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Iron nanoparticles for environmental remediation

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 Iron-derived nanoparticles first came under the interest of the scientific community when it was observed that the nanoscale zero-valent iron (nZVI) was able to degrade groundwater pollutants like polychlorinated biphenyls (PCBs) and trichloroethylene (TCE). With this result, the research on nZVI applications in treating other pollutants like pesticides, heavy metals, radionuclides, and others has been increasing over the years. Iron nanoparticles can be prepared using either the top-down or bottom-up approaches. The top-down approach for nZVI synthesis includes hydrogen reduction and the usage of the precision ball milling technique, where the bulk iron material is ground into iron pieces having dimensions of less than 100 nm. The bottom-up approach of nanoparticle synthesis includes the sodium borohydride reduction of ferrous or ferric salts to produce nZVI at a lab scale. Commercial production of nZVI is carried out by reducing goethite or hematite using hydrogen or by electrolytic reduction of ferrous iron. Nowadays, nZVI is being used for the remediation of several pollutants like halogenated organics, arsenic, hexavalent chromium, and uranium. For the removal of halogens, it is largely agreed that the first step in the process is the adsorption of the contaminants at the surface of iron, followed by the breaking of the carbon-hydrogen bonds. Further, iron oxides show a high affinity for arsenic; thus, this property has been exploited for the removal of arsenic from the environment. The process is complex and includes adsorption, oxidation, reduction and intraparticle translocation during arsenic sequestration. The removal of heavy metals like chromium entails a combination of coupled reaction and coprecipitation process that leads to the formation of sparingly soluble Fe(III)-Cr(III) hydroxide. While nZVI seems to be the most viable and developed method for the remediation of pollutants, the problem of toxicity of the nZVIs is yet to be fully studied. Research has shown that nZVI exhibits virucidal and bactericidal properties. Thus, further toxicology research must be done to assess the effects of nZVI nanoparticles in the environment.

Keywords: Iron nanoparticles, Remediation, Heavy metals, Pollutants, Toxicity

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