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A Study on Antimicrobial activity of Magnetic nanomaterial

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Abstract

The production and use of iron oxide nanoparticles are growing exponentially due to its wide applications in different fields of science and technology. The objective of this study is to synthesize iron oxide nanoparticles, and modification of its surface to make it less toxic. The iron oxide nanoparticles were synthesized by chemical co-precipitation method, and surface modification was done using chitosan. The synthesized nanoparticles were characterized using different techniques like UV-Vis and ATR-FTIR spectroscopes. This work confirms that toxicity of nanoparticle can be modulated by surface modification with biocompatible compounds.

Introduction:

Magnetic oxide nanoparticles were synthesized by cost effective co-precipitation method. It possesses strong ferromagnetic behaviour and less sensitivity to oxidation. Iron oxide nanoparticles have attracted much interest because they belong to the class of materials having non-toxicity and biological compatibility due to the presence of Fe (II/III) ions [1]. Due to its 4 unpaired electrons in 3d shell, an iron atom has a strong magnetic moment. Ions Fe^{2+} has also 4 unpaired electrons in 3d shell and Fe^{3+} has 5 unpaired electrons in 3d shell. Therefore, when crystals are formed from iron atoms or ions Fe^{2+} and Fe^{3+} they can be in ferromagnetic, antiferromagnetic or ferrimagnetic states [2]. Mechanisms on the nano-bio interface can be either physical or chemical. Chemicalmechanisms include the production of reactive oxygen species (ROS), termination and release of toxic ions, oxidative damage through catalysis, disturbance of the ion cell membrane transport activity and lipid peroxidation or surfactant properties. ROS is considered as being the main rudimentary chemical process in nanotoxicology which can lead to secondary processes that can ultimately cause cell damage and even cell death. Moreover, ROS is one of the main factors involved in inflammatory processes. This is assumed to happen via up-regulation of genes involved in the pro-inflammatory response stimulated by the activation of certain transcription factors (NF-κB, AP-1). However, free radical formation can also have direct impacts on cell stability.[3, 4]. Physical mechanisms at the nano- biointerface are mainly a result of particle size and surface properties. This includes membrane activity, disruption of membranes transport processes, protein conformation or folding and protein aggregation [5]. Ferromagnetic nanomaterial nanoparticles have been of great interest, not only for fundamental properties caused by their multivalent oxidation states but also for the super paramagnetic, high force, low Curie temperature, high magnetic susceptibility, etc. [6, 7] The phagocytosis is generally for large particles and requires a "recognition" step while the endocytosis is for the trans-membrane transport of liquids and molecules [8]. The organic compounds traditionally used for disinfection produce several disadvantages, including toxicity to the human body, and sensitivity to high temperatures and pressures that are present in many industrial processes. For these reasons, the interest in inorganic disinfectants such as metal oxides is increasing [9].

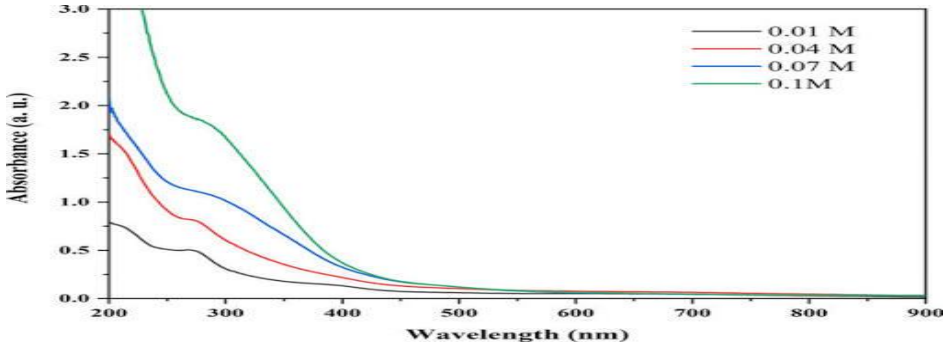
Experimental Work:

