Liquid Fuels and Electricity from IT-Fuel Cells

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Partners

- University of Connecticut – Cell manufacturing technology development
- Pacific Northwest National Laboratory – GTL catalyst and cell development
- Energy and Environmental Research Center at the University of North Dakota – GTL catalyst evaluation and pressurized testing
- Massachusetts Institute of Technology – Electrode interface characterization
Objective

Project Objective:
To develop a cell technology capable of direct conversion of methane to liquid product, methanol or formaldehyde, by electrochemical partial oxidation at intermediate temperatures (<500°C), to provide means for an economic utilization of stranded gas.

Targets:

- High Methane Conversion Yield
- High Selectivity for Methanol Production
- Composite Low Temperature Electrolyte
- Redox Tolerant Anode
- Scalable Manufacturing Methods
Value Proposition

Electrochemical Gas-to-Liquid (EC-GTL) offers a cost effective method for reducing emissions impact of stranded gas sources.

Scalability, modular nature, and transportability of electrochemical system also provide the means to economically utilize associated gas at low production wellheads.

The EC-GTL technology will meet ARPA-E’s Mission Areas:

- Enhance the economic and energy security of the United States
- Ensure that the United States maintains a technological lead in developing and deploying advanced energy technologies
Value Proposition

Electrochemical Gas-to-liquid cell utilizes a metal/metal oxide redox couple, which serves as the anode electrocatalyst, to partially oxidize CH₄ to CH₃OH and HCHO.
Development Approach

- Development of a novel EC-GTL cell presents an opportunity for top-down approach.
- Incorporation of the catalyst within the EC-GTL anode requires ability to withstand constant redox cycling.
- Chosen cathode and electrolyte must provide sufficient electrode activity and $O^{2-}$ ionic conductivity to support the Redox reaction with the EC-GTL anode.
- Institutional experience with MCFC commercialization can be leveraged to facilitate pathway to commercialization.

a) Green Support Tape
b) Pre Sintered Support
c) AFL Coated Anode Support
d) Anode Infiltrated with Catalyst
e) Electrolyte Deposited on Anode
Cell Support

- Developed anode side support with adequate mechanical and electrical properties, capable of withstanding redox cycling.
- Demonstrated operation with carbonate electrolyte.
High Selectivity (>90%) catalyst has been successfully infiltrated onto anode support.

Infiltration process has shown stable particle size after aging tests.

Increased batch-mode conversion rate (~40%) observed with catalyst on anode support material vs. silica support. Fuel cell operation may increase further.

Methanol product stability was demonstrated on fully activated catalyst.
Electrolyte Development

- RSDT has been adapted to co-deposit GDC and carbonate salts.
- Sufficient density achieved at ~ 20 μm.
- Opportunity exists for optimization to achieve full density with thinner layer.

- Parallel path to utilize dense GDC is also under investigation.
- Both approaches have recently shown acceptable microstructure and leak analysis results, awaiting electrochemical testing.
System Design

- Developed system process flow sheet identifying balance-of-plant requirements and performed system simulations based on first-principle methods.
- Cell performance based on project milestones, and cost on prior SOFC development, identified small systems as economically attractive.

Results of the System Analysis
Basis: One Barrel Per Day (BPD) of Methanol Production

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Raw Gas Input</td>
<td>3.0 MCFD</td>
</tr>
<tr>
<td>Cell Area</td>
<td>12.5 M²</td>
</tr>
<tr>
<td>Gross DC Power</td>
<td>12.48 kW</td>
</tr>
<tr>
<td>Plant Parasitic Loads</td>
<td>0.90 kW</td>
</tr>
<tr>
<td>Net AC Power Output</td>
<td>10.9 kW</td>
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Development Roadmap

- Finalize electrolyte fabrication process.
- Revisit cathode deposition with RSDT.
- Optimize anode catalyst deposition for higher activity.
- Map cell operating conditions for optimal performance envelope.
- Increase cell area.
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