Iron nanoparticles based nanofluids for in situ environmental remediation

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Nanoscale zerovalent iron (nZVI) is a useful technology for contaminant water remediation. nZVI can remove a variety of pollutants by redox reactions or adsorption. For *in situ* groundwater treatment, suspensions of nZVI, also named nanofluids (NFs) are injected in the ground, allowing water and soil remediation. The main obstacle is the nZVI tendency to agglomerate, which hinders their injection and prevents further transport. To address this disadvantage, the use of different polyelectrolytes as coating is an efficient solution to stabilize nZVI and improve their mobility in porous media.
In this work, stabilization of commercial nZVI (NANOFER STAR, hereafter NSTAR, provided by NANOIRON s.r.o.) with carboxymethyl cellulose (CMC) was studied. NFs prepared with CMC (CMC-NSTAR) were compared and with NFs prepared without CMC (b-NSTAR). Stabilization was evaluated by sedimentation rate analysis of the nanoparticles in CMC-NSTAR *versus* b-NSTAR.
The mobility of both stabilized and non-stabilized NFs was studied in columns filled with porous media at laboratory and pilot scale. NFs were injected upwards in the column with a peristaltic pump, and the nZVI concentration was monitored with turbidity measurement at the outlet stream. Then, NFs reactivity for the removal of aqueous Cr(VI) was tested in batch and columns experiments. In the batch experiments, 15 mg L^{-1} Cr(VI) solutions and the NFs were mixed with an orbital shaker, with a Fe:Cr molar ratio = 10. In the column experiments, a porous media bed was loaded with 0.5 g of n-NSTAR and then a 100 mg L^{-1} Cr(VI) solution was injected upwards.
In the mobility experiments at both scales, CMC-NSTAR reached up to 80% of the inlet concentration on the outlet stream. After the injection of NFs, the column was washed out with water and a complete elution of the retained material was observed. On the contrary, when the column was fed with b-NSTAR, the nanoparticles accumulated at the bottom of the column and their elution was not achieved.
In the reactivity experiments, different conditions were tested. First, in 100 mL batch reactors, with initial pH = 3 and 15 mg L^{-1} of Cr(VI), a 40% Cr(VI) was removed after 30 minutes with b-NSTAR and 30% with CMC-NSTAR, achieving 37 and 28 mg Cr(VI) removed/ g Fe, respectively. This initial pH was previously optimized for the Cr(VI) removal with nZVI [1].
Then, 200 mL of a 100 mg L^{-1} Cr(VI) solution (pH = 4.5) was pumped upwards a nZVI loaded column, and Cr(VI) was measured spectrophotometrically in the outlet. A total removal of 15.5 mg Cr(VI)/g Fe was achieved. Reactivity experiments in column with CMC-NSTAR are pending.
In conclusion, the NF was proved to have good transport properties and Cr(VI) removal capacity. Results of the Cr(VI) removal experiments with CMC-NSTAR in columns will be employed to simulate realistic applications for *in situ* remediation.

References

1. Montesinos, V., Quici, N., Halac, E., Leyva, A., Custo G., Bengio, S., Zampieri, G., Litter, M. (2014). Highly efficient removal of Cr(VI) from water with nanoparticulated zerovalent iron: Understanding the Fe(III)–Cr(III) passive outer layer structure. *Chemical Engineering Journal*, 244, 569-575.