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A Molten-Salt Electrochemical Approach for *In-situ* Reduction of Martian Regolith

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In-Situ Resource Utilization refers to collecting and processing local resources on celestial bodies, such as Mars. As humanity edges closer to interplanetary habitation, the immense cost of resource transportation has become a growing challenge. Cryogenic rockets designed for travel to Mars contain 60% propellant by mass, 75-80% of which is oxygen, with fuel requirements increasing exponentially with payload size. Round-trip life- support for an optimally sized crew of 6 traveling to Mars, would lead to an estimated Initial Mass in Low-Earth Orbit exceeding 2000 mT—equivalent to about 21 heavy lift launches (e.g., NASA Space Launch System). Analysis of x-ray spectrometry from the Mars Spirit and Opportunity rovers has revealed that Martian regolith (the topmost layer of dust and loose rock) is predominantly composed of Magnesia (MgO), Corundum (Al_2O_3), and Wüstite (FeO), with FeO and MgO, making up 16.3 and 10 weight percent (wt%), respectively. This research proposes a novel Mars-based molten-salt electrolysis approach for the *in-situ* production of metals and O2. With few necessary reagents from Earth, a mission's O_2 demand for life-support and propulsion can be addressed, while the co-electrolysis of multiple feedstock components (*e.g.,* MgO, Al_2O_3, FeO) can produce valuable metals and alloys for use in various systems (*e.g.,* photovoltaic cells). Additionally, with the application of eutectic salt melts as the electrolyte, operating temperatures can be reduced by up to 550°C. A proof-of principle was designed and tested, with the first experimental series will focusing on pure Ferric oxide, with the second series focusing on mixed simulants, developed to accurately reflect regolith properties at the Gusev Crater. A new parametric model using MATLAB Simulink™ was also developed to assess reactor performance across operating temperature, cell pressure, applied voltage, electrolyte properties (electrical conductivity/ionic mobility), and electrode separation.