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Green Synthesis of Iron Oxide (Fe_2O_3) Nanoparticles using *Neolamarckia cadamba* leaves extract and Photocatalytic degradation of Malachite Green

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Abstract:- Due to thermal and chemical stability hematite nanoparticles considered highly suitable for biomedical applications. We recognized a biological method for the synthesis of iron oxide nanoparticles using the leaves extract of the Neolamarckia Cadamba. When we mix the extract and metal precursor solution then leaves extract reduce the feeric ion initially and forms FeOOH. After some time precipitates of Fe_2O_3 were obtained which were identified by the UV-Visible and FT-IR spectroscopy. During the reaction ferric ion reduced by Neolamarckia cadamba leaves extract. The Leaves extract also act as a stabilizing agent. The polyol compound like flavonoid and other compounds such as amine, alkenes are responsible for the reduction of metal ions. The photocatalytic efficiency of Fe_2O_3 nanoparticles was evaluated by the degradation of malachite green under sunlight irradiation. This method has been found to be eco-friendly, low cost and effective for the nanoparticle synthesis in various fields.

Keywords:- *Iron Nanoparticles, Neolamarckia Cadamba, UV-Visible Spectroscopy, FT-IR, Photocatalyst, Reducing Agent, Green Catalyst.*

I. INTRODUCTION

Iron oxide nanoparticles Fe_2O_3 deserves special advert because they are easy to access and their potential applications such as targeted drug delivery, as a photo catalyst, and also used for water purification as compared to other nanoparticles [1, 2]. using plant extract as a natural reducing and capping agent the synthesis of iron oxide nanoparticles will be useful for biological application. Even though many biological rituals are existing for the synthesis of iron oxide nanoparticles**.** [3]

Usually, the phytosynthesis method used plant extract as a natural reagent for the synthesis of nanoparticles. Iron oxide nanoparticles are more stable chemically and thermodynamically. FeNPs have hexagonal crystal structure with densely packed oxygen lattice. Fe_2O_3 nanoparticles are recyclable and reusable catalyst for several organic synthesis reaction and can be easily separated by reaction mixture by filtration. Else these Fe_2O_3 nanoparticles are also popular in the fields of catalysis, colouring, photochemical cell, purifying water and cosmetics. Due to inertness, non-toxicity and compatibility, Fe_2O_3 is useful material for targated drug delivery and reference substance for assessing properties of other metallic oxides. In the present work we accomplished a feasible, green and advantageous synthesis of iron oxide nanoparticles (Fe_2O_3) and assessing their applications in biological sector.

II. MATERIALS AND METHODS

A. Preparation of Extract

Leaves were washed with distilled water. Then leaves were dried in the shade and chopped into small pieces. Small pieces of leaves were placed into the Soxhlet extractor chamber and heated at 60°C. The extract was collected in air tight container for further experiments.

B. Synthesis of Fe_2O_3 nanoparticles using Neolamarckia Cadamba Extract

For synthesis of Fe_2O_3 nanoparticles 1mM $FeCl_3$ solution was prepared. Then 10 ml of leaves extrct was added to 90 ml of prepared metal precursor solution of $FeCl_3$. The reaction mixture was stirred at 1000rpm for 3 hr at 80^OC. Colour changed from light yellow to dark brown color, indicates the formation of iron nanoparticles. By centrifugation the nanoparticles were separated out at 2000 rpm for 15 minutes. These nanoparticles were washed 2-3 times with distilled water to remove any contaminants. Then nanoparticles were placed into hot air oven at 60°C for 1 hr. These NPs were calcinated at 300^OC for 2 h in muffel furnace.

