

Simple Synthesis and Characterization of Superparamagnetic Magnesium Ferrite Nanoparticles Coated with Silica Shell

Harinarayan Das^{1, 2}, Takashi Arai¹, Naonori Sakamoto³, Kazuo Shinozaki⁴, Hisao Suzuki^{1, 3}, Naoki Wakiya^{1, 3}

¹Graduate School of Science and Technology, Shizuoka University, Japan

²Materials Science Division, Atomic Energy Centre, Dhaka-1000, Bangladesh

³Research Institute of Electronics, Shizuoka University, Japan

⁴Department of Metallurgy and Ceramics Science, Tokyo Institute of Technology, Japan

Magnesium ferrite (MgFe_2O_4) is one of the important magnetic materials for technological applications. Recently it is more applicable in achieving local hyperthermia when compared with other ferrites ⁽¹⁾. However, it is necessary to coat the particles with another materials in order to make them biocompatible and suitable for specific applications. In recent years, silica has been widely used as a coating material, because it is nontoxic, biocompatible, optically transparent, chemically inert, and has a well-known surface chemistry ⁽²⁾. In the present study, we report large scale synthesis of monodispersed silica coated magnetic nanoparticles generated by facile chemical method. MgFe_2O_4 nanoparticles were prepared using the single step ultrasonic spray pyrolysis process. The particles were synthesized at 700 °C from nitrate precursor aqueous solutions. Then these nanoparticles coated with silica layer were prepared by hydrolysis and the condensation of tetraethyl orthosilicate (TEOS) using HCl as a catalyst, with the nucleation of the formed silica on the surfaces of the MgFe_2O_4 nanoparticles that were characterized sing XRD, FE-SEM, TEM and VSM etc.

It can be seen in XRD patterns (Fig. 1) that MgFe_2O_4 was successfully coated with silica while the crystal structure was remained unchanged. The coated pattern also exhibited a hump near angles 2θ between 20 °C and 25° which indicating the presence of silica in the surface of nanoparticles. It can be clearly revealed from TEM images (Fig. 2) that all the particles are highly spherical in shape. A layer of silica was coated onto the dispersed nanoparticles using hydrolysis and the poly-condensation of TEOS in the presence of an acidic catalyst. The coating process resulted in a relatively homogeneous amorphous layer, clearly visible on the surface of the crystalline nanoparticles. Occasionally, some individual silica gel were also present. Relatively better coverage of silica on big size nanoparticles than small particles; however, the coating looks rougher compared to uncoated surface. The saturated magnetization value (M_s) for silica coated sample was 11 emu/g which was lower compared to the uncoated sample (16.8 emu/g). This large margin of saturation magnetization decreased due to the effect of amorphous silica layer coated on the MgFe_2O_4 nanoparticles when the introduction of a non-magnetic material shell (i.e. silica) has led to a dilution of the MgFe_2O_4 nanoparticles magnetic behavior due to the additional mass of the silica shell.

Reference:

- [1] Franco *et al.*, J. Appl. Phys. 109 (2011) 07B505.
- [2] Bojana *et al.*, Ceramics International 38 (2012) 6636-6641.

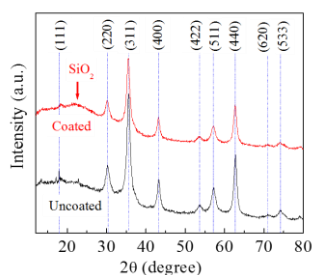


Fig. 1 XRD patterns of uncoated and silica coated MgFe_2O_4 nanoparticles.

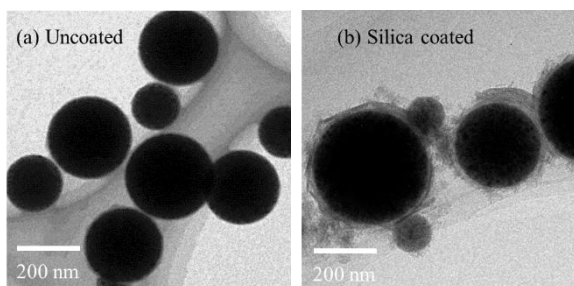


Fig. 2 TEM images of (a) uncoated and (b) silica coated MgFe_2O_4 nanoparticles.