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Research paper

Synthesis and Characterization of Super Paramagnetic Magnetite Nanoparticles for Drug Delivery Application

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Abstract

Attractive nanoparticles have been broadly considered on account of their potential applications as complexity operators in attractive reverberation imaging (MRI) of tumors, cell and DNA partition, attractively guided medication conveyance, tumor hyperthermia. Among the attractive oxides, magnetite nanoparticles are most appropriate because of their low danger and great attractive properties which may be used in drug delivery. Magnetite nanoparticles were synthesized using $FeCl_3$ and $FeSO_4$ as precursors and characterized for size and shape using non-contact AFM. The formation of magnetite was confirmed by XRD pattern. The elemental composition of the obtained phase was determined using EDAX. In this work, we are aiming to develop drug loaded biopolymer Magnetite nanoparticles for biomedical application. Our main objective is to synthesize and characterize Magnetite (Fe_3O_4) nanoparticles.

Keywords: *Drug delivery, Magnetite, nanoparticles*

1. Introduction

Attractive nanoparticles have been widely considered due to their potential applications as differentiation operators in attractive resonance imaging (MRI) of tumors, cell and DNA detachment, attractively guided medication conveyance, tumor hyperthermia and so on [1]. Among the attractive oxides, magnetite nanoparticles are most appropriate because of their low harmfulness and great attractive properties. The little size, modified surface, enhanced dissolvability, and multi-usefulness of nanoparticles will keep on opening numerous entryways and make new biomedical applications. In reality, the novel properties of nanoparticles offer the capacity to communicate with complex cell works in new ways. This quickly developing field requires cross-disciplinary research and gives chances to outline and create multifunctional gadgets that can target, analyze, and regard crushing infections, for example, growth. In this work, we are aiming to develop drug loaded biopolymer Magnetite nanoparticles for biomedical application. Magnetic nanoparticles offer some attractive possibilities in biomedicine. They have controllable sizes ranging from few nanometers up to tens nanometers, which places them at dimensions that are smaller then or comparable to those of cell (10-100μm), a virus (20-450nm), protein (5-50nm). This implies they can draw near to a natural substance of intrigue. In fact, they can be covered with organic atoms to influence them to cooperate with or tie to a natural substance, along these lines giving a controllable methods for labeling or tending to it. The nano particles are attractive, which implies they comply with Coulomb's law and can be controlled by an outer attractive field slope [2-5]. Our main objective is to synthesize and characterize Magnetite (Fe3O4) nanoparticles which may be used in drug delivery and this will be dealt with in a separate communication.

2. Materials and Methods

Synthesis of magnetite nanoparticles:
Method A: A solution mixture of 0.1 M KOH and 0.05 M $FeSO_4$ were mixed in a three neck round bottomed flask under N_2 bubbling. Then 0.2 M of KNO_3 was dropped in to the solution. The temperature was maintained at 90°C by using an oil bath setup. The solution was heated for 24 hours along with stirring. Finally, a black precipitate was formed. The formed black precipitate was washed with ethanol and deionized water. Then, the magnetite nanoparticles were dispersed in ethanol.
Method B: A solution mixture of $FeCl_3$ (0.085 M) and $FeSO_4$ (0.05 M) at pH 1.98 were mixed in a three neck round bottomed

flask under N2 bubbling. In the process, nitrogen was used to keep the system under the atmosphere of non-oxygen so as to protect iron salts from oxidation [6]. At that point, alkali watery arrangement (1.5 M) was dropped in to it and viciously blended with the assistance of attractive stirrer until the point that the pH of the arrangement rose to 9. Quickly a dark accelerate showed up demonstrating the arrangement of magnetite nano particles. pH esteem was noted at the same time with the assistance of pH paper. The got magnetite nano particles were washed promptly with water and ethanol. At long last, magnetite nano particles scattered in ethanol.

3. Results and Discussion

Characterization of magnetite nanoparticles using atomic force microscopy: The size and size-distribution of magnetite nanoparticles were investigated by AFM. AFM images were optimized at different imaging parameters like set point, scan rate and feed-back gain (Typical values -0.05080, 1.00 lps and 0.1). The instrument was operated in Non-Contact Mode. The samples for AFM were prepared by depositing one drop of magnetite nanoparticle solution on top of a cleaved flat mica substrate. AFM images are shown in Figure 1 for two different regions on the sample. The images show that the particles are uniformly spherical in shape and the diameters of the particles were found to be in the range 5-50 nm. The average particle size is around 10 nm as shown in the histogram in Fig.1.

