V.H.1 Center for Intelligent Fuel Cell Materials Design*

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Subcontractors:
Michigan Molecular Institute, Midland, MI
Case Western Reserve University, Cleveland, OH

Start Date: June 2006
Projected End Date: May 2007

*Congressionally directed project

Objectives

- **Objective 1:** Identify new and novel polymer architectures, and innovative polymer modifications and nano-scale additives with the potential of forming highly conductive membranes that will function in elevated temperature (≥ 120°C)/low humidity (≤ 50% relative humidity) range fuel cell operating environments.
- **Objective 2:** Identify new, potential polymer solution casting fabrication processes, alternate process methodologies, and new membrane structures (including multi-layer membranes) suitable to produce commercial scale quantities of thin polymer membranes in roll form that offer improved mechanical stability and water management capabilities.

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
(D) Thermal, Air and Water Management

Technical Targets

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The focus of this project is the research, development and initial evaluation of more robust, higher performance polymer fuel cell membrane materials and membrane formation processes that are consistent with the DOE Technical Plan ("investigate new, lower cost, longer life materials, investigate new MEA configurations, develop MEAs that tolerate incursion to 120°C and/or operate at RH 25-50%, methods for producing low-cost, high-rate fabrication of fuel cell components"). Insights gained from this work will be applied toward the design and development of proton exchange membranes (PEMs) that are commercially producible and that meet the following DOE 2010 targets:

- Membrane conductivity at operating temperature – 0.10 S/cm
- Operating temperature – ≤ 120°C
- Durability – 2,000 hours

Approach

Polymer research will include the identification and development of alternative base polymers and polymer architectures including altered higher temperature polymers, such as sulfonated p-phenylene based thermoplastics. We will also investigate methods of synthesizing highly sulfonated materials via designed nano-fillers that can be intelligently dispersed within a polymer matrix including unique, highly sulfonated nano-filler polyhedral oligomeric silsesquioxane (POSS) or highly phosphonated nano-particle moieties.

Membrane formation research and development will include work to investigate, evaluate, and develop novel process methodologies for membrane fabrication. Improved membrane carrier functionalities will be explored through the investigation of multi-layer membrane structures incorporating discrete functionalities by layer, such as improved water transport and management capabilities. Additional process parameters to be investigated include:

- polymer solubility and rheology requirements,
- time/temperature parameters for drying/curing and annealing,
- potential chemical treatments, and
- development of multi-layer/nano-filled membrane structures.

Accomplishments

Chemsultants and Michigan Molecular Institute have completed an initial project meeting to review the overall project plan, participant responsibilities and individual project team member responsibilities.

- Michigan Molecular Institute project responsibilities include:
  - Baseline polymer characterization: team in place, commercial membrane polymers identified and sourced, potential base polymers identified.
  - Nano-particle synthesis: team in place and target nano-particles identified and initial synthesis underway.
  - Polymer processing: team in place and initial work plan developed.
  - Conductivity testing: team in place, equipment ordered and work plan in development.
  - Material stability: team in place and evaluation plan in development.
- Chemsultants International, Inc. responsibilities include:
  - Membrane casting methodology: base team in place, additional process engineer to be added, four basic solution casting techniques identified, lab test casting equipment identified and to be ordered.
  - Process methodologies: team in place, additional team member (Case Western Reserve University graduate) hired and preliminary research begun.
  - New membrane structure development: team in place, evaluation equipment identified (to be ordered) and initial research begun.