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Biosynthesis of Iron Oxide nanoparticles from *Catharanthus roseus* plant leaves and its Antibacterial Activity

K . Babu[1], S. Shobana[1], Y. A. Syed Khadar[1] and M. Haris[2]*

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Abstract

Bio synthesis of Iron oxide nanoparticles was prepared using Green Synthesis method using the Catharanthus roseus plant leaves. The plant contains more medicinal properties like antibacterial activity, drugs delivery and provides solution for fungus. XRD studies confirmed the size of the nanoparticles. When theta value increases dislocation density also increase. The morphology of iron oxide nanoparticle was studied using SEM analysis. Due to Surface Plasmon Resonance (SPR) Iron oxide NP's were confirmed at 215nm.Using Tauc's plot graph method the energy badgap energy level is 5.76 eV from UV-Vis spectroscopy. From the functional group analysis, Fe-O stretching of iron oxidewere confirmed at 558 and 594 cm^{-1} .

Keywords: *Catharanthus roseus*, Surface Plasmon Resonance, iron oxide, Fe-O stretching

1 Introduction

Over the past decade,there has been a major amplify in the discipline of nanoparticles manufacturing,with managed morphologies and notable factors that make it a huge vicinity of research.The elementary purpose of the nanotechnology is to synthesis nanoparticle in nano range and have an extra ordinary control in the fields such as bio sensors,bio-medical,catalyst for bacterial bio toxin removal.In the Present decades the influences of green synthesis has raised up by eliminate the chemical routine methods due to the toxicity by using chemicals. [1-4]. *Catharanthus roseus* plant are widely used in many biological applications such as cancer treatment.

The family name of the plant we used for green synthesis was Apocynaceae, their botanical name was Catharanthus roseus and called as nithyakalyani, sudukattu mallikai in tamil.The plant part taken for synthesis was only their leaves which are shown in Fig.1.

Fig. 1 Image of *Catharanthus roseus* [5]

The previous report of green synthesis of iron oxides NP's using different plant leaves and spices are such *Mangifera indica, Syzygium aromaticum, Rosa indica, Azadirachta indica, Camellia sinensis, Camellia sinensis, Coffea arabica, Trachyspermum ammi, Magnolia champaca, Murraya koenigii* and so on [6-7].

In our present work, we synthesized iron oxide Nanoparticles using Catharanthus roseus plant extract and characterized different techniques like X-Ray diffraction, Fourier-transform infrared spectroscopy (FTIR) and UV-Visible spectroscopy, photoluminescence and Antibacterial analysis.

2. Experimental

2.1. Collection of Leaves

Catharanthus roseus leaves were collected in arachalur, erode district during the month of November. Fresh leaves were collected and separated for a future purpose.

2.2.Preparation of Extract

Collected leaves were washed in running faucet water and with distilled water. Then the leaves were dried. After drying the leaves were cut into small pieces and then crushed to powder form.

* Corresponding author: babukj92@gmail.com
*[1]Assistant Professor, Department of Physics, K.S.R College of Arts and science for Women, Tiruchengode, Namakkal, Tamilnadu.
[2] Associate Professor,Department of Physics, Karunya Institute of Technology and Sciences,Coimbatore

2.3. Preparation of Iron oxide Nanoparticles

The powdered *Catharanthus roseus* plant leaves (5g) were extracted from solvent (50 ml) by a solvent extract method for 3 hrs. The extract was evaporated at 40°C for 5 hrs. Dried powders of Catharanthus roseus plant leaves were crushed. 0.4 M of $FeSO4.7H_2O$ solution along with 4g of Catharanthus roseus plant leaves was added under continuous stirring for 3 hrs. Before the assessment to remove any suspended particles the aqeous samples were centrifuged at 4000 rpm for 10 minutes. The obtained sample was separated and dried in the open air continuous for 3 days. Yield of the nanoparticles were calcined at 110°C for 20 min. The colour of the sample was changed into dark black from greenish black. Collected iron oxide nanoparticles were crushed into fine nanoparticles for different characterization studies.

3 Results and Discussion

3.1. Structural Analysis

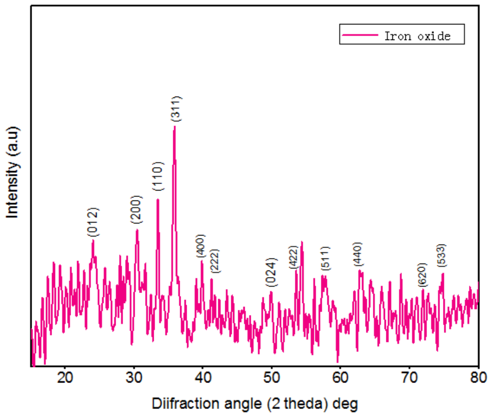

Fig.2. XRD patteren of Iron oxide nanoparticles

Fig 2 shows the XRD spectrum of Iron oxide nanoparticles prepared from *Catharanthus roseus* plant leaves. The 2θ values of intense peaks for 23.92, 30.39, 33.39, 35.76, 39.77, 49.74, 54.23, 62.81, 71.82 and 74.50 corresponds to (012), (200), (100), (311), (400), (024), (422), (440), (620) and (533) planes respectively. These corresponding peaks provided a spinal cubic structure of iron oxide nanoparticles from Catharanthus roseus plant leaves. Crystalline size of iron oxide nanoparticle was calculated using the Debye-Scherrer equation is shown in,

