Development of Methanol Electrolysis System for Hydrogen Production

Thomas I. Valdez, Keith J. Billings, and Adam K. Kisor

Jet Propulsion Laboratory
California Institute of Technology
4800 Oak Grove Drive, Pasadena, CA, 91109, USA

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Presentation Outline

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Background

Waste Streams to Hydrogen

- The U. S. Army is interested in utilizing biomass and waste streams as alternative energy sources for future operations.
- It is envisioned that liquid alcohols generated from biomass and hydrocarbon waste could be converted to hydrogen.
- The hydrogen would be used for the production of electricity in portable and stationary fuel cells.
- Hydrogen could also be used for mobility when used as a fuel in an internal combustion engine.

Fuel Cell System

- Methanol electrolyzer/ H_2-Air system

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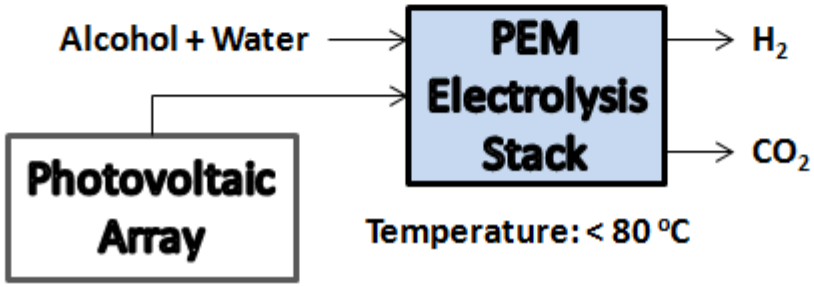
Fuel Processing

