Title

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Dependence of magnetosomes magnetic properties on genetic modifications

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Magnetic nanoparticles (MNP) have wide ranging applications from magnetic recording media and transducers to directed cancer therapy and drug delivery systems. The success of MNP based applications is obviously dependent on the tunability of characteristics such as size, morphology, surface chemistry, magnetic and electronic properties for specific applications and how their surface can be functionalized with appropriate organic materials in order to make them biocompatible with the human body.
Magnetotactic bacteria (Fig.1) are able to synthesize iron minerals (i.e. magnetite, Fe_3O_4) once placed in iron rich environments [3,4,5]. Linear chains of magnetic single crystals are formed in so called magnetosomes, i.e. specialized organelles inside the magnetotactic bacteria, and used for geomagnetic navigation [3]. 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 unknown to chemically produced MNP
5) lower toxicity compared to some artificial MNP
6) enveloped naturally by a biological membrane that can be specifically functionalized
It should be possible to control many of these properties through appropriate genetic modifications of the magnetotactic bacteria [5]. A complete magnetic and electronic characterization of the different magnetic single crystals generated by genetically modified magnetotactic bacteria is essential in order to establish which of them may represent a viable class of MNP for medical applications.
In this study, we have employed X-ray absorption (XA) spectroscopy and X-ray magnetic circular dichroism (XMCD) to determine the magnetic and electronic state of magnetosomes obtained from different genetic modifications of the Magnetospirillum Magneticum strain AMB-1. The XA data (top of Fig.2) are indicative of Fe ions in a mixture of different sites and valence states, i.e. Fe^{2+} and Fe^{3+} in octahedral and tetrahedral site as well as metallic Fe. All three samples show Fe XMCD, i.e. magnetic order, but with distinct spectral features. We conclude that the pure strain AMB-1 forms Fe_3O_4 single crystals [6], while the genetically modified ones show a more typical metallic iron XMCD.
Our results indicate that the characteristics of MNP produced by magnetotactic bacteria can be tuned genetic modification of bacteria and that soft x ray absorption spectroscopies provide valueable information about the resulting MNP.

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