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High Temperature Membrane With Humidification-Independent Cluster Structure

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Objectives

- Operation of PEM fuel cells at elevated temperature is desirable to improve operability on reformate fuel, to increase system efficiency and to simplify the balance of fuel cell power plant
- Develop humidity-independent, thermally stable, low equivalent weight composite membranes with controlled ion-cluster morphology, to provide high proton-conductivity at 120^{o}C and low relative humidity (Overall Goal: Meet DOE 2010 membrane targets)
- Improve mechanical properties to significantly increase the durability and reduce the gas cross-over
- Expand the operating range to sub-freezing temperatures

Technical Targets

This project is developing a composite membrane to meet the following DOE 2010 technical targets for membranes:

- Membrane Conductivity: At 120^{o}C: 0.1 S/cm; at Room Temperature: 0.07 S/cm; at –20^{o}C: 0.01 S/cm
- Cell Area Specific Resistance: 0.02 Ωcm^2

Approach

The approach for the Multi-Component Composite (mC^2) membrane is to improve its conductivity by use of functionalized additives and advanced co-polymer. Figure 1 shows the development plan for incremental improvement towards DOE's 2010 conductivity target for 120^{o}C. Improvements are contributed by each key component of the composite membrane.

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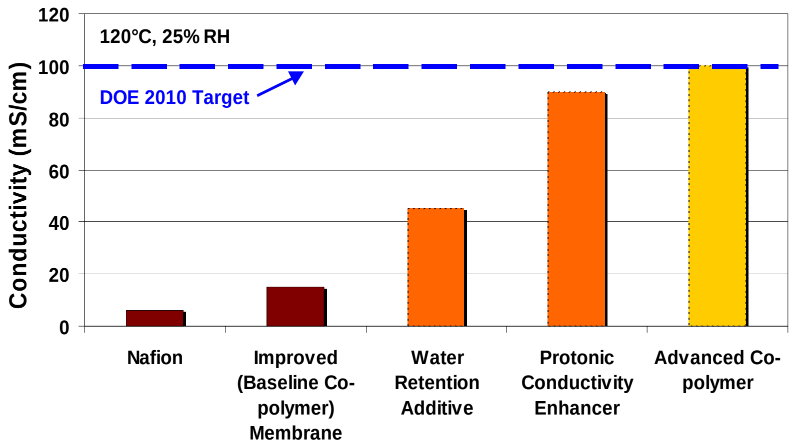

Figure 1. **DEVELOPMENTS STEPS TO THE CONDUCTIVITY GOAL:**
Each Individual Component Contributes to Conductivity Improvements.

Accomplishments

A baseline membrane has been fabricated utilizing an improved polymer. The membrane's physical, chemical and electrochemical properties have been characterized, including proton conductivity as a function of temperature and relative humidity (RH) and tensile properties. This membrane showed a 2.5x higher conductivity compared to the widely used Nafion® membrane at 120°C and 25% RH, as shown in Figure 1. The conductivity measurement was carried out in a 4-electrode in-plane conductivity cell. Tensile tests revealed that this increase in conductivity was achieved without any loss in mechanical properties.

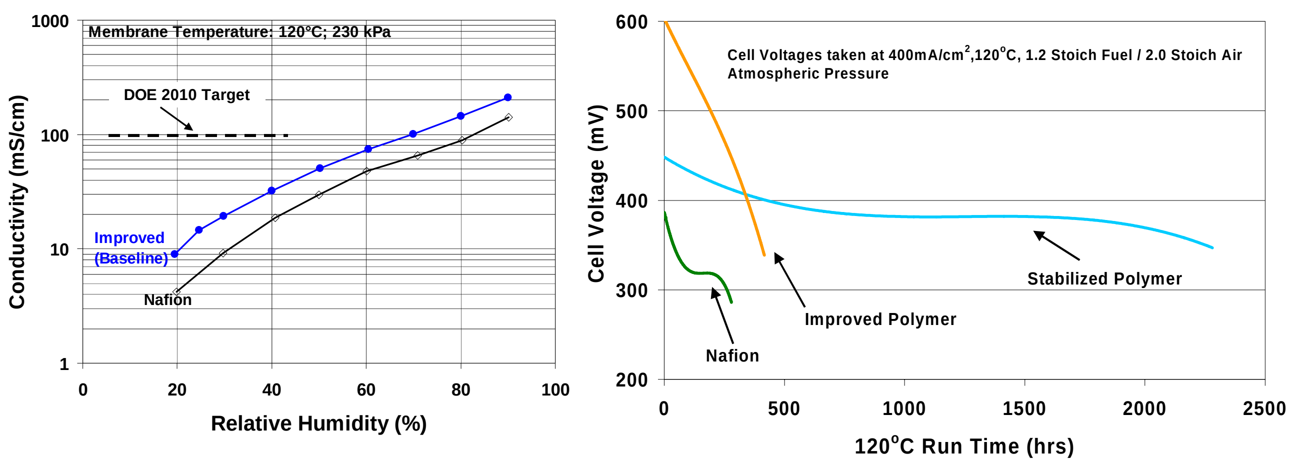

Figure 2. IMPROVEMENTS IN MEMBRANE PERFORMANCE AND STABILITY:
2.5x higher conductivity and 5x increase in cell life at 120°C and low RH.

Two categories of functionalized additives are being developed. One type is water retaining, to increase the hydration level inside the membrane at low RH operating conditions. The other type is a proton conductivity enhancer. These additives are integrated into the polymer structure to form a composite membrane for a better performance at 120 C and sub-freezing conditions. Preliminary conductivity data with each of these additives is promising, with several-fold improvement in conductivity observed.

Publications/Presentations

1. L. Lipp, P. Patel, R. Kopp, "High Temperature Membrane With Humidification-Independent Cluster Structure", 2007 DOE Hydrogen Program Merit Review and Peer Evaluation Meeting, Washington D.C., May 15-18, 2007

2 L. Lipp, P. Patel, R. Kopp, "High Temperature Membrane With Humidification-Independent Cluster Structure", DOE Hydrogen Program, FY2006 Annual Progress Report

3. L. Lipp, P. Patel, R. Kopp, "High Temperature Membrane With Humidification-Independent Cluster Structure", 2006 DOE Hydrogen Program Merit Review and Peer Evaluation Meeting, Washington D.C., May 16-19, 2006

4.Chao-Yi Yuh, Ray Kopp, Pinakin Patel, "Ultra-Thin Composite Membrane-Electrode AssemblyFor High-Temperature Proton Exchange Membrane Fuel Cell", DOE Hydrogen, Fuel Cells, and Infrastructure Technologies, FY 2003 Progress Report