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Research Article

SYNTHESIS OF IRON OXIDE NANOPARTICLES

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ABSTRACT
Surface functionalized magnetic iron oxide nanoparticles (NPs) are a kind of novel functional materials, which have been widely used in the biotechnology and catalysis. This review focuses on the recent development, structure of functionalized iron oxide NPs and their corresponding application briefly. In order to implement the practical application, the particles must have combined properties of high biocompatibility. Moreover, the surface of iron oxide NPs could be modified by organic materials or inorganic materials, such as polymers, biomolecules, silica, metals, etc. The problems and major challenges, along with the directions for the synthesis and surface functionalization of iron oxide NPs, are considered.

Keywords: *NPs, Surface Functionalization, Iron Oxide, X-Ray Diffraction, Scanning Electron Microscope*

INTRODUCTION
Nanoparticle are submicron moieties (diameters ranging from 1 to 100 nm according to the used term, although there are examples of NPs several hundreds of nanometers in size) made of inorganic or organic materials, which have many novel properties compared with the bulk materials (Cha *et al.*, 2008). On this basis, magnetic NPs have many unique magnetic properties such as superparamagnetic, high coercivity, low Curie temperature, high magnetic susceptibility, etc (Patel *et al.*, 2008). Magnetic NPs are of great interest for researchers from a broad range of disciplines, including magnetic fluids, data storage, catalysis, and bioapplications (Magnetic nanoparticles for biomedical NMR-based diagnostics (Zhao *et al.*, 2003). Especially, magnetic ferrofluids and data storage are the applied researches that have led to the intergration of magnetic NPs in a myriad of commercial applications. Currently, magnetic NPs are also used in important bioapplications, including magnetic bioseparation and detection of biological entities (cell, protein, nucleic acids, enzyme, bacterials, virus, etc.), clinic diagnosis and therapy (such as MRI (magnetic resonance image) and MFH (magnetic fluid hyperthermia)), targeted drug delivery and biological labels. However, it is crucial to choose the materials for the construction of nanostructure materials and devises with adjustable physical and chemical properties (Mornet *et al.,* Prog., 2010). To this end, magnetic iron oxide NPs became the strong candidates, and the application of small iron oxide NPs in in vitro diagnostics has been practiced for nearly half a century (Stevens *et al.*, 2008). In the last decade, increased investigations with several types of iron oxides have been carried out in the field of magnetic NPs (mostly includes the iron oxide magnetite, ferrimagnetic, superparamagnetic when the size is less than 15 nm) (Jun *et al.*, 2007), among which magnetite and maghemite is the very promising and popular candidates since its biocompatibility have already proven (Gupta and Gupta, 2008). However, it is a technological challenge to control size, shape, stability, and dispersibility of NPs in desired solvents (Cornell and Schwertmann, 2009).

Magnetic iron oxide NPs have a large surface-to volume ratio and therefore possess high surface energies. Consequently, they tend to aggregate so as to minimize the surface energies (Cabrera *et al.,* 2008). Moreover, the naked iron oxide NPs have high chemical activity, and are easily oxidized in air (especially magnetite), generally resulting in loss of magnetism and dispersibility (Pascal *et al.,* 1999). Therefore, providing proper surface coating and developing some effective protection strategies to keep the stability of magnetic iron oxide NPs is very important (Bomatı´-Miguel *et al.,* 2008). These strategies comprise grafting of or coating with organic molecules, including small organic molecules or surfactants, polymers, and biomolecules, or coating with an inorganic layer, such as silica, metal or nonmetal elementary substance, metal oxide or metal sulfide. Practically, it is worthy that in many cases the protecting shells not only stabilize the magnetic iron oxide NPs, but can also be used for further functionalization (Bharde *et al.*, 2008). In the following, we focus mainly on recent development and various strategies in the preparation, structure and magnetic properties of various surface functionalized strategies of magnetic iron oxide NPs and their corresponding applications, as well as the research advances on functionalizations of magnetic iron oxide NPs worldwide. Further the problems and major challenges still should be solved are pointed out, and the directions in these researches are also discussed (Roh *et al.*, 2009).

