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Datura Inoxia Leaf Extract Mediated One Step Green Synthesis and Characterization of Magnetite (Fe_3O_4) Nanoparticles.

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ABSTRACT

The biological synthesis of nanoparticles using plant extracts plays an important role in the field of nanotechnology. Ferric chloride hexa hydrate and Ferrous chloride tetra hydrate has been used as metal precursors. The phytochemicals present in the Datura inoxia leaf extracts act as a reducing as well as stabilizing agents, which include flavonoids, phenolic compounds, cardiac glycosides and sugars. The formation of the Fe_3O_4 nanoparticles was first monitored using UV-Vis absorption spectroscopy. The UV-Vis spectroscopy revealed the formation of Fe_3O_4 nanoparticles by exhibiting the typical surface plasmon absorption maxima at 270-290 nm. The colloidal solutions were dried in petri-dish to analyze the samples. The dried form of synthesized nanoparticles was further characterized using Fourier transform infrared (FTIR) spectroscopy.

INTRODUCTION

The green method of synthesis of nanoparticles is easy, efficient, and eco-friendly in comparison to chemical-mediated synthesis [1,2,3]. The chemical synthesis involves toxic solvents, high pressure, energy and high temperature conversion and microbe involved synthesis is not feasible industrially due to its lab maintenance. Since, green synthesis is the best option to opt for the synthesis of nanoparticles, therefore the magnetite nanoparticles are synthesized by using aqueous extract of *Datura inoxia* and ferrous and ferric ions. Magnetite was of particular interest due to its unique magnetic and electrical properties. *Datura inoxia* leaf extract was selected as it is of high medicinal value and it does not require any sample preparation and hence is cost-effective. To the best of our knowledge, the use of *Datura inoxia* plant extract at room temperature for the green synthesis of Fe_3O_4 nanoparticles has not been reported [4].

MATERIALS AND METHODS

Materials

Methanol, Sterile distilled water, *Datura inoxia* leaves, ferric chloride hexa hydrate ($FeCl_3.6H_2O$, AR), ferrous chloride tetra hydrate ($FeCl_2.4H_2O$, AR), sodium hydroxide (NaOH) obtained from CDH and Sterile distilled water.

Preparation of *Datura inoxia* leaf extract

Datura inoxia leaves were collected from *Datura inoxia* plant at campus of Mody Institute of technology and science, Lakshmangarh, Sikar (Rajasthan). The leaves were washed several times with distilled water to remove the dust particles and then dried in oven at 50°C to remove the residual moisture. The dried *Datura inoxia* leaves were cut to small pieces and boiled in 500 ml glass beaker along with 300 ml of sterile distilled water and methanol for 10 minutes at 50° C on magnetic stirrer with hot plate. After boiling, the colour of the aqueous

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solution changed from watery to brown colour and allowed to cool to room temperature. The aqueous extract of *Datura inoxia* leaf was separated by filtration with Whatman No.42 filter paper and then centrifuged at 1200 rpm for 5 minutes to remove heavy biomaterials. The *Datura inoxia* leaf extract was stored at room temperature to be used for green synthesis of magnetite nanoparticles.

Figure1: *Datura inoxia* leaf extract

Preparation of Magnetite Nanoparticles

0.53 gm of ferrous chloride tetra hydrate ($FeCl_2.4H_2O$, AR) and 1.11gm of ferric chloride hexa hydrate ($FeCl_3.6H_2O$, AR) after weighing is dissolved in 100ml of sterile deionised water in 250ml Schott Duran beaker. Heat at 80^{0}C under mild stirring. After 10 minutes, 5mL of the aqueous solution of *Datura inoxia* leaf extract was added drop wise. Now 20 ml of 1M NaOH (0.8gms) was measured and dissolved with sterile deionized water in a beaker. After 5 min, the above prepared NaOH aqueous solution is added to the mixture dropwise. The initial color changes to dark red. A change in color of the colloidal solutions and precipitation occurred, confirming green synthesis of Magnetite nanoparticles.