Fuel Reformation System

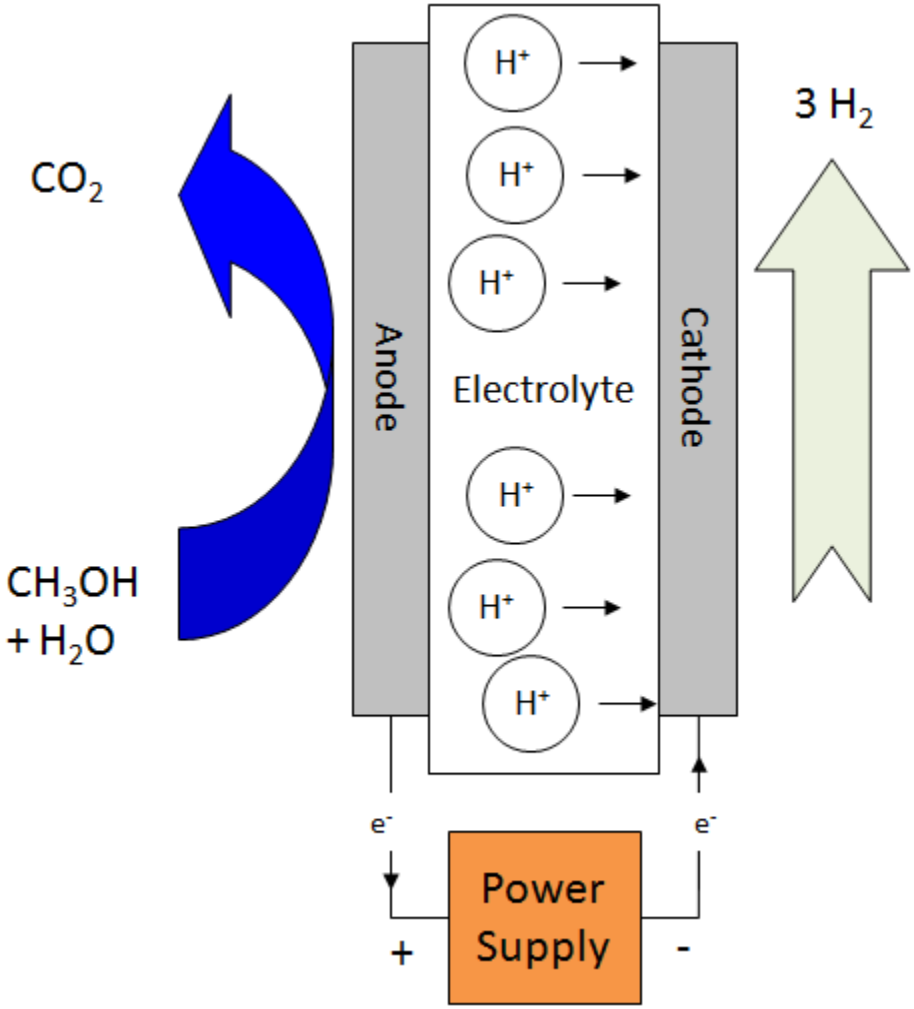
Temperature: 300 – 600 °C

PEM Electrolysis Cell



Temperature: < 80 °C

The Methanol Electrolyzer



<u>At the positive electrode (Anode)</u>

$$CH_3OH + H_2O \rightarrow CO_2 + 6H^+ + 6e^-$$

<u>At the negative electrode (Cathode)</u>

$$6H^+ + 6e^- \rightarrow 3\ H_2$$

<u>The net reaction (Cell)</u>

$$CH_3OH + H_2O \rightarrow CO_2 + 3\ H_2$$

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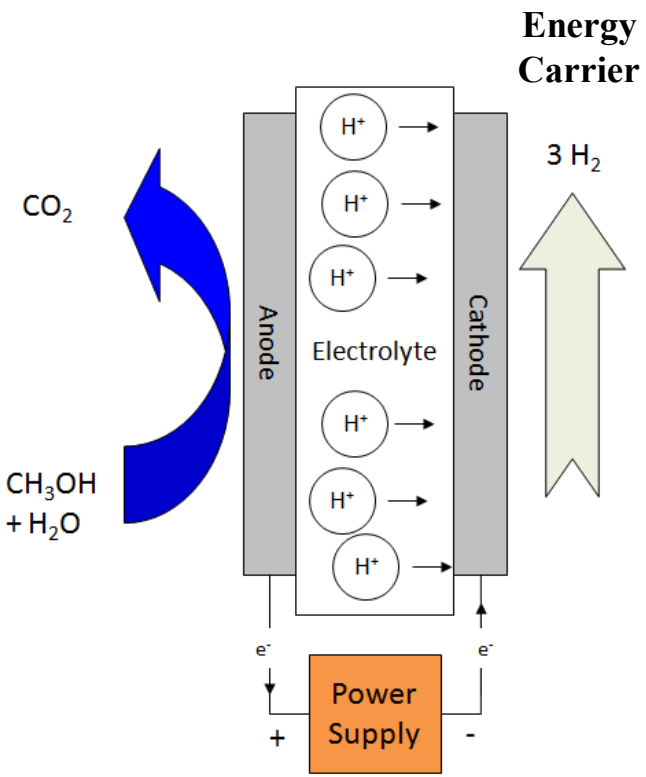
Electrolysis Hydrogen Production, Global View

Energy Source



$$CH_3OH + H_2O \rightarrow CO_2 + 3\,H_2$$

Water Electrolysis

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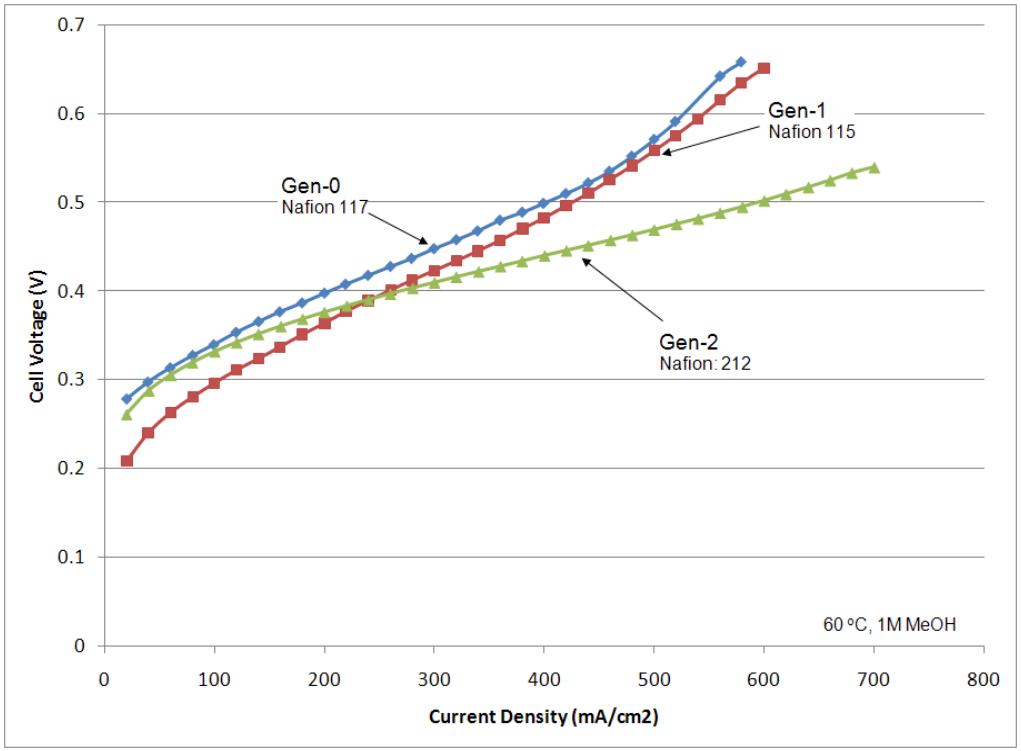
Methanol Electrolysis Cell Development