RESULTS AND DISCUSSION

The morphology of iron oxide samples are shown in figures 1and 2 as obtained from SEM and TEM.

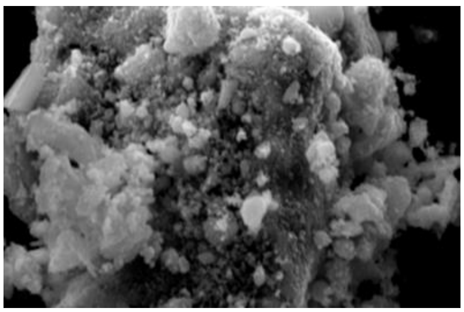

Figure 1: SEM micrograp of iron oxide

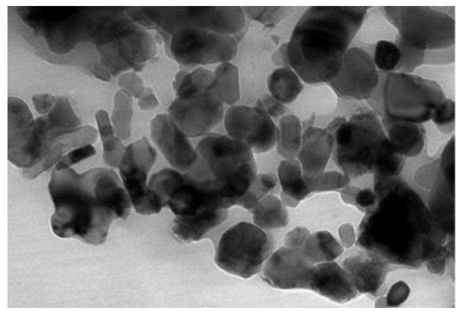

Figure 2: TEM image of iron oxide

Increasing calcination temperature resulted in particles becoming more fine and uniform as observed from figure 1. Figure 2 shows the TEM micrographs, respectively for iron oxide. The particles are well dispersed, very fine a with particle size of ~7-14 nm.

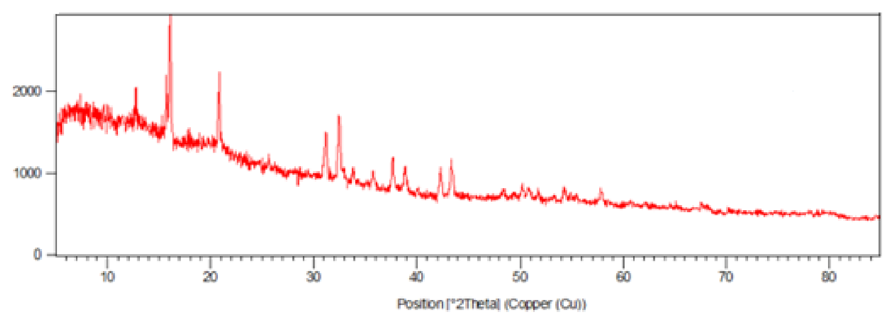

Figure 3: XRD pattern of iron oxide

XRD spectra of the iron oxide are presented in Figure 3. The peaks observed at d values of 2.95, 2.51, 2.08, 1.60, 1.47 Ǻ in iron oxide correspond to cubic phase.

Conclusion

Although in this review there is a strategy for obtaining the iron oxide NPs, the results have shown that three major effectivenesses as follows: (a) Improves the biocompatibility and water solubility; (b) Endows the iron oxide new physico-chemical properties, such as magnetic properties (c) Provides the iron oxide new functional end groups for the subsequent functionalized procedures or the subsequent applications, such as conjugation with the DNA, antibody, protein, etc. Therefore, how to improve the stability and availability of functionalized iron oxide NPs in extreme environmental conditions, how to develop an efficient and orderly magnetic micro- or nano-assembly structures, and how to realize large-scale or industrial synthesis, these problems are urgent to be solved for obtaining a ideal functionalized iron oxide materials. For all that, we still believe the surface functionalization and modification of magnetic iron oxide NPs to introduce additional functionality will attract more and more attention.

Furthermore, multifunctional magnetic iron oxide composite nanoparticle systems with designed active sites will promise for a various applications, such as catalysts, magnetic recording, bioseparation, biodetection, etc. The future work in this area must be focused on the research of the toxicity and degradability of naked or surface functionalized iron oxide NPs, and preparing it via green chemistry for reducing the environmental pollution as much as possible. Successful development in this area will aid the growth of the various scientific researches or industrial applications as well as improving the quality of life in the population.

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