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

DEACTIVATION AND DECOMMISSIONING

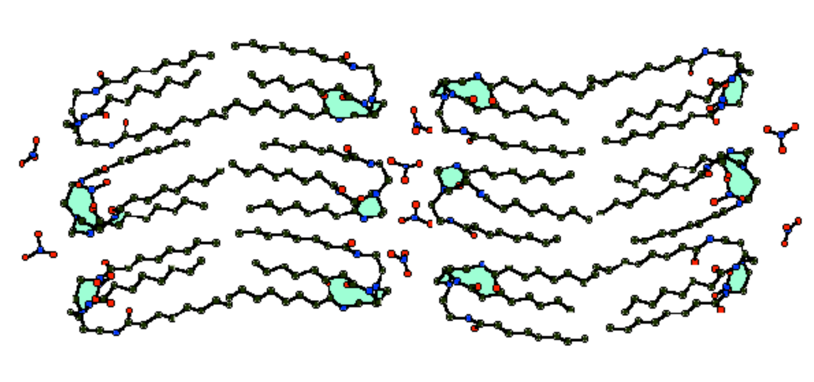
FUNDAMENTAL SCIENCE STUDIES ARE NEEDED TO DEVELOP IMPROVED DECONTAMINATION METHODS FOR SURFACES AND SPENT FUEL BASINS

Deactivation and decommissioning (D&D) of major U.S. Department of Energy (DOE) production facilities presents formidable problems. For example, Rocky Flats has nine major plutonium processing buildings and at least 60 uranium processing and radioactive waste storage buildings. Most of the surfaces of the walls of these buildings are expected to contain low levels of transuranic contamination, and hazardous materials may have diffused into the bulk of more porous materials. Baseline technologies include washing, abrasive blasting, grinding with hand tools, and related methods that may cause excess worker exposure risk and that may generate large amounts of secondary waste, so every major DOE site has cited a need for new metal and porous surface decontamination methods.

- An EMSP project has developed an atmospheric pressure plasma jet for treating surfaces, and the gases used for the plasma can be easily changed from those appropriate to removing paint to those appropriate for removing metals from surfaces.
- Another project has explored the chemistry of hydrous oxide surface layers on metals as well as potential electrochemical decontamination methods.

The removal of radionuclide metal ions from dilute solutions has been extensively studied, but an EMSP project has developed a polymer filtration system for metal-ion recovery that has several advantages over alternate techniques such as ion exchange, reverse osmosis, or electrodeposition. Another project is developing some unique chemical scavengers for negative ions, such as chromate and pertechnetate.

Highly contaminated areas such as hot cells require remote dismantlement operations, and the goal of one EMSP project is to combine artificial intelligence, computer vision, and robotic manipulations. The goal is to have the operator perform virtual reality tasks rather than using joysticks or manually teleoperated devices for complex disassemblies.



Contaminant Binding Science
The crystal structure of a tripodal lipophilic amide with nitrate ion, illustrated above, was developed for a University of Kansas project (54864), which uses a combination of anion and cation complexing agents to extract cesium nitrate.

PROBLEMS/SOLUTIONS

- As described in a need statement (ID-S.2.06), "the fundamental chemistry of adsorption and binding of radioactive isotopes to alloys . . . needs study." One EMSP project has made detailed studies of the interactions of hydrous oxide surface layers with contaminants, and the utility of a new electrochemical device for decontamination of metal surfaces was also being explored.
- Another science need (RL-DD026-S) notes that "Hanford seeks improved understanding of contamination chemistry . . . to allow for the development of improved fixatives and decontaminants." Two EMSP projects (55380 and 54724) were cited in a technical response as possible contributors to a solution for this need.

ANTICIPATED IMPACT

- Decontamination of spent fuel storage basins is a high priority throughout the DOE complex (14 production reactors and more than 100 test and research reactors) and at the 109 commercial nuclear power plants. Although many ion exchange and other separation technologies have been used for this purpose, a polymer filtration system developed by an EMSP project for recovery of metal ions from dilute solutions may have several advantages over competing technologies.
- Potentially valuable scrap metal that has low levels of surface contamination is currently disposed of as waste since there are no cost-effective ways to decontaminate them for free release. An improved plasma jet system could impact metal recovery at sites such as Oak Ridge, Portsmouth, Paducah, Rocky Flats, and Savannah River.
- Even though there have already been extensive efforts to develop robotic techniques, improved remote dismantlement methods are still needed at almost every DOE site. An EMSP-developed teleoperated robotics system could enhance both worker productivity and safety in performing complex disassembly tasks in highly contaminated environments.