- Focus of this project was maximize hydrogen production (Not efficiency), thus operation at the highest current density
- Gen-0 and Gen-1 MEAs fabricated by direct deposition, Gen-2 utilized a spray deposition

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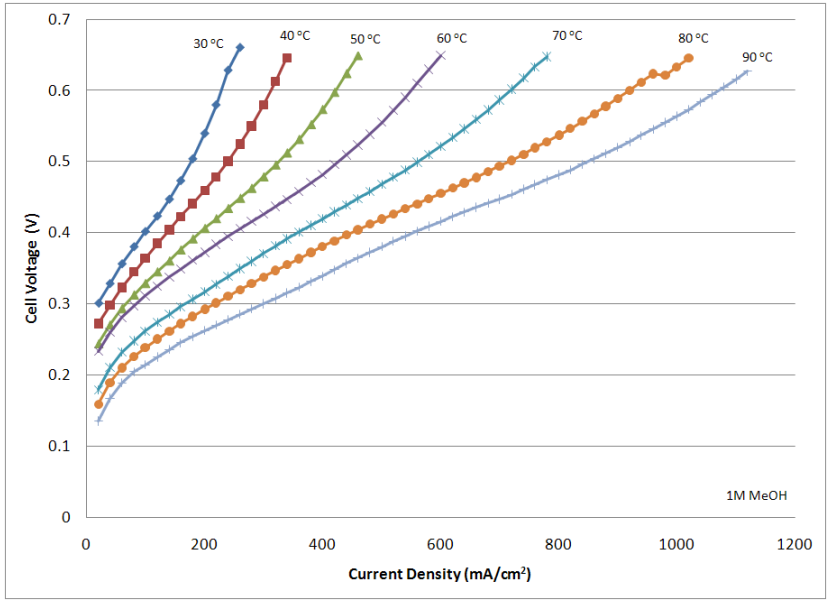
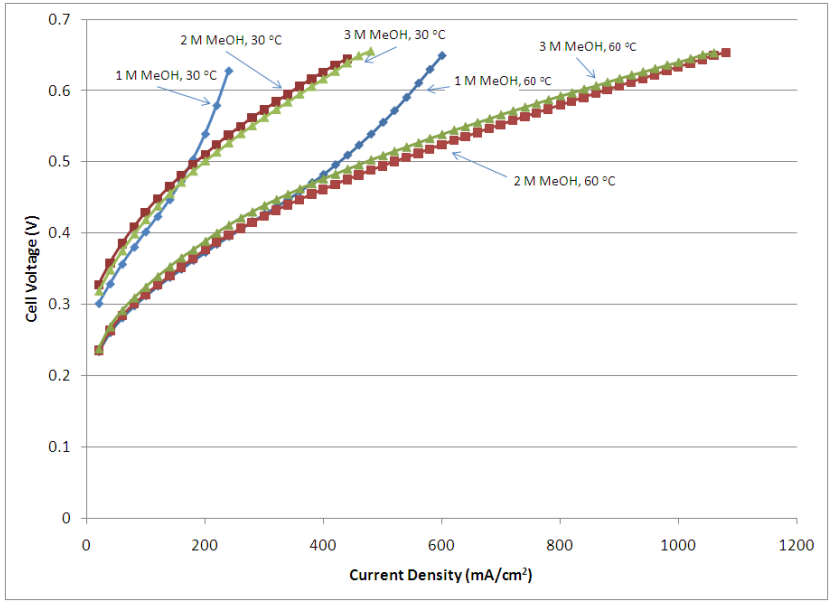
Methanol Electrolysis Cell Performance

