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Ferrite Nanoparticles for the treatment of cancer using hyperthermia

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ABSTRACT

Hyperthermia – a therapy used for the treatment of malignant cancer. In this technique, the temperature of the affected part of the body has been raised to 41 - 45°C by using superparamagnetic nanoparticles of ferrite materials. The killing of the cancer cells is done by heating the affected area by infusing the magnetic nanofluid prepared using magnetic nanoparticles and then applying an alternating current (AC) induction field. This heat kills cancer cells by damaging proteins and structures within the cells. The temperature of the heat used in hyperthermia treatment is carefully controlled to limit damage to normal cells and tissues. There are different ways of supplying heat to cancer cells. The most common way for the killing of cancer cells is use of magnetic nanoparticles.

1. INTRODUCTION

Cancer is a deadly disease. The removal of cancer cells from any part of body can be done by hyperthermia technique in which temperature gradient is produced with the help of superparamagnetic nanoparticles using external magnetic field [1]. Exposing cancer cell to an optimum temperature is effectively destroying cancer cells without harming the normal ones. The various techniques used for the treatment of cancer such as chemotherapy, radiotherapy also utilizing hyperthermia because of its effectiveness, and since it has least side effects than others. In the technique of hyperthermia the temperature of the effective tumor area is raised 42 - 48^{o}C, and heat so produced result in lysis of cancer cells, without making any harm to the normal tissues or surrounding cells [2]. It has been found that use of nanomaterials because of its high surface to volume ratio, and high porosity make enables these to absorb more efficiently drug [3].

The fundamental requirement for the nanoparticles to be used for hyperthermia is that it must be have large surface area, superparamagnetism, low toxicity, and high recoverability. Magnetic nanoparticles based on metal ferrites with a general chemical formula of $MFeO_3$/MFe_2O_4 (M=Co, Zn, Ni, Mn) exhibits above said characteristics and seems to be best fitted one [4]. Moreover the coating of organic molecules, inorganic molecules and polymers stabilize them, and stops its agglomeration. This happens due to presence of various functional groups such as hydroxyl, amino, and carboxylic acid groups. The chitosan, known as poly-(β-1/4)-2-amino-2-deoxy-D-glucopyranose is seems to be more biocompatible and already find applications in food, drugs, cosmetic and biomedical fields [5]. Magnetic nanoparticles coated with Chitosan are widely applied to biomedical applications.

2. RESULTS AND DISCUSSION

Ferrite nanoparticles have been synthesized by sol-gel method and subsequently co-precipitation process [6]. Figure 1 shows XRD pattern for bare and chitosan coated Fe_3O_4 nanoparticles. The XRD characteristic peaks of ferrite nanoparticles have been found to be similar to indices of inverse spinel structure (220), (311), (400), (422), (511) and (440) for bare and chitosan-coated ferrite nanoparticles.

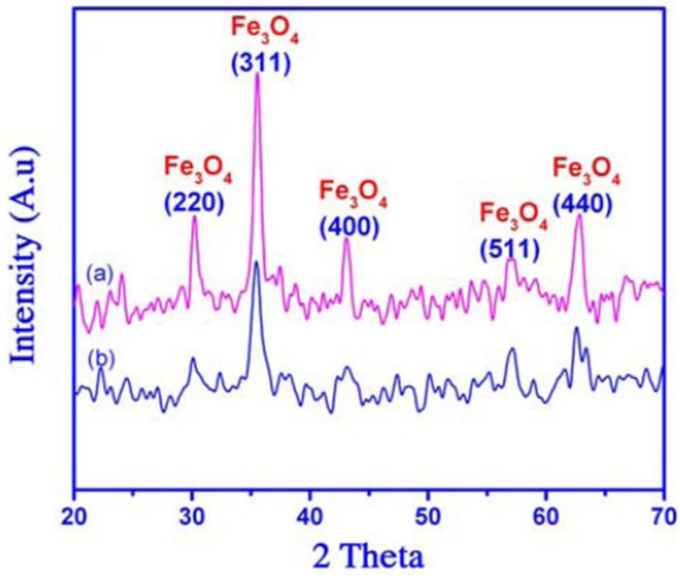

Figure 1 X-ray diffraction patterns for bare and chitosan coated ferrite nanoparticles (adopted with permission from ref. [6]).

