Project Title: Improved Decontamination: Interfacial, Transport, and Chemical Properties of Aqueous Surfactant Cleaners

Publication Date: July 28, 2001

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RESEARCH OBJECTIVE

This investigation is focused on decontamination using environmentally benign aqueous solutions, specifically the removal of organics and associated radionuclide contaminants by synthetic surfactants. Facilities throughout DOE have need for removal of organics (oils, PCBs, etc.) and associated contaminants from solid substrates, particularly metals surfaces such as ductwork, pumps, tools, gloveboxes, etc. Aqueous-based solutions are attractive alternatives to chlorinated/fluorinated solvents that have been banned or are being phased out. They promise several advantages for decontamination processes, including low hazard potential, low cost, and reduced secondary waste volume through solvent recycle, solvent degradation, and/or incineration.

The work aims at gaining an understanding of interfacial, transport, and chemical processes that govern the effectiveness of aqueous-based surfactant solutions for decontamination of surfaces. In addition, efficient means for separation of waste materials from aqueous-based cleaners will be investigated. It is intended that the understanding developed in this work will be directly applied to decontamination tasks by testing on materials characteristic of DOE contaminated sites and that the tests will provide the basis for improved approaches for removal of organic contamination.

RESEARCH PROGRESS AND IMPLICATIONS

Following is a summary of the work after 33 months of a 3-year project. To date, the project has consisted of laboratory-scale research and theoretical modeling. Technical progress has been made in two areas: surface decontamination involving oil removal using aqueous-based surfactant solutions, and separation of waste from process materials. The first area deals with the theory and practice of cleaning surfaces, while the second addresses the subsequent task of treating the resultant solutions to minimize waste volume.

Surface Decontamination – Bench-scale experiments were carried out to investigate the removal of oil from surfaces using aqueous surfactant solutions. The experiments employed anionic, cationic, nonionic, and zwitterionic surfactants; the surfactants involved were SDS, CTAB, Triton X-100, and Chaps, respectively. The studies have included several different experiments:

- measurements of contact angle evolution and detachment time of oil droplets from stainless steel surfaces with varied process conditions.
- coupled tests of oil removal from metal surfaces

These experiments have indicated that the nature of surfactant adsorption at the substrate surface plays a key role in the efficiency of cleaning using aqueous surfactant solutions. A novel technology for cleaning that may improve performance has been devised based on these results; communications are in progress with an industrial firm for further development and application of the technology.

In addition to bench scale experiments, a theoretical investigation has been initiated in an attempt to explain the results obtained and predict system parameters controlling the removal of organic contamination using aqueous surfactant solutions. This work will help direct and improve understanding of further bench or pilot experimentation. The thermodynamic framework of the model under development incorporates surfactant monomer micellization, solid surface aggregation, and adsorption at the organic/water interface. Comparison of the model results obtained to date with published experimental results and our laboratory work has indicated that the theoretical framework appears valid and the results match experimental trends.

Separation of Waste from Process Materials – studies have been conducted using synthesized effluents from aqueous-based cleaning operations. Anionic, cationic, and nonionic surfactants were used – SDS, CTAB, and Triton X-100, respectively. Three surfactant concentrations have been studied: at sub-critical micelle levels, near the critical micelle point, and above the critical micelle point. Phase splitting involving agitated surfactant solution is more complicated than that with oil and water alone; typically, 3 phases result from the separation, an oil-rich phase, a water-rich phase, and a surfactant-modified phase. The goal of this part of the experimental program is to understand how to design separation systems and to better understand the nature of the recovered materials so that wastes are minimized and useful materials such as the surfactants may be reclaimed for reuse.

PLANNED ACTIVITIES

Planned activities include the following: (1) fundamental studies, (2) connection to applications, and (3) applicability studies. The fundamental studies will involve both theoretical work extending our current thermodynamic modeling and experiments to elucidate surfactant adsorption under various process conditions. These studies are aimed at improving our understanding of the underlying mechanisms controlling oil removal and phase disengagement. Efforts will be continued in parallel to communicate the goals and results of this project with end-users at DOE facilities, such as the Idaho large-scale demo, to determine pertinent applications. Technology-transfer efforts will continue with our industrial partner. We intend to perform bench testing with surfaces and contaminants characteristic of such applications to determine whether the understanding developed in this project can help to improve DOE decontamination efforts.

INFORMATION ACCESS

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