

Mechanism and thermodynamics of adsorption for aromatic hydrocarbon models via a coagulation process with a ferric sulfate–lime softening system.

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The adsorption mechanisms for model hydrocarbons, 4-nitrophenol (PNP), and naphthalene were studied in a coagulation-based process using a ferric sulfate–lime softening system. The Box–Behnken design with Response Surface Methodology enabled the optimization of the conditions for the removal (%) of the model compounds for the coagulation process. Three independent variables were considered: coagulant dosage (10–100 mg/L PNP and 30–100 mg/L naphthalene), lime dosage (50–200%), and initial pollutant concentration (1–35 mg/L PNP and 1–25 mg/L naphthalene). The response optimization showed a 28% removal of PNP at optimal conditions: 74.5 mg/L ferric sulfate, 136% lime dosage, and initial PNP concentration of 2 mg/L. The optimal conditions for naphthalene removal were 42 mg/L ferric sulfate, 50% lime dosage, and an initial concentration of naphthalene (16.3 mg/L) to obtain a 90% removal efficiency. The coagulation process was modeled by adsorption isotherms (Langmuir for PNP; Freundlich for Naphthalene). The surface properties of flocs were investigated with pH_{pzc}, solid-state UV absorbance spectra, and optical microscopy to gain insight into the role of adsorption in the ferric coagulation process. Kinetic and thermodynamic adsorption parameters for this system were obtained under variable ionic strength and temperature. An in situ method was used to investigate kinetic adsorption profiles for PNP and naphthalene, where a pseudo-first order kinetic model adequately described the process. Thermodynamic parameters for the coagulation of PNP and naphthalene reveal an endothermic and spontaneous process. River water was compared against lab water samples at optimized conditions, where the results reveal that ions in the river water decrease the removal efficiency (RE; %) for PNP (RE = 28 to 20.3%) and naphthalene (RE = 89.0 to 80.2%). An aluminum sulfate (alum) coagulant was compared against the ferric system. The removal of PNP with alum decreased from RE = 20.5% in lab water and to RE = 16.8% in river water. Naphthalene removal decreased from RE = 89.0% with ferric sulfate to RE = 83.2% with alum in lab water and from RE = 80.2% for the ferric system to RE = 75.1% for alum in river water. Optical microscopy and dynamic light scattering of isolated flocs corroborated the role of ions in river water, according to variable RE and floc size distribution.