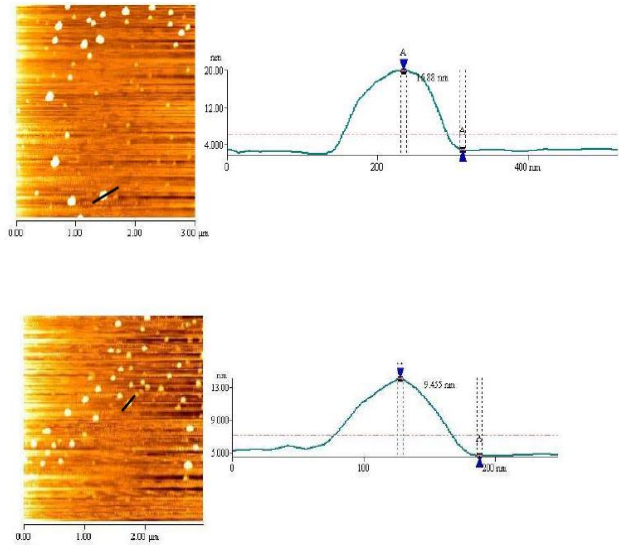

Fig.1 histogram

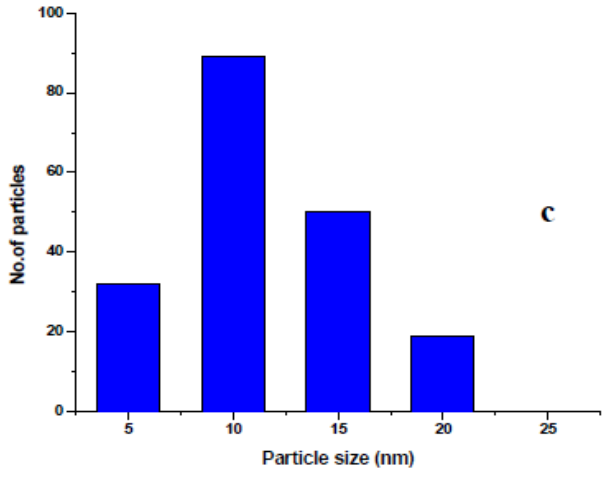

Figure 1 (a) & (b) Non-contact mode AFM image of scan size 3 μm, showing spherical magnetite nanoparticles and (c) Histogram of magnetite particle size distribution

Scanning Electron Microscopy (SEM): SEM was done to determine the morphology of the magnetite nanoparticles and the results are shown in Fig.2. It can be from the figure that the resulting magnetite nanoparticles are almost spherical and quite small. The approximate particle size is around 13 nm.

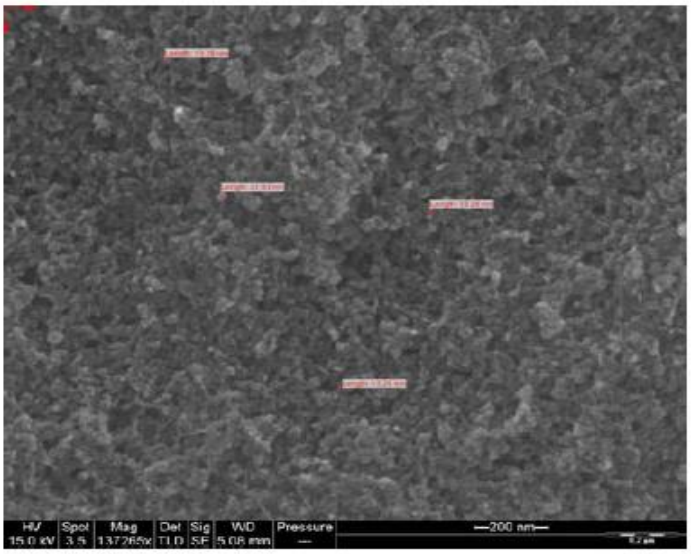

Figure 2 SEM morphology of Magnetite nanoparticles

X-Ray Diffraction (XRD): X-Ray diffraction is a useful technique used to determine the crystal structure of a material. XRD was done on Fe_3O_4 nanoparticles to confirm that the obtained phase is magnetite (Fe_3O_4) and not a different iron oxide or its derivative. Polymer coated magnetite nanoparticles were not characterized with XRD because the polymer is not crystalline and so it is not expected to contribute anything to diffraction. The position of all diffraction peaks matched with standard Fe_3O_4 diffraction data. Figure 3 shows the X-beam diffraction examples of the shaped Fe3O4 nanoparticles. We could watch an expansive low crystallinity zone with 2 Θ = 30.190. The basic portrayal by XRD is mind boggling. This is on the grounds that the diffractograms demonstrate expansive and covering .diffraction tops. This is additionally because of limited number of disseminating crystalline planes. that are making the positions and states of the pinnacles fluctuate as per the nano molecule size and on account of this it is hard to translate the diffractograms. (The peak at (220) and (311)). A better technique like Mossbauer spectroscopy is needed to identify two different magnetic ions occupying two classes of building sites in the crystallite sizes in the crystal lattice tetrahedral ,A and octahedral

