V.B.18 Design and Development of High-Performance Polymer Fuel Cell Membranes

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Objectives

- Design, synthesize, and characterize new high-performance polymer structures and hydrophilic organic additives for high temperature and low relative humidity (RH) polymer electrolyte membrane (PEM) fuel cell membranes.
- Demonstrate proton conductivity (0.1 S/cm at 120°C, 50% RH), economic feasibility ($40/m^2$), and durability with temperature and humidity cycling (2,000 h at >80°C) of best membranes.

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 project is to design, synthesize, and characterize new PEM materials to improve performance at high temperature and low RH. These materials will be designed to meet the DOE 2010 targets for fuel cell membranes for transportation applications, particularly:

- Proton conductivity: 0.1 S/cm at 120°C, 50% RH
- Cost: $40/m^2$
- Durability: 2,000 h at temperatures >80°C

Approach

Our approach to achieving membranes with the desired performance properties at high temperature and low RH is illustrated in Figure 1. New aromatic hydrocarbon polymer architectures will be designed and synthesized to promote the formation of membrane morphologies that will increase proton conductivity with lower water uptake. The polymer structures will be designed with chemical architectures that will enhance hydrophilic/hydrophobic phase separation.

The new polymer structures by themselves may not be enough to produce the high proton conductivities required at high temperature and low RH. Therefore, hydrophilic organic additives will also be designed and synthesized to help retain water under these conditions. The additives will be hydrophilic/hygroscopic, water-insoluble, and thermally and hydrolytically stable.

Accomplishments

We have screened and determined the feasibility of several approaches to synthesizing a completely aromatic hydrocarbon polymer with the designed structure. A viable synthetic route has been developed. Current efforts are focused on completing the synthesis.

Several hydrophilic organic compounds have been synthesized, and composite membranes containing up to 10 mol% of additives have been fabricated and tested for proton conductivity and water uptake. At these loadings, water uptake was relatively unchanged. Proton conductivity varied depending on the nature of the additive. The best composite membrane in this group of

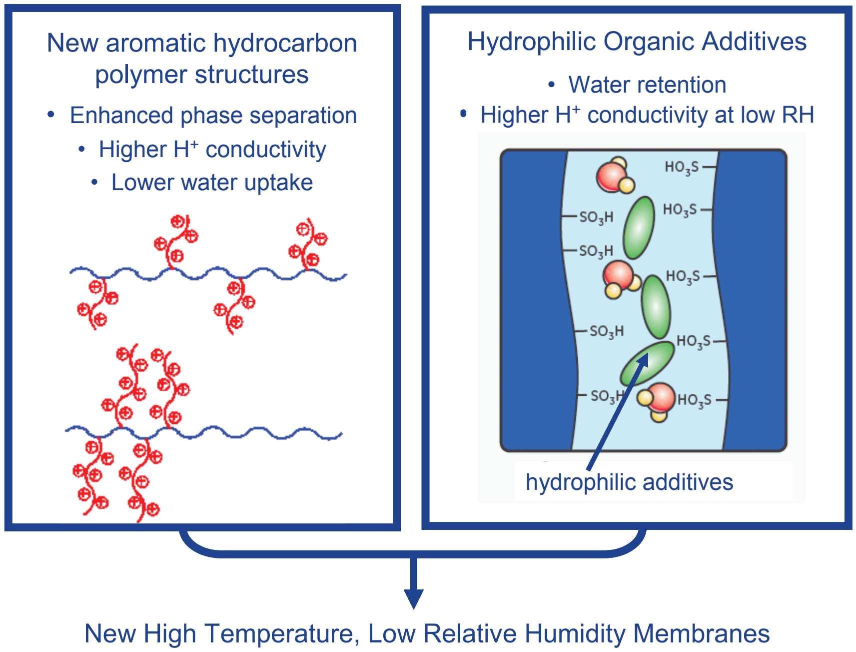

FIGURE 1. New Aromatic Hydrocarbon Polymer Architectures, Coupled With Hydrophilic Organic Additives

samples had a similar conductivity to the pure polymer membrane, except at 60°C, 50% RH, where the proton conductivity was three times higher (0.03 S/cm).

FY 2006 Publications/Presentations

1. Presentation at 2006 DOE Hydrogen Program Review – May 16, 2006, Arlington, VA.

2. Presentation at High Temperature Membrane Working Group Meeting – May 19, 2006, Arlington, VA.