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BIOMATERIALS SYNTHESIS AND CHARACTERIZATION

Superparamagnetic MFe O (M = Ni, Co, Zn, Mn) nanoparticles: synthesis, characterization, induction heating and cell viability studies for cancer hyperthermia applications

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Abstract Superparamagnetic nanoferrites are prepared by simple and one step refluxing in polyol synthesis. The ferrite nanoparticles prepared by this method exhibit particle sizes below 10 nm and high degree of crystallinity. These ferrite nanoparticles are compared by means of their magnetic properties, induction heating and cell viability studies for its application in magnetic fluid hyperthermia. Out of all studied nanoparticles in present work, only $ZnFe_2O_4$ and $CoFe_2O_4$ MNPs are able to produce threshold hyperthermia temperature. This rise in temperature is discussed in detail in view of their magneto-structural properties. Therefore $ZnFe_2O_4$ and $CoFe_2O_4$ MNPs with improved stability, magnetic induction heating and cell viability are suitable candidates for magnetic hyperthermia.

1 Introduction

After decades of intense study, the superparamagnetic nanoparticles have been explored for various biomedical applications, including magnetic resonance imaging [1, 2], drug targeting [3] magnetic separation [4–6] and hyperthermia [7–9]. In hyperthermia, an AC magnetic field is used to induce a temperature increase. This magnetic heating of superparamagnetic nanoparticles originates from two relaxation processes, namely Néel and Brownian relaxations [6, 7, 10]. Néel relaxations is the reorientation of the magnetic moment within the particles in which an anisotropy barrier is crossed, thereby causing increase in temperature. Brownian relaxation is the reorientation of the magnetic particle itself in a fluid, resulting in friction between the particle and the fluid. In spite of extensive research is carried out in synthesis and large scale production of superparamagnetic nanoparticles for application in magnetic particle hyperthermia; only limited number of magnetic nanoparticles are commercially available [11, 12]. Magnetic iron oxide (magnetite) nanoparticles such as Fe_3O_4 due to their proven biocompatibility as well as high saturation magnetization have been explored extensively for various biomedical applications [13, 14]. Indeed, they are stable in water and are able to form aqueous colloids. They are also assumed to be biocompatible within certain threshold limits. Their magnetic properties can be tuned through their chemical composition by doping M^{2+} ion like Zn^{2+}, Co^{2+}, Ni^{2+}, Mn^{2+}, Mg^{2+} etc. and cation distribution. The substitution of a large part of Fe^{2+} cations by nonmagnetic M^{2+} in A sites (general chemical formula of ferrite is written as AB_2O_4) greatly reduces the resultant magnetization according to the canted ferrimagnetic Yafet–Kittel-like model [15]. However, if M^{2+} ions are simultaneously located in A and B sites, the cation is weakened and the magnetization reduction is limited, still leading to suitable saturation magnetization values as well as biocompatibility [16, 17]. Hence M^{2+} ion substituted ferrite synthesis and studies on its properties are planned in this work.

In recent years, synthesis of MFe_2O_4 (M = Zn, Ni, Mn and Co) nanoparticles of desired size and magnetic

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Studies on catalytic activity of $MnFe_2O_4$ and $CoFe_2O_4$MNPsas mediators in hemoglobin based biosensor

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Abstract

$MnFe_2O_4$ and $CoFe_2O_4$ magnetic nanoparticles (MNPs) were synthesized using simple polyol method by refluxing in diethylene glycol. The size of obtained $CoFe_2O_4$ MNPs was found to be 4.0 nm and $MnFe_2O_4$ MNPs was found to be 7.0 nm with surface area 291.04 M^2/g and 165.39 M^2/g respectively. These MNPs due to its high surface area and nanosize were used in the hemoglobin based biosensor for the detection of H_2O_2 as a mediator. The EIS measurements show that the $CoFe_2O_4$ MNPs are more conducting than the $MnFe_2O_4$ MNPs. The surface area of $CoFe_2O_4$ MNPs was found to be higher than the $MnFe_2O_4$ MNPs. The GCE/CS/$CoFe_2O_4$/Hb modified biosensor shows wider linearity range (1×10^{-7} to 8×10^{-4} M) than the GCE/CS/$MnFe_2O_4$/Hb modified biosensor (1×10^{-6} to 4×10^{-4} M) because of higher conductivity and greater surface area of $CoFe_2O_4$ which increases the catalytic activity.

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***Keywords*:**$CoFe_2O_4$; $MnFe_2O_4$; H_2O_2, Hemoglobin; Biosensor

1. Introduction

Nowadays, there has been considerable interest among the chemists and biochemists in the detection of H_2O_2 as it is a byproduct of enzymatic reactions in the field of biosensing [1]. Various methods have been employed for the analysis of H_2O_2 such as volumetry, spectrophotometry, chemiluminescence, chromatography and electrochemistry. The electrochemical methods are more preferable due to its low cost, simplicity, efficiency and high sensitivity. The redox enzyme (Horse radish peroxidase, cytochrome and hemoglobin) based biosensors are extensively employed for the detection of H_2O_2 due to their high selectivity and specificity [2-3]. The known

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