

# Bioproduction of magnetic nanoparticles: an environmental route to new materials

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Fe(III)-reducing bacteria such as *Geobacter* species can produce copious quantities of extracellular nanoscale magnetite (Fe<sub>3</sub>O<sub>4</sub>) through the anaerobic respiration of poorly crystalline Fe(III) oxides and oxyhydroxides (Fig. 1a). Biogenic nano-Fe<sub>3</sub>O<sub>4</sub> can be engineered to effectively remediate organic and inorganic contaminants through the incorporation of transition metals into or onto the Fe<sub>3</sub>O<sub>4</sub>. These changes can also alter the magnetic properties for applications such as in hyperthermia cancer treatment or electronic devices and in addition can allow the Fe<sub>3</sub>O<sub>4</sub> to act as a catalyst in fine chemical production through the incorporation of Pd<sup>0</sup>. X-ray magnetic circular dichroism (XMCD) is uniquely able to characterise the structure of nano-Fe<sub>3</sub>O<sub>4</sub> and assess mechanisms of reduction/removal utilised by the biogenic magnetic materials through analysis of the Fe L<sub>2,3</sub>-edge and other transition metal L-edges using calculated spectra to give site and oxidation specific information on the metal species present. For example the removal of toxic Cr(IV) from contaminated solutions by nano-scale biogenic was twice as effective as a synthetic analogue as the bio-magnetite was able to reduce Cr(VI) to the less toxic Cr(III), which from XMCD experiments was found to become incorporated and therefore ‘locked up’ into the structure of the Fe<sub>3</sub>O<sub>4</sub> (Fig. 1b). Other contaminant metals and metalloids that are removed efficiently by bio-Fe<sub>3</sub>O<sub>4</sub> include As(V), V(V), Tc(VII) and Hg(II), all effectively integrated into or onto the biogenic Fe<sub>3</sub>O<sub>4</sub> for magnetic recovery and safe disposal.

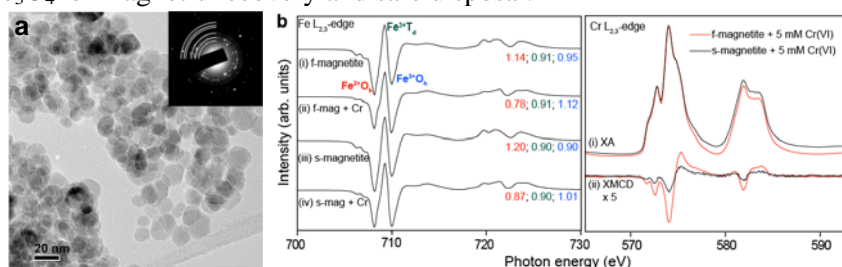


Figure 1. (a) TEM image of biogenic nano-magnetite, (b) Fe and Cr L<sub>2,3</sub>-edges before and after Cr(VI) exposure.

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