Stevens Institute of Technology

Nanotechnology Graduate Program

In-situ reductive destruction of chlorinated solvents and immobilization of toxic metals in soils using polysaccharide-stabilized nanoparticles

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Remediation of soils and sediments contaminated with chlorinated solvents and heavy metals has been a major environmental challenge for decades. Yet, cost-effective in situ remediation technology remains lacking. We developed a particle stabilization strategy using starch or carboxymethyl cellulose (CMC) as a stabilizer, and found that the stabilizers can facilitate controlling the size, delivery and transport of the nanoparticles and resulted in faster reaction rate. The stabilized ZVI nanoparticles can be readily delivered to the targeted contaminated zones, and can in situ effectively destroy chlorinated solvents such as trichloroethylene (TCE). Bench- and field scale experimental data showed that the stabilized ZVI nanoparticles can completely and rapidly dechlorinate TCE in water and soils. Field tests also indicated that the application of stabilized ZVI nanoparticles can boost long-term biodegradation of chlorinated solvents. Based on the stabilized ZVI nanoparticles, we developed a technology for in situ reductive immobilization of Cr(VI) in soils and groundwater. When a Cr(VI)-laden soil column was treated with 5.7 bed volumes of 0.06 g/L of the nanoparticles at pH 5.60, only 4.9% of the total Cr was eluted compared to 12% for untreated soil under otherwise identical conditions. Moreover, the ZVI treatment reduced the TCLP leachability of Cr in the soil by 90%, and the California WET leachability by 76%.

Remediation of soils and sediments contaminated with heavy metals has been a major environmental challenge for decades. Yet, cost-effective in situ remediation technology remains lacking. To address this issue, we prepared three types of nanoparticles of controllable size and transport in soils/sediments by use of various starch or carboxymethyl celluloses (CMC) as a stabilizer, and tested the feasibility of using the nanoparticles for in situ reactive immobilization of mercury (Hg), chromate (Cr(VI)) and lead (Pb) in soils and groundwater. Mercury is one of the most pervasive and bio-accumulative contaminants. To reduce the leachability of Hg in soils and sediments, we synthesized a new class of stabilized FeS nanoparticles using soluble starch and CMC as stabilizers. The nanoparticles can be easily delivered and dispersed in various soils and sediments by gravity. When the Hg-laden sediment was treated at an FeS-to-Hg molar ratio of 26.5, the Hg concentration leached into the aqueous phase was reduced by 97% and the TCLP (toxicity characteristic leaching procedure) leachability of Hg in the sediment was reduced by 99%. The substantial reduction in soluble Hg can potentially greatly reduce the bioavailability and methylation of Hg.

Professor DONGYE (DON) ZHAO is the Elton Z. and Lois G. Huff Associate Professor of Civil/Environmental Engineering at Auburn University. Professor Zhao received his BS and ME degrees in Civil & Environmental Engineering and Environmental Engineering, respectively, from Taiyuan University of Technology (China) before receiving his PhD in Civil and Environmental Engineering from Lehigh University in 1998. His research interests include physical and chemical processes for treatment of water/wastewater and for remediation of soil/sediment, nanoscale materials and nanotechnologies for environmental remediation uses, and environmental fate and impacts of man-made nanoparticles.

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