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Fig. 1

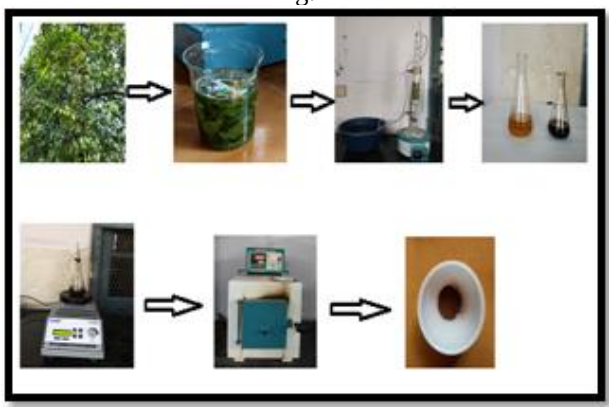

Fig:1 Synthesis of FeNPs

III. CHARACTERIZATION

A.UV-Visible spectrophotometric analysis of Fe_2O_3 **:** The UV-Visible spectroscopy is used for the optical characterization of synthesized nanoparticles Fe_2O_3 in the range of 200-700 nm.

C. *FT-IR Spectrophotometer :* FTIR spectroscopy is used for the characterization of functional groups which are present on the surfacr of nanoparticles, in the range of 400-4000 cm^{-1}.

D. *Photocatalytic degradation of dye:* We investigated the degradation of dye by $NaBH_4$ using Fe_2O_3 nanoparticles as a catalyst. In this experiment, 20 ml of $NaBH_4$ (0.01) was mixed with 100 ml of malachite green (10^{-3}) solution and then we add 25 mg of iron oxide nanoparticles. The intensity of colour of the mixture was decreased. In the UV-Visible spectrum the intensity of peaks also decreased which indicates the catalytic activity of the Fe_2O_3 nanoparticles.

IV. RESULTS AND DISCUSSION

During the reaction the change in colour of reaction mixture confirms the formation of Fe_2O_3 nanoparticles. On the treatment of $FeCl_3$ solution with the leaves extract the appearance of brick red colour suggested the formation of nanoparticles. Fig. 2 shows the leaves extract and reaction mixture of leaves extract and $FeCl_3$ solution. After mixing the leaves extract and $FeCl_3$ solution suddenly color change from pale green to dark brown was observed and particles wre settled down at the bottom of conical flask. After calcination red coloured NPs were obtained which confirms the formation of Fe_2O_3.

Fig: 2 (i)Plant Extract, (ii)Colloidal solution of NPs

The synthesis of nanoparticles was intially confirmed by the UV-Visible spectroscopy in the range of 200-700 nm (Fig: 3).

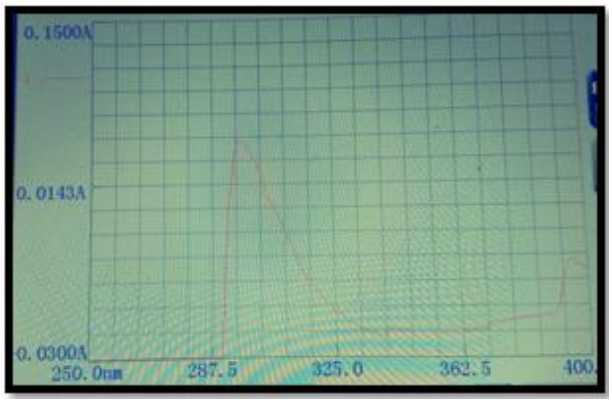

Fig: 3 UV-Visible Spectrum of FeNPs

The peak obtained at 310 nm confirms the formation of iron nanoparticles. Electronic excitation of iron nanoparticles the peak was obtained in the spectrum [5]. Concentration of metal precursor (1 mM $FeCl_3$) affect the formation of nanoparticles. For the detection of interaction between nanoparticles and functional groups of bimolecules FT-IR spectroscopy is used [6]. Three stong peaks 3401, 1637.15 and 472.5 cm^{-1} observed in the FTIR spectrum (Fig: 4) of synthesized FeNPs. Kumar et al have been reported the presence of identical bands at 472, 1634 and 3438 cm^{-1} when colloidal β-Fe_2O_3 was synthesized in the presence of varying Co^{2+} amount. [7].

