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Superconducting Open-Gradient Magnetic Separation for the Pretreatment of Radioactive or Mixed Waste Vitrification Feeds

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Research Objective

The objective is to reduce the volume and cost of high-level waste glass produced during U.S. DOE remediation activities by demonstrating that magnetic separation can separate crystalline, amorphous, and colloidal constituents in vitrification feed streams known to be deleterious to the production of borosilicate glass. Magnetic separation will add neither chemicals nor generate secondary wastestreams. The project includes the systematic study of magnetic interactions of waste constituents under controlled physical and chemical conditions (e.g., hydration, oxidation, temperature) to identify mechanisms that control the magnetic properties. Partitioning of radionuclides to determine their sorption mechanisms is also being studied. The identification of fundamental magnetic properties within the microscopic chemical environment in combination with hydrodynamic and electrodynamic models provides insights into the design of a system for optimal separation. Following this, experimental studies using superconducting open-gradient magnetic separation (OGMS) will be conducted to validate its effectiveness as a pretreatment technique.

Research Progress and Implications

The team working on this project includes Argonne National Laboratory, Westinghouse Savannah River Technical Center (SRTC), the University of South Carolina (USC), and University of Texas (originally University of Illinois.)

As of October 1997, a drum of Hanford C-103 sludge which has a high Fe concentration and hence should be amenable to magnetic separation, SRTC flyash, and a Pu-flyash from Rocky Flats were sampled and studied by SEM. Initial chemical characterization by SRTC was augmented with investigations of mineral composition and magnetic susceptibility using a SQUID magnetometer. Interestingly, the Hanford C-103 sludge magnetic susceptibility shows a strong temperature dependence while the flyash showed virtually no temperature response. In addition, the flyash contains many particles in the sub-micron range which present significant material handling challenges for a pre-treatment system. All this suggests that Hanford C-103 sludge will be the candidate for initial detailed engineering studies.

Engineering considerations for magnetic separation require that an optimal system screen the highest susceptibility materials using a high-gradient magnetic separation (HGMS) system. As of April 1998, these initial screening studies have been concluded at USC. They suggest that considerable beneficiation for the Hanford C-103 sludge can take place using conventional HGMS. Silica, gibbsite, and boehmite were present in considerable amounts and apparently served as nucleation or coordination sites for Fe.

As of April 1998, considerable progress was made in adapting two modeling programs to support the engineering of an OGMS system at Argonne. In both of these cases, the simplest case of a free-fall system was investigated. The first of these models follows only the trajectory of a single particle

passing through an OGMS system. Results from this model relate the initial radial position free-falling through the vertical bore of a superconducting quadrupole field with a 70 cm length superconducting magnet having a maximum gradient of 60 T/m will be sufficient to effect the magnetic beneficiation of even paramagnetic fractions. Particle size will have a considerable impact on trajectory with the optimal size being 50-100 microns.

As of April 1998, a multi-particle simulation at Argonne based on ICRKFLO also has been developed. This builds on work currently being conducted for the EPA to beneficiate petroleum cracking catalysts which are comprised of paramagnetic kaolin and zeolite spherical particles around 50 microns in diameter. Results from the ICRKFLO work suggest that care must be taken to introduce the particles so as not to introduce excessive dispersion by minimizing the spray angle. Assuming plutonium oxide particles were in the feed, the study showed that they would be effectively captured by the OGMS.

Planned Activities

Tests of the Open-Gradient Magnetic Separation will be conducted during the fourth quarter FY98 to establish operating conditions for these feeds and provide data for model validation. Initial preparation for the neutron activation analysis studies at UT has taken place, and further progress is expected during third and fourth quarter FY98.

Other Access To Information

Nunez, L., R.D. Doctor, M.D. Kaminski, and A.E. Visser, "Superconducting Open-Gradient Magnetic Separation for the Pre-treatment of Radioactive or Mixed-Waste Vitrification Feeds," Tenth Symposium on Separation Science and Technology for Energy Applications, Gatlinburg, TN (October 20-24, 1997).

Ebner, A., J.A. Ritter, and L. Nunez, "High Gradient Magnetic Separation for the Treatment of High Level Radioactive Waste," Separation Science and Technology, (accepted for publication.)