Temperature Performance



Concentration Performance



- The performance of the methanol electrolysis MEA increases with operating temperature
- Increasing the methanol concentration above 2M methanol had little impact on over potential

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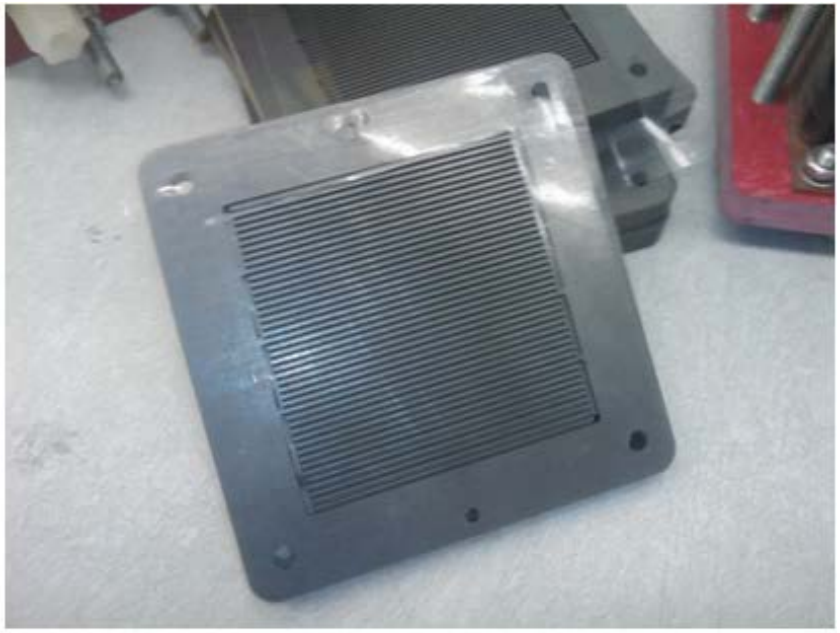
Stack Development

10-Cell Stack Hardware



50 cm^2 Active Area

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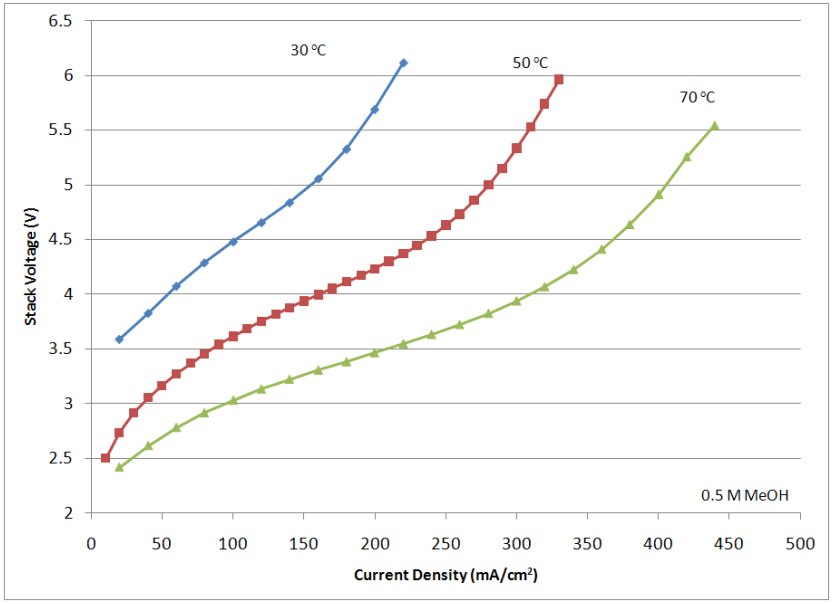
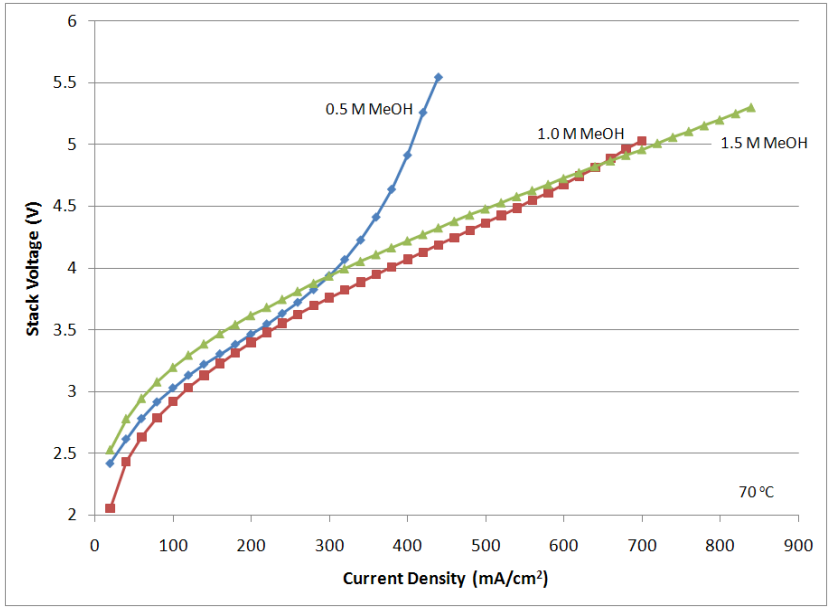
Methanol Electrolysis Stack Performance

