Summary

Developing efficient technologies for producing carbon and oxygen in Mars conditions is becoming one of the most discussed challenges for Mars exploration missions. It is already known that 95% of Mars's atmosphere is carbon dioxide (CO_2) [1] and considering this fact, there is a need to find ways to utilize this CO_2 for the purpose of carbon and oxygen production. Currently, the Mars Oxygen In-Situ Resource Utilization Experiment also known as MOXIE is the only major project in the field that has been used in an exploration mission [2]. However, there are several challenges with MOXIE technology such as wasting carbon monoxide output by emitting to the atmosphere during the reaction and using very low percentage of its power for the actual oxygen production. One of the most promising alternatives to MOXIE is the Molten Salt Carbon Capture and Electrochemical Transformation (MSCC-ET) technology in which eutectic mixture of carbonate salts are used to capture and convert CO_2 into valuable carbon nanomaterials (that can be used in space industry, including battery and ultracapacitor technologies, conductive and strengthening coatings, polymer formulations, water filters, etc.) without wasting the carbon monoxide. However, there is a limited information available about the stability of different carbonate salts under Mars conditions as part of MSCC-ET reactions and the aim of this work is to analyze the stability of three different carbonate mixtures to fill this knowledge gap.

In this work, the stability of three carbonate mixtures (Li_2CO_3-Na_2CO_3-K2CO_3, Li2CO3-Na_2CO_3, and Li_2CO_3-K_2CO_3) was investigated for use in the MSCC-ET process. The experiment was divided into three steps: First, the mixtures were melted while exposed to argon flow for several hours in order to quantify the weight loss in a neutral state. Secondly, the gas flow was changed to a mix of CO_2, Ar and N_2 to imitate the Martian atmosphere and the reaction was carried out in this condition. At final step, electrodes were inserted to each carbonate salt, and electrolysis was initiated by supplying a voltage to generate oxygen and carbon. To test the stability of the presented molten carbonate salt in three distinct situations, the weight of each electrolyte combination was measured before and after the reactions and the decay rates were calculated.

It was found that both Li_2CO_3-Na_2CO_3 and Li_2CO_3-K_2CO_3 mixtures are promising candidates for MSCC-ET reaction in the Martian atmosphere owing to their superior stability in all of the studied conditions. Li_2CO_3-K_2CO_3 might be the electrolyte of choice for future Mars exploration missions using MSCC-ET technology since the carbon generated in the Li_2CO_3-K_2CO_3 combination was further investigated and found to be favourable for usage as a support material for fuel cell catalyst. Future research might focus on further optimizing this eutectic mixture to improve stability and carbon/oxygen generation efficiency, as well

as using thermogravimetric analysis (TGA) to better understand the reasons behind high decay rates.

[1] Markus Hotakainen, “Mars: from myth and mystery to recent discoveries,” *Choice Reviews Online*, vol. 46, no. 09, 2009, doi: 10.5860/choice.46-4996.

[2] EVAN ACKERMAN, “MOXIE Might Be the Most Exciting Thing Perseverance Has Brought to Mars,” May 2021.