A bacterium reveals the crucible of its metallurgical activity

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An international consortium led by CEA researchers in collaboration with the CNRS, has succeeded in characterizing the structure and function of a protein involved in the production of magnetite nanomagnets in magnetotactic bacteria. This protein, MamP, is crucial to the metallurgical activity of the bacterium. It is this protein that gives the magnetite its magnetic properties. This work constitutes an important advance in the understanding of these bacteria and the magnetite biomineralization process. It is expected to result in the development of additional biotechnological applications for these nanomagnets, especially in the fields of medical imaging and the decontamination of water. These results were published on the *Nature* website on October 6, 2013.

Magnetotactic bacteria have the ability to synthesize nanocrystals of magnetite (Fe_3O_4) enabling them to align themselves with the terrestrial magnetic field in order to find the position in the water column that is most favorable to their survival. The alignment of the nanomagnets is similar to that of a compass needle. The magnetite crystal synthesis process is a complex one, and it is little understood at the present time. Magnetite is a compound of oxygen and iron in a mixture of two different oxidation states [$Fe(II)Fe(III)_2O_4$]. In this study, the researchers have described the mechanism by which the bacterium produces these two states, one of which, Fe(III), is essentially insoluble.

The determination of the structure of the protein MamP has shown for the first time that a section of this protein possesses an original folding structure known as a magnetochrome. This structure is only found in magnetotactic bacteria. The structure has a crucible-like shape capable of containing iron. Additional experiments have shown that MamP has the ability to oxidize iron from the Fe(II) state to the Fe(III) state, and to stabilize the latter in its crucible. Mutagenesis studies and the phenotyping of magnetotactic bacteria variants have confirmed the physiological importance of this crucible.

Finally, a number of *in vitro* experiments have shown that MamP is capable of producing a magnetite precursor when incubated in the presence of Fe(II) alone, proving that the Fe (III) results from the activity of this protein.

This fundamental study reveals part of the process whereby iron is biomineralized and nanomagnets are synthesized in magnetotactic bacteria. The potential applications of these nanomagnets appear promising. They may, for example, by used as a contrast agent in magnetic resonance imaging. Another possible application relates to the decontamination of water supplies. Magnetotactic bacteria carrying an enzyme that breaks down a contaminant may be used to treat effluent and may then easily be removed from the water by means of a magnet.

More information: Structural insight into magnetochrome-mediated magnetite biomineralization. Marina I. Siponen, Pierre Legrand, Marc Widdrat, Stephanie R. Jones, Wei-jia Zhang, Michelle C.Y. Chang, Damien Faivre, Pascal Arnoux, David Pignol. *Nature*, 2013.

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