Defects on Nano-sized Magnetic Crystals Produced by Uncultured Magnetotactic Bacteria collected at Rio de Janeiro State.

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Biomineralization is a process in which organism concentrate metal ions and synthesize crystalline structures. One group of organisms capable of biomineralization is the magnetotactic bacteria (MTB). MTB are able to orientate to magnetic fields because of chains of iron-rich intracellular nano-particles called magnetosomes. Each magnetosome is formed by a magnetic crystal composed of magnetite (Fe_3O_4) or greigite (Fe_3S_4) enveloped by a lipoprotein membrane. MTB aligns the magnetosome chains along the geomagnetic field lines while propelled by flagella is a phenomenon named magnetotaxis. The characterization of magnetosome microstructure, morphology and chain organization can provide the structural basis for the correct interpretation of magnetotaxis and understand the biomineralization processes during magnetosome formation. Here, we used high resolution transmission electron microscopy (HRTEM) and Scanning Transmission Electron Microscopy (STEM)/High Angle Annular Dark Field (HAADF) tomography to investigate magnetosomes biomineralized by uncultured MTB. MTB were collected at Macaé (Rio de Janeiro State), magnetically concentrated using a properly aligned magnet. For whole-mount preparations, samples were deposited on formvar-carbon 300 mesh copper grids and air-dried. For ultra-thin section electron microscopy, samples were fixed with 2.5% glutaraldehyde in 0.1M cacodylate buffer, dehydrated with acetone and embedded in Poly/Bed 812 resin. Ultrathin sections were obtained using a Leica Ultracut ultramicrotome and stained with uranyl acetate and lead citrate. Samples were imaged using a FEI Morgagni or FEI TECNAI G2 F20 transmission electron microscopes. Vibrioid-shaped cells with a single chain of prismatic magnetosomes was the predominant morphotype in samples. Ultra-thin sectioning showed that magnetosomes are enveloped by a membrane. HRTEM, and Fast Fourier Transform indicate that the mineral in magnetosomes is consistent with magnetite (Fe_3O_4) particles elongated along the [111] direction. STEM showed crystalline defects in both extremities of some magnetosomes. 3D modeling based on STEM tomography showed the relative spatial distribution of each magnetosome along the chain. The presence of crystalline defects is possibly associated with the biomineralization process of magnetosome formation. Our data confirm that STEM/HAADF tomography is a powerful technique to better characterize the crystalline structure and defects at nanometric scale in magnetosomes.

Key-words: high-resolution transmission electron microcopy, STEM/HAADF tomography, magnetosome, biomineralization.

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