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Preparation of water-soluble magnetic nanoparticles with controllable silica coating

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Abstract: This work provides a general method for preparing monodisperse, water-soluble and paramagnetic magnetic nanoparticles which are easy to be modified. Firstly, magnetic silica with core-shell structure was prepared according to a previous work. Then, the magnetic silica was treated with alkali solution to afford magnetic nanoparticles. With the increase of calcination temperature for the preparation of magnetic silica, the crystallinity and the magnetic responsibility of magnetic silica strengthened, meanwhile, the corresponding magnetic nanoparticles kept monodisperse without any aggregation. The magnetic nanoparticles are comprised of cobalt ferrite and a silica coating. The silica coating on the cobalt ferrite facilitates the magnetic nanoparticles well dissolved and monodisperse in water, and easy modification.

Key words: magnetic nanoparticles; monodispersity; water-solubility; surface structure

1. Introduction

Magnetic nanoparticles have attracted a great attention in various fields due to magnetic responsibility [1,2]. For the application of magnetic nanoparticles in biomedical field or other hydrophilic system, such as forward osmosis system and food inspection, good dispersibility in water is essential [3-6]. High performance of magnetite nanoparticles is also required, including surface chemistry suitable for further functionalization, suitable size with uniform dispersion and high magnetization.

Many strategies have been explored to synthesize highly water-dispersible superparamagnetic magnetite nanoparticles. Co-precipitation is a common and simple route for synthesis of nanoparticles [7-9]. Mauricio et al [10] prepared highly hydrophilic magnetic nanoparticles of Fe_3O_4 using a co-precipitation approach of Fe^{2+} and Fe^{3+} ions in a basified aqueous solution. However, serious agglomeration of pristine nanoparticles was found. Thermal-decomposition method has been widely researched for synthesis of monodisperse magnetic nanoparticles. But harsh conditions and expensive chemicals hinder the extensive application of the method [11,12].

Sol-gel method [13,14], microemulsion with oil in water micelles [15,16] or reverse micelles [17] and hydro/solvent-thermal process [18] have been used to prepare magnetic nanoparticles. The sol-gel method enables to control the reaction rate and provides a way to control the size and