Green synthesis and characterization of iron oxide nanoparticles using brown seaweed extract of Turbinaria ornate

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Abstract

Turbinaria Ornate is brown alga which is extremely rich in sea side and an outstanding origin of bio-active compounds. In this study, the green synthesis of iron oxide nanoparticles using brown seaweed extract of Turbinaria Ornata act as a reducing agent. The synthesized iron oxide nanoparticles were characterized by UV (Ultra Violet Spectroscopy), FTIR (Fourier Transform Infrared Spectroscopy), XRD (X-ray Diffraction) and SEM (Scanning Electron Microscopy). The antibacterial activity of iron oxide nanoparticles against human pathogens such as staphylococcus aureus and proteus. The antioxidant activity of iron oxide nanoparticles also studied. The synthesized iron oxides nanoparticles through green approaches is an environmentally safe and cost effective and it will act as a good chemotherapeutic agent to the society.

Keywords: Antibacterial activity, Antioxidant activity, Green synthesis, Iron oxide nanoparticles, *Turbinaria Ornata.*

Introduction:

Nanotechnology is one of the fast growing fields of research science. It is the science of exploitation of matters of the nano scale to produce unique products with extensive potentials to change society [1, 2]. Nano materials distribute with the application of matters in nano scale at minimum one external dimension 1-100nm. The synthesized nano particles have particular properties. They are used in various applications such as catalyst, pigment, sensors, data storage etc., [3, 4]. The application of nano materials environmentally friendly, non-toxic and safe reagents. . Nano particles are also studied for possible applications as for delivery of biologically active substances. Various biological systems, such as yeast, fungus, bacteria, marine algae extracts and plant extracts are now largely employed in green synthesis approaches for the production of Nano particles [6].

Iron oxide nanoparticles are multi-function compound, which have many biomedical properties, including antimicrobial activity and they are used in the targeted drug delivery, cancer hyper thermal treatment, prevention of microbial contamination [7].

Classically seaweed is a readily available food source that has been consumed by coastal areas and many countries in southeast-Asia. Marine macro algae or seaweed, are plant like organisms are classified by their pigmentation [8]. *Turbinaria Ornata* also called as brown algae was chosen for the synthesis of Iron Oxide nano particles. Since it is common in tropical and subtropical oceans. This brown algae contains a variety of bioactive substances, including saponins, poly phenols, tannins, and alkaloids.

Iron oxides are easily available in nature and play an important role in many biological and geological purposes. They are used as many field such as, pigments, catalysts and present in hemoglobin. Iron oxide are preferred as a biomedicine because they are biocompatible and non-toxic to human and easily degradable [9]. Iron oxide nanoparticles are used in cancer therapy that has the potential to destroy or arrest the growth of cancer cells and can be thought as therapeutic strategy against cancer [10]. Here we present the work report green synthesis and characterization of iron oxide nanoparticles and their antibacterial properties.

Material and methods

Collection of seaweed

Brown seaweed of *Turbinaria Ornata* was collected from CSMCRI, Mandapam, and Ramanathapuram - District.

Fig 2.1 *Turbinaria Ornata*

Preparation of brown seaweed extract of *Turbinaria Ornata*

Seaweed is freshly washed with tap water then distilled water to remove all unwanted particles then dried at room temperature for 3 weeks. The dried seaweed were grounded to fine particles and stored at room temperature. The 5 gm of finely powdered *Turbinaria Ornata* added to 100 ml distilled water and heated at 60°C for 15 mints. Then the extract were filtered through filter paper and used for further experiments.

Fig 2.2 Dried seaweed

Fig 2.3 Seaweed powder

Fig 2.4 Preparation of seaweed extract

Fig 2.5 Filtration of seaweed

Preparation of ferric chloride solution:

100 ml of Ferric Chloride ($FeCl_3 \cdot 6H_2O$) Solution was prepared using distilled Water

Fig 2.6 Preparation of Ferric chloride solution

Preparation of iron oxide nanoparticles

A solution of ferric chloride was prepared. To this solution NaOH was added to adjust the pH of solution followed by the addition of seaweed extract with constant stirring on magnetic stirrer. Brown coloured precipitate was formed in the solution. Formed precipitate was then collected by filtering this solution. The obtained precipitate was in oven and stored for further use.

