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Bosch Reactor Development for High Percentage Oxygen Recovery From Carbon Dioxide

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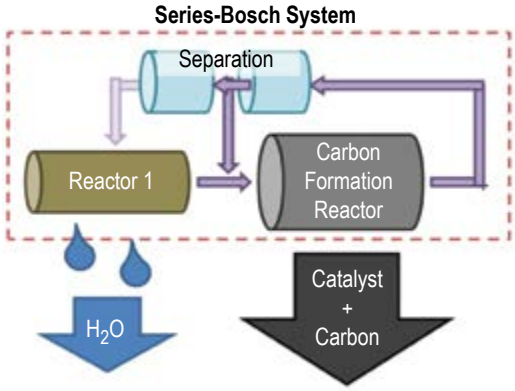
Sponsoring Program(s)

Space Technology Mission Directorate
Game Changing Development

Project Description

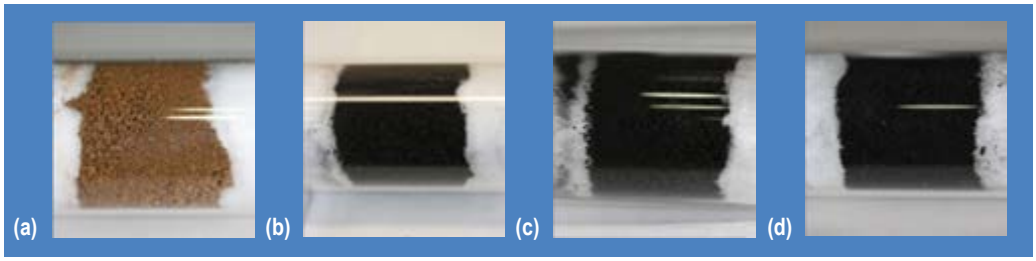
This next Generation Life Support Project entails the development and demonstration of Bosch reaction technologies to improve oxygen recovery from metabolically generated oxygen and/or space environments. A primary focus was placed on alternate carbon formation reactor concepts to improve useful catalyst life for space vehicle applications, and make use of in situ catalyst resources for nonterrestrial surface missions. Current state-of-the-art oxygen recovery systems onboard the International Space Station are able to effectively recover approximately 45% of the oxygen consumed by humans and exhausted in the form of carbon dioxide (CO_2). Excess CO_2 is vented overboard and the oxygen contained in the molecules is lost.

For long-duration missions beyond the reaches of Earth for resupply, it will be necessary to recover greater amounts of constituents such as oxygen that are necessary for sustaining life. Bosch technologies theoretically recover 100% of the oxygen from CO_2, producing pure carbon as the sole waste product. Challenges with this technology revolve around the carbon product fouling catalyst materials, drastically limiting catalyst life. This project successfully demonstrated techniques to extend catalyst surface area exposure times to improve catalyst life for vehicle applications, and demonstrated the use of martian and lunar regolith as viable catalyst materials for surface missions. The Bosch process generates carbon nanotube formation within the regolith, which has been shown to improve mechanical properties of building materials. Production of bricks from post reaction regolith for building and radiation shielding applications were also explored.



Series Bosch reaction, reacts hydrogen with CO_2 to produce recover oxygen by producing water.

Lunar regolith sintered brick.



Carbon formed on martian regolith used as catalyst in Bosch reaction: After (a) zero hours, (b) 1 hour, (c) 4 hours, and (d) 16 hours.

Anticipated Benefits

The Bosch reactor is capable of recovering 100% of the oxygen from metabolically generated CO_2. This has the potential to significantly close the loop of regenerable life support system architecture, reducing the reliance on consumables that must otherwise be transported on long-duration human missions beyond the reach of Earth for resupply. Additionally, the use of regolith materials as Bosch catalysts on surfaces such as Mars offers the potential for unlimited oxygen supply to maintain life and support other oxygen-consuming systems.

Potential Applications

A potential application may be long-duration human space missions including both vehicle and surface habitats.

Notable Accomplishments

Notable accomplishments include demonstrating the ability to extend the length of traditional catalyst materials by separating Bosch into two distinct reactions, thereby minimizing the amount of catalyst exposed to carbon formation; demonstrating techniques to significantly improve the life of traditional metal catalyst materials by tumbling and/or systematically adding catalyst in a continuous reaction process; and successfully demonstrating the use of both martian and lunar regolith as catalyst materials for in situ resource utilization.