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# Photocatalytic and Antibacterial Activity of Green Synthesized Iron Oxide Nanoparticles

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**Abstract:** ***Iron oxide ($Fe_3O_4$) nanoparticles are synthesized by a green route using Tinospora cordifolia leaf extract has been presently investigated. Synthesized iron oxide nanoparticles are characterized by X- ray diffraction technique reveals its crystalline nature. Fourier transform infrared spectroscopy affirmed the role of Tinospora Cordifolia leaf extract as a reducing and capping agent of Fe ions. Particle Size Analyser result indicate the size of the synthesized nanoparticles. In addition, antibacterial activity against E.coli and B.subtilus, showed maximum zone of inhibition of 17 ± 0.2 mm and 20 ± 0.3 mm respectively. The photocatalytic activity of the sample are studied based on the degradation of Malachite green as a model compound, where the results showed that the green synthesized iron oxide nanoparticles have a good photocatalytic activity.***

**Keywords:** Green route, Tinospora Cordifolia, Antibacterial activity, Photocatalytic activity

## 1. Introduction

Nanotechnology is fast growing area in the development of scientific research and technology, especially in biotechnology and nanoparticles are considered as particles with diameter between 1 to 100 nm. It exists in natural world and also created by various physical, chemical and biological processes. Synthesis of metal oxide nanoparticles using leaf extract is important in the field of nanotechnology which is one of the most developing areas of research in material science [1]. Among different nanoparticles Iron oxide nanoparticles play an important role in many biological and geological processes. In recent years green synthesis of Iron-based nanomaterials has been a focus of extensive research in the field of agriculture and environmental remediation due to its non-toxicity and low cost. In addition, which are inexpensive to produce, physically and chemically stable, biocompatible and environmentally safe [2], [3].

In this paper, we report the green synthesis of Iron oxide Nanoparticles using Tinospora cordifolia leaf extract for the first time. T. cordifolia commonly named as "Guduchi" in Sanskrit belongs to the family Menispermaceae. It mainly contains alkaloids, diterpenoid lactones, glycosides, steroids, sesquiterpenoid, phenolics, ali-phatic compounds and polysaccharides [4], [5]. T. cordifolia leaf extract is extensively used in various herbal preparations which have anti-periodic, anti-spasmodic, anti-microbial, anti-osteoporotic, anti-inflammatory, anti-arthritic, anti-allergic and anti-diabetic properties [6]. Various components present in leaves of T. cordifolia (Figure 1) are antioxidants and may act as good reducing agent for the preparation of Nanoparticles. Therefore, this study attempts to exploit T. cordifolia extract as reducing agent for the synthesis of Iron oxide Nanoparticles. The procedure involves a self-sustained reaction in homogeneous solution of ferrous sulphate, Ferric chloride and T. cordifolia extract. So the present work shows that Tinospora cordifolia leaf extract on the applicability of Iron oxide nanoparticles more beneficial to the medicinal and environmental remediation purpose.

**Figure 1:** Leaves of Tinospora cordifolia

## 2. Materials and Methods

T. cordifolia leaves were sourced from local Agri land, Erode, Tamilnadu, India. The plant material was shade dried and powdered into 100 mesh size and stored at room temperature in an airtight container.

### 2.1 Preparation of leaf extract

The coarsely powdered plant material was mixed with water (1:10 proportion) and extracted at 100°C with a reflux arrangement for 5 h. The extract was filtered through a Whatman filter paper and centrifuged to eliminate any un-dissolved material. Then the extract, stored in airtight bottles at 4°C. The filtrate used for the synthesis of Iron oxide nanoparticles.

### 2.2 Synthesis of Iron oxide nanoparticles

For the synthesis of nanoparticles 0.1M of ferric chloride and 0.2 M of ferrous sulphate was dissolved in 40 ml deionized water under magnetic stirring at room temperature. After obtaining a homogenous solution, 10 ml of an aqueous solution of T. cordifolia leaves extracts was added drop by drop. The mixture was stirred for 2 hours in $80^o$ C. Afterwards the suspended particles were purified by dispersing in sterilized distilled water and centrifuged 4 times. Afterwards, the nanoparticles were washed with double distilled water and calcinate at $400^o$ C.

## 3. Results and Discussion

### 3.1 X-ray Diffraction

The crystal structure of the sample was analyzed by recording the X-ray diffraction (XRD) spectrum at room temperature using X-ray diffractometer (PAN analytical X'Pert) with a nickel filtered radiation ($\lambda$ = 1.5418 Å) at 40 KV and 20 mA in the 2θ range 10º to 90º was used. The X-ray spectra generated by this technique thus provide a structural fingerprint of the unknown sample. The XRD spectra of magnetite sample obtained via Green synthesis method was given in figure 2. The results show that the sample has six peaks at 2 theta of 30.36, 35.74, 43.52, 53.95, 57.34 and 63.0 representing the corresponding indices of (220), (311), (400), (422), (511), and (440) respectively. All the peaks could be indexed to rhombohedral structure, for iron oxide (JCPDS NO. 89-8104).