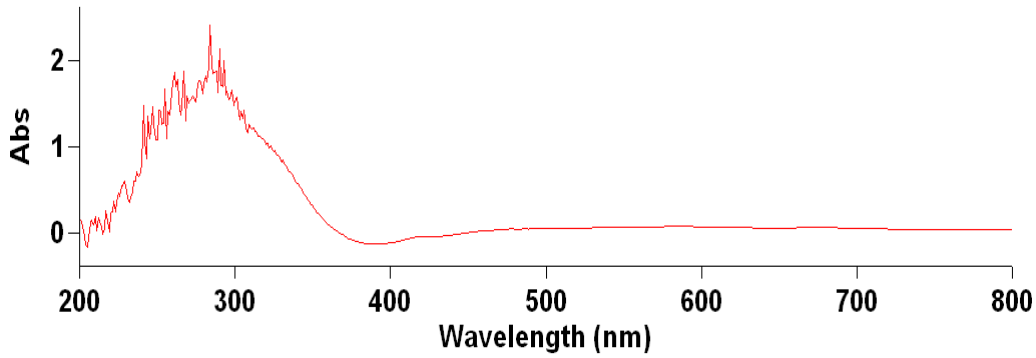
Figure 2: Change in color of Ferrous and Ferric Chloride solution during the course of experiment. (a) Before treatment with DI extract. (b) After addition of DI extract, occurs dark yellow turbid (c) After addition of NaOH dark red and precipitation of magnetite nanoparticles. (d) Magnetite Nanoparticles sticked to Magnetic bar.

(a) (b) (c) d)

RESULTS AND DISCUSSION

Formation and stability of magnetite nanoparticles in aqueous colloidal solution is confirmed by using UV-Vis spectral analysis. The absorption peaks from wavelength 270-290 nm indicate the formation of iron oxide nanoparticles [2].

Figure3: UV-Vis absorption spectra of magnetite nanoparticles



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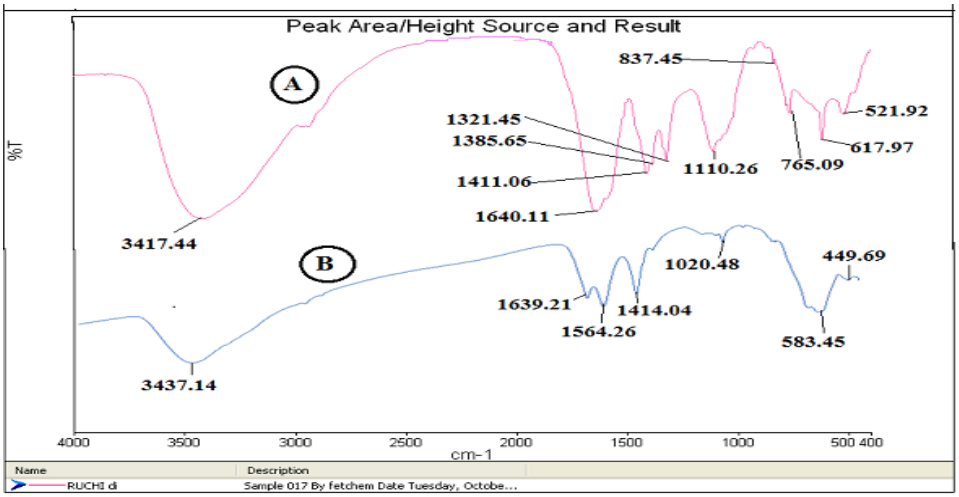
FTIR spectroscopy was used to identify the functional groups of the active components based on the peak value in the region of infrared radiation.

Figure 4: FT-IR spectrum for the DI powder (A) and Fe_3O_4-NPs from the green synthesis reaction (B)