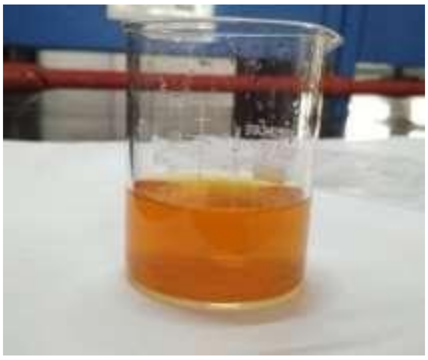

Fig 2.7 Ferric chloride solution

Fig 2.8 Seaweed extract

Fig 2.9 IONPs solution

Fig 2.10 Preparation of IONPs

Fig 2.11 Iron oxide nanoparticles

Result and discussion

Characterization of iron oxide nanoparticles

UV–Visible spectrophotometric analysis of iron oxide nanoparticles:

The bio reduction of metallic element ions in aqueous solutions was monitored by measurement UV/Vis spectra. In order to examine the absorption spectra of green synthetic Iron oxide nanoparticles, UV/Vis spectral analysis at a wavelength range of 200-1100 nm was performed. As previously reported, the excitation of surface Plasmon vibrations in Fe_2O_3NPs caused the absorption peaks to be found at 300-400 nm ranges (Kaviya et al., 2011). Due to the stimulation of surface Plasmon vibrations in the iron oxide nanoparticle solution, an absorption peak was seen between 244 and 365 nm regions, which is equivalent to the properties of iron oxide nanoparticles.