The Iron oxide nanoparticles were synthesized by the co-precipitation of Iron chloride tetra hydrate ($FeCl_2.4H_2O$) and Iron chloride hexahydrate ($FeCl_3.6H_2O$). Iron chloride tetra hydrate ($FeCl_2.4H_2O$) and Iron chloride hexahydrate ($FeCl_3.6H_2O$) solutions were prepared in 100 ml of deionised water maintaining the molar concentration 0.1M and 0.2M respectively. The solution was mixed in a beaker and then stirred in a magnetic stirrer to get homogeneous solution. The solution was sealed and heated at 600C for 15-20 min in a water bath. Then 14 ml of Sodium hydroxide (NaOH) was added to the previous solution. A black precipitate was formed after the completion of the reaction. The precipitate was centrifuged at 7000 rpm for 15 min and pellet was collected. Then the pellet was dried at 50 oC to get the powder form of Iron oxide nanoparticles.

Characterization of Iron oxide nanoparticles:

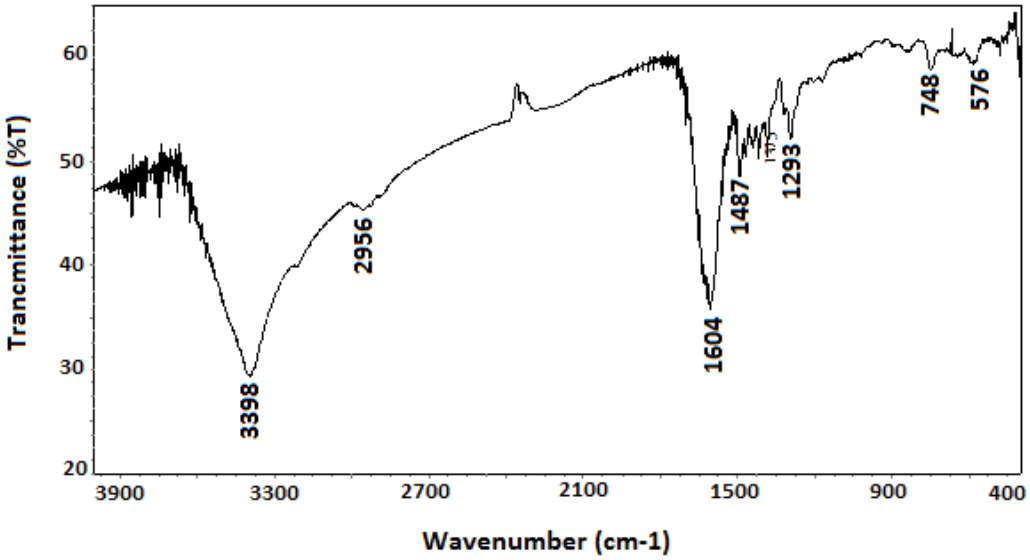
UV-Visible spectroscopy:

The UV-Visible spectra of iron oxide nanoparticles and chitosan modified iron oxide nanoparticles. Iron oxide nanoparticle shows the peak at 222 nm where as chitosan modified iron oxide nanoparticle shows peak at 268 nm. The shifting of peaks confirms the coating of chitosan on the surface of Iron oxide nanoparticles.



FTIR:

The FTIR spectra for Iron oxide and modified Iron oxide nanoparticles. The peaks at 576 cm-1and 748 cm-1confirm the presence of nanoparticles in the synthesized samples and surface modified samples. For chitosan, the amide-I vibration comes around 1676 cm-1 and for modified iron oxide nanoparticles it is shifted to 1604 cm-1, which confirms the hydrogen bonding between oxygen molecule present in Iron oxide nanoparticles and hydrogen molecule present in chitosan. Moreover, FTIR study confirms the coating of chitosan on the surface of iron oxide nanoparticles.



Conclusion:

The iron oxide nanoparticles were prepared by using co-precipitation method. Iron oxide nanoparticle showed the peak at 222 nm, whereas chitosan modified iron oxide nanoparticle showed peak at 268 nm. The shifting of peaks confirmed the coating of chitosan on the surface of iron oxide nanoparticles. The morphology of particles formed was studied by the FE-SEM analysis. Zeta potential analysis confirmed the increase in stability by surface modification. The iron oxide nanoparticles have the potential to inhibit the growth of both Bacillus subtilis and E. coli, whereas modified iron oxide nanoparticles doesn't possess this property.

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Conflicts of interest

The authors declare that there are no conflicts of interest regarding the publication of thesis paper.

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