Characterization of Carbon-coated Iron and Cobalt Nanocapsules Synthesized by Chemical Vapor Condensation Process

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Introduction

Nanoparticles have been intensively investigated because of their potential applications [1]. In the nanoparticles, nanocapsules are of interest for their unique core-shell structure and properties. Graphite or boron coated metal or compound nanocapsules are fabricated by various method such as arc discharge[2], pulsed laser deposition and chemical vapor condensation (CVC). As compared with other methods, CVC process can prepare almost all kinds of materials because a wide range of precursors are available, and the CVC can produce a large amount of nanocapsules[3]. In the present work, we synthesized carbon-coated iron and cobalt nanocapsules were prepared by CVC process using metalorganic precursors. The microstructural and magnetic characterizations of carbon coated Fe and Co nanocapsules were systematically investigated.

Experimental

To produce iron and cobalt nanocapsules, various carrier gases such as Ar, CO, H_2 and CH_4 are fed through a heated bubbling units containing the iron pentacarbonyl ($Fe(CO)_5$) and cobalt octabarbonyl ($Co_2(CO)_8$) precursors. Experiments were conducted with a tubular furnace between 400 and 1100^{o}C. The evaporated precursors were condensed into the nanocapsules in the collector. The morphology, size and lattice images of particles were determined with HRTEM. Identification of the phases in the samples was carried out in X-ray diffractometer. Magnetization was measured by a vibrating sample magnetometer (VSM) at room temperature.

Results and discussions

The carbon coated Fe (Fe(C)) nanoparticle shape produced CVC is nearly spherical and it consists of dark core and light shell. The size of Fe(C) nanoparticles checked by

TEM images varies from 20nm to 100nm. As shown in Fig. 1., the shell thickness of the Fe(C) nanocapsule was about 5-6nm. The images of TEM show that the nanoparticles are composed of a core and an amorphous or crystalline graphite shell. The core phase of the Fe(C) is different with CVC reaction temperature and carrier gases. At low temperature below 700°C, the core is b.c.c. Fe, but at high temperature above 700°C, the core phase is Fe_3C. The particles sizes of Co(C) nanocapsules ranges from 20 nm to 60 nm. All shells are amorphous with a thickness of 6nm. The core of the Co(C) nanocapsules had f.c.c. and h.c.p. cobalt phase and Co_2C and Co_3C carbide with different decomposition temperature.

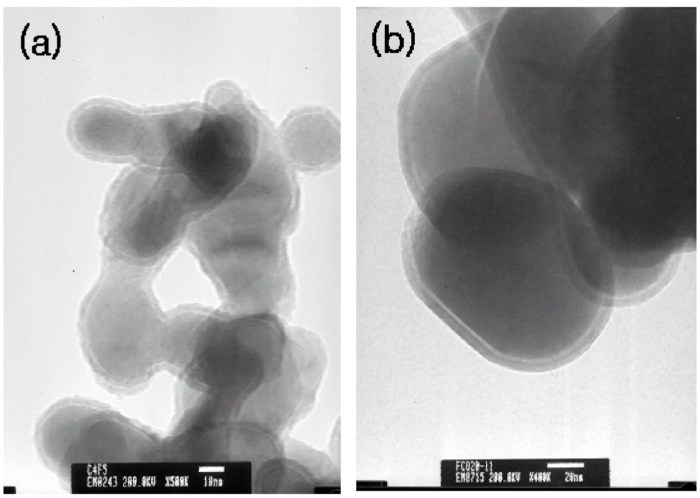

Fig.1. TEM images of Fe(C) nanocapsules with core-shell structure at different reaction temperatures; (a) 500°C, (b) 1100°C

The saturation magnetization and coercivity of the Fe(C) decreased with the increasing the reaction temperature because the existence of Fe_3C lead to a decreased in the saturation magnetization of the Fe(C) nanocapsules. With increasing the flow rate of CO carrier gas the saturation magnetization was increased. However, the saturating magnetization the Co(C) nanocapsules increased with increasing decomposition temperature, because of increasing the particle size.

Conclusion

The carbon coated Fe and Co nanocapsules successfully produced by CVC under different conditions. The carbon coated Fe and Co nanoparticles showed nearly spherical shape and it consisted of dark core and light shell. The Fe and Co cores had different phase and crystalline structure with reaction temperatures. The saturating magnetization the Fe(C) and Co(C) nanocapsules varied with increasing the decomposition temperature and the changes of the particle size.

References

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