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Influence of Rod Length and Particle Concentration on AC Magnetization Properties of Spherical and Rod-shape Magnetic Nanoparticles

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Magnetic nanoparticles are well known to generate heat by magnetization response when an AC magnetic field is applied to magnetic nanoparticles. There are many kinds of particle shapes such as spherical, cubic, and rod-shaped, and the magnetization responses are quite different among these particle shapes and their size [1,2]. Particularly, because rod-shape magnetic nanoparticles have an aspect ratio, it is important to elucidate the magnetic anisotropy resulting from particle shape anisotropy and the fundamental principles of heat generation. In this study, the influence of rod length of rod-shaped magnetic nanoparticles on their AC magnetization characteristics was investigated experimentally and compared with those of spherical magnetic nanoparticles. In addition, because rod-shape magnetic nanoparticles become difficult to move in high concentration, we also examined the influence of particle concentration. The magnetic nanorods were synthesized with gradually increasing the rod length by using a hydrothermal method [3] with controlling heating temperature and time. AC magnetization characteristics are measured using an electrical circuit consisting of an excitation circuit for magnetizing samples and a detection circuit for measuring magnetic response of the sample. When an alternating current is applied to the excitation coil, AC magnetic field is generated at coils, and the test sample is magnetized in the coils. The electromotive force is induced by the AC magnetic field and magnetization property of the test sample can be detected by the detection coil. The frequencies of AC magnetic fields in this study were 1 kHz, 10 kHz, and 100 kHz. The experimental results indicate that both spherical and rod-shaped particles show similar tendencies with respect to particle concentration at 1 kHz. In contrast, spherical particles exhibit larger magnetic loss at higher particle concentrations than rod-shaped particles at 100 kHz. Compared with spherical particles, rod-shape particles tend to have shorter interparticle distances under high-concentration conditions. This leads to stronger magnetic interactions between particles and the ability of the particles to follow the applied magnetic field may be reduced. Other results and detailed discussion will be presented in the conference. References [1] S. Nigam et al., Small, 20 (2024), 2305300. [2] Q. Li et al., Scientific Reports, 7 (2017), 9894. [3] T. Zhu et al., J. Phys. Chem. C, 115 (2011), pp. 9814-9820.

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