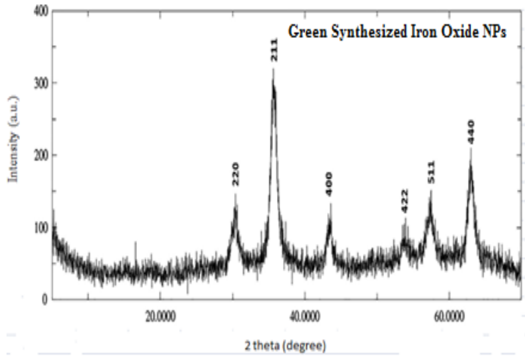



**Figure 2:** XRD pattern of green synthesized Iron Oxide Nanoparticles

### 3.2 FTIR Spectroscopy

The FT-IR spectra was recorded to identify the possible biomolecules responsible for the reduction of the Fe ions and capping of the bio-reduced Iron Oxide Nanoparticles synthesized by the T. cordifolia leaf extract. Figure 3 shows the FTIR spectra of Iron Oxide NPs.

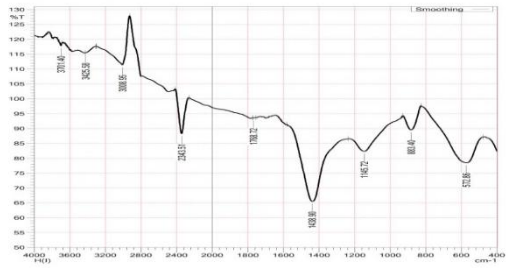


**Figure 3:** FT-IR spectra representing the functional groups associated with the reduction and stabilization of T. cordifolia leaf extract mediated Iron Oxide Nanoparticles

In the FT-IR spectra, less intensity band observed at 3425 $cm^{-1}$ has been attributed to hydroxyl group. Strong band occurring at 2343$cm^{-1}$ in the spectrum correspond to the triple bond and δ asymmetrical H-O-H. The peak obtained at 1438 $cm^{-1}$may correspond to H-O-H characteristics. The band obtained at 572 $cm^{-1}$is characteristic of M-tetrahedral resonance with O. This peak also relate to Fe-O group. These results are in confirmation with the previous reports of $Fe_3O_4$ nanoparticles [7].

### 3.3 Particle Size Analysis

Particle size distribution can be calculated using the light intensity distribution pattern of scattered light which is generated from the sample particles when laser irradiates them. The synthesized particles are analyzed by Laser diffraction Particle size analyzer.The results show that synthesized nanoparticles are in the nanometer range are indicated in Figure 4

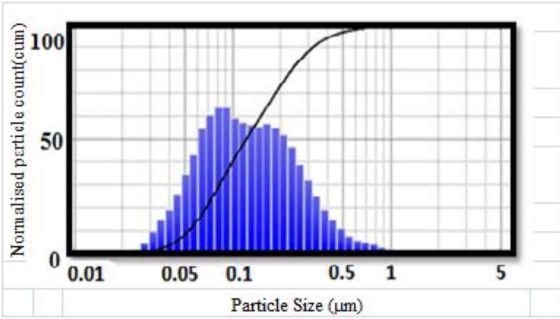
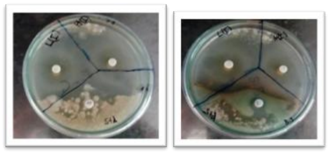



**Figure 4:** Particle size analysis of Iron Oxide Nanoparticles

### 3.4 Antibacterial studies

The antibacterial activity of the Iron oxide nanoparticles was assessed against Gram – ve E. coli and Gram + ve B.subtilus using the agar well diffusion method. Iron oxide nanoparticles showed significant antibacterial activity on the bacterial strain tested as shown in Figure 5. Table 1 illustrates the statistical observations of bacterial inhibitions of Iron oxide nanoparticles.



**(a)** **(b)**

**Figure 5:** Zone of inhibition of (a) E. coli and (b) B.Subtilus

**Table 1:** Antibacterial activity of $Fe_3O_4$ nanoparticles on pathogenic bacterial strains

| Sample Name | Zone of inhibition (mm) | |
|---|---|---|
| | E.coli | B.subtilus |
| $Fe_3O_4$ NPs | 17±0.2 | 20±0.3 |

### 3.5 Photocatalytic degradation of Malachite Green dye by Iron Oxide nanoparticles

The photocatalytic activity of the biosynthesized Iron oxide nanoparticles was assessed by monitoring the changes in the colour of MG solution. The degradation process involves photochemical reactions on the surface of the iron oxide nanoparticles. The size and the dispersion of the photocatalyst in the solution play an important role in the degradation of dye. Figure 6 shows the time dependent degradation of MG dye using iron oxide nanoparticles as a photocatalyst under visible light.

**(a) 2 min (b) 4 min (c) 6 min (d) 8 min (e) 12 min**

**Figure 6:** Time dependent degradation of MG dye using Iron Oxide nanoparticles

## 4. Conclusion

The Iron Oxide ($Fe_3O_4$)Nanoparticles was synthesized using leaf extract of T. cordifolia. The synthesized nanoparticle was characterized by XRD, FT-IR spectroscopy and Particle size analyzer. XRD data suggests that rhombohedral structure of Iron Oxide nanoparticles was formed. Biosynthesis of Iron Oxide NPs using green resources like T. cordifolia is a better alternative to chemical synthesis, since this green synthesis is pollutant free and ecofriendly.The biosynthesized Iron Oxide NPs have shown good antibacterial efficiency and hence has a potential to be used as antibacterial agent against B.Subtilus than E. coli. These Iron Oxide NPs was proved to be powerful source of antibacterial activity.The carcinogenic dye such as malachite green was found to degrade very effectively by Iron Oxide nanoparticles in the presence of Sun light. Although, the time taken by the green technology method is a little longer than the chemical Reduction method, scaling up the process and synthesizing iron oxide nanoparticles in a larger quantity by processing larger volumes of the plant extract can increase its efficiency.

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