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HIGH-CAPACITY, SELECTIVE SOLID SEQUESTRANTS FOR  
INNOVATIVE CHEMICAL SEPARATION: INORGANIC ION  
EXCHANGE APPROACH

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## 1.1 High-Capacity, Selective Solid Sequestrants for Innovative Chemical Separation: Inorganic Ion Exchange Approach

### Task Description

The approach of this task is to develop high-capacity, selective solid inorganic ion exchangers for the recovery of cesium and strontium from nuclear alkaline and acid wastes. To achieve this goal, Pacific Northwest Laboratory (PNL) is collaborating with industry and university participants to develop high capacity, selective, solid ion exchangers for the removal of specific contaminants from nuclear waste streams. This work is one of two parallel projects. Contracts were awarded in 1992 to the AlliedSignal Company in partnership with Texas A&M. During 1993, they screened and developed three classes of exchangers: sodium titanates, zirconium arylphosphonate phosphates, and modified layered minerals. This included the scale-up of these materials, and a series of studies related to pelletization to a useful size range for ion exchange column use.

The preferred strontium selective exchanger for use in highly alkaline waste is a unique phase of sodium titanate,  $\text{Na}_4\text{Ti}_9\text{O}_{20}$ , which has a layer spacing of 10 Å. This material exhibits a strontium  $K_d$  of 21,000 mL/g from a feed containing 80 ppm strontium, 0.1 M NaOH and 5 M  $\text{NaNO}_3$ . The material is being pelletized to a useful size range for tests in a column mode under several sets of conditions. The powder has been scaled up to the 1-kg batch size for PNL testing.

A modified sodium biotite mica and synthetic micas have been developed for the recovery of cesium from alkaline waste. Interaction of these exchangers in the presence of both potassium and cesium is being studied with the goal to produce an enhanced ion exchange material.

Pelletization screening trials are being completed that allowed evaluation of more than 20 inorganic binders for the powdered exchangers noted above. These trials resulted in the elimination of the great majority of the binders as incompatible with the highly alkaline feed, but identified an excellent candidate for use with sodium titanate powders.

### Technology Needs

This project is designed to test the capacity, selectivity, and stability of selected solid ion exchangers in representative physical, chemical, and radiation environments. Emphasis is on developing and demonstrating ion exchange materials with potential applications in nuclear waste management that would result in major cost reductions and environmental benefits. Although contributions from this task should be useful in addressing a variety of problems in the DOE complex, specific applications at Hanford have been targeted. A major goal for AlliedSignal/Texas A&M for FY 1994 is to continue to obtain necessary scientific and engineering information required to remove cesium and strontium from highly alkaline wastes at the Hanford site.

## Benefits

The benefits gained by developing this technology are cost reduction in separating and disposing of nuclear wastes and making technology available for selective sequestering of cesium, strontium, and technetium.

The cost of waste treatment depend on the ability to efficiently and selectively remove elements that complicate waste disposal. This technology emphasizes removal of the heat-emitting isotopes  $^{137}\text{Cs}$  and  $^{90}\text{Sr}$  to reduce the amount of waste glass routed to final disposal, thereby reducing the cost.

In addition, several nonradioactive elements in the waste must be incorporated in large amounts of glass to produce a stable waste form. For example, removing chromium from the waste streams would enable the number of glass canisters to be reduced.

Finally, this technology applies to the environmental sector, because the materials developed for separating traces of cesium, strontium, and technetium from voluminous liquid wastes could be adapted to treat small waste streams.

## Accomplishments

The crystalline form of  $\text{Na}_4\text{Ti}_9\text{O}_{20}$  has been compared with other known ion exchange media to recover strontium from alkaline waste. This material appears to have the highest known distribution coefficient for strontium in the presence of 6 M sodium nitrate and  $\text{pH} > 13$ . The cellulose acetate binder first used to prepare pellets of this exchanger was found to be insufficiently durable to radiation and/or highly basic solutions. After an exhaustive survey, a binder has been selected that is stable but does not reduce the extraction capacity of the pelletized form of titanate.

The natural micas containing potassium have been replaced with synthetic micas that hold the potential to extract cesium from alkaline waste. Additional studies are being conducted to refine this powder and to prepare it for pelletization for initial field trials to recover cesium.

