V.J.2 Novel Materials for High Efficiency Direct Methanol Fuel Cells

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Subcontractors:
- QuantumSphere Inc. (QSI), Santa Ana, CA
- Illinois Institute of Technology (IIT), Chicago, IL

Project Start Date: May 1, 2010
Project End Date: April 30, 2013

Objectives

- Develop ultra-thin membranes having extremely low methanol crossover, high conductivity, durability, and low cost.
- Develop cathode catalysts that can operate with considerably reduced platinum loading and improved methanol tolerance.
- Produce a membrane electrode assembly (MEA) combining these two innovations that has a performance of at least 150 mW/cm^2 at 0.4 V and a cost of less than \$0.80/W for the membrane and cathode catalyst.

Technical Barriers

This project addresses the following technical barriers from the Fuel Cells section of the Fuel Cell Technologies Program Multi-Year Research, Development and Demonstration Plan:

(A) Durability
(B) Cost
(C) Performance

Technical Targets

This project is conducting focused research on next generation membrane and cathode catalyst materials for direct methanol fuel cells. Insights gained from these studies will be applied toward the design of a MEA for portable power applications that meet the DOE 2010 targets:

- Performance: Specific Power (100 W/kg), Power Density (100 W/L), and Energy Density (1,000 Wh/L)
- Cost: \$3/W
- Lifetime: 5,000 hours

In translating DOE-published targets, we have defined the following goals for the membrane, cathode catalyst, and MEA performance based on our modeling efforts in Table 1.

TABLE 1. Targets for this Project

Characteristic	Units	Industry Benchmark	Project Target
Methanol Permeability	cm^2/s	$1\text{-}3 \cdot 10^{-6}$	$5\text{-}3 \cdot 10^{-8}$
Areal Resistance 70°C	Ωcm^2	0.120 (Nafion® 117)	0.80 (2 mil thick)
Catalyst Mass Activity (RDE, 70°C and 0.45V)	mW/mg Pt	22.5	>100
MEA Cathode Catalyst Loading	mg/cm^2	4	1.5
MEA I-V Cell Performance (0.4 V)	mW/cm^2	90	150
MEA Lifetime	hours	>3,000	5,000

RDE = rotating disk electrode; I-V = current-voltage

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Approach

Arkema and IIT are developing a new generation of thin membranes with very low methanol cross-over and high conductivity. The membranes are formed from blends of polyvinylidene fluoride with a variety of highly sulfonated polyelectrolytes, technology that was developed in two previous projects. A number of variables can be easily adjusted in the blending process to tailor the membrane properties. The key to obtaining the desired properties resides in control of composition, architecture, and morphology of the membrane components. These are controlled on a practical level through polyelectrolyte chemistry, membrane composition, processing, and additives, which will be systematically investigated and correlated with properties.

QSI will develop a new series of cathode catalysts with improved mass activity obtained by suppressing methanol oxidation. These cathode materials will be palladium-based nanocatalysts mixed with platinum carbon with considerably reduced platinum loadings. These catalysts are prepared using gas phase condensation, which allows for control of particle size, alloy ratio, and core-shell structure.

Accomplishments

The award contract for this project was signed on June 30th. Work is in progress on the preparation of initial membrane and catalyst compositions for property screening. Methods are also being established for MEA preparation, conditioning, and testing. While new membrane and catalyst materials are being prepared, tests are being run on MEAs constructed from currently available Arkema and QSI materials as a baseline for the project. Without any modifications to the cathode catalyst and membrane, significant improvement in 10 M methanol is already observed over a 7 mil perfluorosulfonic acid membrane-based MEA (Figure 1).

Future Directions FY 2010-2011

- Prepare and screen a library of membrane samples to identify compositions that produce the lowest methanol crossover, while maintaining adequate conductivity.
- Synthesize and screen the properties of a series of Pd-based catalysts, including palladium and palladium-metal alloys. Reactor operating parameters (pre-alloy conditions, gas flow, voltage) will be optimized for the preparation of 3-10 nm particles.
- Continue efforts to establish procedures for MEA conditioning and testing.

FY 2010 Publications/Presentations

1. Poster presentation at the 2010 DOE Hydrogen Program and Vehicle Technologies Program Annual Merit Review and Peer Evaluation Meeting, C. Roger and D. Mountz.

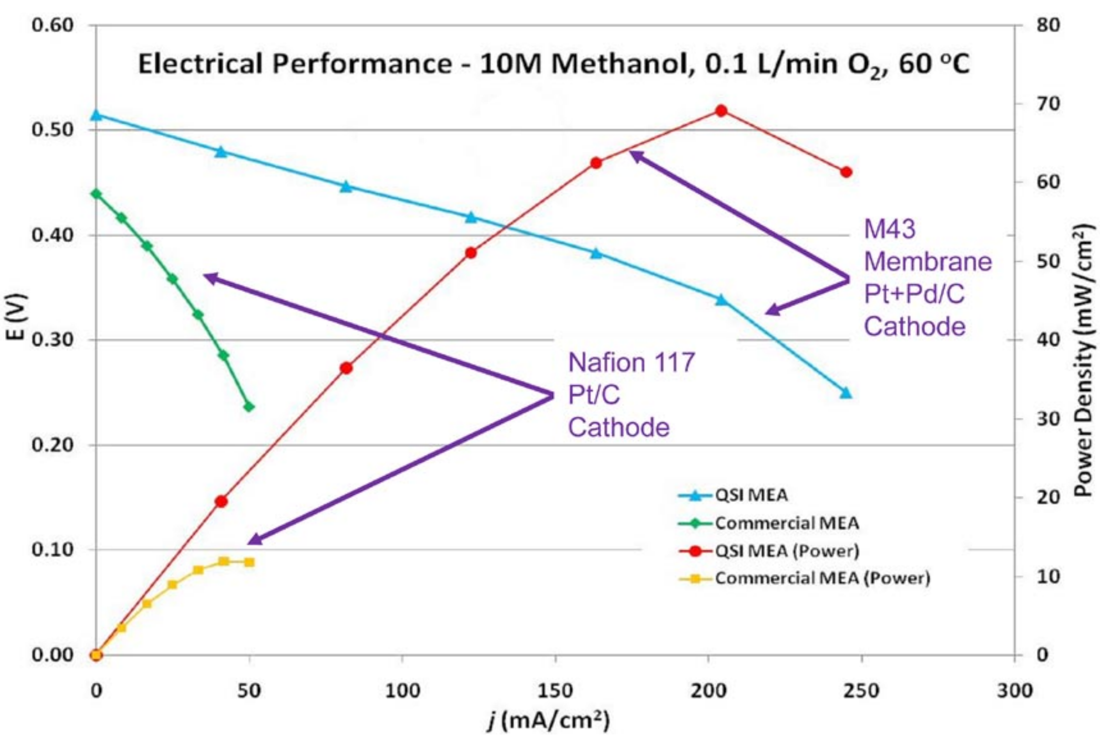

FIGURE 1. Preliminary performance of an MEA constructed with Arkema's M43 membrane and QSI-Nano® cathode.