Fabrication of Hard/Soft Magnetic Nanoparticle Nanocomposite Magnet

Young Soo Kang*
Department of Chemistry, Sogang University, Seoul 121-742, Korea

Soft and hard magnetic nanoparticles were prepared by hydrothermal methods. Soft phase magnetic nanoparticles such as α-Fe, Fe_3O_4, FeCo and Co were synthesized and characterized on the structure and magnetic property with XRD, TEM and VSM. The homogeneous dispersion of them in the solution could be accomplished by coating dispersing surfactant on their surface and sonication with ultra-sonicator. On the other hand, hard phase magnetic nanoparticles such as $Nd_2Fe_{14}B$, $SmCo_5$ and $Sm_2Fe_{17}N_3$ nanoparticles were synthesized by hydrothermal method and annealing and reduction process. The size, morphology, structure and magnetic property were characterized with SEM, TEM, XRD and VSM. The dispersing ability in the solution was characterized by checking SEM and TEM images after coating dispersing surfactants on their surface. The soft phase magnetic nanoparticles were coated with cationic surfactant and hard phase magnetic nanoparticles were coated with anionic surfactant and mixed in the organic solvent to get neutral charge by the equi-molar ratio between soft and hard phase magnetic nanoparticles. The mixed solution of hard and soft phase magnetic nanoparticles was sonicated for 30 min at room temperature under the argon gas to suppress the oxidation of magnetic nanoparticles. A 30 min sonication resulted in the neutrally charged particle solution by the electrostatic interaction and neutralization of the surface charges of hard and soft phase magnetic nanoparticles. Then, the solvent was evaporated in a short period under the reduced pressure to suppress oxidation of the magnetic particles. The solid mixture of the magnetic particles was transferred into the glove box of nitrogen gas and pressed as a pellet. A mixture pellet of magnetic particles was reduced at 600 – 900 ^oC with Ar/H_2 (v/v%, 95/5) gas flowing for 5 hrs. The prepared hard/soft nanocomposite magnetic material was characterized with VSM on the magnetic property. $Nd_2Fe_{14}B$ alloy has been successfully synthesized by the nitrate-citrate auto-combustion followed by reduction and diffusion process with low energy consumption. H_3BO_3, $Fe(NO_3)_3 \cdot 9H_2O$, $Nd(NO_3)_3 \cdot 6H_2O$ were used as precursors and citric acid is used as chelating ligands of metal ions. The ammonia water was used to adjust pH to 7. CaH_2 is used as reducing agent for reduction and diffusion process. $NdFeO_3$ and Fe_2O_3 were produced during auto-combustion of gels. The combustion process of gel has been investigated by TGA/DTA curve measurements. The phase compositions are studied by XRD measurement. The difference of overall morphology and magnetic property are measured by SEM, TEM and room temperature (300 K) vibrating sample magnetometer (VSM). The comparison on the magnetic property of the reduced samples between pellet type and random powder type has been studied with VSM and showed the better magnetic property of pellet type $Nd_2Fe_{14}B$. Making a compact pellet type sample for reduction is more efficient for solid reduction and phase transition for the higher coercivity.

References

[1] Hao Xuan and Young Soo Kang, Preparation of $Nd_2Fe_{14}B$ by Nitrate-citrate Auto-combustion Followed by Reduction-diffusion Process, *Nanoscale* **2015**, *7*, 8016.

[2] Chang Woo Kim, Young Hwan Kim and Young Soo Kang, Facile Synthesis and Magnetic Phase Transformation of Ln-TM-B Nanoclusters by Oxygen Bridging *J. Material Chemistry C* **2013**, *1*, 275