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Synthesis of Fe_3O_4 Nanoparticles Prepared by Various Surfactants and Studying their Characterizations

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Abstract. Magnetite (Fe_3O_4) nanoparticles were prepared simply by the reverse co-precipitation method from the solution of ferrous/ferric mixed salt in the presence of cationic surfactant (cetyl trimethyl ammonium bromide, CTAB) and nonionic surfactant (Polyethylene glycol, PEG) in two concentrations. Meanwhile, Fe_3O_4 nanoparticles without surfactant are also synthesized under the same condition for comparison. In addition via the reverse co-precipitation method, the pH which is an important factor in synthesis of magnetite was controlled at high values easily. The experimental results reveal that addition of surfactants affected on the size and morphology of the nanoparticles based on the X-ray diffraction (XRD) and scanning electron microscope (SEM) characterizations.

Introduction

In recent years, various nanomaterials have been extensively pursued for their catalytic, optical, electrical, mechanical, and magnetic properties, which are quite different from those of their bulk counterparts [1]. Metal oxides have important applications, such as magnetic storage media, solar energy transformation, electronics, catalysis and biological applications such as imaging, and delivery [2]. Especially, iron oxides are used in more aspects due to the development of preparation technology of nanometer powders.

Magnetite (Fe_3O_4) is one of the iron oxides with a non-normal spinel structure which can offer a great potential applications in different fields such as recording materials [3], photocatalysis [4], ferrofluid technology, magnetocaloric refrigeration [5], magnetic resonance imaging (MRI), drug delivery [6], and pigment [7], etc.

Various methods have been reported for the synthesis of Fe_3O_4 nanoparticles, such as sol-gel technique[8], reduction of hematite by CO/CO_2 [9] or H_2 [10], co-precipitation from the solution of ferrous/ferric mixed salt [11], microwave hydrothermal synthesis [12], γ-ray radiation [13], microemulsion methods [14], hydrothermal technique [15], thermal decomposition of organic metals [16], microwave plasma synthesis [17], etc.

In spite of the method of synthesis, the preparation conditions (e.g., surfactants, concentrations, PH, reaction temperature, stirring rate, etc.) strongly influence the chemical composition, particle size, size distribution, particle morphology, crystal structure and consequently the properties and applications of the products [18,19].

Co-precipitation from the solution of ferrous/ferric mixed salt is one of the simple and fast techniques. There are two methods of adding precursors to synthesis magnetite in this technique: 1) Normal co- precipitation method. 2) Reverse co- precipitation method. In the first case, the pH value gradually increases, because an alkali solution is dropped into the mixed metal solution. In the second case, the mixed metal solution was directly dropped into an alkaline solution; consequently, the pH which is a critical factor in synthesis of magnetite could be controlled at high values easily.

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