Effect of protein aggregation and protein structure on magnetite formation

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Magnetotactic bacteria (MTB) are a diverse group of microorganisms that have in common the ability to passively align and swim along the Earth's magnetic field. This is because MTB biomineralize magnetite or greigite crystals through a controlled biomineralization process. Magnetosome nanocrystals are surrounded by a lipid bilayer forming the magnetosome organelle. Being also biocompatible, magnetosomes could be used in many biomedical applications as in cell separation, etc. MamC from Magnetococcus marinus MC-1 has been shown to control the size of magnetite crystals in in vitro experiments, thereby demonstrating its potential as a candidate protein for the production of magnetite nanoparticles possibly useful in medical and other applications. However, the importance of the structure and aggregation state of the protein on the resulting biomimetic nanoparticles has not been yet assessed. One method normally used to prevent the aggregation of integral membrane proteins is the introduction of detergents during protein purification. In this study, results from protein aggregation following the addition of three detergents are presented. Magnetite particles formed in the presence of MamC purified using these three detergents were compared. Our results show that detergents alter the structure of the folded recombinant protein, thus preventing the ability of MamC to control the size of magnetite crystals formed chemically in vitro. Furthermore, we show that the introduction of detergents only at the dialysis process during the protein purification prevents its aggregation and allows for correct, functional folding of MamC. These results also indicate that the population of the active protein particles present at a certain oligomeric state needs to be considered, rather than only the oligomeric state, in order to interpret the ability of magnetosome recombinant proteins to control the size and/or morphology of magnetite crystals formed chemically in vitro.