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Green Synthesis of Magnetite Nanoparticles (via Thermal Decomposition Method) with Controllable Size and Shape

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Abstract
Magnetite (Fe_3O_4) nanoparticles with controllable size and shape were synthesized by the thermal decomposition method. In contrast to previously reported thermal decomposition methods, our synthesis method had utilized a much cheaper and less toxic iron precursor, iron acetylacetonate ($Fe(acac)_3$), and environmentally benign and non-toxic polyethylene oxide (PEO) was being used as the solvent and surfactant simultaneously. Fe_3O_4 nanoparticles of controllable size and shape were prepared by manipulating the synthesis parameters such as precursor concentrations, reaction durations and surfactants.

Keywords: magnetic nanoparticles, magnetite, thermal decomposition, green synthesis

1. Introduction

Iron-based magnetic nanoparticles such as magnetite (Fe_3O_4) have received numerous attentions due to their unique properties and potential applications in biomedical applications[1-4]. Fe_3O_4 nanoparticles can potentially be used as magnetic targeted drug delivery carriers and magnetic resonance imaging (MRI) contrast agents due to their high saturation magneitzation, low toxicity, and biocompatibility. Magnetic properties of magnetic nanoparticles can be tailored by their particle sizes and size distributions. The particle sizes and size distributions of magnetic nanoparticles are in turn, affected by the synthesis route. For these reasons, various synthesis approaches have been developed to produce Fe_3O_4 nanoparticles in order to obtain desired properties.

Synthesis methods of Fe_3O_4 nanoparticles that have been developed include co-precipitation [5-7] thermal decomposition [8,9] microemulsion route [10] hydrothermal synthesis [11] and continuous flow technique [12]. However, success in precise particles size control of Fe_3O_4 nanoparticle has only been achieved through thermal decomposition using large quantities of toxic and expensive precursors and surfactants in organic solvent. Laborious purification steps are required before the end product can be used in biomedical applications. Thermal decomposition of iron pentacarbonyl [$Fe(CO)_5$] has been used for the preparation of monodisperse γ-Fe_2O_3 nanoparticles with average diameters from 4 to 16 nm by careful control of the molar ratio of metal precursor to surfactant, [$Fe(CO)_5$] and oleic acid respectively[13]. Since $Fe(CO)_5$ is very expensive and toxic, some attempts have been made to replace $Fe(CO)_5$ with iron acetylacetonate [$Fe(acac)_3$]. Fe_3O_4 nanoparticles of narrow size distribution have been synthesized by thermal decomposition of $Fe(acac)_3$ in phenyl ether in the presence of stearyl alcohol, oleic acid and oleylamine [14].

In this study, we have attempted to synthesize Fe_3O_4 nanoparticles by the thermal decomposition method without using toxic organic