$d=k\lambda/\beta\cos\theta$

where,

d is average crystalline size, k is the Scherrer constant(0.89),

λ is the wavelength of CuKa (0.15418 nm),

β is the full width at half maximum in radian (FWHM),

θ is the diffraction angle[8-12].

The average crystalline size of the particles is 12.96 nm as shown in the table 1.The dislocation density (δ) of the iron oxide in which the number of dislocation occurs in unit volume which were determined by the formula $\delta = 1/D^2$

where, δ = Dislocation density and D = the crystalline size [13]. The dislocation density of iron oxide nanoparticle density gradually decreased which is shown in table 1.

Table 1. Calculation of Grain Size, Dislocation density of iron oxide nanoparticle from XRD analysis.

S.No	2θ (deg)	θ (deg)	FWHM (deg)	d-spacing (A)	hkl plane	Grain size (nm)	Dislo-cation density $\delta = 1/D^2$
01	23.92	11.96	1.53	3.71	012	5.23	0.036
02	30.39	15.19	0.79	2.93	200	10.3	0.009
03	33.39	16.69	0.66	2.68	100	12.32	0.007
04	35.76	17.88	0.75	2.50	311	10.93	0.008
05	39.77	19.88	0.70	2.26	400	11.82	0.007
07	49.74	24.87	0.59	1.83	024	14.51	0.005
08	54.23	27.11	0.55	1.68	116	16.03	0.004
10	62.81	31.40	0.46	1.47	440	19.95	0.003
11	71.82	35.91	0.34	1.31	620	28.23	0.001
12	74.50	37.25	0.37	1.27	533	26.31	0.001

3.2. Morphological and Elements studies

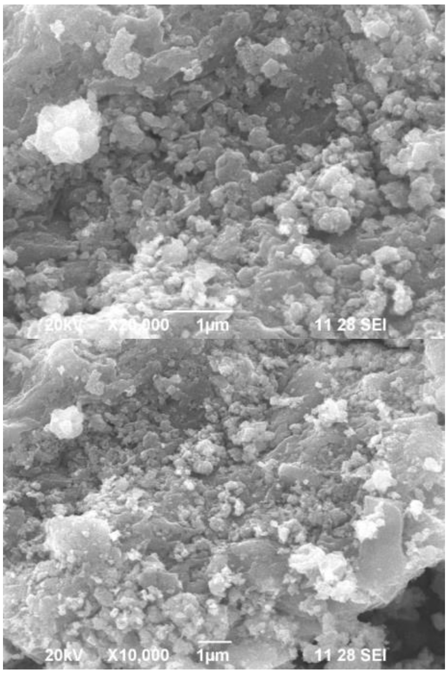

Fig.3. SEM micrograph of Iron oxide nanoparticles

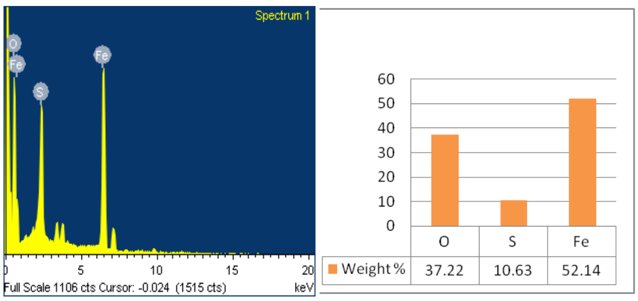

Fig.4. EDAX spectrum of Iron oxide nanoparticles

Fig 3 shows the SEM Morphology of iron oxide nanoparticles.The reports obtained from SEM analysis clearly shows that the shape was cubic structure. The chemical composition in the iron oxide nanoparticle are shown in Fig4. The spectrum of iron oxide nanoparticles shows Fe (52.14 %), O (37.22 %) and S (10.63%) respectively [14]. This spectrum shows the purity of iron oxide nanoparticles.

