Testing thermal-reflective paint on Mars soil simulant JSC Mars-1a

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Abstract

The goal of this project is to measure the thermal reflectivity and durability of paints containing titanium dioxide and mullite-coated glass microspheres on Mars soil simulant JSC Mars-1a, with the intent of utilizing the compressibility of nanoparticulate iron oxide found in Martian soil alongside pre-existing technology to create sustainable and comfortably habitable structures. Thermal or infrared reflective roof paint has been successful in reducing energy costs used on air conditioning in subtropical countries like Malaysia and Brazil, and ceramic microsphere additives are sold as an insulator for paint. In this project we used x-ray diffraction, infrared reflectometry and thermal measurements under an 1100-watt sun lamp to determine the feasibility of the simulant substrate with paint. X-ray diffraction was used to identify the phases present in the Mars soil simulant, the mullite-coated microspheres, and the paint. Our diffraction of JSC Mars-1a confirmed the presence of several minerals identified by previous studies. Exploiting the binding properties of the nanoparticulate iron oxide constituent of JSC Mars-1a gave a strong solid after quasi-static compression at 30-50 MPa. No additional additives or binding agents were used to produce the sample chips. Reflectivity measurements showed that bare, compressed JSC Mars-1a reflected less than 30% of incoming light. The addition of thermal reflective paint almost tripled the reflectivity, reflecting a little over 90% of light. The addition of mullite-coated microspheres decreased the reflectivity by roughly 5%. Preliminary thermal measurements showed that samples had an average of 5°C difference between the top and the bottom of each sample. The plain JSC Mars-1a chip reached a maximum temperature of 50°C, the painted chip reached 42°C, and the chip with paint and ceramic microspheres reached 44°C. Thermal measurements will be repeated with sample chips of similar thickness and longer exposure time. Based on the findings of this project, the combination of thermal reflective paint and JSC Mars-1a is a feasible option for a building material that requires inexpensive and easily accessible resources and can also reduce the transportation load. It has the potential to be a sustainable building material in Martian colonies that can help stabilize internal temperatures, reducing or eliminating some of the energy need associated with heating and cooling structures.