V.B.1 Poly(p-Phenylene Sulfonic Acid)s with Frozen-in Free Volume for use in High Temperature Fuel Cells

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Objectives

- Resynthesis and characterization of best graft polymer polyelectrolyte for baseline properties. Improve mechanical properties.
- Synthesis, copolymerization (random first and then block) and characterization of new comonomers and structures. Objective is to make materials with large frozen-in free volume to hold water at low relative humidity (RH).
- Make membrance electrode assemblies (MEAs) of best materials and do preliminary method development and testing in small fuel cells.
- Present materials to meet DOE 2006 objectives. Will aim to get better high and low temperature conductivity in new materials.
- Study thermal degradation of proton exchange membranes (PEMs) in realistic fuel cell environments.

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

All described work was done before the project start date. The membranes come close to the DOE conductivity goals for 2004. However, the membrane organization must be randomized for best results. We have not measured gas crossover yet.

Progress Toward Meeting DOE Conductivity Requirements (2004)

Temperature, °C	Relative humidity, %	Conductivity S/cm	2004 Target S/cm
-20	50	0.007	0.01
20	50	0.07	0.07
80	50	0.10	0.07
120 (2005)	25	0.07	0.1

Approach

This is a two pronged study. The rigid rod polymer properties will be improved by synthesizing and copolymerizing bulky, very hydrophobic comonomers. This will increase dimensional stability and enhance frozen-in free volume. The next step is to make block copolymers: these should have structures that can resist dehydration better than the random copolymers and thus retain conductivity at lower relative humidities.

The second approach (first projected structure) is to make a completely rigid 2-D structure with ~2 nm hexagonal pores. These are designed to have a lambda (number of water molecules per acid group) value of ~10. Capillary attraction should be strong enough in these materials that they could meet the 2010 DOE goals.

FY 2006 Progress

This project is in the process of being initiated.

Special Recognitions & Awards/Patents Issued

1. There is one patent pending on the liquid crystal, rigid rod polyelectrolytes, based on our previous work.