Biochar supported magnetite and zerovalent iron nanoparticles for selenium removal

Xue Wei, Xiaodong Li, Lin Tang*

College of Environmental Science and Engineering, Hunan University, Changsha 410082, China
Keywords: biochar, magnetite, zerovalent iron nanoparticles, selenate
*Presenting author email: tanglin@hnu.edu.cn

Selenium plays a fundamental role in several major metabolic pathways of human and animals, but high daily dose (above 400ug per day) of selenium can result in severe illness (Li, 2015). Fe-based nanoparticles (FNPs) based process, combining adsorption, catalyze and reduction, possesses great potential for in situ selenium removal with advantage of its low cost and toxicity (Tang 2014). Supported FNPs show good stability and transport properties while still possess high reactivity of FNPs, which recently have attracted much attention in practical environmental remediation (Sheng 2015).

One step pyrolysis of Fe preloaded biomass is a fast and robust way to produce biochar supported FNPs. Sawdust, an abundant forestry residue, has been proved to be an ideal precursor to synthesis biochar supported FNPs because of its low ash content.

This work presents a comparative study of biochar supported magnetite nanoparticles (BC-nFe_3O_4) and zero valent iron nanoparticles (BC-nFe^0) for selenate removal for the first time. The biochar supported nanoparticles were produced from one step pyrolysis of $FeCl_3$ pretreated pine wood sawdust, and the iron phase was controlled by pyrolysis temperature.

XRD patterns (Fig. 1) showed that the Fe_3O_4 nanoparticles were formed at 500 °C that these particles were reduced to zero valent iron nanoparticles at 700 °C. SEM images showed that the size of the nanoparticles were about 10-100nm in diameter and were anchored separately in the biochar matrix.

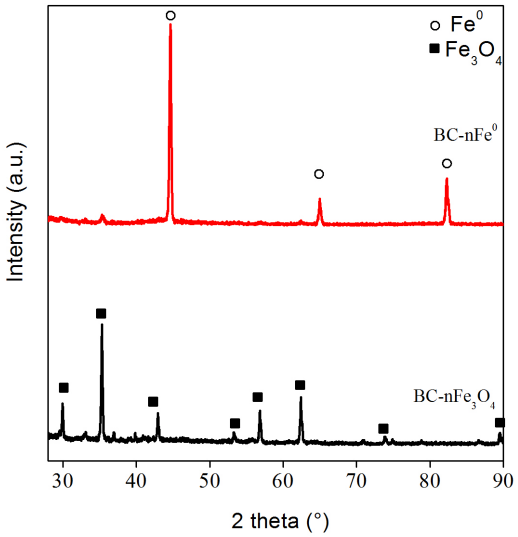

Fig.1. XRD patterns of BC-nFe_3O_4 and BC-nFe^0

Batch experiments showed that the removal efficiency of selenate and sulfate by BC-nFe_3O_4 and BC-nFe^0 was pH dependent, as shown in Fig. 2. BC-nFe_3O_4 was more effective for selenate removal under pH above 4 while BC-nFe^0 was more effective under pH below 4.

The strong influence of ion strength on removal efficiency of both BC-nFe_3O_4 and BC-nFe^0 especially under neutral to alkaline pH conditions implies an outer sphere complexation of selenate with the material surface.

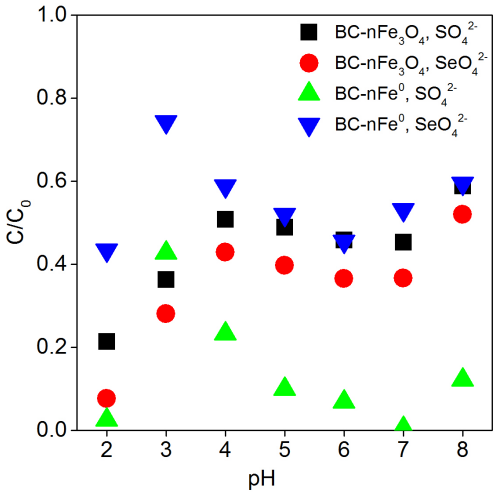

Fig.3. Removal efficiency of selenate and sulfate in binary system

The XPS characterization of the reacted materials showed that the removal of selenate by BC-nFe_3O_4 was mainly through adsorption while that by BC-nFe^0 was mainly through reduction.

Binary removal of selenate and sulfate showed that the adsorption by BC-nFe_3O_4 had little selectivity toward selenate while BC-nFe^0 preferred to react with selenate through reduction especially under acidic conditions.

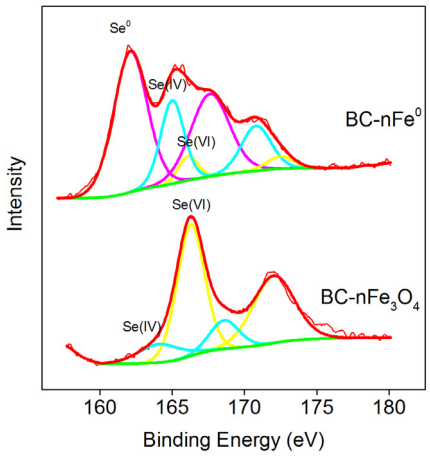

Fig.2. XPS of Se 3p spectra after reaction

Acknowledgements

The study was financially supported by Projects 51579096 and 51521006 supported by National Natural Science Foundation of China, the Key Research and Development Project of Hunan Province of China (2017SK2241).

References

[1] Li Y, Cheng W, Sheng G, et al. Synergetic effect of a pillared bentonite support on SE(VI) removal by nanoscale zero valent iron. Applied Catalysis B Environmental, 2015, 174: 329-335.

[2] Tang C, Huang Y H, Hui Z, et al. Reductive removal of selenate by zero-valent iron: The roles of aqueous Fe^{2+} and corrosion products, and selenate removal mechanisms. Water Research, 2014, 67: 166-174.

[3] Sheng G, Alsaedi A, Shammakh W, et al. Enhanced sequestration of selenite in water by nanoscale zero valent iron immobilization on carbon nanotubes by a combined batch, XPS and XAFS investigation. Carbon, 2015, 99: 123-130.