Engagement Opportunities in NASA STEM 2023 (EONS-2023)
NASA Research Announcement (NRA)
MUREP Space Technology Artemis Research (M-STAR)
Number: NNH23ZHA001N-MSTAR

Title: A Penetrolyzer for Extracting Oxygen and Hydrogen from Mars Regolith

Institution: Desert Community College District (dba College of the Desert)

City/State: Palm Desert, California

PI: Ahmed ElShafie

FY: 2023

Summary: Production of propellant and life support consumables in-situ on Mars is of high importance to NASA as it paves the way for a sustainable and affordable human exploration of the red planet. Hydrogen and oxygen are needed as a propellant with oxidizer-to-fuel mass ratio of (3.4:1) and as a breathing gas. For crewed mission to Mars, sufficient consumables such as oxygen and hydrogen cannot be transported. In order to backup for regenerative life support systems for long-duration missions on the surface of Mars, oxygen and hydrogen must be extracted in-situ, thus creating large caches of life-supporting consumables for humans.

Significant work has been performed over the last several decades to demonstrate the feasibility of extracting oxygen from the adsorbed carbon dioxide from the Martian atmosphere utilizing the theory of Solid Oxide Electrolysis (SOE). As discovered by many missions on Mars, Martian regolith brines have dissolved Perchlorate salts (Na, Ca, and $MgClO_4$) that are considered one of the significant components of the soil. Also, Perchlorates are deliquescent, which means these compounds are able to absorb humidity from the atmosphere and remain in liquid form on the surface of Mars at a temperature of around 203.15º K. Therefore, they are considered a great asset for hydrated salts as well as a source of Oxygen molecules.

Currently, extracting oxygen and hydrogen from Martian regolith has never been thoroughly researched nor has an instrument to extract them directly been developed. Herein, we propose a methodology to extract the oxygen and hydrogen from the Martian regolith based on the theory of electrolysis and develop an instrument to do the extraction on future Mars missions which aligns to M-STAR Goal 1. To meet this objective, we propose the following tasks:

Task 1: Design, build, and test the most optimized laboratory electrolyzer to be used in Martian regolith analogs.

Task 2: Extraction of O_2 and H_2 from brines and perchlorates mixed with Martian regolith analogs under Mars environmental conditions.

Task 3: Design, build, and test an instrument (penetrometer/electrolyzer) electrically, mechanically for use on future Mars missions (TRL 6)

Task 4: Extraction of O_2 and H_2 using the (penetrometer/electrolyzer) instrument in brine-regolith simulant under Mars environmental conditions.

Task 5: Analyze, interpret, and publish the results of this research.

Task 6: Education and Public Outreach.

This proposal will address: resource extraction, material handling and transport, resource processing, and In-Situ Resource Utilization (ISRU) unique development and certification capabilities, which comprise four out of the seven elements of NASA ISRU capabilities.

This proposal will increase the institutional capabilities and the advancement of research here at College of the Desert (COD) pertaining to the development of technology related to ISRU while aligning with NASA's STMD primary goals of Live and Explore. Lab equipment, purchased from this grant, will directly increase COD's ability to conduct research across interdisciplinary programs and departments which aligns with M-Star Goal 2 and our institutional goals and missions. Throughout this research, participating faculty and students from COD will increase their knowledge, professional development, and research capacity, thus benefiting current and future students creating a better prepared future NASA workforce. Students participating in this research will have an opportunity to summer intern at NASA-JPL, which aligns with M-Star Goal 3 and potentially increase the number of STEM transferring students. Upon transfer, students may pursue graduate degrees in aerospace related fields. As a result, COD will be better situated to secure future funding opportunities offered by NASA, and the private industry.