## Collaboration/Technology Transfer

AlliedSignal  
Texas A&M

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#### Bibliography

Lumetta, G. J., D. W. Wester, J. R. Morrey, and M. J. Wagner. 1993. "Preliminary Evaluation of Chromatographic Techniques for the Separation of Radionuclides from High-Level Radioactive Waste." *Solvent Extr. Ion Exch.* 11(4):663-682.

Lumetta, G. J., M. J. Wagner, D. W. Wester, and J. R. Morrey. 1993. *Evaluation of Solid-Based Separation Materials for the Pretreatment of Radioactive Wastes*. PNL-8596, Pacific Northwest Laboratory, Richland, Washington.

Yates, S. F., A. Clearfield, and I. G. G. DeFilippi. 1993. *Cesium and Strontium Ion Specific Exchangers for Nuclear Waste Effluent Remediation*. AlliedSignal Company, Des Plaines, Illinois.

#### 4.1 High-Capacity, Selective Solid Sequestrants for Innovative Chemical Separations: Membrane-Supported, Bound-Particle Approach

##### Task Description

The approach of this task is to develop high-capacity, selective solid extractants for cesium, strontium, chromium, silver, technetium, and noble metals from nuclear wastes. To achieve this goal, Pacific Northwest Laboratory (PNL) is collaborating with industrial partners. The work described is one of two parallel projects to develop high capacity, selective, solid sequestrants for the removal of specific contaminants from nuclear waste streams.

Contracts were awarded in 1992 to 3M working in cooperation with IBC Advanced Technologies, Provo, UT. A major emphasis during the initial work was to provide improved molecular-recognition technology agents, and to implement their use in the form of webs or structures. Novel agents have been selected for screening tests. The capabilities, distribution coefficients as a function of feed composition, physical properties, and chemical and radiolytic stability of materials with demonstrated potential for application in radiochemical separations are being determined.

Empore™ extraction membrane technology provides a state-of-the-art method for enmeshing surface-active particles in a net-like matrix of polytetrafluoroethylene (PTFE) fibrils to form a membrane that has good integrity and handling strength and an extremely high particle surface availability. These membranes are placed in cartridges or filters, allowing the solution of interest to be passed through or by the web, allowing the selective solid extractant to remove the metal ion of interest. Under severe radiation fields PTFE becomes brittle, thus other materials of web construction have successfully complemented this original concept.

The membranes are able to achieve equal or better performance than ion exchange columns by using a very high surface area through the use of small (10 micron) active particles. No adhesive or binders are used so the full activity of the particles is retained. A polymer membrane that is more radiolytically stable (up to 300 megarad) than PTFE has been combined with active particles. Samples were sent to PNL for confirming tests using a <sup>60</sup>Co source. In addition, other membranes have been made with a range of support particles selected to meet DOE's needs.

##### Technology Needs

This project is designed to test the capacity, selectivity, and stability of selected sequestering agents in representative physical, chemical, and radiation environments. Emphasis is on developing and demonstrating extractants with potential applications in nuclear waste management that would result in major cost reductions and environmental benefits. Although contributions from this task should be useful in addressing a variety of problems in the DOE complex, specific applications at Hanford have been targeted. A major goal for 3M/IBC for FY 1994 is to continue to obtain necessary scientific and engineering information required to remove cesium and strontium from highly alkaline wastes at the Hanford Site.

## Accomplishments

The first opportunity to test the 3M/IBC system with actual radioactive waste was successfully completed at the Idaho National Engineering Laboratory using acid radioactive waste containing both  $^{137}\text{Cs}$  and  $^{90}\text{Sr}$ . Synthetic "mimic" wastes were used to test the system both at the 3M laboratory as well as at INEL prior to the actual hot cell test. The results from those tests were confirmed in actual waste testing. The experience provided 3M/IBC/INEL/PNL staff an opportunity to obtain excellent results using a major radioactive waste stream. Additional actual waste tests are being proposed, while cartridge design, ligand-particle combinations, and web technologies are continuing to be improved.

## Benefits

The benefits gained by developing this technology are cost reduction in separating and disposing of nuclear wastes and making technology available for selective sequestering of cesium, strontium, and technetium.

The cost of waste treatment depend on the ability to efficiently and selectively remove elements that complicate waste disposal. This technology emphasizes removal of the heat-emitting isotopes  $^{137}\text{Cs}$  and  $^{90}\text{Sr}$  to reduce the amount of waste glass routed to final disposal, thereby reducing the cost.

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## Collaboration/Technology Transfer

3M  
IBC Advanced Technologies

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