 A1: Solid Polymer Electrolyte Membrane Composite Containing Laser Etch Porous Support (Application).

**2.** U.S. 2006-065522 A1: Solid Polymer Electrolyte Composite Membrane Comprising Plasma Etch Porous Support (Application).

## FY 2006 Publications/Presentations

**1.** May DOE Hydrogen Program Review, Washington, D.C. Poster and working-group presentations.