

General Features of Metal Sulfide Biomineralization And Latest Findings About Microbial Copper Sulfide Biomineralization

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Metal sulfides are one of the most commonly discovered mineral phases in nature and often produced by biomineralization processes initiated by microorganisms as well. [1] A few metal sulfide biominerals are found in the form of intracellular biominerals in microorganisms and often appear as a response to metal ion toxicity in the environment.[2] Intracellular biomineralization of metal sulfides occurs in various forms and degrees of biological control[1], and one of the tightest biological control is representatively found in greigite (Fe_3S_4) produced by magnetotactic bacteria[3] and cadmium sulfide produced by yeasts.[4] In this context, we discovered a new type of intracellular biomineral composed of copper sulfide in a sulfate-reducing magnetotactic bacterium *Desulfamplus magnetovallimortis* sp. BW-1.[5, 6] The bacterium could biomineralize spherical nanoparticles composed of copper sulfide in their periplasmic space at an enhanced copper ion concentration of about 14 mM. In general, the crystal structure of particles and their organizations show high-level of biological control based on organic matrices. Remarkably, the particles are based on 1-2 nm nanocrystallites that accord with the hexagonal crystal system, which are expected to stay in a thermodynamically unstable state. Moreover, the nanoparticles do not easily aggregate with each other, which is not a common phenomenon in other periplasmic biominerals discovered in microorganisms or in extracellular particles found in the BW-1 culture. This particular organization is tentatively based on organic substances surrounding the particles, and controlled by biogenic macromolecules. Thus, we further investigated on associated proteins using differential proteomics, of which the result suggests that two periplasmic proteins, a DegP-like protein and a heavy metal-binding protein, are possibly attributed to the biomineralization of an unknown mechanism for intracellular biomineralization.

[1] Park & Faivre (2022), *ChemPlusChem* **87**, e202100457.

[2] Carney *et al.* (2006), *Topics in Current Chemistry* **270**, 155-185.

[3] Mann *et al.* (1990), *Nature* **343**, 258–261.

[4] Dameron *et al.* (1989), *Nature* **338**, 596–597.

