NASAfacts

Space Technology
Game Changing Development
Space Synthetic Biology

Astronauts on the International Space Station rely on resupply from Earth as well as the availability of redundant parts when they need to replace items that have been consumed or are in need of repair. When considering human missions beyond low-Earth orbit, the amount of resources required to sustain a crew on an exploration mission are too great to launch into space, and the distance is too far for affordable resupply—so a solution is needed.

To be sustainable, exploration missions will require highly reliable, closed-loop life support systems and the ability to use in situ (local) resources to recycle and produce many of the items traditionally brought from Earth. The Space Synthetic Biology project is helping NASA address these challenges.

Synthetic biology is an emerging, game changing discipline that applies engineering principles to biology to develop reliable, predictable biological systems with useful purposes. NASA is using synthetic biology to create transformative biological tools and technologies that will increase the capability of astronauts in space and reduce risk. One example of this is the Synthetic Biology Environmental Closed Loop Life Support (SB-ECLSS) project.

The SB-ECLSS project uses synthetic biology to create a special bioreactor to provide novel solutions for the purification of air and water. The bioreactor is a type of biological fuel cell. On the anode side, microorganisms treat wastewater and produce carbon dioxide (CO2), electrons (e-), and Hydrogen (H+). This is very similar to the process that occurs in wastewater treatment plants here on Earth. However, on Earth, we are not worried about what happens to these products. In space, we do not want extra CO2 in the crew cabin, and we must reuse all the products to help close the life support loop. This is where synthetic biology comes into play. On the cathode side of the fuel cell, specially engineered organisms use the electrons through a process known as electrosynthesis to convert the

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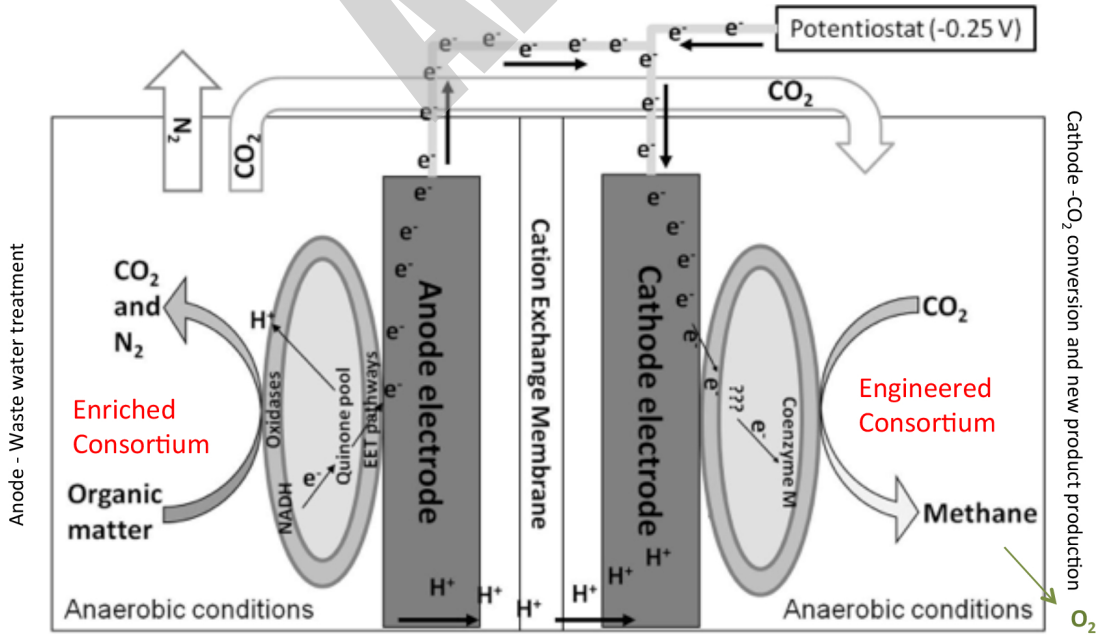


The Bioelectrosynthesis bioreactor is a type of biological fuel cell. Waste water is treated on the anode side and new products are produced on the cathode side.

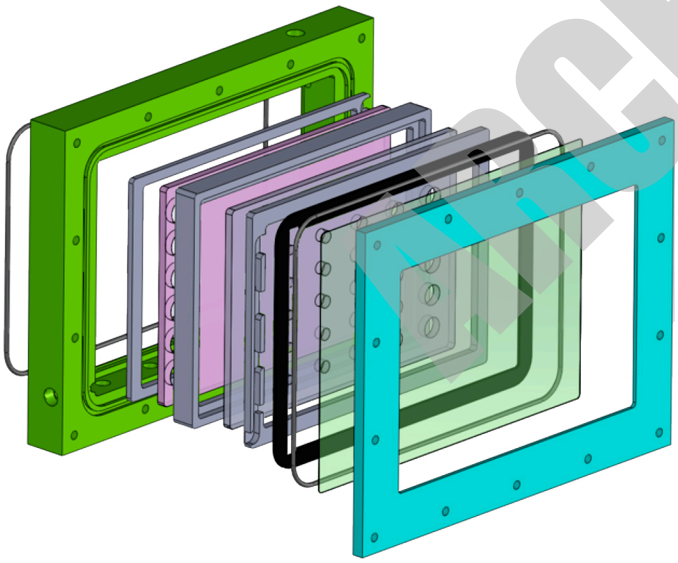
CO_2 and H^+ into water (H_2O) and methane (CH_4). The water can then be further cleaned for the crew to use or split again to produce oxygen for the crew to breathe. While for this project the organisms are engineered to produce methane, they can also be engineered to use in situ resources and waste materials to create a large variety of valuable products (e.g., biopolymers, therapeutics) that may be required.

