Summary/Project Report Required Data

"Foaming in Radioactive Waste Treatment and Immobilization Processes"

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Number of graduate students/post-doctoral students involved: 2/1

ANNUAL REPORT

RESEARCH OBJECTIVE

The Department of Energy's (DOE) Savannah River Site (SRS) is responsible for the safe storage, processing and immobilization of the High Level (radioactive) Waste (HLW) currently stored in approximately fifty million-gallon underground storage tanks. Foam is present in many areas of the HLW processing including HLW chemical processing, HLW evaporation and HLW cesium decontamination. Foam impacts the production rates of each of these facilities. The presence of foam during chemical processing and evaporation steps leads to slower production rates in the high level waste evaporators and in the Defense Waste Processing Facility (DWPF) waste pretreatment and may lead to higher capital costs or slower production in cesium decontamination. Also, excessive foam causes radioactive contamination of the condensate and equipment. Hence, the objective of this research is to study the mechanisms that produce foaming during nuclear waste treatment, to identify key parameters which aggravate foaming, and to identify effective ways to eliminate or mitigate foaming.

RESEARCH PROGRESS AND IMPLICATIONS

This report summarizes the work completed during the third year of a three-year project. Laboratory tests were conducted at IIT using a non-radioactive simulant slurry containing high levels of noble metals and mercury similar to the High Level Waste. In our second annual report, we concluded that foaminess of the simulant sludge is due to the presence of colloidal particles such as aluminum, iron and manganese, and has a maximum when particle concentration is increased. During this year, we have established the two major mechanisms of stabilization of foams containing such colloidal particles: (i) structural and depletion forces; and (ii) steric stabilization due to the adsorbed particles at the surfaces of foam lamellae. During the generation and interaction of bubbles a foam lamella is formed. Hhydrophilic (attracted to water) solid particles get trapped inside the lamella and subsequently due to the film (lamella) confinement these particles form a layered structure inside the foam lamella. The repulsive structural barrier arising due to in-layer structure formation at high concentrations of hydrophilic solid particles leads to the stabilization of the foam lamella, and hence, foaminess. However, partially wetting or biphilic (exhibiting both hydrophilic - attracted to water, and hydrophobic - repels water) particles in the sludge get adsorbed at the gas-liquid surfaces providing a steric barrier for foam lamella stability.

Figure 1 depicts the steric stabilization mechanism and also shows a photomicrograph showing the adsorption of biphilic particles at the gas-liquid surface. We have characterized both the hydrophilic and biphilic particles in the sludge by using a specially designed optical cell. If the particles are hydrophilic in nature, then they remain inside the solution and can be viewed microscopically using transmitted light. However, biphilic particles which attach at the gas-liquid interface (as seen in Fig. 1) form a three-phase contact angle and can be viewed using reflected light.

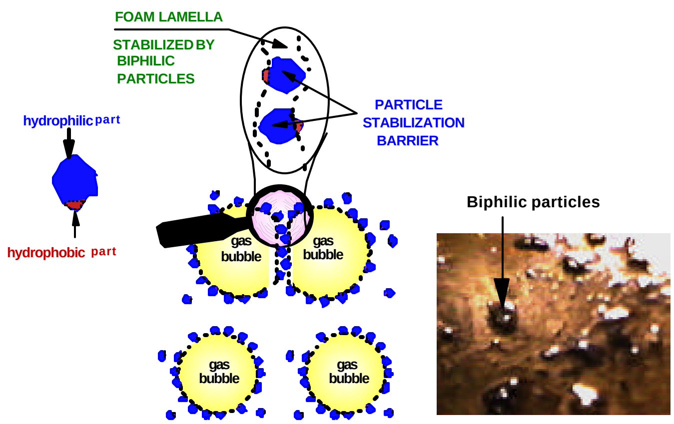

FIGURE 1. FOAMINESS AND\FOAM STABILITY IN THE PRESENCE OF BIPHILIC POLYDISPERSED PARTICLES.

