【Grant-in-Aid for Scientific Research (S)】

Broad Section C

Title of Project： Elucidation of magnetic particle dynamics for diagnostic and therapeutic applications

TAKEMURA Yasushi
(Yokohama National University, Faculty of Engineering, Professor)

Research Project Number: 20H05652 Researcher Number：30251763
Keyword：magnetic nanoparticles, magnetization dynamics, magnetic particle imaging, hyperthermia

【Purpose and Background of the Research】

Development of methods for early detection of disease and treatment with less patient's burden is significant. In this project, we study new diagnostic and therapeutic methods using magnetic nanoparticles.

When an alternating magnetic field is applied to the magnetic nanoparticles selectively accumulated in a tumor, the magnetic nanoparticles rotate (physical rotation) and the magnetization in the magnetic nanoparticles rotate simultaneously as to respond the magnetic field (Fig. 1). These rotation can be detected as an electromotive force induced in a coil positioned outside of the body. The detected signal is used for a medical imaging to diagnose disease called magnetic particle imaging. In case of applying the magnetic field at higher frequency, the magnetic nanoparticles are heated. This heat dissipation can be used for thermal therapy for cancer (hyperthermia).

The purpose of this project is to elucidate the magnetization response (dynamics) of magnetic nanoparticles and to develop these diagnostic and therapeutic methods.

【Research Methods】

Two types of responses of magnetic nanoparticles are shown in Fig. 2. They have different characteristics especially their frequency dependence. We will observe these two responses accurately by using the measurement system developed in this project. As for the measurement samples, we use magnetically fractionated particles with less size distribution, and particles of oriented

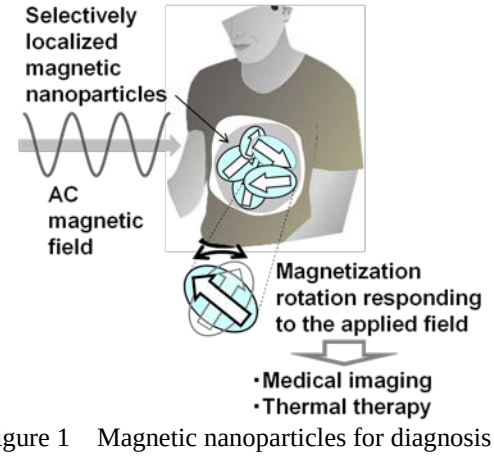

Figure 1 Magnetic nanoparticles for diagnosis and therapy

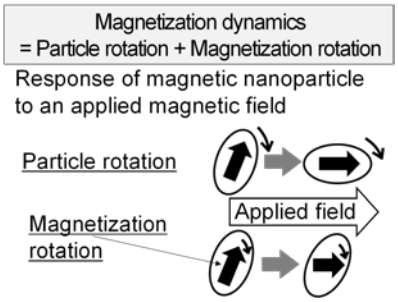

Figure 2 Magnetization dynamics of magnetic nanoparticle

magnetization easy axis. By elucidating the magnetization dynamics, we will optimize the field condition to maximize the intensity of detected signal for medical imaging, and heat generation for thermal therapy.

【Expected Research Achievements and Scientific Significance】

This project is expected to improve the detection sensitivity of magnetic nanoparticles in diagnostic imaging and the amount of heat generated for hyperthermia. The spatial resolution of 1 mm required for practical use of magnetic particle imaging can be achieved. As for hyperthermia, the magnetic field intensity and frequency can be reduced as to be capable in use of a body-sized coil.

【Publications Relevant to the Project】

・Satoshi Ota, Yasushi Takemura, "Characterization of Neel and Brownian relaxations isolated from complex dynamics influenced by dipole interactions in magnetic nanoparticles", The Journal of Physical Chemistry C, Vol. 123, No. 47, pp. 28859-28866, 2019.
・Suko Bagus Trisnanto, Yasushi Takemura, "Modulating relaxation responses of magnetic nanotracers for submillimeter imaging", Applied Physics Letters, Volume 115, Issue 12, 123101, 2019.

【Term of Project】 FY2020-2024

【Budget Allocation】 151,200 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.takemura.ynu.ac.jp/