New High Performance Water Vapor Membranes To Improve Fuel Cell Balance of Plant Efficiency and Lower Costs

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Tetramer Technologies
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Overview

Timeline

- Start: June 17, 2011
- End: March 16, 2012
- Phase I Effort Complete: 100%

Budget

- Total project funding
  - DOE share: $150,000
  - Contractor share: $0
- Phase I Funding FY11: $150K

Barriers

- Cost
- Durability
- Performance – stack water management

Partners

- General Motors (Automotive Prototype Membrane Performance Testing)
- Ballard (Non-automotive Prototype Membrane Performance Testing)
- Membrane Technology Research (Module Prototype Production)

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Relevance

Design and develop high performance, low cost water vapor membranes for cathode humidification

DOE Barriers	2017 DOE Technical Targets for Cathode Humidifier Membrane	Tetramer 2012-2013 Goals
Cost	<$10/m^2	~ $20/m^2
Durability	5000 hours with < 10% drop in performance	20,000 cycles in GM durability test at 90 °C with a leak rate <150 GPU.
Performance – stack water management	• Operate at >95 °C • Pressure differential <75 kPa • Water transfer flux =0.025 g min^{-1} cm^{-2}	20,000 GPU with less than 20% loss projected over 2 years

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Phase I Approach and Technical Objectives

Progress	Objective	Status
100%	Demonstrate water vapor transport membrane with >18,000 GPU	GM has measured membranes demonstrating 18,319 GPU
80%	Water vapor membrane with less the 20% loss in performance after GM stress test	Demonstrated 11% decrease in permeability after 500 hours of continuous operation
90%	Crossover leak rate: <150 GPU	Membranes have demonstrated <50 GPU in short term tests
80%	Temperature Durability of 90 °C to excursions to 100 °C	Test were run at 85 °C and membranes achieved 20,000 cycles
50%	Cost - <$10/$m^2$ at medium volumes	Variable costs depending on polymer structure. Phase I membranes estimated at $20/$m^2$

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Approach: Technical Tasks

% Completion	Tasks	Status
95%	Ionomer Membrane Performance Optimization through Improvements in Molecular Architecture	Tetramer has produced over 20 new polymer structures that exceed competition
40%	Durability Improvement	Demonstrated 21% decrease in permeability after 1,800 hours of continuous operation
100%	Scale up of High Performance Materials	Multiple samples have been scaled up for testing

