EMSP
Environmental Management Science Program
Project Summary Fact Sheet • April 2000

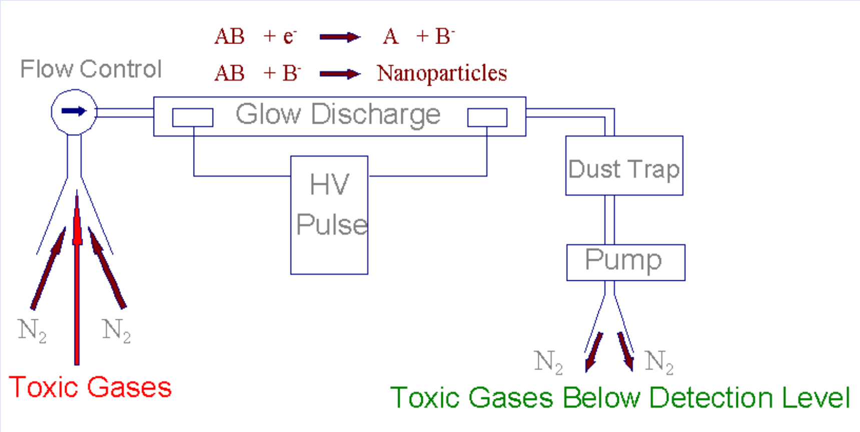
MIXED WASTE – CHARACTERIZATION, OFF-GAS STREAMS, AND STABILIZATION OF SALTS AND ASH

EMSP BASIC RESEARCH PROJECTS HAVE POTENTIAL APPLICATIONS IN EACH OF THESE AREAS

Some examples of needs for nondestructive characterization methods that have been cited by Site Technology Coordination Groups include characterization of wastes stored in boxes, improved chemical analysis methods for transuranic wastes, an alternative nuclear assay method, and characterization of heterogeneous waste. One EMSP project is exploring the development of a neutron source with a thousand-fold increase in neutron flux compared to conventional sources that are suitable for nondestructive analysis applications. Another project involves research in the area of molecular recognition technology with the goal of developing new sensors for specific heavy metal ions.

Although incineration is the preferred method for destroying many organic wastes, there are some cases in which dioxins, furans, or other hazardous species may be present in the effluent gases. In some subsurface contaminant remediation efforts, hazardous organics may be present in an air stream that is brought to the surface. The basic science of a new plasma method for destroying organics has been investigated in an EMSP project, and this work has led to three patent disclosures, including one for the "destruction of low concentrations of volatile toxic compounds using a glow discharge."

The immobilization of fly ash and other incinerator wastes has already been extensively investigated, but alternative stabilization technologies are still cited as needs at several facilities because the current technologies frequently involve large volume increases with uncertain waste form integrity. The properties of iron phosphate glasses have been investigated by an EMSP project, and the potential of this material as a waste stabilization medium has been explored. Another study has explored the use of supercritical carbon dioxide for removing metal salts from mixed wastes.



Removing Hazardous Contaminants from Off-Gas Streams
An ORNL project (54973) is studying a glow discharge process (shown above) for remediation of contaminated gas streams.

PROBLEMS/SOLUTIONS

- Current stabilization techniques for wastes containing high concentrations of hazardous metal oxides meet basic disposal needs, but at the expense of low loadings and high volume increases. One EMSP project is investigating iron phosphate glasses as an alternate durable waste form that can contain higher concentrations of metal oxides with satisfactory leach rates.
- The removal of salts, particularly those containing radionuclides, could simplify many mixed waste disposal problems, but the use of metal-complexing agents in solvents for this purpose may simply produce another mixed waste disposal problem. An EMSP project has explored the use of supercritical carbon dioxide for salt removal from mixed waste because there are no disposal problems with this solvent.

ANTICIPATED IMPACT

- The highest priority work package in the Mixed Waste Focus Area involves improved nondestructive characterization methods. An EMSP project has as its goal a new high-fluence neutron source with a thousand-fold increase in sensitivity for nondestructive analysis methods. If this development is successful, it could greatly increase the rate of disposal without the dangers to workers from opening and sampling waste containers.
- Reliable methods for control of dioxins, furans, and other hazardous organic compounds in the off-gases are needed if incineration is to remain a viable method for the destruction of large volumes of organic compounds in mixed wastes. An EMSP project has explored a new plasma method for potential application to this problem.
- It has been estimated that 170,000 cubic meters of mixed, low-level waste will be generated over a ten-year period by remediation activities at U.S. Department of Energy (DOE) sites. Alternative waste stabilization technologies could greatly reduce the huge volumes of stabilized waste that would be produced by the use of current methods.

