Active Project (2014 - 2015)

Mars Propellant Production with Ionic Liquids Project

Center Innovation Fund: KSC CIF Program | Space Technology Mission Directorate (STMD)

ABSTRACT

This project seeks to develop a single vessel for carbon dioxide (CO_2) capture and electrolysis for in situ Mars propellant production by eliminating several steps of CO_2 processing, two cryocoolers, a high temperature reactor, a recycle pump, and a water condenser; thus greatly reducing mass, volume, and power.

ANTICIPATED BENEFITS

To NASA unfunded & planned missions:

Propellant production and oxygen production for life support for human Mars missions in the 2030s at reduced mass and power. Demonstration on a Mars Sample Return mission in the 2020s would verify the technology for human missions.

To other government agencies:

The Department of Energy could benefit from a successful outcome of this project.

To the commercial space industry:

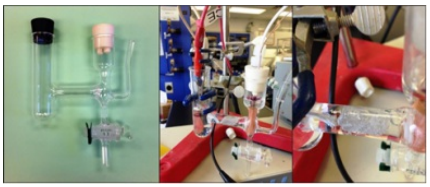
SpaceX has declared its intentions to send settlers to Mars. Propellant and oxygen production would be essential for such efforts.

To the nation:

As noted above, the ability to recycle CO_2 from fossil fuel combustion would greatly reduce greenhouse gas emissions and develop a simple energy storage capability.

DETAILED DESCRIPTION

Electrolysis of CO2 captured by Ionic Liquids (ILs) and H2O directly to CH4 and O2 has the potential to be much more efficient than CO2 freezing/methanation/water electrolysis by



Electrolysis of CO2 in an Ionic Liquid (Right Electrode) and Water (Left Electrode)

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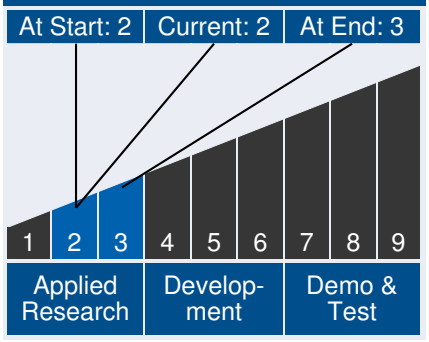
Technology Maturity



Management Team

Program Director:

- John Falker

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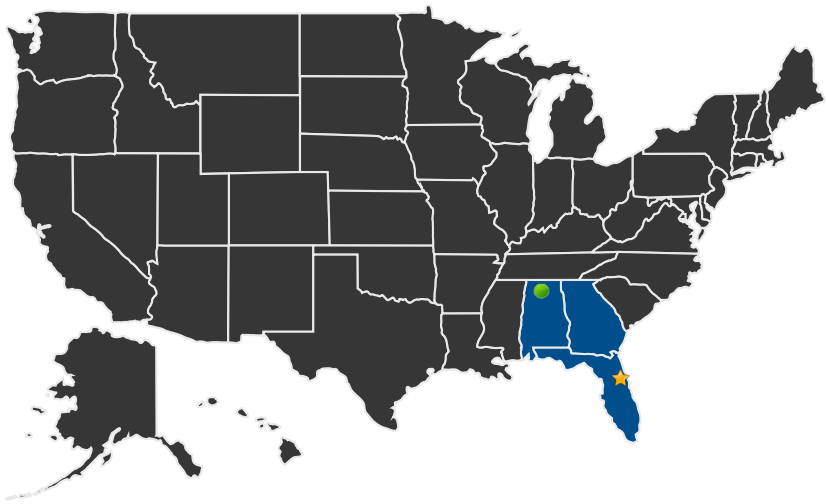
having five less process steps, ~50% less mass, and ~25% lower energy requirements. The objectives are to verify these advantages that would greatly improve in situ Mars propellant production for Mars Sample Return and human missions by reducing power, mass, and complexity through the use of a single vessel for CO2 capture and electrolysis to propellant. These steps have not been demonstrated together for Mars applications, which are quite demanding.

Electrolysis of CO_2 + H_2O in ionic liquids to CH_4 and O_2 has not been demonstrated, TRL = 2. The expected TRL at completion of the research effort is TRL = 4.

U.S. LOCATIONS WORKING ON THIS PROJECT



U.S. States With Work

Lead Center:
Kennedy Space Center

Supporting Centers:

- Marshall Space Flight Center

Management Team *(cont.)*

Program Executive:

- Karen Thompson

Program Manager:

- Nancy Zeitlin

Principal Investigator:

- Anthony Muscatello

Technology Areas

Primary Technology Area:
Human Exploration Destination Systems (TA 7)
└ In-Situ Resource Utilization (TA 7.1)
└ Consumables Production (TA 7.1.3)

Secondary Technology Area:
Resource Acquisition (TA 7.1.2)

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Other Organizations Performing Work:

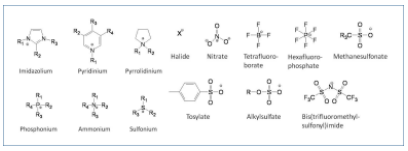
- AZ Technology Inc (Huntsville, AL)

Contributing Partners:

- Mercer University

IMAGE GALLERY

Comparison of Process Steps for Freezing CO2/Sabatier/Electrolysis and CO2 Capture/Ionic Liquid Electrolysis



Typical Ionic Liquid Cations and Anions

DETAILS FOR TECHNOLOGY 1

Technology Title

Mars Propellant Production with Ionic Liquids

Technology Description

This technology is categorized as a hardware subsystem for unmanned spaceflight

Some Ionic Liquids have the capability to adsorb carbon dioxide at low partial pressures and provide a conductive medium for electrolysis of the captured CO_2 to oxygen and other products. Ionic Liquids can also dissolve water, allowing for co-electrolysis of water. Catalysts and operating conditions will be sought that enable the production of methane and oxygen from CO_2 and water in a manner that would be useful for their production on Mars from CO_2 from the atmosphere and water from the regolith. Also, new Ionic Liquids will be synthesized to optimize the process.

Capabilities Provided

The tangible benefits to NASA would be creation of a new, simpler, much more efficient capability for Mars propellant and life support oxygen that would reduce risk for Mars missions, both robotic and crewed.

Potential Applications

The ability to recycle CO_2 from fossil fuel combustion would greatly reduce greenhouse gas emissions and develop a simple energy storage capability.

Performance Metrics

Metric	Unit	Quantity
Reduced mass compared to Sabatier/Electrolysis	%	50
Reduced power compared to Sabatier/Electrolysis	%	25