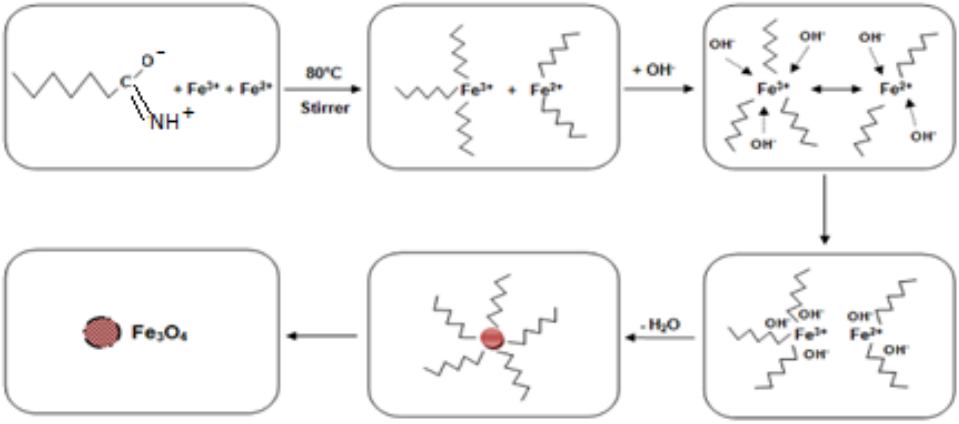


The shift in band from 3417.44cm^{-1} to 3437.14 cm^{-1} show the involvement of the OH group in the stabilization process. The strong band at 1640.11 cm^{-1} and the shoulder peak at 1411.06 cm^{-1} are identified as the amide I and amide II, which arise due to C=O and NH stretching vibrations in the amide linkage of the protein.

The shift of the band from 1,640.11 cm^{-1} to 1,639.21 cm^{-1} was attributed to the binding of a C=O group with the nanoparticles. The peaks at 1414.04 and 1020.48 cm^{-1} are attributed to the asymmetric and symmetric stretching vibration of COO-. The band at 1110.26 cm^{-1} can be assigned to the symmetric C–O vibration associated with a C–O–CN group. The presence of Magnetite nanoparticles can be seen by two strong absorption bands at around 583.45 and 449.69 cm-1 which, corresponding to the Fe-O stretching band of bulk magnetite (Fe_3O_4). These results revealed that the C=O groups were bonded on the magnetite particle surface. Overall the observation confirms the presence of protein in DI leaf extract, which acts as a reducing agent and stabilizer for Magnetite nanoparticles [2, 5].

A possible formation mechanism of magnetite nanoparticles by this green method has been depicted in Figure 5. Ferric chloride $FeCl_3.6H_2O$ and ferrous chloride $FeCl_2.4H_2O$ and *Datura inoxia* leaf extract are in one aqueous phase in the reaction system. The C=O of amide group in *Datura inoxia* leaf extract chelated with Fe^{3+} and Fe^{2+} to form ferric and ferrous Protein. With heating, OH^- of NaOH would be involved in the reaction. A competition between of C=O....Fe^{3+} and C=O....Fe^{2+} bonds and the formation of HO^-...$Fe^{3+}$and OH-...Fe^{2+} ...bonds and a result of formation of ferric hydroxide, $Fe(OH)_3$ and ferrous hydroxide, $Fe(OH)_2$.The formation of ferric hydroxide and ferrous hydroxide form a shell core structure with Protein chain of *Datura inoxia* leaf extract as core. Ferric hydroxide and ferrous hydroxide in core dehydrated (-H_2O) forming magnetite (Fe_3O_4) nanoparticle crystals. The shell of Protein of *Datura inoxia* leaf extract chains attached on Fe_3O_4 surface through chelation of C=O...Fe^{3+} and C=O...Fe^{2+} at the end of the reaction, Fe_3O_4 nanoparticle crystals were capped and stabilized by Protein chain of *Datura inoxia* leaf extract [1].

Figure 5: A schematic illustration of the formation mechanism of magnetite nanoparticles



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CONCLUSION

A critical need in the field of nanotechnology is the development of reliable and ecofriendly processes for synthesis of metal oxide nanoparticles. Fe_3O_4-NPs were synthesized by bioreduction of ferric chloride solution with a green method using *Datura inoxia* aqueous extract containing proteins as the reducing agent and efficient stabilizer. The involvement of these groups in biosynthesis is revealed by FT-IR analysis. Biosynthesis of Fe_3O_4-NPs using green resources is a simple, environmentally friendly, pollutant-free and low-cost approach. Functional bioactivity of Fe_3O_4-NPs (antimicrobial) is comparably higher than particles which were synthesized by chemical method. This green method of synthesizing Fe_3O_4-NPs could also be extended to fabricate other, industrially important metal oxides.

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