MAGNETIC CHARACTERIZATION OF NON-INTERACTING ULTRAFINE FERRIMAGNETIC NANOPARTICLES

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Ultrafine ferrimagnetic particles are vital not only for understanding fundamental fine-grain rock magnetism theory but also for applications in industrial and biomedical technology. However, magnetic properties of ultrafine ferrimagnetic grains are very poorly understood due to rarity of samples and ambiguity caused by magnetostatic interactions and size distributions. Magnetoferritin is usually composed of a spherical protein cage and a magnetite/maghemite core. Because the protein impose strictly controls on the core formation, magnetoferritin may provide an ideal system to study magnetic properties of ultrafine ferrimagnetic particles and biomineralization process. We successfully synthesized ferrimagnetic iron oxide cores (magnetite and/or maghemite) with theoretically 2300 Fe loading in highly controlled conditions (pH, 8.5; T, 65°C) using recombinant human H chain ferritin (HFn). These synthesized ferrimagnetic HFn were examined by various low-temperature magnetic measurements in conjunction with transmission electron microscopy (TEM) analysis. TEM revealed that their averaged core diameter is about 4 nm. Selected area electron diffraction (SAED) analysis indicated that the ferrimagnetic HFn cores are probably magentite (maghemite). Acquisition of isothermal remanent magnetization (IRM) and corresponding dc field demagnetization measured at 5K show a crossing point value of 0.5, and Henkel plot has nice linearity; both indicated no magnetostatic interactions of these ferrimagnetic HFn cores. The saturated IRM acquired at 5 K decreased rapidly with increasing temperature, suggesting a median blocking temperature of 8 K. The Néel frequency factor f_0 determined from AC susceptiblity is 10^{11} Hz. The calculated magnetic anisotropy constant K, 1.15×10^5 J/m^3, is larger than that of bulk magnetite/maghemite and other magnetoferritins, indicating larger surface anisotropy contribution. These experimental data of non-interacting ferrimagnetic HFn provide useful constrains on numerical modeling of superparamagnetic particles, and new insight into applications of ferrimagnetic HFn in magnetic separation, medical diagnosing and MRI contrast enhancement.

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