Magnetic Separation Nanotechnology for Water Remediation and Spent Nuclear Fuel Recycling

Huijin Zhang[1], Qian Xie[2], Tao Xing[3], and You Qiang[1,4]

[1]Environmental Science Program, University of Idaho, Moscow, ID 83844, USA
[2]Department of Chemistry, University of Idaho, Moscow, ID 83844, USA
[3]Department of Mechanical Engineering, University of Idaho, Moscow, ID 83844, USA
[4]Department of Physics, University of Idaho, Moscow, ID 83844, USA
Email: zhan3921@vandals.uidaho.edu, xie2041@vandals.uidaho.edu, xing@uidaho.edu and youqiang@uidaho.edu

Abstract: The greater quantities of waste generation and the more stringent regulations for waste discharge/disposal call for a more effective and efficient treatment process to overcome the drawbacks existing in the traditional separation methods. Novel magnetic nanosorbent—surface functionalized magnetic nanoparticles conjugated with specific metal chelators—has been developed for separation of metal ions from aqueous systems, which offers a simple, fast, effective, and environmentally benign technique in wastewater treatment and spent nuclear separation. Our current study has coupled DTPA chelators to double coated magnetic nanoparticles (dMNPs). The batch sorption experiments have demonstrated that the dMNP-DTPA conjugates is an effective and excellent sorbent material for cadmium (Cd) and lead (Pb) adsorption. The sorption of Cd or Pb onto the dMNP-DTPA conjugates was fast which reached the equilibrium in 30 min. Desorption of metal ions and regeneration of the sorbents was achieved by 0.1 M HCl stripping, which showed that the dMNP-DTPA conjugates can be reused more than 10 sorption/desorption cycles without significant decrease in sorption efficiency. With a saturation magnetization of ~20 emu/g, dMNP-DTPA conjugates can be easily manipulated and separated from solution in less than 1 min by applying an external magnetic field with a field gradient of above 300 G/mm. The static magnetic separation results were used to validate the Computational Fluid Dynamic (CFD) simulations. With the help of CFD, a new magnetic separation system will be designed operating under continuous flow conditions. By tailoring the surface functionality of the magnetic nanosorbents, this kind of separation nanotechnology has also been applied for uranium or other valuable element recovery from spent nuclear waste.