Technical Summary and Progress

Contaminant Binding Science

The removal of radionuclides is an essential task prior to decommissioning a number of DOE facilities. A polymer filtration system for recovery of metal ions from dilute solutions has been extensively studied by investigators involved in the LANL/University of California – Davis/University of Massachusetts – Lowell project (54724), and they have shown that the system has several advantages over competing technologies such as ion exchange, precipitation, reverse osmosis, evaporation, or electrodeposition. The technique involves the synthesis of new water-soluble polymers that may be used to bind the target metal ions followed by removal of the polymer-metal ion complex from solution by ultrafiltration. In addition, the use of the polymers for rapid assays of very dilute solutions of metal ions (10 parts per billion) has been demonstrated, and improved ultrafiltration equipment has been built and tested.

Chemical species that form selective complexes with metal ions have been used for many years for both sensing and separation applications, but relatively little effort has been directed toward the formation of selective complexes with anions, e.g., nitrate, chromate, and pertechnetate. The University of Kansas/ORNL project (54864) is directed toward the design and synthesis of anion-complexing species and to detailed understanding of the nature of the interactions. Their work suggests that simultaneous use of complexing agents for cations and anions may lead to greatly improved techniques for selective decontamination procedures.

Project Teams

Lead Principal Investigator (Award Number)

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  University of California – Davis
  University of Massachusetts – Lowell
- University of Kansas
  PI: Kristin Bowman-James (54864)
  Oak Ridge National Laboratory
- University of California – Los Angeles
  PI: Robert F. Hicks (54914)
  Los Alamos National Laboratory
- Clemson University
  PI: Robert J. Schalkoff (55052)
- Argonne National Laboratory
  PI: Carlos A. Melendres (55380)
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Decontamination of Contaminated Metal and Porous Surfaces

The goal of the UCLA/LANL project (54914) is to develop an atmospheric pressure plasma jet for removing transuranic wastes from surfaces. The plasma etches actinide materials by using a fluorine-containing feed gas to produce a volatile metal fluoride. Because the jet operates at atmospheric pressure, it could be used to remove surface contamination from machinery, duct-work, concrete, and other building materials. By changing the feed gas mixture to produce oxygen atoms or hydroxy radicals, the same system could be used to remove paint from contaminated surfaces prior to removal of actinide contaminants. Spectroscopic characterizations of the effluent from a helium/oxygen plasma have shown that oxygen atoms are produced downstream of the plasma, so the plasma may be used at relatively large distances from surfaces for reactive etching. Etching rates for some metals ten times faster than conventional plasma systems have been demonstrated. Ongoing work included installation in a radioactive material research laboratory for studies of etching of actinide metals.

A major decontamination task at several DOE facilities is the removal of radionuclide contaminants from metal surfaces, and the objective of the ANL/Northern Illinois project (55380) is to gain a fundamental understanding of the structure, composition, and mechanism of formation of contaminated surface films on metals. Thin films of nickel hydroxide and nickel oxyhydroxide have been prepared and used as models for hydrous oxide surface layers. Some metal hydroxides or oxides were found to form separate domains when codeposited with the nickel, whereas chromium ions were incorporated into lattice vacancies in the nickel hydroxide structure and would probably be more difficult to remove. Studies were underway to understand correlations between the local structures of incorporated metal ions in iron oxide/hydroxide films and the ease of removal by dissolution methods. The practical utility of a new electrochemical device for decontamination of pipes and storage tanks was also being investigated.

Robotics

The Clemson University project (55052) is intended to advance the technology of semi-autonomous teleoperated robotics as applied to D&D tasks. The goal is to combine artificial intelligence, computer vision, and multi-manipulator robotics for complex disassembly tasks. The intention is for the operator to perform tasks in the form of virtual reality actions rather than by the use of joystick interfaces or by manually teleoperated devices. If these goals are achieved, then the system should be applicable to both repetitive tasks and also to operator-guided unstructured tasks. In either case, the system would enhance both worker productivity and safety in D&D activities in hazardous environments.

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