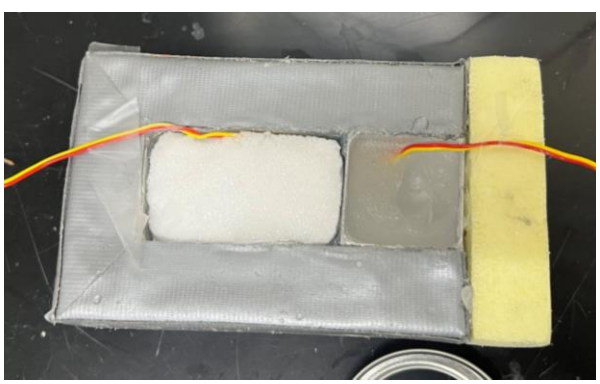
EXTRACTING WATER FROM THE MARTIAN ENVIRONMENT. L. E. Tonani[1], [1]Worcester Polytechnic Institute

Introduction: For many years, space organizations have studied, planned, and prepared for a crewed mission to Mars. Although water occurs on Mars as frozen brine and water ice [1], ensuring an abundant potable water supply remains a fundamental obstacle to crew survival. The Mars Phoenix Lander found evidence of permafrost only a few cm below the regolith surface and found that perchlorate was five times more abundant than chloride [2]. Based on this observation, this project aimed to develop a water treatment method to convert frozen perchlorate brine into potable water. To achieve this goal, a progressive freeze concentration method was selected as the water purification process, and a prototype was designed to sustain the process in Mars's conditions (assuming a habitable crew environment).

The prototype utilized during the experiments consisted of a dry ice container and an aluminum water treatment component within a covered box of R-5 Polystyrene Foam. The use of dry ice during the experiments allowed the prototype's internal components to approximate Martian atmospheric conditions because of the significant increase in carbon dioxide within the prototype and the low temperatures within the ice box, reaching -68 degrees Celsius (see Figure 1 for an image of the prototype after experimentation). After collecting the thermal data throughout the experiments and completing the progressive freeze concentration, I used a Model 150 Orion Conductivity Meter to measure the electrical conductivity of the resulting solutions to ascertain their concentrations.

Figure 1

Experimental Setup after the Brine's Extraction



The project's experiments used a one-molal magnesium perchlorate starting solution due to the substance's abundance in the planet's regolith [5], and all experiments successfully produced a treated product of reduced salt concentration along with a residual brine of elevated salt concentration. However, the experiments with slower cooling and freezing rates, more consistent temperature control, longer process durations, and greater quantities of frozen aqueous solution were the ones that yielded less concentrated magnesium perchlorate solutions.

In light of these observations, for future iterations of water purification mechanisms on Mars, I recommend the implementation of a multi-step process that uses an initial thawing station for all the Martian ice to become liquid at Earth's atmospheric pressure, decantation, filtration, 2-3 cycles of progressive freeze concentration, and the use of other purification mechanisms such as ion-exchange resin or particle activated carbon to increase the solutions' purity until it is deemed safe and potable for the astronauts' consumption. I would also advise that future research and prototype iterations use slower cooling and freezing rates, more consistent temperature control, longer process durations, and produce more substantial amounts of a frozen aqueous solution to approach thermodynamic equilibrium and steady-state conditions and maximize the project's yields. Finally, I propose removing the dry ice component in the prototype's final iteration and utilizing Mars's natural atmospheric temperature as part of the cooling process to increase the device's energy efficiency. This modification would mean that only a few heating plates or Peltier modules would be added to the device and connected to the microcomputers overseeing the water purification system to ensure consistent temperature control and steady-state conditions while the progressive freeze concentration occurs.

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