ABSTRACT

Title: Novel Anionic Clay Adsorbents for Boiler-Blow Down Waters Reclaim and Reuse – Phase II

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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 the project is on treating and reusing such effluents, particularly on dealing with Se and As impacted boiler blow-down streams. We will 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 a project combining the expertise of three uniquely qualified groups USC, M&PT and GCSC. USC and M&PT have collaborated over the last ten years, and have significant expertise in the preparation of such materials. The GCSC is one of the nation's largest Utilities, and a pioneer in environmentally friendly power generation.

ACCOMPLISHMENTS TO DATE

During Phase I of our project, equilibrium uptakes and kinetics were investigated in batch experiments. The emphasis in Phase II has shifted to measuring kinetics and adsorption rates in flow experiments utilizing packed-bed columns. The uptake rates will be measured first using surrogate boiler blow-down waters as a function of heavy metal concentration, temperature, pH and space times. Of interest will be whether the equilibrium uptakes, measured in the batch experiments, are consistent with those measured in flow experiments. Verification of the maximum capacity reduction as a result of the competing ions, determined via batch testing, is another focus. Upon completion of the experiments with simulated effluents, we will initiate experiments with real effluents. The goal here is to validate the effects observed with the simulated effluents with the data with real effluents. During the first year of the project we accomplished the following:

- We set-up and tested the experimental system. We have operated a number of packed-bed, flow columns simultaneously in order to investigate a variety of effluents.
- Using the experimental system we have measured adsorption rates in flow experiments and studied the effect on adsorption of heavy metal concentration, temperature, pH and space times. Of interest has been whether the equilibrium uptakes, measured in the batch experiments, are consistent with those measured in the flow experiments.
- We have developed a flow-column model which is to be used in the design and optimization of field-scale columns and devices. We have begun to validate the model using the experimental flow column data.

FUTURE WORK

The following work is planned for second year of the project:

- We will continue the validation of the flow column model. Using the model, we will calculate breakthrough profiles, and will study the influence of external mass transport and column and flow dispersion characteristics.
- We will characterize the fresh and spent adsorbents by various surface techniques. The goal will be to develop a quantitative understanding of the phenomena that determine the selectivity of the anionic clays that we utilize.
- We will carry out molecular simulations of the adsorbent structure as well as of the adsorption and transport of the metallic anions. The results of the simulations will be compared with the adsorption and the structural characterization data.

LIST OF PAPERS PUBLISHED

The following paper was presented at the 2006 AIChE Annual Meting in San Francisco “N. Kim, M. Sahimi, T. Tsotsis, Molecular Simulation of Adsorption in Polycrystalline Nanoporous Materials.”

A paper is in preparation, and will be submitted to Industrial Engineering Chemistry Research. Results of this research will also be presented at the upcoming AIChE Annual Meeting.

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