Direct Electrolysis of Molten Lunar Regolith for the Production of Oxygen and Metals on the Moon

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When considering the construction of a lunar base, the high cost ($100,000 a kilogram) of transporting materials to the surface of the moon is a significant barrier. Therefore in-situ resource utilization will be a key component of any lunar mission. Oxygen gas is a key resource, abundant on earth and absent on the moon. If oxygen could be produced on the moon, this provides a dual benefit. Not only does it no longer need to be transported to the surface for breathing purposes; it can also be used as a fuel oxidizer to support transportation of crew and other materials more cheaply between the surface of the moon, and lower earth orbit (~ $20,000/kg). To this end a stable, robust (lightly manned) system is required to produce oxygen from lunar resources.

Herein, we investigate the feasibility of producing oxygen, which makes up almost half of the weight of the moon by direct electrolysis of the molten lunar regolith thus achieving the generation of usable oxygen gas while producing primarily iron and silicon at the cathode from the tightly bound oxides.

The silicate mixture (with compositions and mechanical properties corresponding to that of lunar regolith) is melted at temperatures near 1600 °C. With an inert anode and suitable cathode, direct electrolysis (no supporting electrolyte) of the molten silicate is carried out, resulting in production of molten metallic products at the cathode and oxygen gas at the anode. The effect of anode material, sweep rate, and electrolyte composition on the electrochemical behavior was investigated and implications for scale-up are considered.

The activity and stability of the candidate anode materials as well as the effect of the electrolyte composition were determined. Additionally, ex-situ capture and analysis of the anode gas to calculate the current efficiency under different voltages, currents and melt chemistries was carried out.

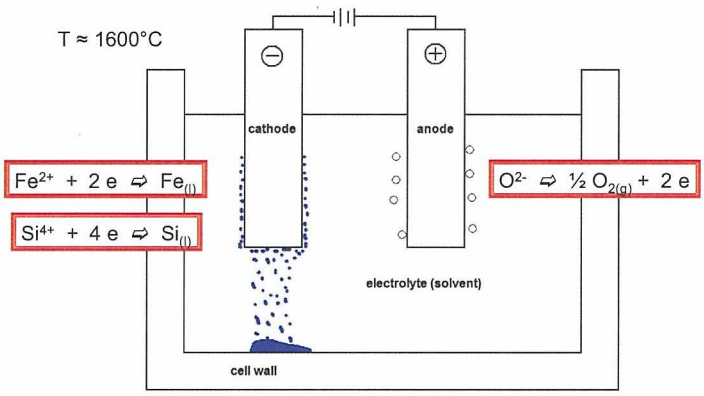

Figure 1: Schematic overview of direct molten oxide electrolysis of a lunar basalt.

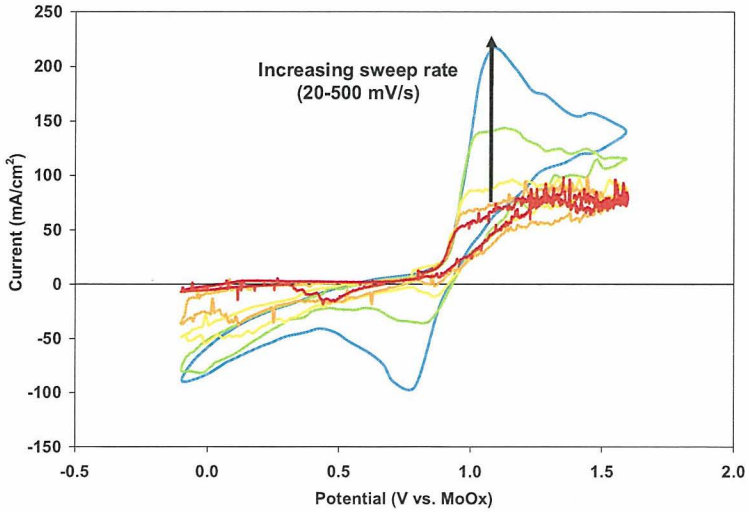

Figure 2: Cyclic voltammogram of transition metal free molten oxide (SiO_2, Al_2O_3, CaO, MgO), iridium wire working electrode, molybdenum rod counter electrode, molybdenum reference electrode, 1575 °C