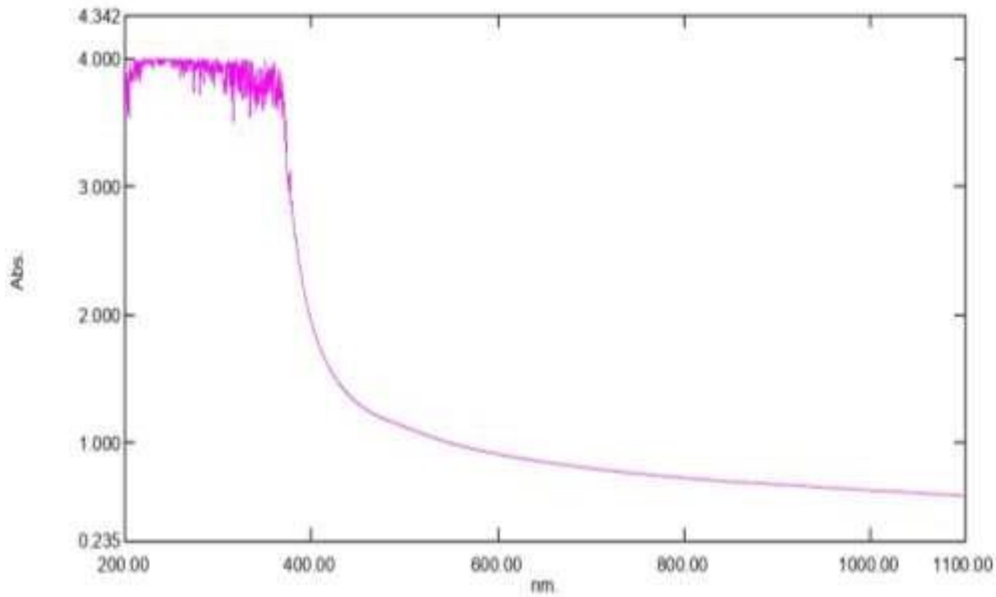

Fig 3.1 UV analysis of iron oxide nanoparticles

FT-IR analysis of iron oxide nanoparticles

FT-IR analysis of synthesized iron oxide nanoparticles gave the stretching vibrations at 3601cm-1, 2883 cm-1 and 1689 cm-1 with in the region of 500-4000 cm-1 (Figure 3.2). The peak at 3601cm-1 corresponds to the –OH stretching frequency, 2883 cm-1 corresponds to the C-H stretching vibrations, 1689 cm−1 for conjugated carbonyl (–C=O) group stretching vibrations. The identified functional groups are found in previous FT – IR analysis of iron oxide nanoparticles. It has been noted that, in the IR spectra of iron oxide nanoparticles, the bands observed between 422-578 cm^{-1} have been evaluated magnetite. In the recorded IR spectrum (Figure 4.2), the bands recorded in 422 cm-1, 516 cm-1 and 578 cm-1, could be the different forms of iron oxide nanoparticles.