We have investigated the effects of both hydrophilic and biphilic particles present in the sludge on their foaminess. Fig. 2 shows these results. It is seen that foaminess increases with an increase in concentration of either of the type of particles. However, hydrophilic particles produced a maximum of about 260% of foaminess, whereas the biphilic particles resulted in significantly higher degree of foaminess, i.e. 950% over the same range of particle concentrations.

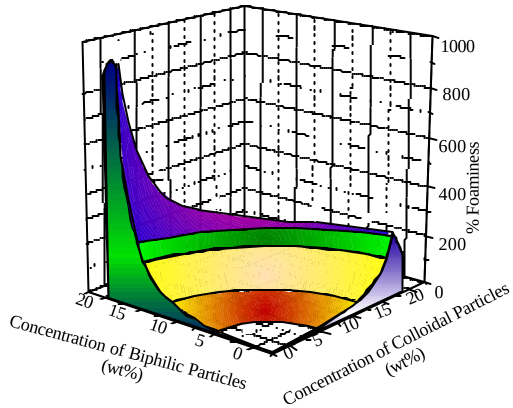

Figure-2 : Effect of Hydrophilic and Hydrophobic particles on Foaminess (Heating Temperature : 445-450 C)

Based on this mechanistic understanding of foam generation and stability, an improved antifoam agent (IIT 747) was developed by us, since commercial antifoam agent (Dow Corning 544) was found to be ineffective in the aggressive physical and chemical environment present in the sludge processing as indicated by the foaminess data presented in Fig. 3. The IIT antifoam agent was found to be more effective in minimizing foam and was more effective over time than Dow Corning 544. The improved antifoam agent, IIT 747, was subsequently tested in a pilot plant at Savannah River Site (SRS) and was found to be effective (Ref. 1). This new antifoam soon will be implemented at the Defense Waste Processing Facility at the Savannah River Site.

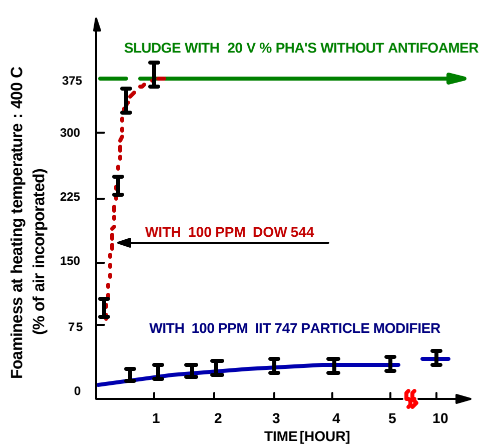

Figure 3. EFFECT OF BOILING TIME ON THE ANTIFOAMER EFFICIENCY

PLANNED ACTIVITIES

The sludge is a multiparticle complex system. Therefore, to understand the role of individual components on foaminess, we plan to develop a single component sludge simulant and study its effect on factors affecting foaminess. We are also studying the antifoaming mechanism that will help in developing a more effective antifoam agent for other DOE sites, especially Hanford.

We are also planning to prepare a series of papers for possible publication in refereed journals. Three such technical papers are currently in preparation.

PUBLICATIONS

The research work has been presented in the following conferences this year:

a. Industrial Advisory meeting of Interfacial and Colloidal Phenomena Lab, IIT, Chicago, October 22, 1999
b. American Institute of Chemical Engineers meeting, Atlanta, March 5-9, 2000
c. American Chemical Society meeting, San Francisco, March 26-31, 2000
d. EMSP National Workshop, Atlanta, April 24-27, 2000
e. One Master's thesis entitled, "Study of Three-Phase Foam System," by S. K. Bindal has been submitted, IIT, December, 1999

REFERENCE

D.C. Koopman, " Comparison of Dow Corning 544 Antifoam to IIT 747 Antifoam in the 1/240 SRAT (U)", WSRC-TR-99-377, 2/29/00.