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Impact of Genetic Modifications on the Magnetic and Electronic Structure of Nanoparticles Particles Synthesized by Magnetotactic Bacteria.

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To optimize magnetic nanoparticles (MNP) for applications such as cancer therapy and drug delivery, the ability to tailor their size, morphology, surface chemistry as well as their magnetic and electronic properties is of critical importance. Moreover, the appropriate functionalization of their surface to ensure biocompatibility with the human body is necessary.

Magnetotactic bacteria (MTB) represent a promising approach for the synthesis of MNP for biomedical applications. Once placed in iron rich and oxygen poor environments [3,4,5], they synthesize single crystals of magnetite (i.e. Fe_3O_4) which form of linear chains within the bacteria. Compared to chemically engineered MNP, the magnetosomes single crystals display numerous advantages:

1) narrow size distribution and uniform morphologies
2) typical sizes (10-130 nm) not easily achievable through chemical synthesis
3) superparamagnetic properties
4) genetic control with access to morphologies inaccessible with chemically methods
5) lower toxicity compared to some artificial MNP
6) enveloped naturally by a biological membrane that can be specifically functionalized

To controll and tune the particle properties through genetic modifications of the MTB is expected to be possible [5] but needs to be confirmed through the detailed characterization of their magnetic, structural and electronic properties.

We have employed X-ray absorption (XA) spectroscopy and X-ray magnetic circular dichroism (XMCD) to determine the magnetic and electronic state of MNP synthesized by different genetic modifications of the Magnetospirillum magneticum strain AMB-1. The XA data are indicative of Fe ions in Fe^{2+} and Fe^{3+} in octahedral and tetrahedral sites as well as metallic Fe. In all samples a Fe XMCD was observed at ambient temperatures in external fields of 0.2 T. From a detailed analysis of the spectral shape of the XMCD signal we conclude that the pure strain AMB-1 forms Fe_3O_4 single crystals [6], while the genetically modified strain forms MNP with Fe in different states of oxidation.

Our results indicate that the characteristics of MNP produced by magnetotactic bacteria can be tuned through genetic modification of bacteria and that soft x-ray absorption spectroscopies provide valuable information about the resulting MNP.

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