Thermodynamics and Kinetics of Toluene and Water Adsorption / Desorption on Athabasca Oil Sands Tailings

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The Athabasca oil sands deposit in Canada is a naturally occurring mixture of bitumen, quartz sands, clays, trace minerals, and water. Current technology uses warm water to extract the bitumen from the oil sands for oil production, but the resulting accumulation of large volumes of wet tailings is a serious environmental risk. One approach to avoid the accumulation of wet tailings is to use solvents to extract bitumen from the oil sands instead of water. The main challenge for solvent-based extraction process is the recovery of residual solvents from the extraction tailings. Past research has shown that water is extremely effective in reducing the interaction of non-polar solvents with clay minerals. Therefore, efficient recovery of solvents from oil sands tailings requires a clear understanding of (1) the interactions of the solvents and water with the components in the tailings, including organic-rich fine clays, residual bitumen fractions (mainly asphaltenes), and sands, and (2) the thermodynamics and kinetics of desorption of solvents from the aforementioned tailings components. In this project, the adsorption-desorption isotherms and kinetics of solvent vapors (toluene, water and their mixtures) were studied on several components of solvent extracted oil sands tailings, i.e., asphaltenes, kaolinite, organic-rich fine solids (< 45 μm), and coarse tailings (> 45 μm). The isotherms and kinetic rate constants of adsorption and desorption, and adsorption enthalpy of toluene and water on the solids materials were compared and discussed in terms of differences in the adsorption mechanisms. The preliminary results indicated competitive adsorption of toluene and water on the solids materials, showing marked differences in both the adsorption density of toluene and its rate constants on the studied solids materials in the presence and absence of water.