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Green Synthesis Of Iron Oxide Nanoparticles Using Catharanthus Roseus Leaf Extract

Author: **B. Nadhiya**, Assistant professor & Co-author **L. Priya Dharshini**

Department of physics

Arcot Sri Mahalakshmi women's college, Villapakkam, India.

Abstract:

Iron oxide Nanoparticles (IONPs) have garnered significant attention due to their diverse application in biomedicine, environmental remediation, and catalysis. In this study, we report the synthesis of IONPs using Catharanthus roseus leaf extract as a green reducing and stabilizing agent. The nanoparticles were characterized using Fourier-transform infrared spectroscopy (FTIR), and UV-Vis spectroscopy. FTIR spectra indicate the presence of biomolecules from the leaf extract adsorbed onto the nanoparticle surface, contributing to their stability and biocompatibility. UV-Vis spectroscopy results showed characteristic absorption peaks in the UV region, indicative of the electronic transitions within the nanoparticles. The green synthesis approach offers several advantages such as cost-effectiveness, eco-friendliness, and scalability. The unique properties of Catharanthus roseus leaf extract facilitate the synthesis of well-defined IONPs suitable for various biomedical and environmental applications. This study underscores the potential of plant-mediated synthesis as a sustainable route for nanoparticle production and encourages further exploration in this emerging field.

Keywords: Fe3O4 -NPs, Green synthesis, Catharanthus roseus.

1. INTRODUCTION:

Nanostructures have led to revolutionary developments in many scientific fields. However, nanoparticle researches are still an intense field since the products have various applications in various fields. The distinct and rare physical and chemical features of metal oxide nanoparticles have attracted interest. Metal oxide nanoparticles are also well-known due to their important roles in a wide range of sectors, including biomedical, information technology, medicine, materials, chemistry, electronics, biomedical, biology, catalysis, environment, and energy. Metal oxide nanoparticles features, including their magnetic, chemical, and electrical capabilities, alter when their size is reduced. This also results in an increase in surface area. In magnetic storage devices and magnetic resonance imaging techniques, for instance, magnetite-type iron oxide nanoparticles have been employed as a contrast agent. Since 1990, iron oxide nanoparticles have been applied in a variety of sectors, including biotechnology, medicine, the environment, and photocatalysis. Magnetite and maghemite ($Fe3O4$ and $Fe2O3$) are two distinct forms of iron oxide that exhibit exceptional physicochemical characteristics, superparamagnetic behavior, and lack of toxicity. Many physical, chemical, biological, and hybrid techniques are already available to synthesis various kinds of nanoparticles. The nanoparticles produced by each technique have particular characteristics. However, research is currently being done on plats ability to biosynthesize metal nanoparticles. Green nanotechnology, which involves a variety of methods to lesson or get rid of harmful compounds in order to improve the environment, has garnered a lot of interest. A contemporary method for producing metal nanoparticles is the creation of such particles from inactivated plant tissue, plant extracts, exudates, and other plant components. Green synthesis of nanoparticles uses safe, non-toxic, and environmentally friendly chemicals.

The majority of the inorganic materials produced by biological processes, including plants and microbes, are found in nanoscale dimensions. These biological creatures cellular extracts can be used to create nanoparticles with a variety of sizes and chemical compositions. Green synthesis is the most efficient method of synthesizing metal nanoparticles at a very low cost. These particles are collected from various parts of the plant, mostly the leaf. Metal ion bioreduction occurs throughout the synthesis process. The components included in the plant extract are said to be in charge of the reduction of iron ions, while the soluble heterocyclic components keep the produced nanoparticles stable. The plant extracts can be reduced with suitable precursors, such as ferric chloride. Green nanotechnology, which involves a variety of methods to lessen or get rid of harmful compounds in order to improve the environment, has garnered a lot of interest.

