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ADVANCING MOLTEN SALT ELECTROLYSIS FOR LUNAR ISRU: MATERIAL CHALLENGES, TESTING, AND SCALABILITY PERSPECTIVES

Abstract

In-Situ Resource Utilization (ISRU) is the extraction, processing, and use of extraterrestrial resources for human or robotic space exploration to replace materials that would otherwise have to be supplied from Earth, consequently reducing launch masses and costs.

Due to the current capabilities of commercially available lunar landers, the first ISRU demonstration missions to the Moon will most likely be restricted to one lunar day operation and suffer from severe mass and power budget constraints. Lightweight compact payloads are expected to start landing on the Moon by the second half of this decade.

Molten Salt Electrolysis (MSE) is a promising ISRU technology that electrochemically reduces planetary regolith in a bath of molten salts to produce oxygen and metals. However, MSE imposes significant material compatibility challenges to payload designs, including high-temperature oxidation, molten salt corrosion, salt byproduct reactivity, or dusty environments.

We present a systematic review, trade-off and testing of suitable materials for all MSE payload components. These include promising options for electrodes, crucible, insulation, reactor vessels, seals and fluid and gas management components. In particular, inert anode materials are of strategic importance to demonstrate the production of oxygen without significant electrode degradation. Therefore, we assess the scalability of the material choices for long-term operation beyond the scope of ISRU demonstration missions and evaluate the technology transfer potential to the terrestrial metal electrowinning and electrorefining industry.