ELECTROLYTIC PRODUCTION OF LUNAR IRON AND OXYGEN AT ROOM TEMPERATURE, William N. Agosto, Lunar Industries, P.O. Box 590004, Houston, TX 77259-0004

Studies of aqueous Hydrofluoric acid (HF) leaching of coal fly ashes (1) approximating the average lunar soil composition in (2) have indicated that the relative solubilities of the major cations are functions of the HF and ash concentrations of the leachates. For example, when 5 and 10 wt% aliquots of the fly ash with composition listed in Table 1 were agitated in 5% and 35% HF solutions for one hour at room temperature, calcium and magnesium were partially leached at 5% HF, but fully precipitated at 35% HF (see Tables 1 & 2).

In addition, the aluminum to iron ratio in the 5% and 35% HF leachates declined with increasing HF and initial solids concentrations from approximately 1.1 to 0.1 on an atomic basis despite the fact that the Al/Fe atomic ratio in the ash was 4.5. On the other hand, the titanium to iron ratio in the leachates increased from .36 to .87 with increasing HF and solids concentrations from a Ti/Fe atomic ratio of about 0.5 in the ash. Further, and most significant, all of the titanium, much of the iron, but almost none of the aluminum were leached at the highest HF and solids concentrations under these dissolution conditions (see NASA/JSC analysis, Tables 1 & 2).

Substantial silicon was held in solution at both 5% and 35% HF concentrations, apparently because the fluoride ion concentration was not high enough in either case to evolve significant amounts of SiF_4 which is a gas at room temperature. However, recent studies of the dissolution of of 15 wt% fly-ash solids of the above composition in 70% HF at room temperature resulted in vigorous evolution of SiF_4.

Accordingly, the dissolution of any lunar soil in high concentration aqueous HF solutions is likely to yield a leachate enriched in iron and titanium and depleted in silicon, calcium, magnesium, and aluminum. In particular, basaltic leachates may be excellent candidates for aqueous electrolytic plating of lunar iron and the evolution of lunar oxygen at room temperature and atmospheric pressure. Electrodes made of simple lunar iron or magnesium are appropriate. Both metals are products of the HF process. Hydrogen evolution can be suppressed by controlling the pH of the electrolyte.

The balance of the major elements and/or oxides may be extracted by hydrolysis of evolved SiF_4 to silica, and by selective precipitation, or ion exchange separation, of calcium, magnesium, and aluminum (1,3). Water and reagents can be recycled at temperatures under 300C using reactions gleaned from the industrial and patent literature (4).

ROOM TEMPERATURE LUNAR ELECTROLYSIS

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REFERENCES: (1) Agosto W.N. and Yun S.J. (1989) Separation of Metal Oxides in Industrial Fly Ash by Fluoroacid and Ion Exchange Techniques and Its Application to In-Situ Lunar Resource Utilization, NASA/JSC Contract T-9720P, Houston, TX. (2) Mason B. (1973) Chemistry in Britain, Vol 9, p. 456-461. (3) Waldron R.D. (1985) Space Manufacturing 5, Engineering with Lunar and Asteroidal Materials, Proceedings of the 7th Princeton/AIAA/SSI Conf., AIAA, p. 132-149. (4) Kirk-Othmer (1978-1984) Encyclopedia of Chemical Technology; Fluorine Compounds (Inorganic), V 10.

Table 1: Fly Ash Sample Analyses Compared with Mean Lunar Soil Composition (wt %)

	AMS Composite Analysis September 1987[b]	NASA/JSC Analysis	Mean Lunar Soil[a]
SiO_2	35.9	41.7	45.0
TiO_2	nd	2.5	1.1
Al_2O_3	18.7	14.6	22.3
Fe_2O_3	5.4	5.1	(FeO) 7.6
MgO	5.1	4.8	8.0
CaO	23.7	19.7	14.9
Na_2O	3.1	nd	0.5
SO_3	3.0	nd	-
K_2O	nd	nd	0.2
P_2O_5	nd	nd	-
Total	94.9	88.4	99.6

(a) from (2)
(b) reported by Ash Management Systems, Inc. Houston, TX.

TABLE 2

Leachate Compositions of Coal Fly-Ash in HF
One Hour Dissolution, 25C, One Atmosphere (mg/l)

	10 wt% Ash in 5% HF	% Diss./Element[a]	5 wt% Ash in 35% HF	% Diss./Element[a]	10 wt% Ash in 35% HF	% Diss./Element[a]
Silicon	6806	34.9	8318	85.3	8471	48.5
Aluminum	1011	13.1	413	10.7	10	0.13
Titanium	601	40.1	484	64.5	1681	100
Iron	1940	53.9	1030	57.2	2253	63.1
Calcium	2240	15.9	not detected		41	0.29
Magnesium	2100	72.4	2.8	0.2	2.1	0.07

(a) based on NASA/JSC fly-ash analysis