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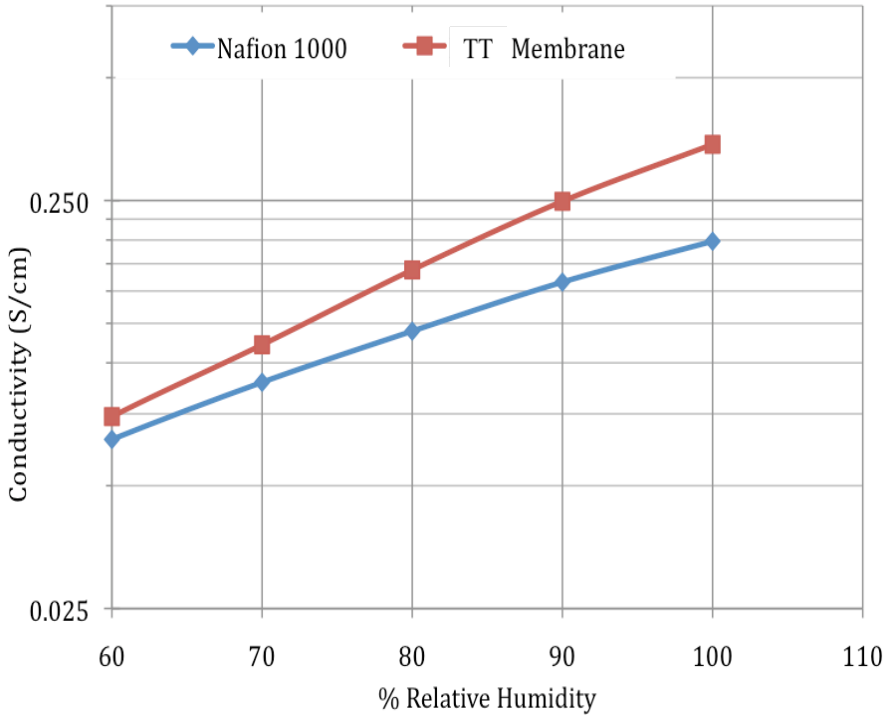
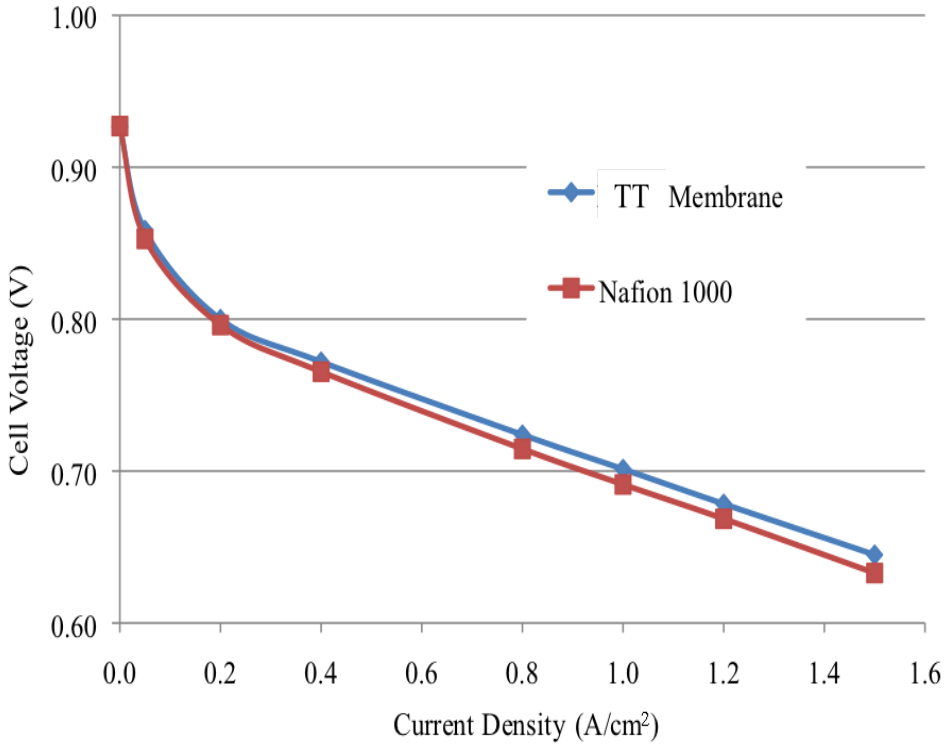
Improved PEM Performance vs. Nafion® 1000





- Membrane conductivity as a function of relative humidity (RH) for proprietary Generation 1 TT PEM ionomer and Nafion® 1000.
- Fuel cell polarization curve at 150 % RH_{out} for proprietary TT ionomer membrane and Nafion® 1000.

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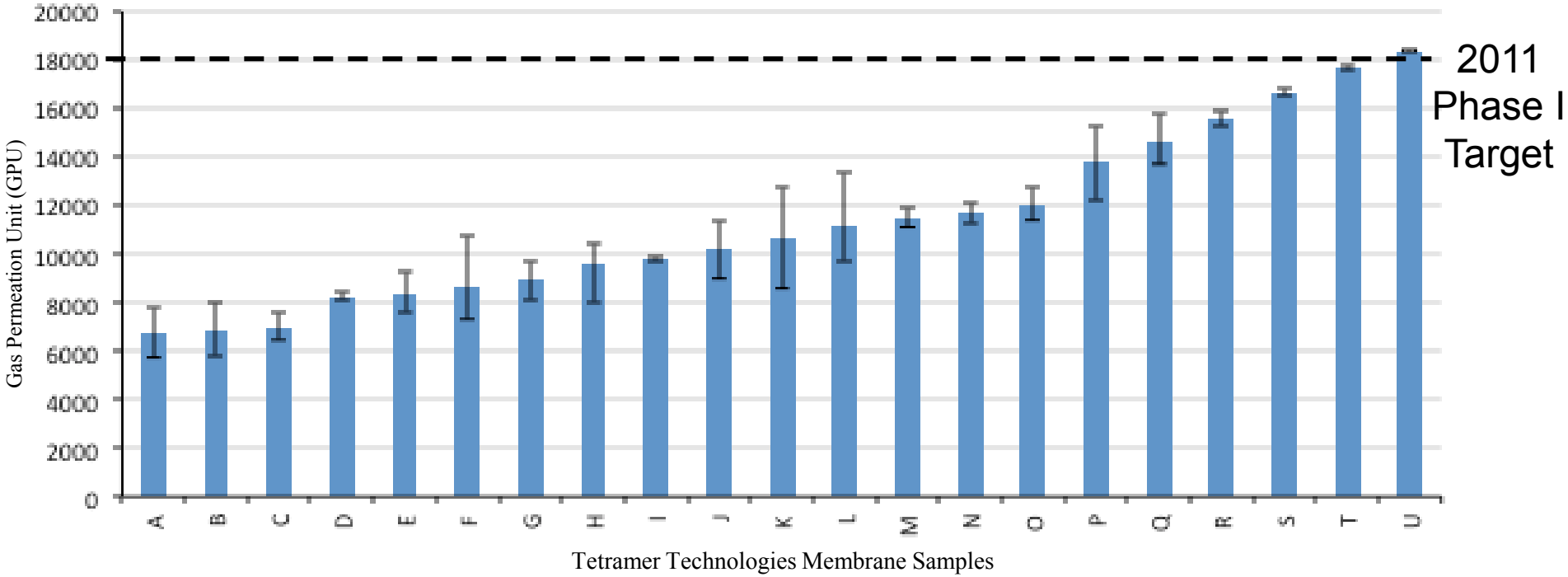
Results of Different Molecular Architectures During Phase I