Temperature Performance



Concentration Performance



- Gen-2 MEA used for stack construction, Nafion 212
- Methanol concentration was limited to 1.5M, prevent swelling of membrane
- Electrolyzer produced a measured 3.1 SLPM at 840 mA/cm^2 (223 Watts)

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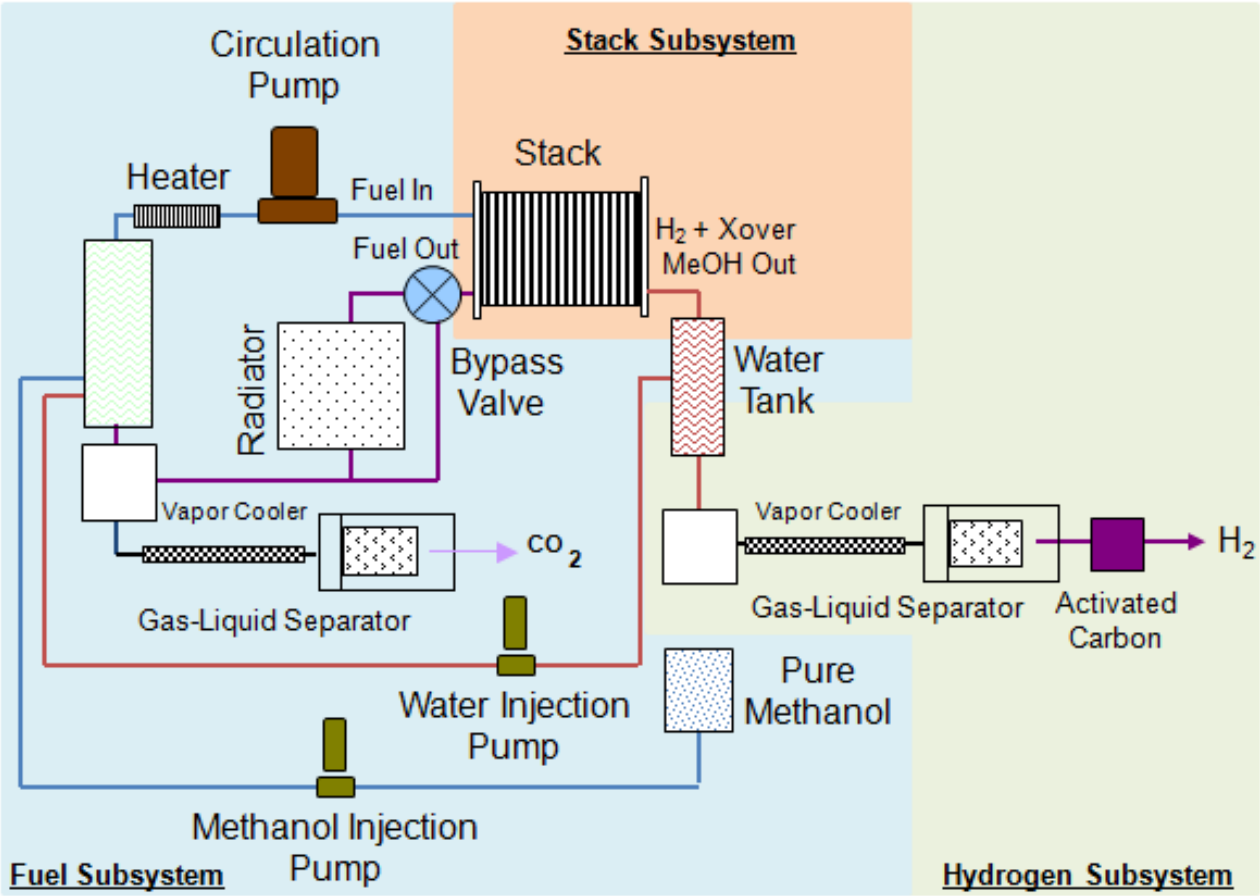
Fuel Reformation Systems