Waste Characterization

There is a need for improved nondestructive assay (NDA) ability for contaminants inside of containers, and it is anticipated that the primary NDA method will use neutron irradiation and subsequent detection of gamma rays. The objective of the LANL project (54751) is to develop a source at the 10^{11} neutron/second level to enable a thousand-fold increase in the sensitivity of neutron-based characterization methods. The target is a device that costs about $100 K and that can operate for 10,000 hours with 10-kilowatt power consumption. A triple grid inertial electrostatically confined plasma design is intended to enable the production of a plasma at lower densities so that a collisionless plasma with high-energy, beam-beam collisions can be achieved. Accelerating voltages of about 75 kilovolts (kV) are required to reach the fusion threshold for D-D and D-T fusion reactions, and 52 kV had been achieved by June 1999.

PROJECT TEAMS

LEAD PRINCIPAL INVESTIGATOR (AWARD NUMBER)

- Los Alamos National Laboratory
  PI: Mark M. Pickrell (54751)
- University of Notre Dame
  PI: Joan F. Brennecke (54942)
  Western Michigan University
- Oak Ridge National Laboratory
  PI: Lal A. Pinnaduwage (54973)
- University of Missouri – Rolla
  PI: Delbert E. Day (55110)
- Argonne National Laboratory
  PI: Michael R. Wasielewski (55247)
  University of California – Berkeley
  Tufts University

The ANL/University of California – Berkeley/Tufts University project (55247) is a cooperative effort among some of the leading researchers in molecular recognition technology. The goal is to develop new sensors for detecting specific heavy metal ions. The strategy is to use molecular recognition of the metal ions by polymers that change their luminescence or conductivity properties upon metal binding. A number of different polymers have been prepared, and ligands specific for iron, plutonium(IV), uranyl, and lead ions and that are suitable for incorporation into the polymers have made. High selectivity for Pu(IV) complexation was demonstrated with one of the resins prepared. Other work using similar polymers has been directed toward preparation of fiber optic sensors for metal ions.

Removing Hazardous Contaminants from Off-Gas Streams

The ORNL project (54973) is directed toward the development of a more efficient plasma process for the destruction of volatile organic compounds in the effluent from incineration of hazardous wastes or in the off-gases resulting from air stripping of contaminated soils or water. They have shown that electron attachment to highly excited states of molecules is much more probable than to the ground states of the same molecules. Energy transfer from metastable states of rare gases can be used to produce the excitation with subsequent electron attachment followed by dissociation of the organic molecule. These processes are carried out in the one to ten torr pressure range, and the efficiency for destruction is projected to be greater than with conventional plasma techniques.

Stabilization of High Metal Content Salts and Ash.

The University of Missouri – Rolla group (55110) has investigated the properties of iron phosphate glasses as a possible alternative for vitrification of wastes with high concentrations of metal oxides. They have incorporated a wide variety of metal oxides into the glasses, i.e., uranium, strontium, molybdenum, sodium, bismuth, and cesium oxides. They have shown that certain wastes that are not suitable for borosilicate glasses can be incorporated into iron phosphate glasses, and the resulting leach rates are considerably lower than with borosilicate glasses. The waste compositions for some metal oxides were as high as 35 weight percent without seriously degrading the properties of the iron phosphate glass. Commercial alumina, zircon, or chrome refractories can be used to melt iron phosphate glasses and their waste forms.

Metal complexing agents (ligands) in a solvent provide a potential route for removal of metal salt contaminants from mixed wastes, but the resulting solution may present an almost equally severe disposal problem. An attractive alternative solvent is supercritical carbon dioxide because there are no disposal problems for pure CO_2. The University of Notre Dame/Western Michigan University group (54942) has investigated the solubility of some common metal complexes in supercritical CO_2 and in mixed solvents containing small amounts of methanol in addition to the CO_2. They have measured the solubilities over a wide range of pressures, and they find that the solubilities of the metal complexes are higher in the mixed solvents. They are also implementing better techniques for computations of phase equilibria for use in improved designs of processes to extract components from mixed wastes.

FOR ADDITIONAL INFORMATION ABOUT THE EMSP, PLEASE CONTACT ONE OF THESE REPRESENTATIVES:

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