- Significant improvements have been made during Phase I to improve gas permeation of water through Tetramer's proprietary membranes.
- New molecular architectures were vital towards success.

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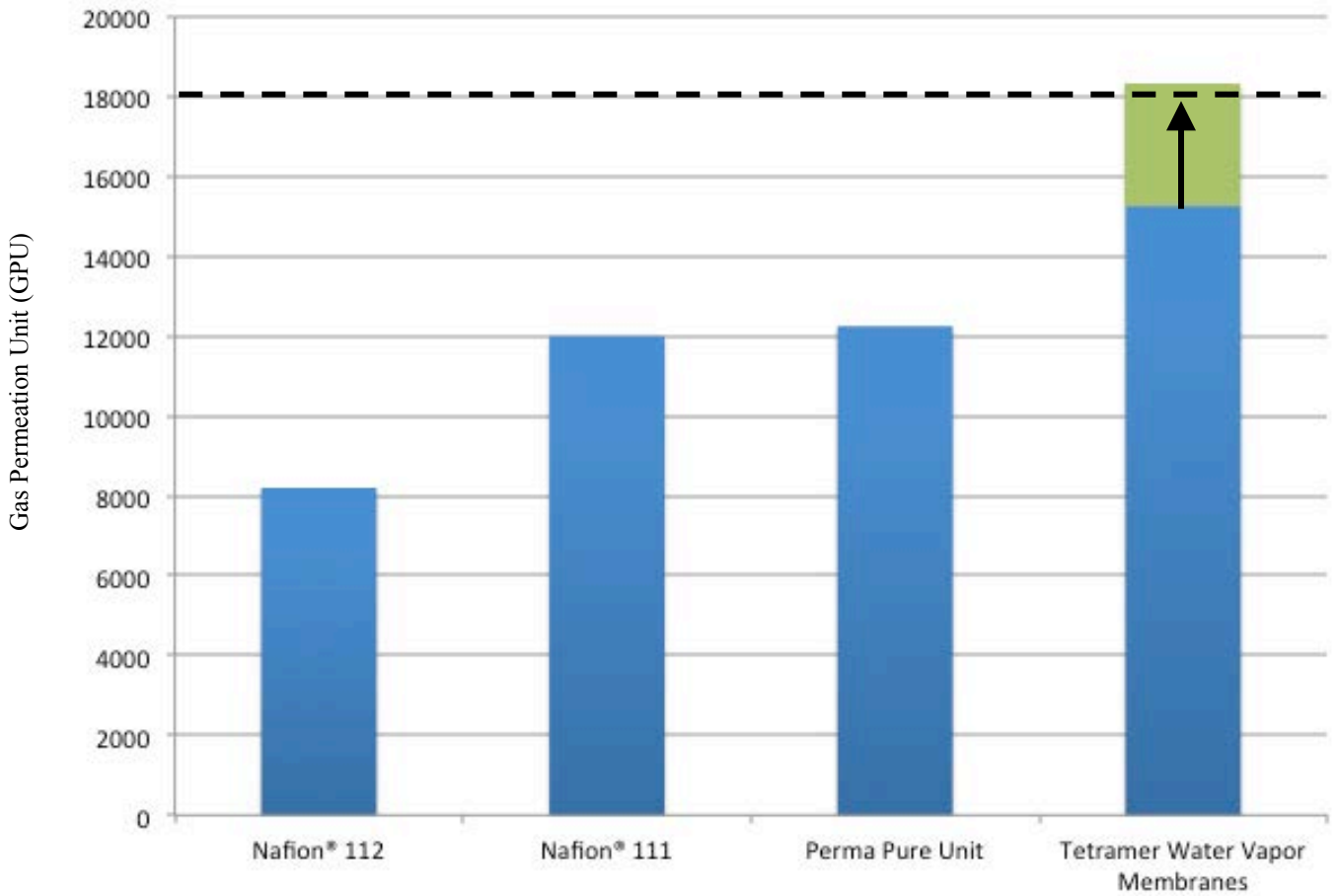
Generation 1 Water Vapor Membranes



- Generation 1 WVT membranes showed high water vapor gas permeation. These materials exceeded current commercial materials.

