Arsenic Removal by Iron Nanoparticles and Micro-Mesoporous Materials

Dilshad Masih

Department of Environmental Chemistry and Engineering,
Tokyo Institute of Technology, Japan

Arsenic contamination of ground water sources is a global problem. Iron based economical materials were developed for the arsenic removal ender environmental conditions. Series of iron-intercalated montmorillonites (Fe-montmorillonites) were prepared by: ion exchange, insertion of iron ions followed by stabilization with base hydrolysis, and intercalation of hydrolyzed particles. After the intercalation, basal spacing increased from 12.2 Å to 15.3 Å, and BET surface area from 26 m^2 g^{-1} to 211 m^2 g^{-1}. The size of iron particle was estimated to be 6.0 Å along the direction perpendicular to clay layers. High unsaturation of Fe···Fe coordination number (*N* 2.5), and nanoparticle size was confirmed by X-ray absorption fine structure (XAFS) studies. Next, it was further explored to increase the number of active adsorbent sites by preparing micro-mesoporous iron materials. Dodecylsulfate was used as a surfactant to organize lamellar structure of mesostructured $FeO_x(OH)_y$ composite. Instead of calcination, solvent extraction and ion exchange methods were used to remove surfactant from the composite. The $FeO_x(OH)_y$ composite was essentially non-porous with a specific surface area of 2.8 m^2 g^{-1} that increased to a maximum of 230 m^2 g^{-1} after the modifications. The materials were employed for arsenic removal from low concentration aqueous solutions. Arsenic adsorption capacity and efficiency of iron nanoparticles intercalated montmorillonites was better as compared to bulk iron oxyhydroxides. Arsenic adsorption capacity was a function of coordinative unsaturation of homogenously distributed nano-sized iron particles rather than its amount loaded in the montmorillonite. Among all Fe-montmorillonites, the one prepared by hydrolysis of inserted iron ions was the best in performance. Importantly, arsenite adsorbed from low concentration test solutions on the iron nanoparticles was oxidized to arsenate as revealed by the comparison of As $K\alpha_1$ emission spectra, and high-energy-resolution XAFS studies. On adsorbent basis the micro-mesoporous materials were highly efficient for arsenic removal, and Fe-montmorillonite on the iron basis. High surface area modified $FeO_x(OH)_y$ exhibited the greatest saturated sorption capacity of 21 mg g^{-1} and equilibrium sorption constant (1.0×10^7 ml g^{-1}). The materials are promising candidates for application in Pakistan and other developing countries facing arsenic problems.

dilshad@chemenv.titech.ac.jp