How else can we use synthetic biology?

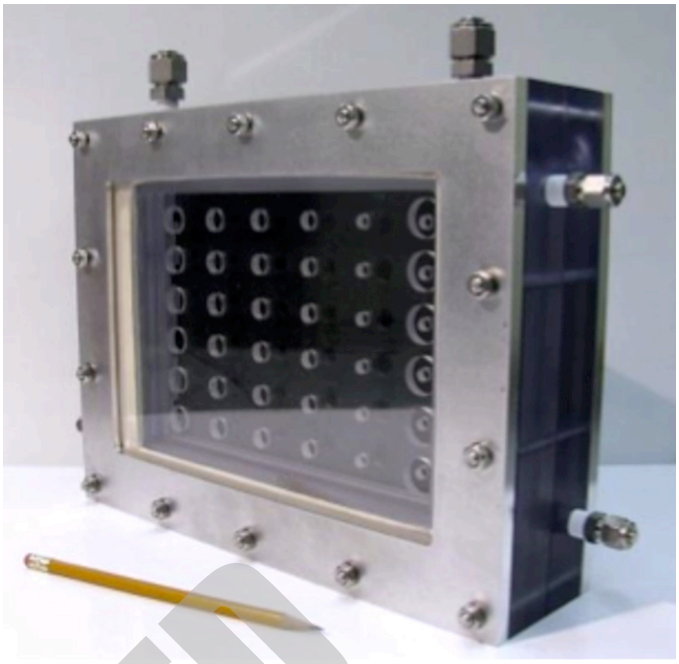
The potential applications are vast. In one project, it was demonstrated that proteins could be mixed with a lunar or Martian regolith (soil) simulant to produce a concrete-like material that could be used for the construction of habitats or other structures. The ability to use in situ resources to make construction materials at a destination, rather than transport all the required materials to the destination, would greatly reduce the amount of material NASA must launch into space.

The Game Changing Development (GCD) Program investigates ideas and approaches that could solve significant technological problems and revolutionize future space endeavors. GCD projects develop technologies through component and subsystem testing on Earth to prepare them for future use in space. GCD is part of NASA's Space Technology Mission Directorate.

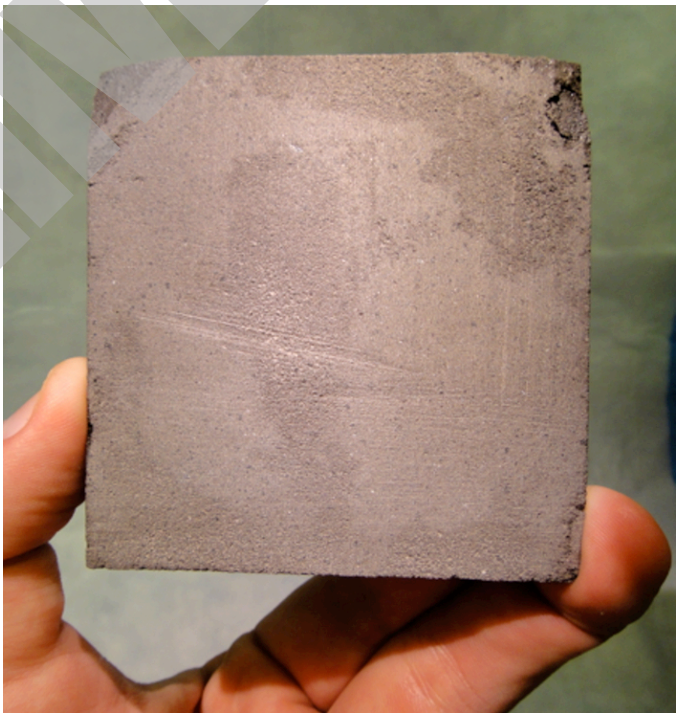
For more information about GCD, please visit http://gameon.nasa.gov/



The Bioelectrosynthesis bioreactor is made with a series of chambers, electrodes and membranes to help evenly distribute the flow of wastewater. It also provides surfaces for the organisms to grow and transfer products between one chamber to the next.



The prototype system holds and processes about a liter of fluid at a time.



This concrete-like material is made from 90% lunar simulant and just a small amount of protein. The savings of upmass to produce construction materials could be significant.

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