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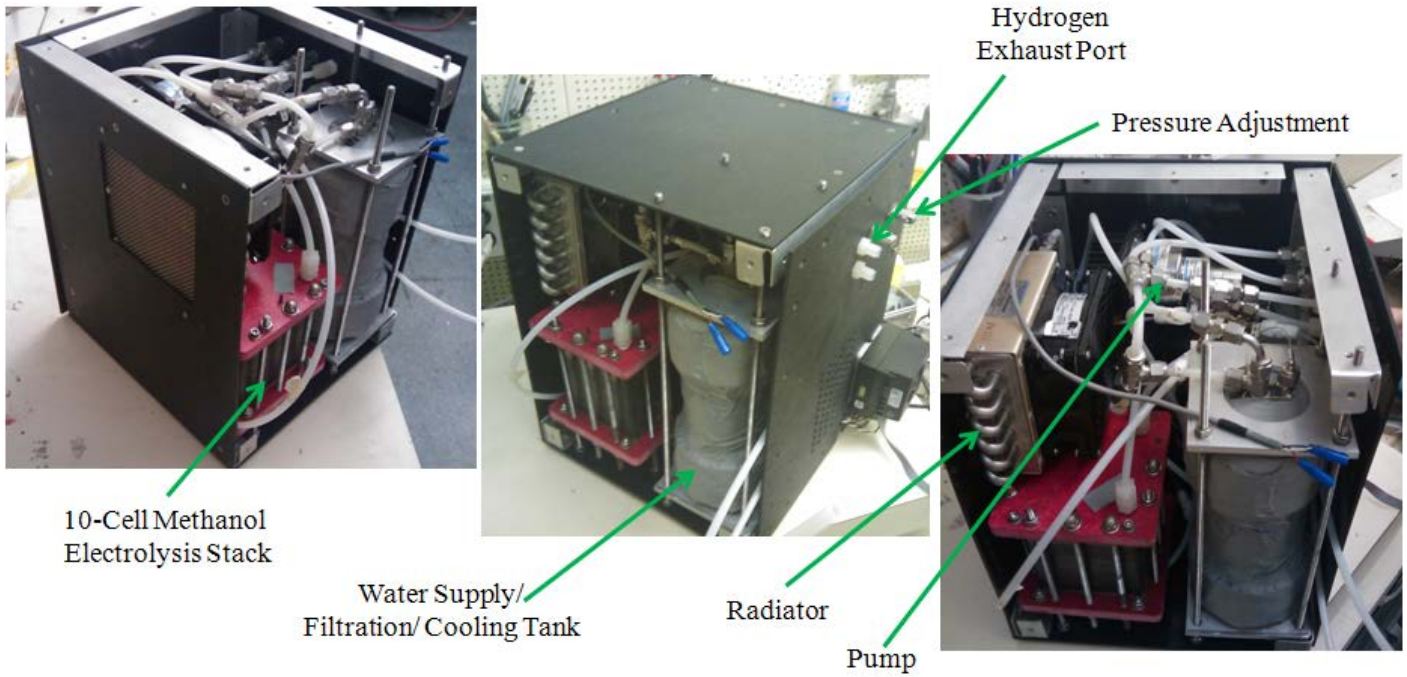
Methanol Electrolysis System



- Deliver an estimated 450 Liters of hydrogen at (3.1 SLPM)
- Measured concentration of methanol in hydrogen stream ~ 0.1 PPM
- Estimated system power consumption of approximately 300 Watts.

