ABSTRACT

Title: Novel Anionic Clay Adsorbents for Boiler-Blow Down Waters Reclaim and Reuse.

Authors: Muhammad Sahimi and Theodore T. Tsotsis, Department of Chemical Engineering, University of Southern California, 925 Bloom Walk, HED-210, Los Angeles, CA 90089-1211; Phone Number: 213 740 2225; Fax Number: 213 740 8053; E-Mail Address: tsotsis@usc.edu; Industrial Collaborator: Media and Process Technology, Inc.; Grant Number : DE-FG26-04NT42177; Performance Period 9/01/04-8/31/05:

OBJECTIVES

U.S. electric utilities are a large user of water. New regulations to diminish the effect of power generation on aquatic life will mean, that Utilities will have to retrofit from the once-through cooling technology, to recirculating cooling towers, and to reclaim/reuse discharged water throughout the power-plant (e.g., boiler blow-down water). Concerns exist today, in particular, about heavy metals, such as Hg, As and Se, found in many of the power-plant effluents. Most of these streams fall today under the category of high volume, "too clean to clean" effluents. They require highly efficient treatment techniques, particularly for the removal of trace-level metal contaminants. Little emphasis, so far, has been placed on such discharges. The focus of this project is on treating and reusing such effluents, particularly on dealing with Se and As impacted boiler blow-down streams. Our goal is to study the utilization of novel anionic clay sorbents for treating and reclaiming/reusing power-plant effluents, in particular, boiler blow-down waters containing heavy metals, such as As and Se. Developing and using novel materials for such application is dictated by the challenge posed by reclaiming and recycling these "too clean to clean" effluent streams, generated during electricity production, whose contaminant levels are in the ppm/ppb (or even less) trace levels. This is an exploratory project combining the expertise of three uniquely qualified groups USC, M&PT and GCSC.

ACCOMPLISHMENTS TO DATE

We contacted a number of utilities in the Southern California region identified in collaboration with the GCSC and various State Agencies. Two utilities (Harbor Co-generation Station and the Redondo Generating Station) were selected and waste-water samples from these two utilities were collected and analyzed for their metal content (including As and Se) using ICP-MS. In addition to our own analysis of these two sites, we received further information about effluents from various power plants in our state and elsewhere. All the various sources of data indicate the presence of As and Se in power plant discharges, usually in small concentrations up to 50 ppb. Based on these findings model effluent streams containing from 20-200 ppb of As and Se were generated to study the removal of metals using these anionic clay materials.

These blow-down streams have been treated in batch experiments at the relevant blow-down

stream temperatures. Adsorption isotherms as a function of pH/temperature have been established for both As and Se. Upon completion of the equilibrium studies, emphasis has been shifted to the measurement of rates (as they also impact design, adsorber service life, and process viability), using ground adsorbent particles, to eliminate transport limitations that may falsify the data. The rates are measured as a function of concentration, temperature, pH and space time. Similarly with the equilibrium measurements, we have studied the As/Se interaction, and competition from background anions. Flow experiments in packed-beds are also being carried out. The goal of these experiments are to determine the adsorption capacity under flow conditions, and to compare it with the capacity estimated from the adsorption isotherms determined from the batch studies. A mathematical model to describe the packed-bed behavior has also been developed.

FUTURE WORK

The following work is planned for the remainder of this project:

- Using the experimental data generated with the batch and flow experiments, we plan validate the column model to predict the observed breakthrough patterns for various operating conditions and design parameters; the outcome of this effort will be the development of an effective tool useful in the design of full-scale adsorption systems.

- In parallel with the sorption experiments, we will initiate research to understand what determines sorbent selectivity. The sorbents before and after adsorption, will be subjected to tests by techniques such as, Al-Se-NMR, DRIFTS, and TGA/TDA/MS. These experiments will be coupled with molecular simulations of the sorbent structure, and its interactions with oxyanions of interest. The combined simulation and experimental studies will provide insight into how the existing sorbents work, and guidance in the development of 2^{nd} generation sorbents.

LIST OF PUBLICATIONS

Yang, L., Shahrivari, Z., Liu, P.K.T., Sahimi, M., Tsotsis, T.T. “Removal of Trace Levels of Arsenic and Selenium from Aqueous Solutions by Calcined and Uncalcined Layered Double Hydroxides (LDH),” Submitted for Publication Ind. Eng. Chem Res.

STUDENTS WORKING ON THE PROJECT

Ms. M. Dadwhal, Dr. L. Yang, Ms. Z. Shahrivari,