PRODUCTION OF STRUCTURAL MATERIALS BY COMBUSTION OF LUNAR REGOLITH WITH METALS. C. White[1], F. Alvarez[2] and E. Shafirovich[3], The University of Texas at El Paso, Center for Space Exploration Technologies Research, Mechanical Engineering Department, 500 W. University Ave., El Paso, TX 79968, [1]cwhite2@miners.utep.edu, [2]falvarez@miners.utep.edu, [3]eshafirovich2@utep.edu

Introduction: Future activity on the Moon will involve using construction materials for radiation shielding, landing/launching pads, and thermal wadis (a new concept for heating the rovers during the night [1]). These materials could be produced *in situ* from lunar regolith using microwave sintering and other methods involving high temperatures. One promising method is to prepare combustible mixtures of regolith with active metals such as aluminum or magnesium. Since regolith primarily consists of oxides, the mixtures of regolith with Al or Mg are combustible (thermites). Upon ignition, thermites exhibit self-sustained propagation of the combustion wave. In general, this process is called self-propagating high-temperature synthesis (SHS), and it has been used for synthesis of numerous ceramic and other compounds [2-5]. Owing to high temperatures during the process, SHS in regolith/metal mixtures may produce dense and strong materials, which could be used for construction applications. An important advantage of this method is that only small energy is required for ignition, while the high temperatures during the process are generated by the reaction heat release with no external energy required.

Recently, the combustibility of regolith/aluminum mixtures has been demonstrated experimentally [6]. A lot of work still needs to be done, however, to determine the process characteristics and product properties, as well as to evaluate the competitiveness of the combustion-based method. The present paper informs the ISRU community on the research in this area, recently started in the Center for Space Exploration Technologies Research at the University of Texas at El Paso.

Research Objectives: The research aims to conduct a comprehensive study of SHS in mixtures of lunar regolith simulant with metal powders and evaluate the products' suitability for construction applications. Since the applications may involve different geometries of structural elements, such as bricks and tiles, the research includes the experiments with two types of sample shape. One of them is a cylindrical pellet, which is used frequently in SHS research and can be considered as a brick analog. The pellet is usually ignited at the top and the combustion front propagates downwards (Fig. 1). The other shape is a thin layer of the reacting mixture on the regolith surface. Such a layer could be used for fabricating small tiles as well as for producing a large ceramic disk on the Moon surface through a single SHS process (Fig. 2). Such a disk could be used as a landing/launching pad or for thermal wadis applications.

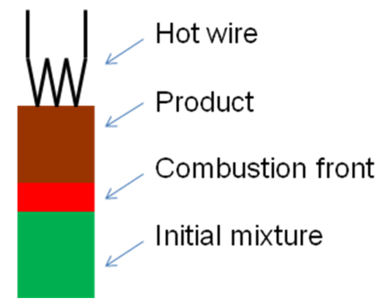

Fig. 1. Schematic of a typical SHS process.

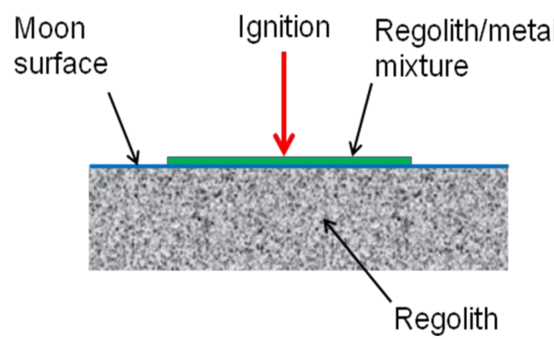

Fig. 2. Schematic of fabricating a ceramic layer.

The research objectives include determination of the minimum metal loading that ensures stable combustion wave propagation over both types of samples (a cylinder and a layer), as well as characterization of the reaction products and their structural properties.

Experimental: The experimental setup includes a steel chamber (diameter 30 cm, height 40 cm) with four glass windows (Fig. 1). The chamber lid has two feedthroughs to connect a power supply with a hot-wire igniter and thermocouples with an acquisition system. The chamber is connected to a compressed gas (argon) cylinder and to a vacuum pump. Two different inserts have been fabricated. One is a holder of cylindrical pellets (diameter 1.3 cm, height 2.5-4 cm) while the other can hold a powder bed (diameter up to 20 cm). This bed may consist of two layers: an inert powder (bottom) and a reacting mixture (top). The same igniter can be used in the experiments with pellets and layers. In the latter case, the layer is ignited in the center and the combustion wave propagates outwards.

Fig. 1. A photograph of the reaction chamber.

Thermodynamic calculations: For different regolith/metal mixtures, the adiabatic flame temperature and combustion products are calculated using THERMO (v. 4.3) software which uses the Gibbs energy minimization and includes thermochemical properties of approximately 3,000 compounds [7].

Status of research: The Center for Space Exploration Technologies Research was established on October 1, 2009, and the research on SHS in regolith/metal mixtures started soon after that. For the past time, the experimental setup was constructed and preliminary thermodynamic calculations were conducted. The research is ongoing.

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Acknowledgment: This research is supported by the NASA Office of Education (Group 5 University Research Centers). The authors thank J. Frias and M. Rubio for assistance with manufacturing parts of the experimental setup.