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ABSTRACTS BOOK

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BS-12. Mössbauer and magnetic induction heating studies of Mg-doped maghemite (γ-Fe_2O_3) nanoparticles with plasma treatment.

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INTRODUCTION Magnetic iron oxide nanoparticles are increasingly used due to their wide range of potential applications [1]. Among these applications, iron oxide nanoparticles, which exhibits a high heating efficiency, have drawn a great deal of interest for magnetic hyperthermia [2]. Maghemite (γ-Fe_2O_3) has spinel crystal structure unlike magnetite (Fe_3O_4), all the iron cations are in Fe^{3+}, and the charge neutrality of the cell is guaranteed by the presence of vacancy in the cations. In this study, we successfully prepared Mg-doped maghemite nanoparticles by modified thermal decomposition method. The structure, magnetic and thermal properties of the samples were characterized as a function of the Mg content (5, 10, 15, and 20 %). Furthermore, our results show that the magnetic properties and the heating efficiency of nanoparticles are simultaneously improved by treating with plasma. EXPERIMENT PROCEDURES Mg-doped maghemite (γ-Fe_2O_3) nanoparticles were synthesized by modified high temperature thermal decomposition method under Ar/O_2 gas conditions [3]. The samples were synthesized using Fe(III) acetylacetonate, magnesium acetate tetrahydrate as precursors, mixing them in benzyl ether and oleic acid in the required molar proportion. The solution as heated at 200°C for 1 h in Ar/O_2 atmosphere. Then it was reheated at 298°C for 1 h and let to cool down to room temperature. The resulting nanoparticles were obtained after centrifugation and finally dried at 60°C in a vacuum oven. The synthesized nanoparticles were plasma-treated in Ar for 30 min at atmospheric pressure. The samples were subjected to X-ray diffraction (XRD) on an Ultima IV diffractometer using Cu-*K*α radiation (λ = 1.5406 Å). Magnetic hysteresis curve at room temperature was done by using a vibrating sample Magnetometer (VSM) under an applied magnetic field of 15 kOe. Mössbauer spectra were obtained at various temperature, in transmission geometry with a source of ^{57}Co in Rh matrix. Mössbauer parameters were calculated using the least squares method. The capacity of heat generation was measured using a nanoTherics heater (magneTherm model), with alternating magnetic field (250 Oe), which are generated with a frequency of 112 kHz. RESULTS AND DISCUSSION The crystal structure of Mg-doped maghemite nanoparticles was determined to be spinel structure. However, the XRD peak positions of maghemite and magnetite are very close to each other and they have the same spinel structure. The magnetic hysteresis curves of the prepared Mg-doped maghemite were measured by using a VSM. By increasing Mg(x) contents, the saturation magnetization (M_s) of the samples is found to be 26.9, 29.9, 35.3, and 30.3 emu/g (x = 5, 10, 15, and 20 %), respectively. The M_s value of 15 % Mg-doped maghemite was highest than the other samples. As a result of treating plasma for 30 min with 15 % Mg-doped maghemite having the highest saturation magnetization value, it was confirmed that the M_s value increased to 38.2 emu/g. Figure 1 represents the temperature variation obtained from magnetic hyperthermia experiment as a function of time and Mg-doped maghemite nanoparticles. The initial temperature of all the samples was 23°C. The heating temperature of 5 % Mg-doped maghemite raised to about 50.9°C in 5 min whereas 15 % Mg-doped maghemite caused a temperature increase of about 86.6°C at the same time. Likewise, 15 % Mg-doped maghemite, which have the highest heating temperature was treated the plasma for 30 min. It confirmed that heating temperature rose to 92.4°C after 5 min. The Mössbauer spectra of all the samples at room temperature were analyzed two six-line hyperfine patterns, are each for the tetrahedral site (A-site) and the octahedral site (B-site). The magnetic hyperfine field value of A-site for all the samples was analyzed to be smaller that of B-site. Also, the Mössbauer spectra were measured at various temperatures before and after plasma treatment of the 15 % Mg-doped maghemite having the highest heating temperature and saturation magnetization value. At 295 K, the magnetic hyperfine field value of 15 % Mg-doped maghemite after plasma treatment increased than before plasma treatment, as shown in Fig. 2. Therefore, we investigated the magnetic and thermal properties of maghemite according to Mg contents and conducted the Mössbauer studies to clearly investigate the improved thermal properties by plasma treatment of 0.15% Mg-doped maghemite having excellent heating efficiency.

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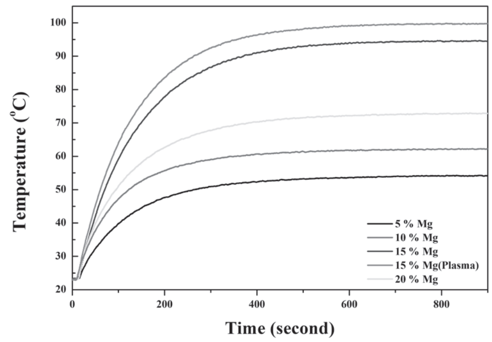

Fig. 1. Heating temperature of Mg-doped maghemite and plasma treated maghemite (15 % Mg).

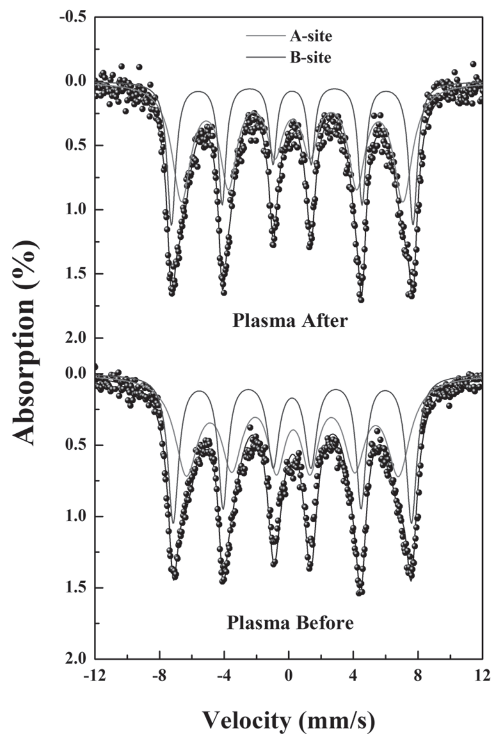

Fig. 2. Mössbauer spectra of Mg-doped maghemite before and after plasma treatment (15 % Mg).