2008 Hydrogen Program

Annual Merit Review Meeting

PEM Electrolyzer Incorporating an Advanced Low-Cost Membrane

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June 11, 2008

Project ID# PDP5

GES

Overview

Timeline

- Project Start: June 2008
- Project End: May 2011
- Percent Complete: 0

Budget

- Total Project Budget: $2.5M
  - DOE Share: $1.99M
  - Cost Share: $0.51M
- FY08 Funding
  - DOE: $810K
  - Cost Share : $206K

Barriers

Hydrogen Generation by Water Electrolysis

- G. Capital Cost
- H. System Efficiency

Targets

Distributed Electrolysis

Characteristics	Units	2012	2017	2007 Status
Hydrogen Cost	$/gge	3.70	<3.00	4.76
Electrolyzer Cap. Cost	$/gge	0.70	0.30	2.14
	$/kW	400	125	987
Electrolyzer Energy Efficiency	%(LHV)	69	74	67*

*2007 status of electrolyzer cell efficiency; System efficiency N/A

Partners

- Virginia Tech University- membrane development
- Parker Hannifin Corporation- system development

Project Objectives

Overall Project

- Develop and demonstrate advanced low-cost, moderate-pressure PEM water electrolyzer system to meet DOE targets for distributed electrolysis
  - Develop high-efficiency, low cost membrane
  - Develop long-life separator
  - Develop lower-cost prototype electrolyzer system
  - Demonstrate prototype system at NREL

FY08 Objectives

- Develop Low-Cost, High-Efficiency. High Strength PEM
  - Electrochemical Performance comparable to thin Nafion (N112)
  - High Strength to allow operation at 300 psig and 80-90°C
  - Long-life
- Initiate separator development
- Preliminary system design and development of lower-cost components

Milestones

- FY08 Go/No Go Decision Points (May 09)
  - Membrane
    - Electrolyzer performance comparable to or better than that of Nafion 1135 at 80°C
    - Electrolyzer lifetime with adv membrane at 80°C ≥ 1000 hrs
  - Cell Separator
    - Demonstrated performance comparable to dual-layer Ti separator
  - System Development
    - Completed preliminary design review

Membrane Development Approach

- Further develop and combine two approaches under development for PEM fuel cell membranes:
  - GES DSM high-strength, high-efficiency membranes
    - PFSA ionomer incorporated in an engineering plastic support
    - Evaluate 2D and 3D supports
  - Advanced hydrocarbon membranes- Virginia Tech (VT)
    - Bi Phenyl Sulfone, H form (BPSH)
    - Random or Block copolymers
  - Consider incorporating BPSH in 2D or 3D DSM supports

Supported Membrane

- Superior Mechanical Properties
  - No x-y dimensional changes upon wet/dry or freeze-thaw cycling
  - Much Stronger Resistance to tear propagation
  - Superior to PTFE based supports
    10x stronger base properties
- Ease of MEA/Stack configurations
  - Direct catalyst inking onto membranes
  - Possible to bond support structures into bipolar frame to eliminate sealing issues
- Customized MEAs
  - Provide more support at edge regions and/or at ports

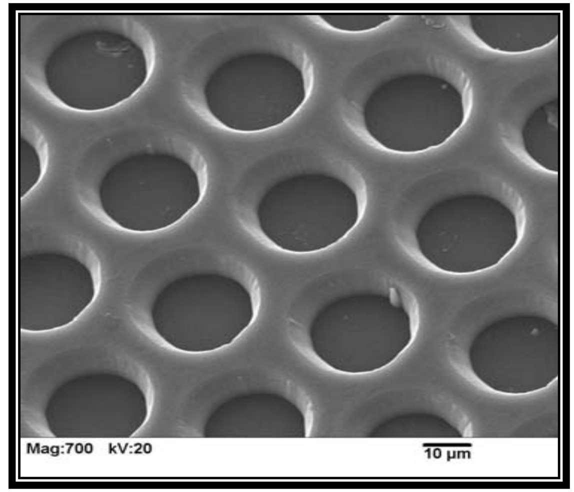


Figure 1. Scanning Electron Microscope (SEM) micrograph of the polymer membrane support structure with definable straight hole pattern

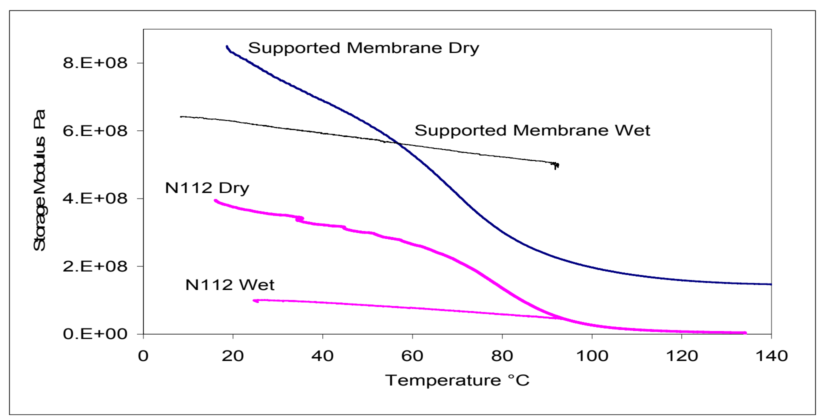
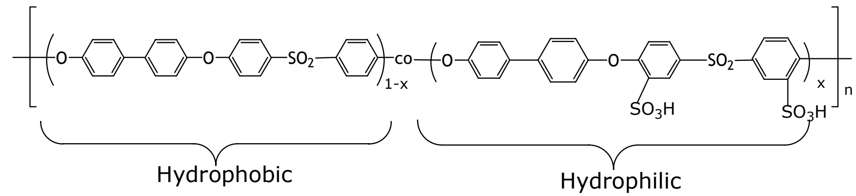


Figure 2. Dynamic Mechanical Analysis (DMA) shows the modulus of the novel supported membrane is ~10 X higher than the N112 membrane.