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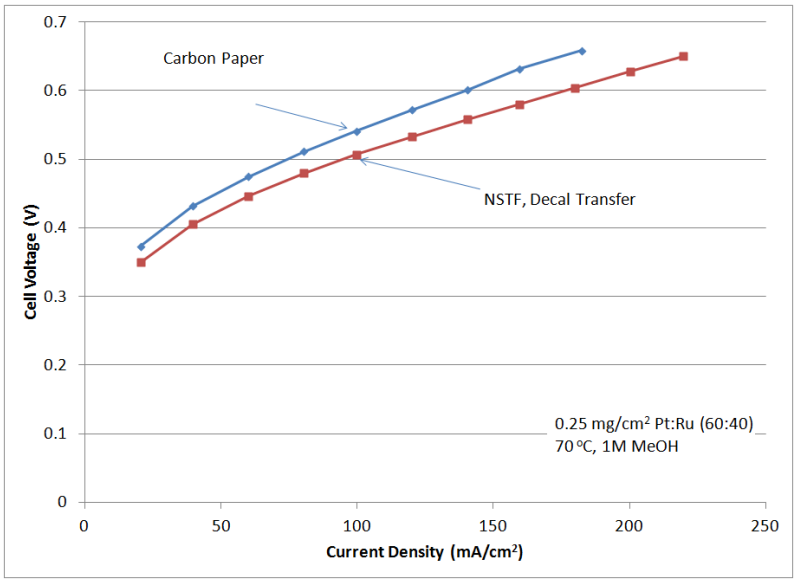
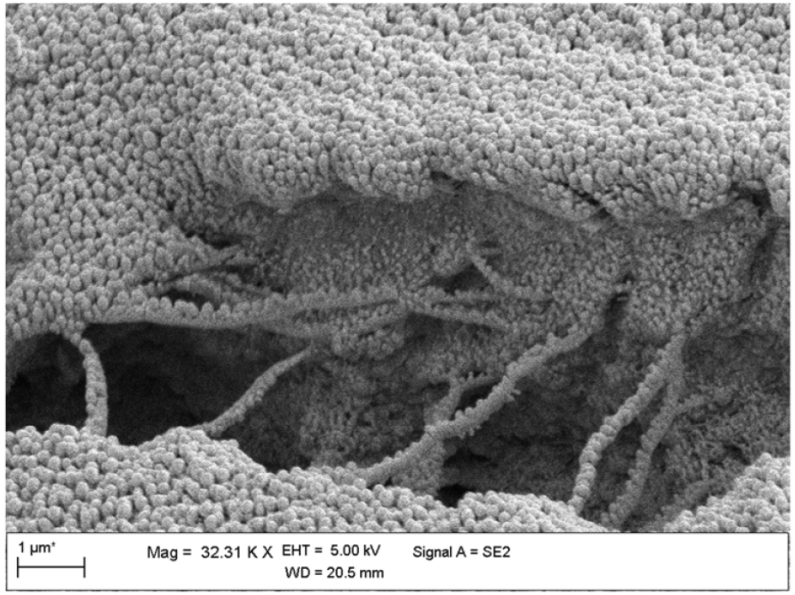
Advanced Catalysts Work

Electrolyzer Performance



Catlaysts Structure



- Performance improvement with NSTF substrate observed
- Pt-Ru (60:40) deposited on NSTF, 0.25 mg/cm^2

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Conclusions

- An electrolysis system for the conversion of alcohols to hydrogen has been demonstrated
- 10-cell methanol electrolyzer produced a measured 3.1 SLPM at 840 mA/cm^2 (223 Watts power consumption)
- A methanol electrolysis system, built as a test stand for steady-state hydrogen production measurements, was estimated to deliver at least 450 Liters of hydrogen at 3.1 SLPM, estimated power consumption in the range of 300 Watts
- An advantage of methanol, versus water, electrolysis systems is that the byproducts of the electrolysis reaction cannot react and as such generating hydrogen at several 1000's of PSI is viable
- Pt-Ru NSTF viable for use in methanol electrolyzer
- Methanol electrolyzer/ H_2-Air system is viable but will need to operate at very low current densities (~200 mA/cm^2) to be efficient (Cell voltage ~ 0.35 Volts)

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