

High Temperature Membrane With Humidification-Independent Cluster Structure

For
DOE Hydrogen Program Review
Meeting

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FuelCell Energy, Inc.

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ultra-clean power

delivered to customers around the world

Project ID #
FCP10



FuelCell Energy

Overview

Timeline

- Project start date: May 2006
- Project end date: May 2011
- Percent complete: 0%

Budget

- Total project funding
 - ▶ DOE share: \$1500k
 - ▶ Contractor share: \$600k

Barriers

- Low Proton Conductivity at 25-50% Relative Humidity and 120°C

Targets

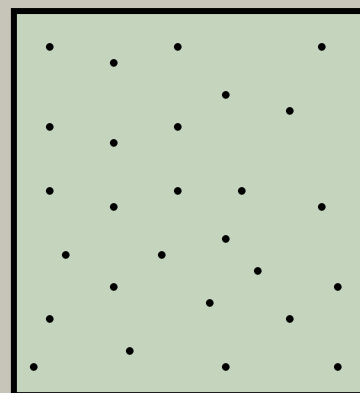
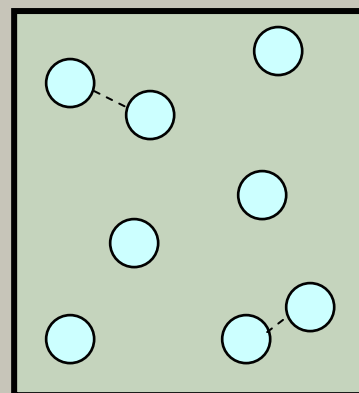
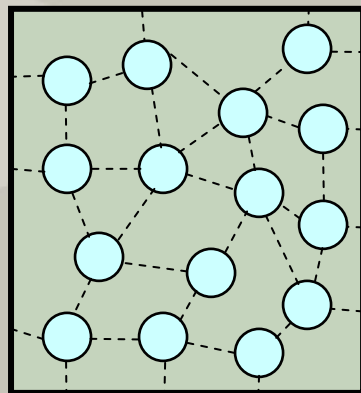
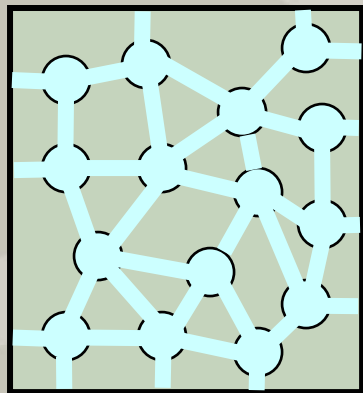
- Membrane Conductivity:
 - ▶ At 120°C: 0.1 S/cm
 - ▶ At Room Temp.: 0.07 S/cm
 - ▶ At -20°C: 0.01 S/cm
- Cell Area Specific Resistance: 0.02 Ωcm^2



Objectives

- Develop humidity-independent, thermally stable, low-EW composite membranes with controlled ion-cluster morphology, to provide **high proton-conductivity** at 120°C (Overall Goal: Meet DOE 2010 targets)
- Improve mechanical properties to significantly increase the **durability** and reduce the gas cross-over
- Expand the operating range to **sub-freezing** temperatures