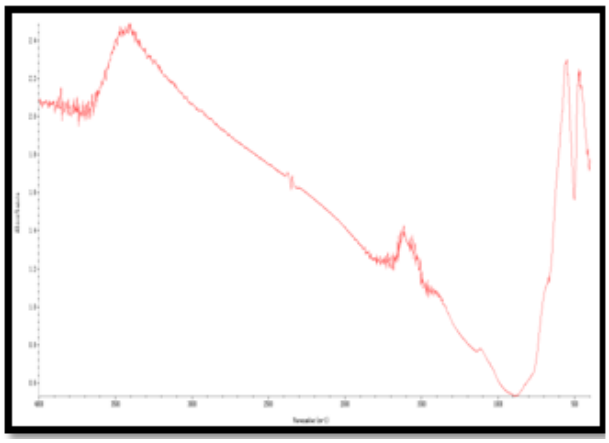

Fig: 4 FT-IR Spectrum of FeNPs

Biomolecules present on the surface of Fe NPs are responsible for the appearance of peaks in the FT-IR spectrum.ha.Fig. 4 [8]. Based on our study the peak obtained at 3855 cm^{-1} assigned the unsaturated nitrogen (C-N), 1618 cm^{-1} indicating the bending vibration of H_2O molecule and a broad peak obtained at 3401 cm^{-1}. The peaks observed at 1508 indicating the C-O stretching and Band obtained at 1457 cm^{-1} indicating the C-C stretching of alcohol [9, 10]. Finally the peaks observed at 549.6 and 472.5 cm^{-1} indicating the Fe-O stretching.

The photocatalytic activity, Fig:5 of synthesized Fe_2O_3 NPs was assessed for the degradation of malachite green dye solution under sunlight irradiation. In the dark there is no chnge in concentration of dye in the presence of catalyst. Also, degradation of the dye in the absence of catalyst under the sunlight irradiation was performed that one may separate the remarkable degradation by the Fe_2O_3 under the sunlight irradiation. The fact that in the absence of the catalyst infinitesimal decrease appeared in the concentration of the dye, indicated that exclusively photo catalysis has takes place in the presence of Fe_2O_3 nanoparticles.

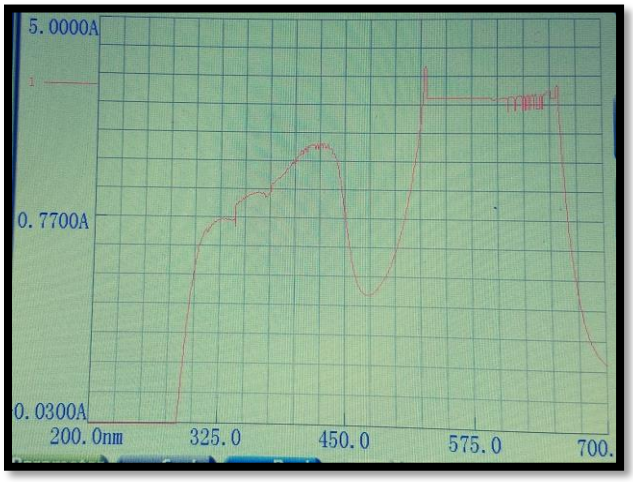

Fig: 5 UV-Visible Spectrum of Malachite Green

Furthermore, the Fe_2O_3 obtained by leaves extract exhibit enhance photocatalytic activities. The peaks of malachite green locate at 421 nm and 615 nm decreased after 30 min reaction. Fig. 6. It further indicated that malachite green could be effectively removed using Fe_2O_3 by cleavage of carbon-carbon double bond and Carbon-nitrogen bond. [11**].**

Fig: 6 UV-Visible Spectrum of Malachite Green after degradation

V. CONCLUSION

By the reduction of ferric ion of metal precursor solution using leaves extract of Neolamarckia *Cadamba* Fe_2O_3 nanoparticles have been successfully synthesized. UV-Visible and FT-IR spectroscopy is used for the determination of nanoparticle synthesis. The bottom up approach of biological synthesis method provide green and profitable method. The secondary metabolites such as flavonoids are responsible for the formation of Fe_2O_3. Fe_2O_3 nanoparticles are found to be appropriate for the degradation of aqueous solution of malachite green under sunlight irradiation.

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