Metallic nanoparticle synthesis by metal-reducing bacteria; the missing link between resource recovery and high technology applications?

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The ability to reduce high valence metals is distributed widely throughout the prokaryotic world, and can result in the formation of nanoparticles with a range of potential applications. Subsurface Fe(III)-reducing bacteria are a particularly useful resource, capable of converting waste iron oxides to catalytically active magnetic nanoparticles. They also have the potential to target non ferrous metals in waste streams, forming mono and bimetallic nanoparticles with tunable properties, including the ability to drive catalytic reactions that could underpin simplified production processes for pharmaceuticals and fine chemicals.

Starting with the conversion of waste Fe(III) oxides, downstream applications including the bioremediation of land and water contaminated with toxic organics, metals and radionuclides will be described, in addition to new work encompassing the energy and agricultural sectors. Other Fe-based bionanoparticle applications that will be discussed will include optimisation of the magnetic properties of nano-scale biomagnetite, including the incorporation of transition metal dopants (where possible derived from bioprocessing e.g Co from lateritic ores).

Finally direct bioreduction of a range of non-ferrous metals to form catalytically active bionanoparticles will also be discussed, aiming to produce the next generation of industrial catalysts from a range of waste-streams. Single and multi-step catalysis will be reviewed; for the latter chiral resolutions for the pharmaceutical industries have already been demonstrated by combining biosynthesised Pd nanoparticles and recombinant enzymes, in a single genetically engineered bacterium. A wider discussion of this "biometallic" approach will be given, including the bioproduction of other highly active catalytic nanoparticles for processes including "click chemistry" reactions.

Where possible life cycle analyses are required to support the adoption of these potentially disruptive biotechnologies, and will also be discussed.