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Study on Magnetic Behaviour of Iron Oxide Nanoparticle, A Nano Anticancer Drug Delivery Vehicle Synthesized by Modified Chemical Co-Precipitation.

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ABSTRACT

The development of Magnetic nanoparticles (MNPs) has been greatly accelerated in the past decade by advances in nanotechnology and molecular cell biology. MNPs of various formulations have been developed to diagnose and treat diseases for which conventional therapy has shown limited efficacy. In particular, the use of MNPs as drug carriers has drawn enormous attention, as it holds great potential of providing new opportunities for targeted therapies. This article focuses on the synthesis of iron oxide nanoparicles by modified chemical method and the investigation on its magnetic behavior using Superconducting Quantum Interference Device (SQUID) magnetometer. The so confirmed superparamagnetic behavior of the MNP system is important for its usage as drug targeting carrier in cancer therapy.

KEYWORDS : Superparamagnetic iron oxide nanoparticles (SPIONs), SQUID magnetometry, Superparamagnetism, saturation magnetization.

INTRODUCTION

Nanoscale science and engineering are providing us with unprecedented understanding and control of matter at its most fundamental level: the atomic and molecular scales. In particular, nanoscale particles have attracted much attention due to their unusual electronic (Poizot et al.,2000), optical (Tari et al.,1979) and magnetic (Mahmoudi et al.,2010) properties. Ideally, they must also have a high magnetization so that their movement in the blood can be controlled with a magnetic field and so that they can be immobilized close to the targeted pathologic tissue (Tartaj and Serna,2003). However, highly magnetic materials such as cobalt and nickel are toxic and susceptible to oxidation. Hence, they are of little interest for biomedical applications.

Iron oxide particles such as magnetite (Fe_3O_4) or its oxidized form magnetite (γ-Fe_2O_3) are by far the most commonly employed for biomedical applications. The biocompatibility and toxicity of SPIONs (Superparamagnetic Iron oxide NPs) are other important criteria to take into account for their biomedical applications. SPIONs can be an effective system to deliver drugs to the specific site with the aid of external magnets as they show interesting properties such as superparamagnetism, high field irreversibility, high saturation field, extra anisotropy contributions or shifted loops after field cooling (Kodama, 1999). Due to these properties, the particles no longer show magnetic interaction after the external magnetic field is removed.

MATERIALS AND METHODS

1- MATERIALS

Ferrous chloride tetra hydrate, Ferric chloride (anhydrous), Dimethyl sulfoxide (DMSO) and Triethylamine were purchased from Merck, Germany.

2-METHODS

2-1. Synthesis of Superparamagnetic iron oxide nanoparticles (SPIONs)

Synthesis of iron oxide nanoparticles was done as per the protocol by Berger et al. (1999) with little modification. Fe_3O_4 magnetite nanoparticles can be produced by mixing Fe (II) and Fe (III) salts together in a basic solution. 4.0mL of 1M $FeCl_3$ and 1.0mL of 2M $FeCl_2$ solution (both prepared in 2M HCl) was taken in a round bottom flask and 50mL 1.0 M aqueous NH_3 solution added to it over a period of about 5 minutes. Stirring was continued on a magnetic stirrer in N_2 atmosphere, throughout the process. Discarded the clear liquid without losing a substantial amount of solid by keeping a magnet under the container and washed the particles 2-3 times with ethanol.

2-2.Study on Magnetic behaviour:

The magnetic properties of the MNPs were investigated by a Superconducting Quantum Interference Device (SQUID) magnetometer (MPMS5, Quantum design) with fields up to 3T and temperatures of 10K and 300 K respectively.

3-RESULTS AND DISCUSSION:

3-1. Magnetization Studies

Superconducting Quantum Interference Device (SQUID) magnetometer is one of the most effective and sensitive ways of measuring magnetic properties as it uses superconducting coils to sense magnetic fields. Magnetizaton (M) versus applied magnetic field (H) measurements (hysterisis loop measurements) are a time dependent measurement of a sample as the magnetic field is increased and decreased in a hysterisis fashion. Fig.1a shows the M vs H plots of unmodified and silanated (functionalization with ϒ-APTES) MNPs where the applied magnetic field was increased until the saturation magnetization was achieved. Then the applied field was reduced to zero to measure the remanence magnetization (residual magnetization). The result obtained confirms the superparamagnetic behaviour off synthesized MNPs. The saturation magnetization value was found to be decreased on surface modification of MNPs with silane. Surface modification of the iron oxide usually leads to the formation of a non-magnetic shell due to the formation of particle outer layer and the thickness of such a layer could be in the order of 1–20nm(Tourinho et al.,1989).

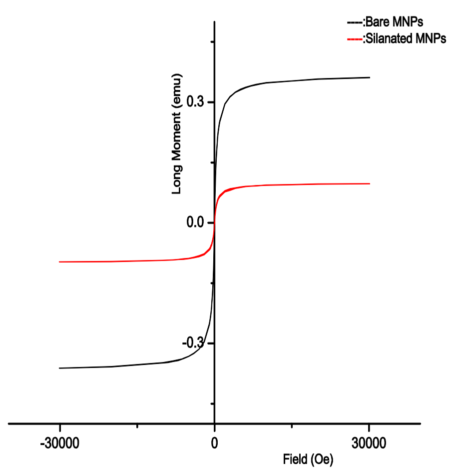

Fig.1b: Magnetization (M) vs applied magnetic field (H) curves of both bare and silanated MNPs at 300K showing the decrease in saturation magnetization upon surface modification

The plots of magnetization vs magnetic field strength (magnetization-magnetic field strength-loop) at room temperature (300K) and 10K for the typical magnetic nanoparticles without a coating of silane are shown in Fig.1b. A clear hysteresis At 10 K revealed the resultant magnetic nanoparticles to be super paramagnetic in nature, and the particles were so small that they may be considered to have a single magnetic domain (Murakami et al.,2002).

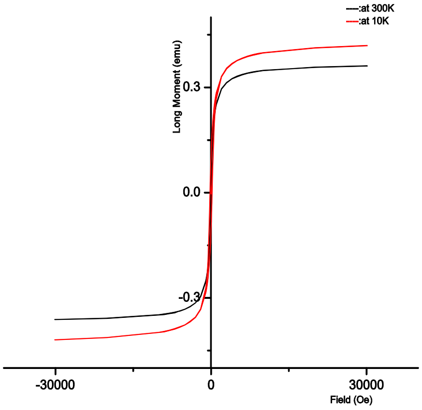

Fig.1b: Hysteresis curves for bare MNPs, at 10 K and at room temperature (298 K) confirming the superparamagnetic behaviour of MNPs.

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