Challenge: Low RH Operation



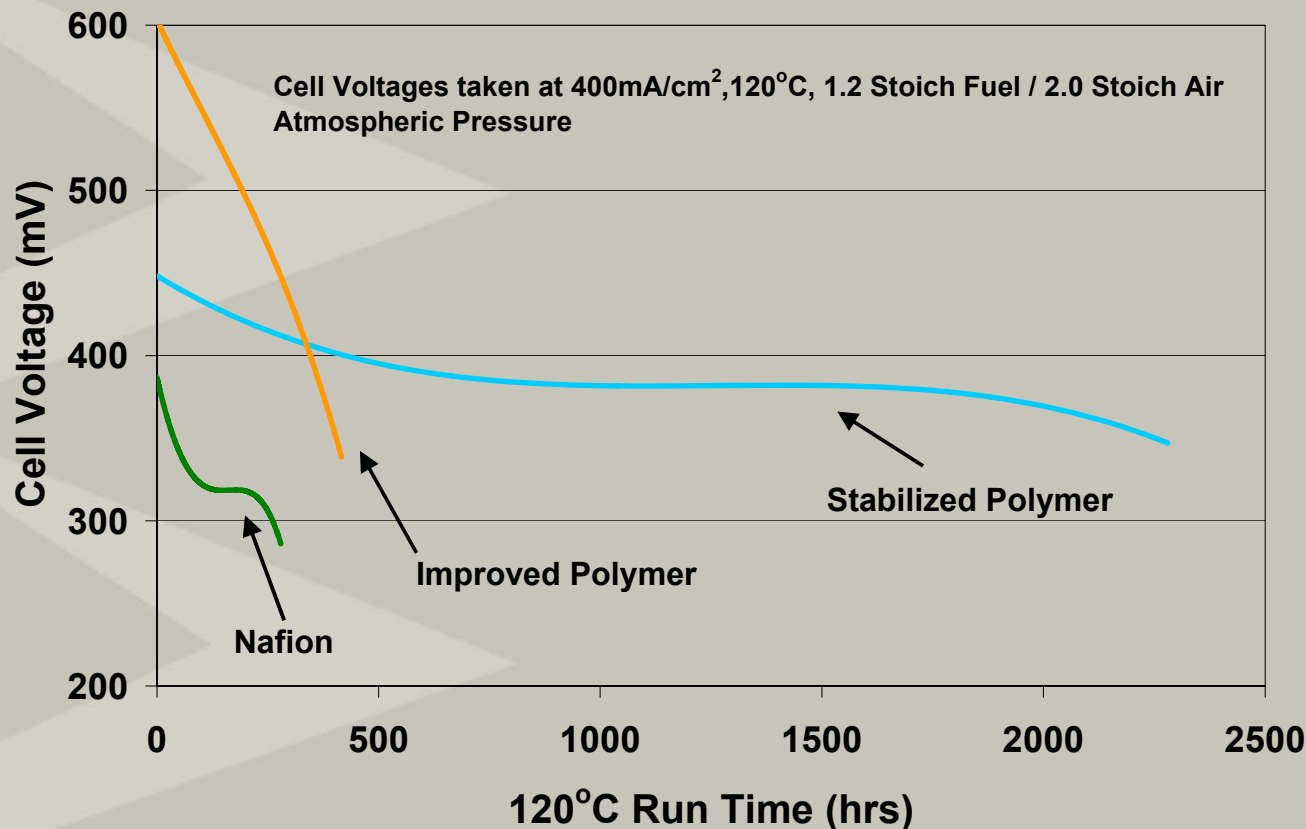
**High RH:
Excellent Channels
for Ion Conduction**

**Low RH:
Poor Channels**



Ensure ion conducting path through the membrane even
at low Relative Humidity (RH) conditions

FCE's Development Status



The improved/stabilized polymers show significant increase in cell life at 120°C, ~35% RH

Approach for the Composite Membrane

Target Parameter	DOE Target (2010)	Approach
Conductivity at : 120°C	0.1 S/cm	Lower EW
: Room temp.	0.07 S/cm	Higher number of functional groups
: -20°C	0.01 S/cm	Stabilized nano-additives
Inlet water vapor partial pressure	1.5 kPa	Immobilized cluster structure
Hydrogen and oxygen cross-over at 1 atm	2 mA/cm ²	Stronger membrane structure; functionalized additives
Area specific resistance	0.02 Ωcm ²	Improve bonding capability for MEA
Cost	<40 \$/m ²	Simplify polymer processing
Durability: - with cycling at >80°C - with cycling at ≤80°C	>2000 hours >5000 hours	Thermo-mechanically compliant bonds, higher glass transition temperature
Survivability	-40°C	Stabilized cluster structure design

Future Work: Composite Membrane Dev.

- Conduct project Kick-off Meeting
- Develop Baseline and Advanced polymer systems
 - ▶ Polymer composition
 - ▶ Polymer processing options
- Develop proton-conducting additives:
 - ▶ Catalog promising additives and their properties (structure, composition, proton conductivity, water adsorption isotherm, particle size, ease of production and cost)
 - ▶ Evaluate concentration ratios (additive to polymer)
 - ▶ Evaluate compatibility with ionomer and solvents used for membrane preparation
 - ▶ Collect experimental data to develop computer model for conductivity estimates in a composite structure

Future Work: Membrane Characterization

- Measure EW, swelling and water uptake at various temperatures and relative humidities
- Evaluate membrane mechanical properties as a function of temperature and relative humidity: tensile modulus, tensile strength, elongation at break, creep, crack formation, crack-spacing-concentration, coefficient of thermal expansion, etc.
- Perform membrane stability tests: Fenton's test for accelerated membrane degradation, stability tests in membrane conductivity cell

Key Milestones for 2006-2007

- Select Baseline membrane material and processing technique (6 months)
- Update list of promising additives for high temperature and low relative humidity (HT-LRH) membrane (12 months)
- Complete characterization of promising membrane options (18 months)

Summary

- A composite membrane incorporating proton conducting additives in an advanced co-polymer system has a potential to meet the DOE requirements
- Candidate materials and processing options for high mechanical strength, durability and low cost have been identified for initial evaluation
- Synergistic exploitation of FCE's experience in PAFC, MCFC and SOFC is planned