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Bimetallic nZVI nanoparticles for chlorinated volatile organic compounds degradation.

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Abstract

Degradation of chlorinated volatile organic compounds (CVOC) using nZVI has attracted significant attention over the past few years. Despite several advantages offered by nZVI, it is associated with drawbacks like agglomeration and passivation. Doping nZVI with traces of other metals has been found to over come this drawback. In this study, we doped nZVI with Palladium (nZVI/Pd), nickel (nZVI/Ni), silver (nZVI/Ag) and copper (nZVI/Cu) and compared their efficiency in the degradation of vinyl chloride (VC), 1,2-dichloroethene (DCE), trichloroethene (TCE) and perchloroethene (PCE) in different media including synthetic contaminated water and groundwater procured from a contaminated site in Novy Bydzov. The doped nanoparticles demonstrated better degradation efficiencies than their undoped counterpart.

Synthesis of bimetallic nanoparticles

nZVI was prepared by reducing 0.2 M of iron(III) chloride hexahydrate solution using 0.5 M sodium borohydride solution added using a peristaltic pump at a rate of 1.5 mL/min under nitrogen atmosphere under stirring for 10 min. The synthesized nanoparticles were washed three times with ethanol and then freeze dried for further use.
Bimetallic nZVI (nZVI/X) was prepared by activating nZVI by 1M HCl for 20 seconds, followed by the addition of 1% Pd/Ni/Ag/Cu metal precursors under stirring for 10 min. The prepared nanoparticles were washed three times with distilled water.

Results and discussion

SEM and EDX

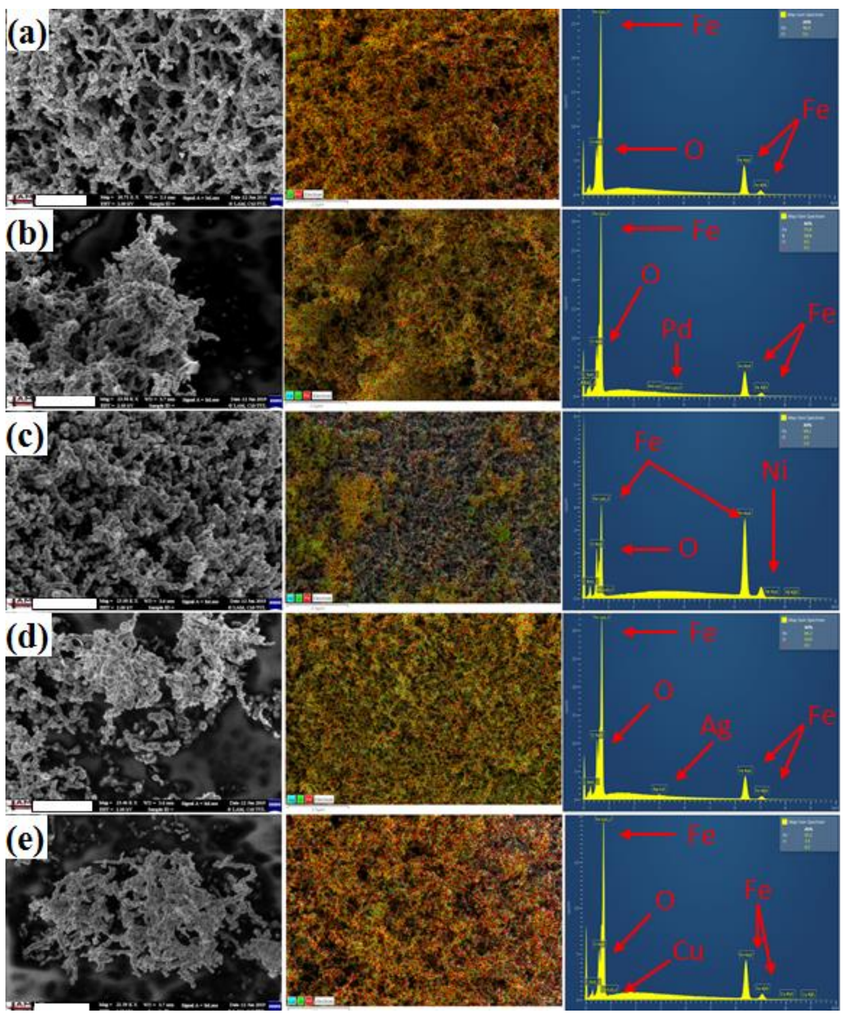

Figure 1. Images of SEM (left, scale bar 1 µm), EDS mapping (centre) and EDS (right) of (a) nZVI, (b) nZVI/Pd, (c) nZVI/Ni, (d) nZVI/Ag and (e) nZVI/Cu. In EDS mapping, Red colour denotes iron, green for oxygen and turquoise for the dopant metal.

