Membrane-Based Separation Technologies for Cesium, Strontium, and Technetium

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EM Focus Areas: high-level waste tank remediation; facility transitioning, decommissioning, and final disposition.

Task Description

This work is one of two parallel projects that are part of an ESP task to develop high-capacity, selective, solid extractants for cesium, strontium, and technetium from nuclear wastes. In this subtask, Pacific Northwest National Laboratory (PNNL) is collaborating with 3M, St. Paul, Minnesota, working in cooperation with IBC Advanced Technologies, American Fork, Utah.

Subtask work began in FY 1992 to develop improved molecular recognition technology agents and implementing their use in the form of flow-through membranes. After selecting novel separation agents, the capacities, 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 were determined.

3M developed a state-of-the-art method, the Empore™ membrane extraction technology, 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 formed into cartridges, within which the solution of interest is 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 densely packed membranes can achieve equal or better performance than ion exchange columns at higher flow rates taking advantage of the very high surface area provided by the use of small (10 μm) active particles. Samples were sent to PNNL for confirming tests using a ^{60}Co source. In addition, other membranes have been made with a range of support particles selected to meet DOE's needs.

Technology Needs

This subtask 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.

Accomplishments

In FY 1995, a successful hot cell experiment was conducted at Idaho National Engineering Laboratory (INEL), in which the technology was used to remove cesium and strontium from acid radioactive waste. Also in FY 1995, technology demonstrations were conducted at the West Valley Demonstration Project and at Test Area North (TAN) at INEL in FY 1996 on dilute, moderate pH waste. A modular processing skid including active adsorber cartridges and effective prefilters, was developed as a part of the West Valley demonstration, and a duplicate unit was used at INEL.

At West Valley, the system was used to remove technetium and cesium from process water running at 0.1 gal/min for 8 days, or a volume of almost 1500 gallons. The technetium cartridge was loaded to a 50% breakthrough after processing ~90 gallons, and the cesium cartridge ran for 40 hours (~250 gallons) with no detectable breakthrough. The cesium in the feed was present at 1200 pCi/L, while the detection limit for the cartridge effluent was about two orders of magnitude lower. These results were particularly encouraging because the feed had already been processed through traditional ion exchange columns.

During an 80-h demonstration at TAN, cesium and strontium were removed to below drinking water standards: 1250 gallons were processed at a flow rate of 0.25 gal/min. Strontium was loaded to a 50% breakthrough after ~800 gallons. No detectable cesium breakthrough occurred for the entire demonstration, with a detection limit of 9 pCi/L. Again, this water had already been through the groundwater treatment facility. All other attempts to achieve this at TAN have been unsuccessful.

More technology demonstrations will be made during FY 1996, with the goal of applying the technology on an increasingly large scale in preparation for transfer to EM-30 and/or EM-40 in FY 1997.

Benefits

The cost of waste treatment depends on the ability to efficiently and selectively remove elements that complicate waste disposal. This technology emphasizes removal of the heat-emitting isotopes ^{137}Cs and ^{90}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 reduce the number of glass canisters required.

This technology can also be adapted to treat other waste streams.

Collaboration/Technology Transfer

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