BPSH Membrane



- Wholly aromatic
  - Strong acid resistance
- Inexpensive starting materials
- Form disulfonate monomer, then random or block copolymerization

❖ **Acronym: BPSH-xx-*Mx***

Bi Phenyl Sulfone: H Form (BPSH)

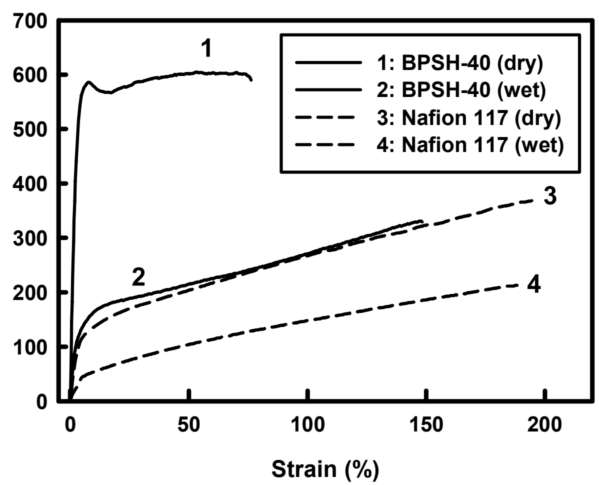
xx= molar fraction of disulfonic acid unit, e.g., 30, 40, etc.

Mx: Acidification method, e.g., *M1*, etc.

❖ **Acidification Treatment**

Method 1: 1.5M H_2SO_4, 30°C, 24hrs, then deionized H_2O, 30°C, 24hrs.

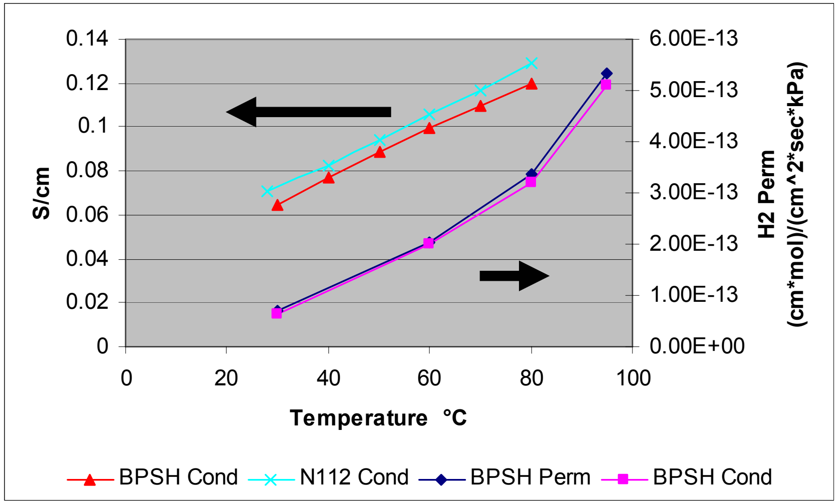
Method 2: 0.5M H_2SO_4, boil, 2hrs, then boiled deionized H_2O, 2hrs.



BPSH has a higher modulus and strength,but is not highly extensible dry

BPSH Development for Electrolyzers

- Determine optimum sulfonation level
  - Trade-off between conductivity and mechanical properties
  - 35 mole% disulfone units provides conductivity comparable to N112
  - Evaluate up to 50 mole% disulfone
- Evaluate cross-linking of high IEC copolymers
- Develop MEA fabrication methods for use with BPSH membranes



High Durability Cell Separator

- Requirements
  - Gas-impermeable (separates H_2 and O_2 compartments)
  - High electrical conductivity and high surface conductivity
  - Resistant to hydrogen embrittlement
  - Stable in oxidizing environment
  - Low-Cost
- Legacy Design
  - Multi-Layer piece consisting of Zr on hydrogen side and Ti on oxygen side
- Single or Dual-Layer Ti separators have been used
  - Ti subject to hydrogen embrittlement
  - Lifetime limited to <5000 hours, depending on pressure and operating conditions
- Approach is to develop a new low-cost dual-layer structure
  - Evaluate methods of bonding dissimilar metal films
  - Evaluate non-metal substrate with conductive coating

Electrolyzer System Design

- Objectives
  - Reduce BOP capital cost
  - Reduce BOP power consumption
  - Improve safety and reliability
  - Design for high-volume manufacturing
- Approach
  - Team with large volume commercial manufacturer (domnick hunter group of Parker-Hannifin Filtration Division)
  - Redesign system to eliminate or replace costly components
  - Laboratory evaluation of lower-cost components and subsystems
  - Develop higher efficiency power electronics