CVOC degradation studies

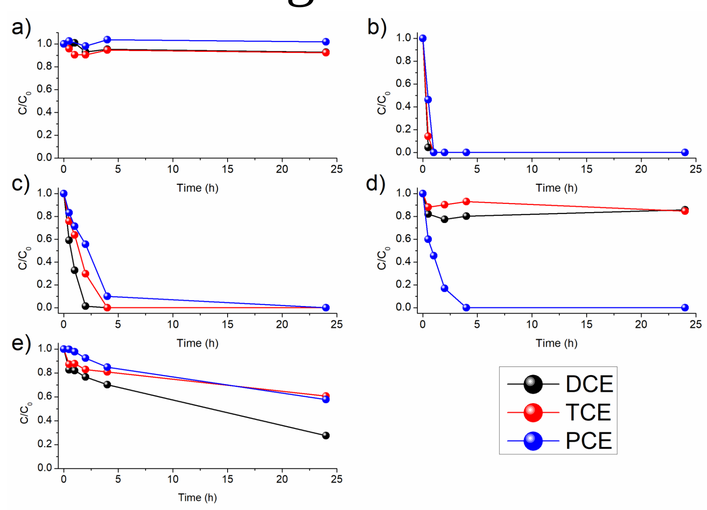

Figure 2. Degradation of CVOC mixtures in synthetic contaminated water by a) nZVI, b) nZVI/Pd, c) nZVI/Ni, d) nZVI/Ag and e) NZVI/Cu (nZVI/X 1 g/L, sum of CVOC 25 mg/L)

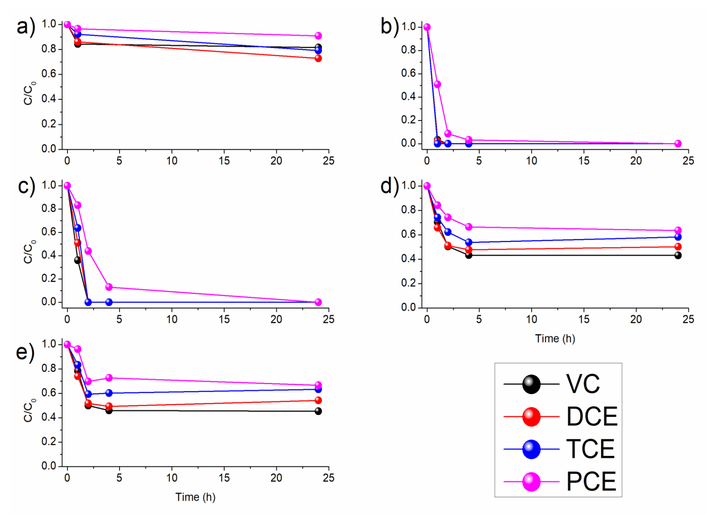

Figure 3. Degradation of CVOC in contaminated groundwater procured from Novy Bydzov by a) nZVI, b) nZVI/Pd, c) nZVI/Ni, d) nZVI/Ag and e) nZVI/Cu, (nZVI/X 1 g/L)

Conclusion

The present work focuses on the development of nzvi doped with traces of different metals and their performance in the degradation of CVOC. SEM images revealed chain like structures which is a typical nZVI morphology, while the EDS mapping confirmed successful doping of metals. The degradation efficiencies of the nanoparticles revealed that the doping process significantly improved the degradation efficiencies of nZVI. Complete degradation of CVOCs were achieved by nZVI doped with Pd and Ni in both synthetic contaminated water and real ground water. While marginal improvements were observed for Cu and Ag doped nZVI particles.

Acknowledgment

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