Catharanthus roseus commonly known as Madagascar periwinkle, stands out as botanical resource rich in bioactive compounds with diverse pharmacological properties. The phytochemical profile of C. roseus encompasses alkaloids, flavonoids, terpenoids, and phenolic compounds, which possess inherent reducing and stabilizing capabilities. Leveraging the inherent reducing potential of C. roseus leaf extract presents an attractive avenue for the green synthesis of $Fe3O4$ NPs. The biocompatibility and eco-friendly nature of this approach make it particularly appealing for biomedical applications, where biocompatibility and safety are paramount considerations. In this study aim to explore the green synthesis of $Fe3O4$ nanoparticles using Catharanthus roseus leaf extract as a reducing and stabilizing agent. Through a comprehensive characterization of the synthesized nanoparticles, including their structural, morphological, magnetic, and surface properties, this research seeks to contribute to the advancement of green nanotechnology. Moreover, by elucidating the potential applications of plant-mediated nanoparticles, this study holds promise for the development of eco-friendly nanomaterials with diverse industrial and biomedical application.

In this work the characterization and formation mechanisms of iron nanoparticles are discussed. The Fe3O4 – NPs were prepared using ferric chloride as iron precursor and Catharanthus roseus as reducing agent and stabilizer.

2.Materials and Method

Fig.1 Catharanthus roseus

A fresh part of catharanthus roseus leaves, Materials are high-grade ($FeCl_3$ $6H_2O$), Distilled water (50ml) was used throughout the experiment. Whatman no. 1 filter papers were used for filtration. 500ml beaker, magnetic stirrer, centrifuge tubes and hot air oven.

2.1Chemicals

The chemical Ferric chloride hexahydrate ($FeCl_3$ $6H_2O$), and solvent used in the study were of highest purity and analytical grade purchased from Harish Lab.

2.2Extraction Preparation

The Catharanthus roseus plant parts were washed and stored at -4 C. Chop the leaves into small pieces and about 5g were boiled with distilled water (50ml) in a beaker while being continuously stirred for 15 min. The solution is filtered using Whatman filter paper.

2.3Preparation of Fe3O4 -NPs

Iron oxide nanoparticles were synthesized by modified protocol. Adding 0.01 M Fecl3 6H20 solution to the Catharanthus roseus leaf extract in a 1:1 volume ratio. Fe3o4 -NPs were immediately obtained with the reduction process. The mixture was continuously stirred for 60 min and then allowed to stand at room temperature for another 30 min to obtain colloidal suspension. The colloidal solution centrifuged manually for 1 hour at 2000 rpm. Collected precipitate from centrifuge was dried at 70c under vacuum to obtain the Fe3O4 -NPs.

Catharanthus roseus leaves have the best reduction capability against ferric chloride when compared to other parts of the plants that is observed by the external color change. From this observation leaves were selected for further procedures. After the confirmation test the Fe3O4 -NPs were synthesized by using the above procedure for further characterization.

3.Results and Discussion

The phytochemicals contain amino, carboxyl, and hydroxyl functional groups which can act as capping agents and efficient metal-reducing agents to give the metal nanoparticles a strong coating in a single step and cause a colour shift. From yellowish brown to brownish black. The synthesis of Fe3O4 -NPs was confirmed by this colour shift. This indicated that compared to other plant parts like seeds and fruit, the leaves of the C. roseus plant have a greater capacity to synthesize Fe3O4 -NPs.

3.1UV – Vis Analysis:

The UV – Vis Spectrum of iron oxide Nanoparticles recorded in the wavelength range from 200 to 2500 nm by using Spectrophotometer at room temperature. The UV – Vis Analysis detected a characteristic absorbance at the Range of 2480nm which is specific for iron nanoparticles. The Band energy was calculated using E.g. = 1240/⅄eV and found in be 0.5 eV which is analysis to reported values of energy band gap for iron nanoparticles