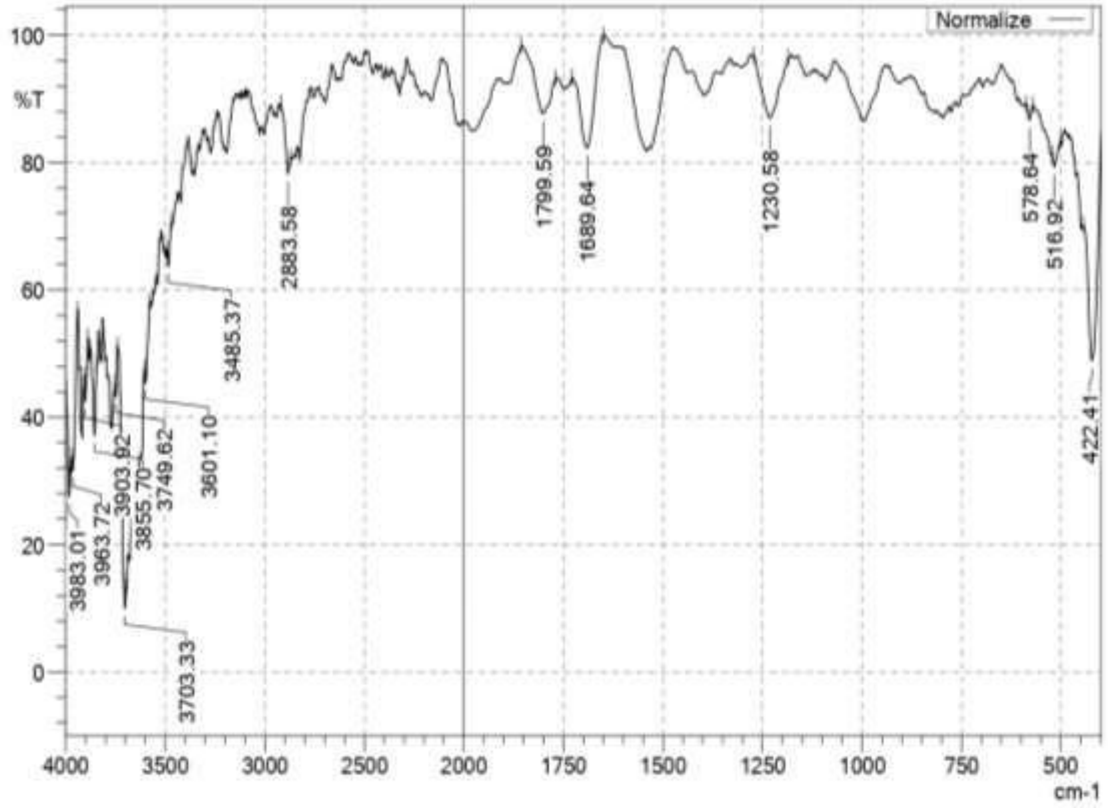

Fig 3.2 FTIR analysis of iron oxide nanoparticles

XRD analysis of iron oxide nanoparticles

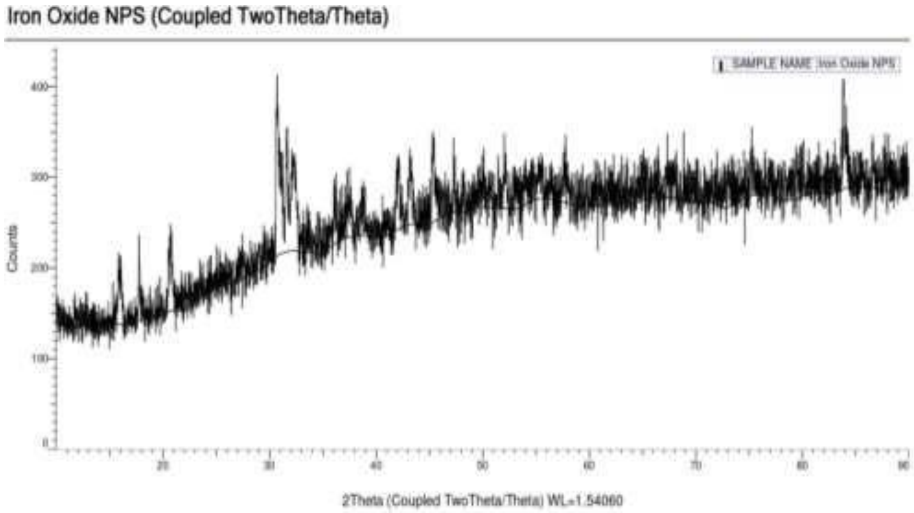

Fig 3.3 XRD analysis of iron oxide nanoparticles

One characterization technique that is widely acknowledged as being crucial to nanoparticle research is XRD analysis [45].Similar XRD peaks of iron oxide nanoparticles obtained by green synthesis have been sometimes labeled for a different form. Demirezen *et al.* reported that the XRD peaks 16° and 21° correspond to the crystal face reflection of γ-Fe_2O_3[12]. Liu *et al.* also recorded that the XRD peaks at 14°, 27°, and 49° indicate the lepidocrocite form [13]. Bhuiyan *et al.* also identified the 26.16°, 35.12°, 35.12°, 36.63°, 40.64° peaks for α-Fe_2O_3 nanoparticle [49]. The XRD pattern [Fig. 3.3] of iron oxide nanoparticle showed peaks at 15.8°, 17.7°, 20.7°, 30.73°, 31.6°, 32.23°, 42.08° , 45.35° , 48.14° and 83.85°. These results confirmed the multiform of the iron oxide nanoparticles formed by the reduction method using brown seaweed extract of *Turbinaria Ornata*. The two distinct peaks at 2θ (°) = 16.6°, and 24.01° which corresponds to phase planes of (111), and (211), respectively, could indicate the γ-Fe_2O_3 form of the nanoparticle. The XRD peaks at 15.8°, 20.7°, 31.6°, 42.08° and 45.35° with the plane of (111), (211), (311), (411) and (420) are the indicators of the α-Fe_2O_3 nanoparticle. The crystallinity of iron oxide nanoparticles are 45.6%. The average crystalline size of the nanoparticle is 3nm.

SEM analysis of iron oxide nanoparticles

Morphological screening of synthesized nanoparticles is important in terms of composition and size analysis and SEM analysis was used for this study. SEM images of the synthesized product are presented in Fig 3.4(a) with a magnification of 5.00K, Fig 3.4(b) with a magnification of 50.00 K, Fig 3.4(c) with a magnification of 10.00 K and Fig 3.4(d) with a magnification of 40.00 K. The particle size was determined in the range of 1–3nm. The figure 4.5 indicate that the nanoparticles get agglomerated and multiform. Building blocks of various bioactive reducing agents, lower capping ability of leaf extract, H-bonding presented in bioactive molecules could be the reason for the agglomeration of the nanoparticles [14-17].