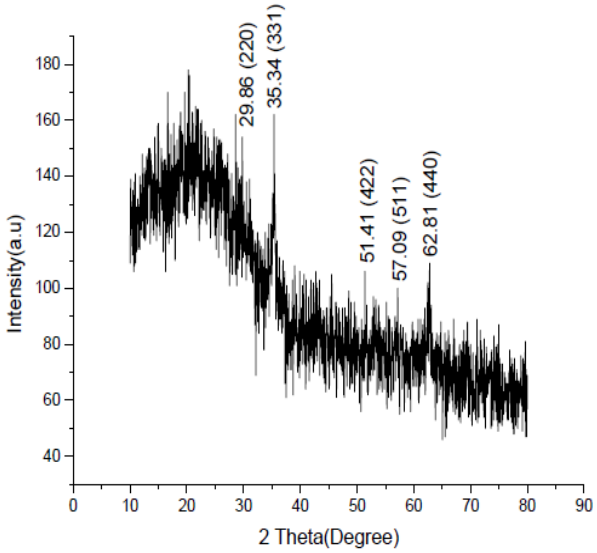

Fig 3 X-Ray diffraction patterns of the Fe_3O_4 nanoparticles

EDAX: The EDAX spectrum of the synthesized Fe_3O_4 nanoarticles, presented in Figure 4, was performed to confirm the elemental composition of the formed product. The ratio of the element Atomic % was found to be 43.85 / 56.15 = 0.78. This value is quite close to that of the expected viz. 0.75. It is clear from this, that the nanoparticles consist of Fe and O elements in the appropriate ratio, further confirming the formation appearance of Fe_3O_4 nanoparticles.

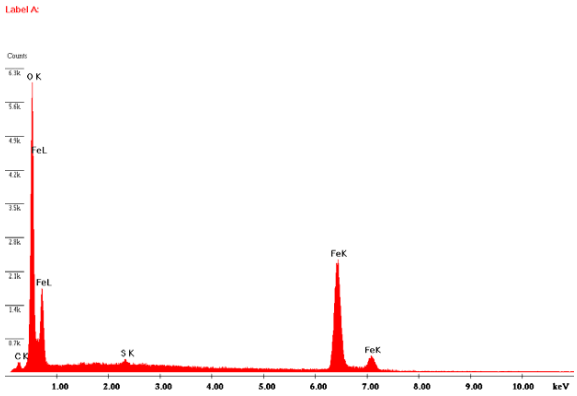

Figure 4 The EDAX Spectrum of synthesized Fe_3O_4 nanoparticles

FTIR: The FTIR of magnetite nanoparticles is shown in Figure 5. The spectra shows peak around 572 cm^{-1}, which is typical characteristic of Fe-O-Fe in Fe_3O_4 sample as reported in literature [7].

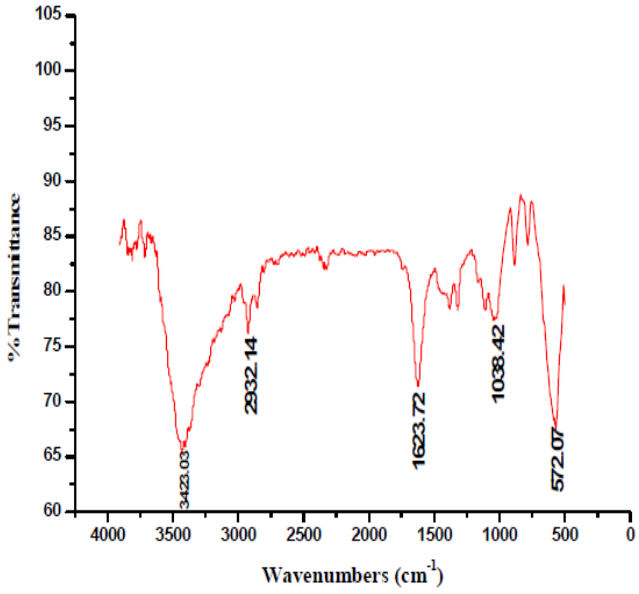

Figure 5 FTIR Spectrum of magnetite nanoparticles

4. Conclusion

Magnetite nanoparticles were synthesized using FeCl3 and FeSO4 as precursors. The magnetite nanoparticles were characterized for size and shape using non-contact AFM. Synthesized Fe3O4 nanoparticles were spherical in shape and the height of the particles was in the range of 5-50 nm with average particle size of 10 nm. The formation of magnetite was confirmed by XRD pattern. The elemental composition of the obtained phase was determined by EDAX, with the ratio of Atomic % found to be ~ 0.78, which is close to the expected value of 0.75.

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