3.3. Functional Group Analysis

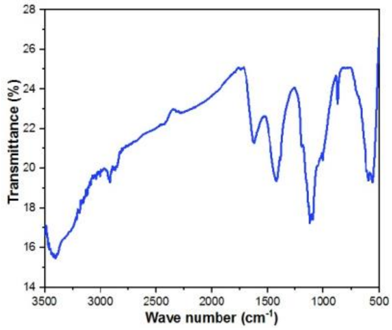

Fig.5. FTIR spectrum of Iron oxide nanaoparticles

Fig.5 shows that the confirmation of chemical bonding structure and functional group of iron oxide nanoparticles. The peaks at 3406 and 2915 cm^{-1} represents the confirmation of Hydroxyl and C-H stretching. The peaks 1620 and 1123 cm^{-1} correspond to C=C aromatic bond and C-O stretching respectively. [15] The absorption bond produced at 558 and 594 cm^{-1} represents the Fe-O Stretching vibration. [16]

3.4. Optical Analysis

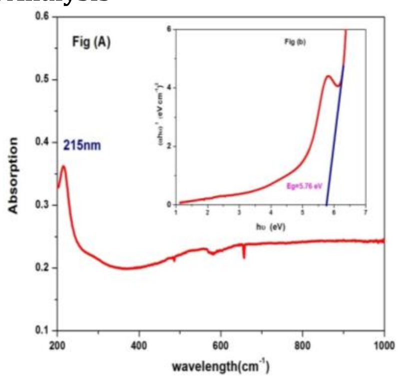

Fig. 6(A). UV–Vis absorption spectra of synthesized iron oxide nanoparticles, Fig B. Tauc's plots for the energy gap of iron oxide nanoparticle

Synthesized iron oxide nanoparticles were studied using UV-Vis spectroscopy which is shown in Fig.6(A). Iron oxide nanoparticle absorption peak arises at 215 nm due to the Surface Plasmon resonance [17-18]. Figure B was shown for the determination of band gap of iron oxide nanoparticles. The graph was plotted between $(\alpha h\nu)^2$ vs. hν energy using Tauc's Plot method. 11]. Calculated Eg values are shown in table 2. Energy band gap was calculated using the formula Eg =1240/λ eV and the calculated band gap energy is 5.76eV.

Table.2. Comparison of Eg values from UV-Vis absorption and Tauc's plot for iron Nanoparticles.

Sample	Energy Band gap /eV	
	UV-Vis absorption	Tauc's Plot
Iron oxide	5.76	5.76

3.5. Photoluminescence analysis

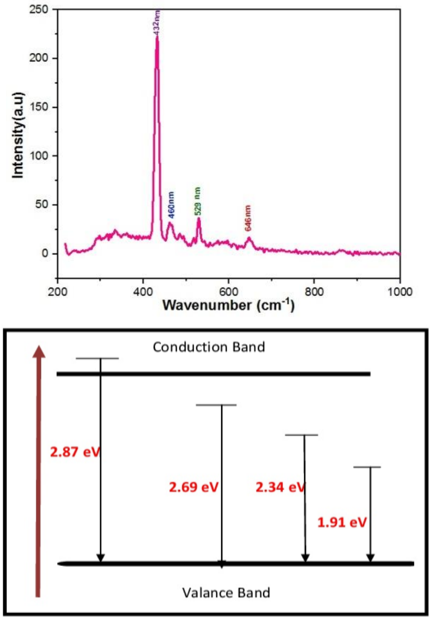

Fig.7. PL Spectra of iron oxide Nanoparticles was carried out at room temperature

In our present work, the emission peaks produced at 432,460,529 and 646 nm and their energy band gaps are 2.87, 2.69, 2.34 and 1.91 respectively shown in Fig 7. The decrease of band gap is due to energy level of quantum confinement effect. The energy level diagram shows that the intermolecular potential energy of the iron oxide nanoparticles between the valence band and conduction band [19].The emission peak produced at 646 nm may be due to the formation of iron vacancy [20].

3.7. Antibacterial Activity

To find out the antibacterial activity of iron oxide NP's were Agar well diffusion method used. In this method, were used Escheria Coli, Staphylococcus Aures, and Pseudomonas aeuroginosa bacterials shows the antibacterial activity in table.3 for iron oxide nanoparticle[21].

Table.3. Antibacterial activity of Iorn oxide Nanoparticles

S.No	Bacteria	Concentration	
		25 μl	50 μl
1	*Escheria coli*	3	4.5
2	*Staphylococcus aures*	2	2.5
3	*Pseudomonas aeuroginosa*	1.8	2.2

4 Conclusions

Iron oxide nanoparticles was synthesized successfully from Catharanthus roseus plant leaves. XRD result shows the formation of the cubic structure of iron oxide and their average grain size 13.68 nm. SEM study verified the excellent morphology of iron oxide due to Catharanthus roseus plant leaves. EDAX show the presented chemical component of iron. From UV-Vis analysis the energy band gap level 5.76 ev it's confirmed from Taut-Plot graph. The Photo Luminance studies confirmed emission of iron oxide. From antibacterial activities analysis, iron oxide Nanoparticles are very effective and it has good antibacterial activities and non-toxic materials. Synthesized iron oxide Nanoparticles are the very simple method and low cost and we can use for many biological applications.

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