National Aeronautics and Space Administration

TECHNOLOGY SOLUTION

Health, Medicine and Biotechnology

In-Situ Resource Utilization (ISRU): Methylotrophic Microorganisms Expressing Soluble Methane Monooxygenase Proteins

Methane Metabolism by Yeast

Long duration missions to planetary bodies and deep space will require new technological developments that support human habitation in transit and on distant bodies. Microorganisms are unique from the standpoint that they can be employed as self-replicating bio-factories to produce both native and engineered mission relevant bio-products. ISRU using In-Space Manufacturing (ISM) to generate mission relevant products could be logical for many applications. Products that consist of a significant amount of carbon (e.g. fuels, and foods etc.) could potentially be derived from single-carbon molecules available on long duration missions. NASA Ames has developed a novel patent-pending technology for an in-space bio-manufacturing of mission relevant bio-products using methane as the sole carbon substrate.

BENEFITS

- Robust and cost-effective
- Microorganisms are unique from the standpoint that they can be employed as self-replicating bio-factories to produce both native and engineered mission relevant bio-products
- Carbon sources for microbial bio-manufacturing could be made from readily available carbon dioxide and methane
- Recapturing the lost methane in space and using it for microbial manufacturing could provide a unique approach in development of in-space bio-manufacturing
- Coupling an existing flight-approved technology and its waste stream to new systems such as bio-manufacturing
- In addition to Sabatier, methane could also be produced from other physico-chemical and non-physico-chemical technologies
- Several methanotrophic generated bio-products that could have mission relevance and unique capabilities in habitat construction, astronaut nutrition, and biomedical applications
- Scalable, programmable and regenerable

THE TECHNOLOGY

Microorganisms are unique from the standpoint that they can be employed as self-replicating bio-factories to produce both native and engineered mission relevant bio-products. Methane (CH_4) usage in In-Space Manufacturing (ISM) platforms has been discussed previously for human exploration and has been proposed to be used in physicochemical systems as a propulsion fuel, supply gas, and in fuel cells. Carbon Dioxide (CO_2) is abundant on Mars and manned spacecraft. On the International Space Station (ISS), NASA reacts excess CO_2 with Hydrogen (H_2) to generate CH_4 and Water (H_2O) using the Sabatier System (Figure 1). The resulting water is recovered in the ISS, but the methane is vented to space. Recapturing this methane and using it for microbial manufacturing could provide a unique approach in development of in-space bio-manufacturing. Thus, there is a capability need for systems that convert methane into valuable materials. Methane (CH_4) is a potential carbon substrate for methanotrophic microorganisms which are able to metabolize CH_4 into biomass. The innovative technology from NASA Ames Research Center ports Soluble Methane Monooxygenase (sMMO) to Pichia, that is, it moves the methane metabolism into a robust microbial factory (Pichia pastoris) (Figure 2). The yeast Pichia pastoris is a refined microbial factory that is used widely by industry because it efficiently secretes products. Pichia could produce a variety of useful products in space. Pichia does not consume methane but robustly consumes methanol, which is one enzymatic step removed from methane. This novel innovation engineers Pichia to consume methane thereby creating a powerful methane-consuming microbial factory and utilizing methane in a robust and flexible synthetic biology platform.

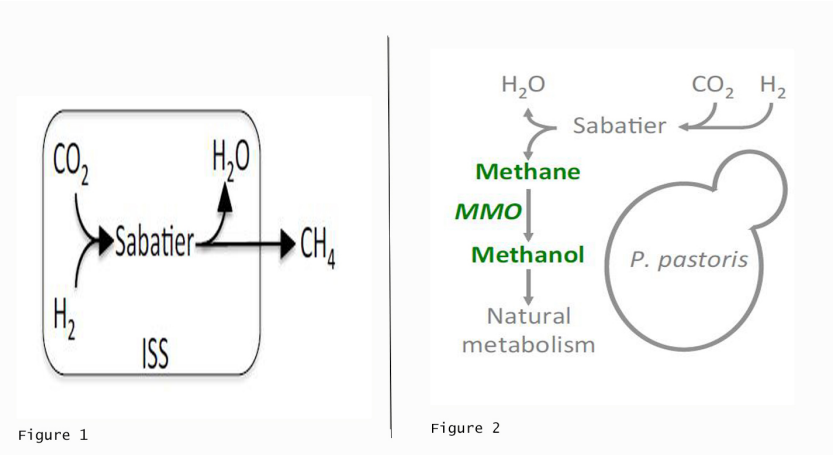

Figure1: Sabatier system on the International Space Station (ISS)
Figure 2: Porting sMMO to Pichia

APPLICATIONS

The technology has several potential applications:

- Space industry -
  Habitat construction, astronaut nutrition, and biomedical applications
- Terrestrial methane-based microbial bio-manufacturing
- Biotechnology industry

PUBLICATIONS

Patent Pending

technology.nasa.gov

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More Information

National Aeronautics and Space Administration

Agency Licensing Concierge

Ames Research Center

MS 202A-3
Moffett Field, CA 94035
202-358-7432
Agency-Patent-Licensing@mail.nasa.gov

www.nasa.gov

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