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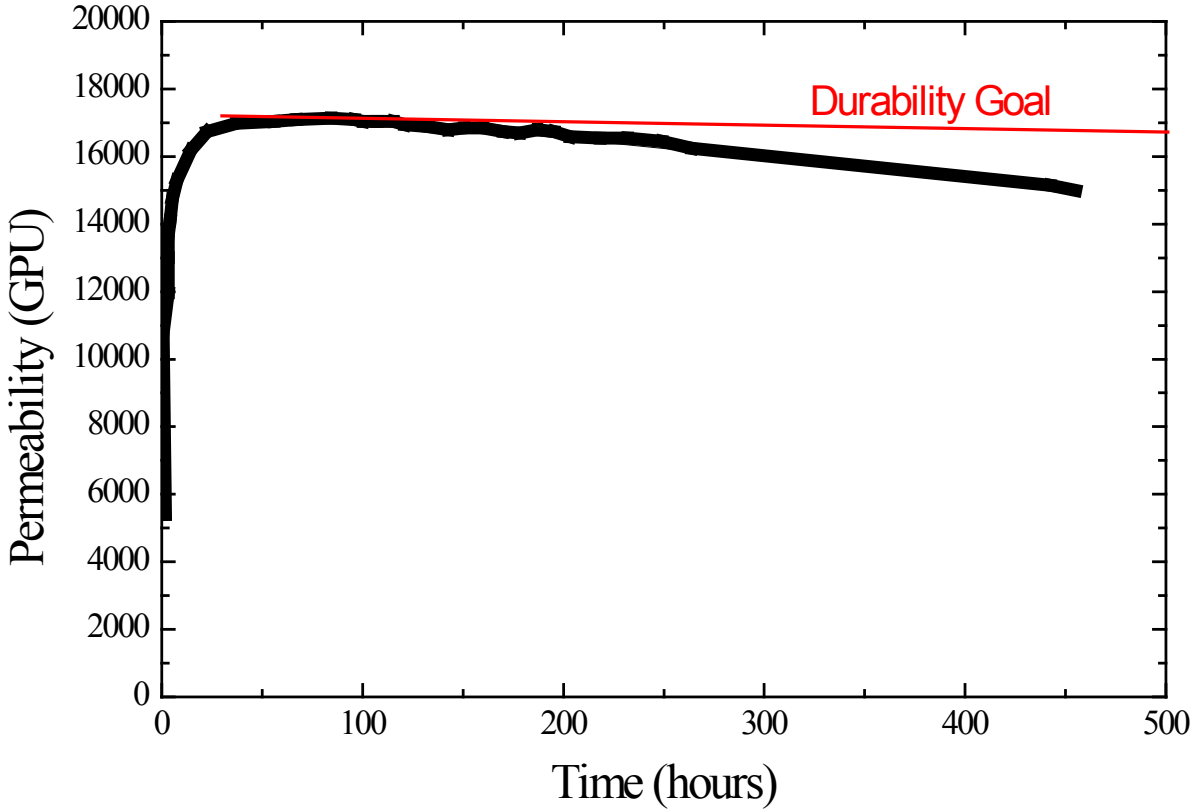
Durability of Current Water Vapor Membranes



- Current rate of degradation is currently below the target 2%/500hr target (shown as a red line).
- Tetramer has identified 7 different methods to reduce the rate of degradation.

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Collaborations

Partners

- General Motors (Industry) – Automotive Prototype Membrane Performance Testing
- Ballard (Industry) – Non-automotive Prototype Membrane Performance Testing
- Membrane Technology Research (Industry) – Module Prototype Production

Phase I Summary

Relevance – Develop water vapor membranes to enable improved cathode humidification modules.

Approach – Develop advanced molecular architectures to increase water vapor transport and durability while decreasing cost.

Technical Accomplishments – Demonstrated improved water vapor transport and durability. Improved processing yields to lower overall cost.

Collaborations – Partners in place to build and evaluate prototype modules with down selected materials.

Future Work – Using structures developed in Phase I, fabricate membranes and optimize tradeoff in performance and durability. Scale up to provide partners with membranes for prototype testing.

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