Synthesis and Characterization of Iron-impregnated Pre-oxidized Activated Carbon Prepared by Microwave Radiation for As(V) Removal from Water

Yuda Yurum (1), Alp Yurum (2), Zuleyha Ozlem Kocabas (1), and Raphael Semiat (3)

(1) Faculty of Engineering and Natural Sciences, Sabanci University, Tuzla, Istanbul 34956, Turkey, (2) Sabanci University Nanotechnology Research and Application Center, Tuzla, Istanbul 34956, Turkey, (3) Faculty of Chemical Engineering, Technion Institute of Technology, Technion City, Haifa 32000, Israel

One of the most efficient ways to treat water is probably by adsorption and catalytic oxidation. Surely, for such a process to be economical, the catalyst and the adsorber should have a high catalytic activity and adsorption capacity, and be inexpensive. One of these materials is iron oxide, which is studied and used in areas like catalysis and environmental applications. It is known that synthesizing iron oxides in nano size enhances the catalytic activity. Pre-oxidized activated carbons impregnated with iron-based nanoparticles are prepared in a single step under hydrothermal conditions with microwave radiation. The hydrothermal treatment provides an important advantage by forming fine particles that can easily impregnate deep in to the porous support by the help of water. Their efficiency for the removal of As(V) from water was compared with the pure pre-oxidized activated carbon and iron oxide nanoparticles impregnated without microwave radiation. The synthesized nanomaterials with different iron oxide loadings were characterized by x-ray diffraction (XRD), scanning electron microscopy (SEM), and Brunauer-Emmett-Teller (BET) surface area analyzer. Iron loadings were calculated using flame atomic absorbance. Microwave radiation provided much faster iron impregnation on the active carbon surface. At the first stage of microwave radiation iron oxide impregnation is low but after 6 minutes, iron oxide nanoparticles of 100 nm size started to cover the surface homogeneously. Further treatment with microwave increased the size of particles and the amount of surface coverage. Additionally, with microwave hydrothermal treatment, relatively higher iron oxide loadings were achieved within 10 minutes. From the XRD characterization it was seen that at the first stage of radiation, iron deposited in the form of β-FeOOH, but after the first stage the structure became Fe2O$_3$. While radiation increased the surface area of the material during the first stages, at the last stage the surface area did not increase because of complete surface coverage. Laboratory experiments were carried out to analyze removal capacities of the adsorbents, and also to achieve adsorption isotherms and kinetic parameters. The adsorption was strongly dependent on pH, adsorbent dose and As(V) concentration. Percentage removal of As(V) increased with the decrease in pH value of solution and in order to obtain an effective arsenate removal, the adsorption experiments would require pH values between 3 and 5 for the adsorbent materials. According to kinetic sorption data, for all adsorbent materials, higher regression coefficients (R2) were obtained after the application of pseudo-second order to the experimental data of As(V)'s initial concentrations. The results indicated that iron-impregnated pre-oxidized activated carbon is one of the appropriate adsorbents which can be used for water contaminated with arsenic.