

Low Temperature Regolith Bricks for In-Situ Structural Material. Kevin Grossman^{1,2}, Tamil S Sakthivel¹, James Mantovani², Sudipta Seal¹, ¹Advanced materials processing and analysis center (AMPAC), Nanoscience and Technology center (NSTC), Materials science and Engineering (MSE), University of Central Florida, Orlando, FL, 32826 (USA) Kevin.grossman@ucf.edu, ²NASA, Kennedy Space Center, FL 32899

Abstract: Current technology for producing in-situ structural materials on future missions to Mars or the moon relies heavily on energy-intensive sintering processes to produce solid bricks from regolith. This process requires heating the material up to temperatures in excess of 1000 °C and results in solid regolith pieces with compressive strengths in the range of 14000 to 28000 psi, but are heavily dependent on the porosity of the final material and are brittle[1]. This method is currently preferred over a low temperature cementation process to prevent consumption of precious water and other non-renewable materials. A high strength structural material with low energy requirements is still needed for future colonization of other planets.

To fulfill these requirements, a nano-functionalization process has been developed to produce structural bricks from regolith simulant and shows promising mechanical strength results[2]. Functionalization of granular silicate particles into alkoxides using a simple low temperature chemical process produces a high surface area zeolite particles that are held together via inter-particle oxygen bonding. Addition of water in the resulting zeolite particles produces a sol-gel reaction called “inorganic polymerization” which gives a strong solid material after a curing process at 60 °C. The aqueous solution by-product of the reaction is currently being investigated for its reusability; an essential component of any ISRU technology.

For this study, two batches of regolith bricks are synthesized from JSC-1A; the first batch from fresh solvents and chemicals, the second batch made from the water solution by-product of the first batch. This is done to determine the feasibility of recycling necessary components of the synthesis process, mainly water. Characterization including BET surface area, SEM, and EDS has been done on the regolith bricks as well as the constituent particles, . The specific surface area of 17.53 m²/g (average) of the granular regolith material was obtained from nitrogen adsorption isotherm measurement. The size, shape and textures of regolith from SEM shows that the particles are 25-50 μm in size and mostly irregular in shape (Figure 1a). The elemental composition of regolith was identified from EDS analysis showed the presence of Si, Al, Fe, Na, Mg, Ca, Ti, O and C (see figure 1b). Each set of cylindrical brick samples were prepared by low energy

process, and cured for 21 and 28 days, respectively to compare their compressive strength. Figure 1c, and d shows the JSC-1A brick and the compressive strength measurements. The results from the 21 day cured bricks (2 bricks) have been done and yielded an average strength of 3050 psi, considerably higher than Portland cement mortars (Type IV and V)[3].

This promising technology provides the benefits of construction material similar to concrete, with a low complexity, low energy synthesis process and the likelihood of complete reusability of precious resources. Compressive strength using this method can be improved by increasing the surface area of the particles, using bi-modal particle size distribution, and adding certain additives to increase inter-particle forces.

Figures:

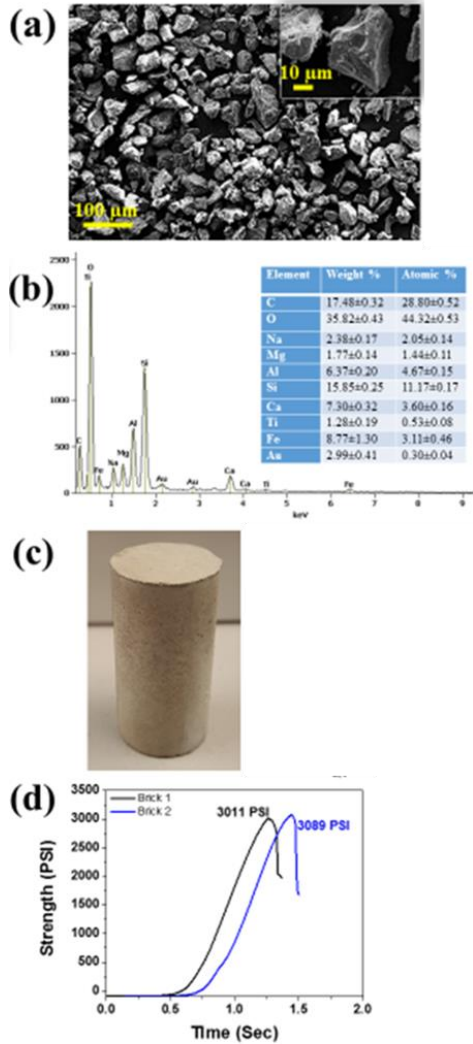


Figure 1: (a) SEM image of the regolith particles, (b) EDS spectrum and relative proportion of elements present in the regolith particles, (c) regolith brick prepared for compressive strength, and (d) Compressive strength results of regolith brick.

References:

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