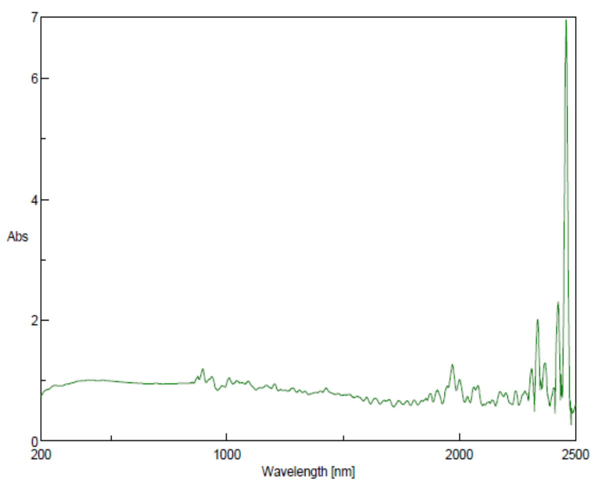

Fig.2 UV- Visible absorption of Fe2O3 NPs

Highest peak of Iron oxide (Fe2O3) nanoparticle is above 2412 nm for the reflectance analysis. It provides information about the structure and composition of the medium

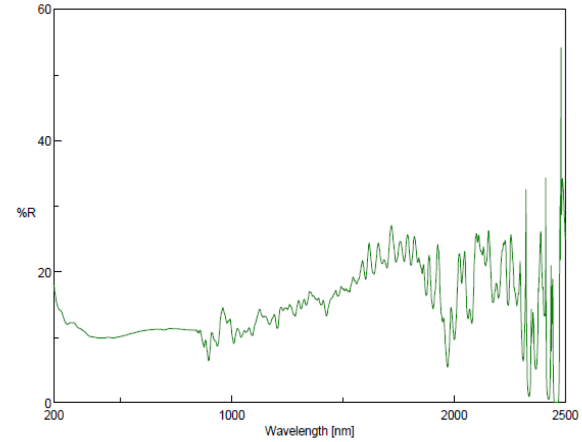

Fig.3 UV- Visible reflectance of Fe2O3 NPs

3.2FT-IR

Analyzing a substance using Fourier Transform Infrared Spectroscopy (FTIR) yields information on its molecular structure and chemical bonds. The synthesized Fe3O4 nanoparticles are examined for composition and crystalline nature using FTIR measurement at room temperature in the 400–4000 cm-1 range. FT-IR analysis gave the stretching vibrations at 3347.81 cm-1, 1614.06 cm-1, 1432.68, 1043.19 cm-1, 1309.07 cm-1, 797.28 cm-1, and 417.18 with in the region of 400-4000 cm-1(fig.2). These peaks represent the following bonding in the sample confirms the reducing agent role in the formation of Fe3O4 -NPs. The peak at 3347.81 cm-1 corresponds to the O-H bond stretching denotes the aqueous phase as well as the reduction of the Ferric chloride, 1614.06 cm-1 corresponds to the H-O-H group, 1432.68 cm-1 and 1308.07 cm-1 corresponds to the C=C group, and 1043.19 cm-1 is corresponds to the C-O.

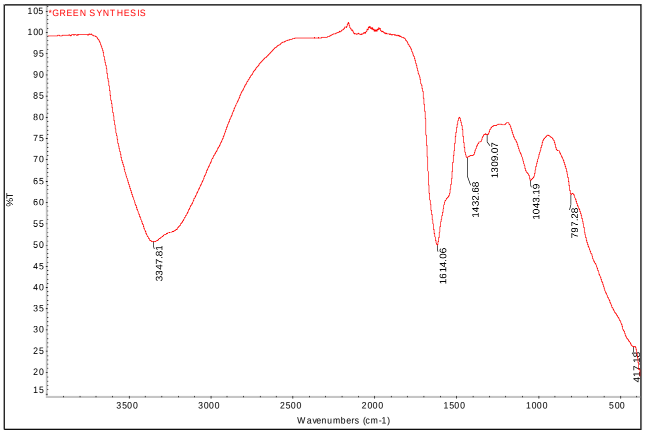

Fig.4 FT-IR of Fe3O4

4.Conclusion:

This study successfully investigated the synthesis and application of iron oxide nanoparticles using Catharanthus roseus extract. Our findings demonstrate the potential of these nanoparticles in various fields, including biomedicine, environmental remediation, and agriculture. In UV visible spectroscopy absorption peak was observed at 2480 nm, and UV Visible reflectance peak was observed at 2412 nm which is specific for iron oxide nanoparticles. In Fourier Transform-Infra-red (FTIR) spectroscopic analysis shows absorption peak of Fe_3O_4 bonding between 1627 to 1390 cm-1.

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