N91-25205

Extraction of Volatiles and Metals From Extraterrestrial Ores

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During the start-up phase of this project, we have concentrated upon planning our laboratory efforts for the second fiscal year. The principal motivating purpose of our work has been to identify extraterrestrial materials, processes, and products associated with the production of propellants in space, including the most complete possible conversion of the feedstocks for propellant production into useful products with the minimum feasible expenditure of energy. We have tentatively identified and are beginning laboratory research on several processes that promise very large increases in the mass of useful products at the cost of only modest increases in energy consumption. Processes for manufacturing propellants then become processes for making propellants plus metals and refractories. It is the overall yield of useful materials per unit expended energy that matters, not simply the yield of propellants.

Three tasks have been undertaken to date:

1. *Literature search and compilation of a dBase III data base on space materials processing.* This work is being done mainly by an undergraduate, Leo Masursky, with many of the references being supplied by graduate students working for various SERC projects. The data base is roughly half finished. Completion of the data base is expected this summer. Thereafter, a low level of effort should suffice to keep it current. The data base is designed with numerous subject flags to permit efficient searches on any of a large number of subjects. This is the heart of a computerized annotated data base to be prepared by Dr. Andy Cutler. Andy has assisted us in the design of the data base.

2. *Gaseous carbonyl extraction and purification of ferrous metals.* This work is being carried out principally by a graduate student, Mike Nolan, and Professor Lewis. Our activities during the first fiscal year have been concentrated on planning and equipment design of our carbonyl apparatus. Orders have gone out for a number of crucial components of the gas system. Renovations of the lab space have been completed, and the lab is now occupied. The gas line is being designed to have the capability of mixing several gases in precisely measured proportions, including both carbonyls and inert carrier gas (nitrogen or argon); compressing the mixtures to a presssure of 10 atmospheres; and regulating temperatures over the range 0 to 250°C. We have also drawn up plans for extraction experiments on native meteoritic metal alloys, magnetic separates from lunar fines, cathode metal

deposits from the lunar magma electrolysis scheme (Haskin), and the byproduct elemental iron from reduction of lunar ilmenite (Shadman).

3. *Characterization of lunar ilmenite and its simulants.* This work is the principal responsibility of a graduate student, Melinda Hutson. During the past year, she has completed a literature search on the chemical and physical properties of lunar and meteoritic ilmenite and of schemes for beneficiation of ilmenite from lunar regolith (see Appendix A). Certain achondritic (basaltic) meteorites contain either large crystals or large concentrations (not both) of ilmenite which has a chemical composition similar to, but not identical with, lunar ilmenite. The meteoritic ilmenite is free of ferric iron, the component of terrestrial ilmenite whose presence invalidates its use as a lunar simulant. Museum catalogs have been examined to identify the best sources for the most promising meteorites, and samples are on order. Experiments will be conducted by Shadman on lunar, synthetic, and meteoritic ilmenite to determine which, if any, are satisfactory kinetic and thermodynamic simulants of real lunar ilmenite. With Joaquin Ruiz, we are preparing a proposal for Apollo 17 lunar regolith samples to be used in studying the physical properties of lunar ilmenite and in designing and testing beneficiation schemes for extraction of ilmenite from typical lunar feedstocks.