KSC Partnerships Office

Research Title: Conversion of CO_2 into Fuel

Research Overview: The original research at NASA aimed to investigate and demonstrate the conversion of CO_2 in the presence of H_2O vapor to fuel (i.e. CH_4) using novel photocatalysts in a photocatalytic reactor under Mars and Earth simulated solar spectrums. Results demonstrated production of hydrocarbon fuel, which was likely CH_4, as observed by GC and FTIR data. If peak performance parameters can be isolated and then honed in on, better understanding of the kinetics and mechanisms can aide in making the reaction more efficient for future scale up purposes.

Organization: NASA Kennedy Space Center

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Related Publications: *Photocatalytic Conversion of CO2 on Mars*, September 21, 2016.
Carbon Dioxide Methanation for Human Exploration of Mars: A Look at Catalyst Longevity and Activity Using Supported Ruthenium, April 18, 2018, Great Plains Catalysis Society Symposium, Manhattan KS.

Additional Information: The photocatalyst materials tested in the photoreactor were initially generated from the Science Innovation Fund Project "An In-Depth Study of Photocatalytic Charge Transport and Material Development through Synthesis, Characterization, and Photocatalytic Properties for In Situ Resource Utilization and Fuel Production on Mars". Further developments at Kennedy Space Center (KSC) continued during this project where photocatalyst materials were synthesized at KSC and the University of South Florida (USF) for photoreactor testing at KSC. The photocatalyst materials underwent structural/morphology analysis and optical characterization and were believed to have bandgap values in the regime for photocatalytic H_2O splitting and CO_2 conversion. The hydrogen evolution reaction produces available hydrogen that may react with CO_2 in a series of reduction and oxidation (redox) reactions for the production of fuels such as CH_4, which is a necessity for liquid O_2 and liquid CH_4 propulsion systems of deep space, as well as fuels used on earth. The data in this work looked at MoS_2, $(ZnO)_{1-x}(GaN)_x$, $(ZnO)_{1-x}(AlN)_x$ materials in the photoreactor under Earth and Mars conditions.

KSC Partnerships Office (continued)

Research Title: Evaluation of Low Pressure Air Plasma for Passivation of Metal Components

Research Overview: Currently there is no International Space Station capability for disinfecting pick and eat crops, food utensils and production areas, or medical devices. This deficit is extended to projected long duration missions. Small, portable, Cold Plasma (CP) devices would provide an enhanced benefit to crew health and address issues concerning microbial cross contamination. New technology could contribute to the reduction of solid waste since currently crews utilize benzalkonium chloride wet wipes for cleaning surfaces and might use organic acid based wipes for cleaning vegetables.

Previously an innovation was designed to allow for passivation of aerospace components using a low-pressure air plasma system. The system operates as it is designed to (functional operation of low-pressure plasma system) but instead of the normal feed gases (hydrogen, oxygen, or argon) a k-bottle of breathing air is utilized. The compressed air is fed into the plasma system and ionized, allowing for cleaning of all available surfaces within the chamber. Plasma cleaning is a dry, non-thermal process which can provide broad-spectrum antimicrobial activity. It is microgravity compatible since cold plasma uses no liquids and is able to penetrate event eh smallest cracks and crevices. This innovation eliminates hazardous solvents and hazardous waste stream while reducing a multi-step process into single-step process. CP is a technology that could be used in medical facilities in remote areas and third world countries.

Since the cleaning process developed at KSC uses air as the plasma gas, this technology could be used in remote areas for sterilization without any consumables. In Food Science, CP has the potential to be used to disinfect vegetables and reduce considerably the number of foodborne illnesses per year in the world (deaths, medical costs, industry costs) and represents an alternative to the common disinfection method with bleach.

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Related Publications: *Evaluation of Low-Pressure Cold Plasma for Disinfection of ISS Grown Produce and Metallic Instrumentation*, July 16, 2017, 47th International Conference on Environmental Systems, Charleston, SC.

Additional Information: Aerospace components undergo a passivation process to ensure contaminants are removed from the surface of the metals/alloys and to form an inert, protective oxide layer to enhance the corrosion resistance of the material. Current methods require the use of hazardous chemicals, involve multiple steps, and produce hazardous waste streams that must be disposed of. Currently, passivation of corrosion-resistant steels for aerospace applications follows an SAE International Standard, AMS2700, where parts are submerged in either a nitric acid or nitric acid/sodium dichromate bath at predetermined temperatures and contact times. These baths require constant testing to ensure effective treatment, use corrosive and carcinogenic chemicals, and produce hazardous waste.