Using bacteria to produce tailored magnetic nanoparticles

J.M. BYRNE[1]*, V.S. COKER[1], N.D. TELLING[2], G. VAN DER LAAN[1,3], D. J. VAUGHAN[1], R.A.D. PATTRICK[1] AND J.R. LLOYD[1]

[1]SEAES, Williamson Research Centre for Molecular Environmental Science, University of Manchester, M13 9PL, UK (*correspondence: James.Byrne@postgrad.manchester.ac.uk)
[2]Institute for Science & Technology in Medicine, Keele University, Stoke-on-Trent ST4 7QB, UK
[3]Diamond Light Source, Didcot, Oxfordshire OX11 0DE, UK

Magnetic iron oxide nanoparticles of the form $M_xFe_{3-x}O_4$ (M = Co, Zn, Cr, Mn etc.) are useful for a wide range of applications including targeted cancer therapies, remediation of contaminated ground waters and data storage devices. Many current production processes use chemical and mechanical methods which often use toxic reagents and are expensive. This work presents an alternative biotechnological approach, harnessing the reductive capabilities of the subsurface Fe(III) reducing bacterium *Geobacter sulfurreducens* which yields relatively large quantities of magnetite nanoparticles at ambient temperatures.

The intrinsic magnetism and small size of the nanoparticles are paramount to their commercial use, and must be optimised during production for specific applications. In this study, the incorporation of dopants including zinc and cobalt into the structure of the biomagnetite nanoparticles was studied, and changes in the magnetic and structural properties of the resulting iron oxide minerals quantified. We demonstrated a significant increase in the magnetic moment of the particles at 5K and room temperature by doping with relatively low quantities of zinc, whilst cobalt induced large increases in coercivity. The inclusion of dopants also significantly affected the size of the nanoparticle crystals, with decreases from ~20nm to 8nm observed as dopant concentration increased.

Analytical methods including x-ray absorption, (XAS and XMCD), SQUID magnetometry and Mössbauer spectroscopy were used to provide important information about the mineral structure and indications of where in the crystal the dopants were incorporated, i.e. tetrahedral or octahedral components of the magnetite. Such techniques are vital to better understand how to improve bioproduction methods in order to maximize the potential of biogenic nanoparticles.