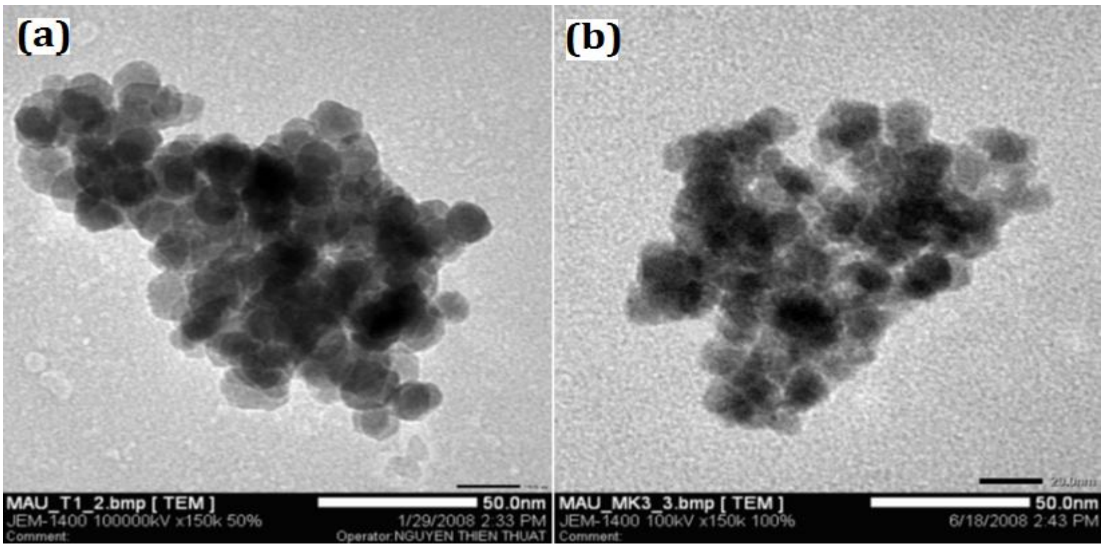

Figure 2: TEM images of (a) bare and (b) chitosan-coated ferrite nanoparticles (adopted with permission from ref. [6]).

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The morphology of bare and coated nanoparticles is shown in figure 2 (a) and (b) respectively. The size of has been found to be 15-17 nm and 23-25nm respectively for bare and Chitosan coated Fe_3O_4 nanoparticles. Figure 3 shows the magnetic MH loops of the synthesized nanoparticles. This confirms the superparamagnetic behavior of the synthesized nanoparticles with zero coercivity and remanence. It has been found that coating of the chistosan leads to reduction in the value of saturzation magnetization, but still the nanopartciels exhibits superparamagnetic character.

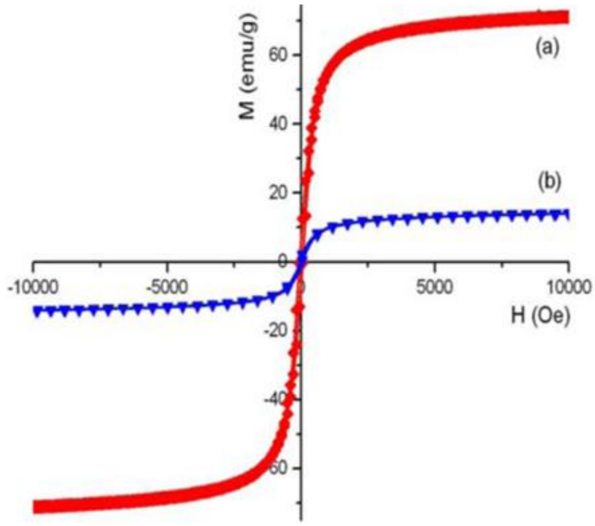

Figure 3 M-H loop of bare and chitosan coated ferrite nanoparticles at room temperature (adopted with permission from ref. [6]).

The value of the saturation magnetization for bare and chitosan-coated ferrite nanoparticles is found to be 70 emu/g and 15 emu/g respectively.

3. CONCLUSIONS

The bare and chitosan coated ferrite nanoparticles have been synthesized by sol-gel and co-precipitation method. The TEM confirmed the spherical morphology which is seems to be monodisperse having mean diameter of 15-17 nm and 23-25 nm respectively for bare and coated nanoparticls. XRD proved the inverse- spinel structure of the synthesized nanoparticles. Magnetic study confirms the formation of superparamagnetic nanoparticles and also revealed that chitosan coating lead to reduction in the value of saturation magnetization. The synthesized nanoparticles have a potential for use in drug delivery systems.

4. ACKNOWLEDGEMENT

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