De-Oxygenated Regolith as a Potential Advanced Material for Lunar Construction Exploration

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Refined regolith, as a product of molten regolith electrolysis, has emerged as a highly promising material for extraterrestrial construction. Its utilization could significantly advance human capabilities for sustainable exploration and long-term habitation of the Moon, Mars, and potentially other celestial bodies. Production levels for refined regolith are anticipated to be high since unprocessed regolith is a viable source of oxygen for space operations. Sourcing usable oxygen directly from lunar regolith will enable sustainable human activity on the Moon as well as facilitate propellant-driven transportation, e.g., lunar landers and hoppers. Exporting oxygen from the Earth carries a high launch cost whether it is intended for use in LEO, the Moon, or other space destinations. As long as this remains true, there is both an economic case and an operational case for ISRU production of oxygen in the low gravity lunar environment, for use in life support and propellant.

Along with oxygen production, the new class of de-oxygenated regolith (DOR) materials are two essential components of lunar infrastructure. Helios has performed preliminary investigations of the oxygen process and the associated DOR production. One possibility is separating the iron and the silicon from the rest of the DOR and using them as feedstock for specialized types of infrastructure construction. Another possibility is the direct use of this Ceramic-metal compound (Cermet), which has the potential to represent unique mechanical properties[2].

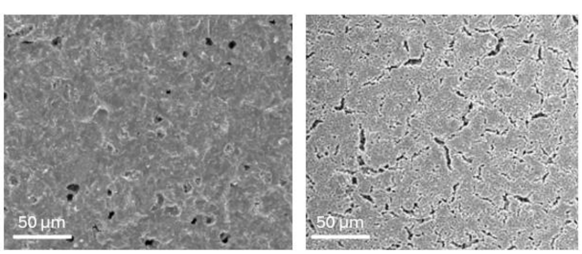

Figure 1: LMS-1 simulant post extraction at the region close to the current collector where extraction occur (right) and bulk (left)

Ceramic derived from molten regolith exhibits several properties that are favorable for construction, including high compressive strength comparable to conventional construction materials on Earth, significant resistance to the harsh thermal environment of space, and the ability to provide protection against cosmic and solar radiation. This potential was shown for Martian regolith by Zheng in 2022[3].

Sample	Bending strength (MPa)	Compressive Strecnth (MPa)	Vickers hardness (GPa)	Young's Modulus (GPa)
HIT-L-1	100.7	67.1	6.09	108.9

Table 1: sample prepared by fully melting lunar regolith simulant[3].

This study aims to explore the potential of refined regolith as a building material, derived from the electrolysis of lunar regolith. It focuses on evaluating its physical, chemical, and mechanical properties and how these can be optimized for construction purposes. Its adaptability to various forms and structures through additive manufacturing techniques, such as 3D printing, further underscores its potential as a versatile construction material.

Future research should focus on optimizing the production process, improving material properties, and developing construction technologies that leverage the unique advantages of refined regolith.

In summary, DOR has the potential to serve as a cornerstone for future construction on extraterrestrial surfaces, paving the way for sustainable human expansion into the lunar surface.

References:

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[2] Subin Antony Jose et al. (2022) *ceramics, 5, 210–236.*

[3] Wei Zheng et al. (2022) *Advances in Space Research., 69,* 3130-3139.