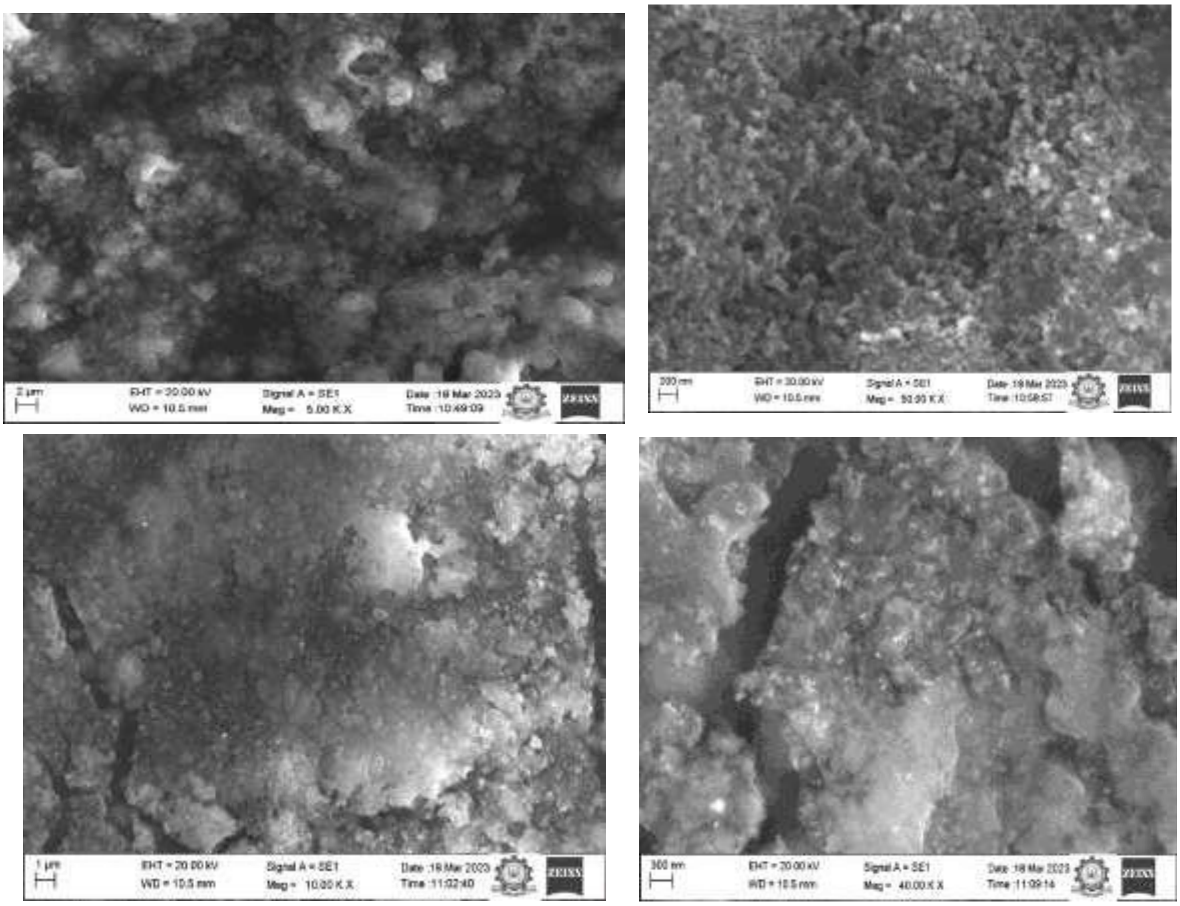

Fig 3.4 SEM analysis of iron oxide nanoparticles

Antibacterial activity of iron oxide nanoparticles

The bioactive compounds present in brown seaweed extract and iron oxide nanoparticles of *Turbinaria Ornata* were tested for its antibacterial activity against clinical pathogens such as *proteus* and *S.aureus* among two pathogens were tested. *Proteus and S.aureus* was found to be more susceptible to the bioactive compounds of the iron oxide nanoparticles with the zone size of 15mm and 10mm. The inhibitory activity of the bioactive substances was found to be more against *proteus* species when compared to *S. aureus*.

Fig 3.5 Inhibition of IONPs against *proteus*

Fig 3.6 Inhibition of IONPs against *S. aureus*

Antioxidant activity of iron oxide nanoparticles

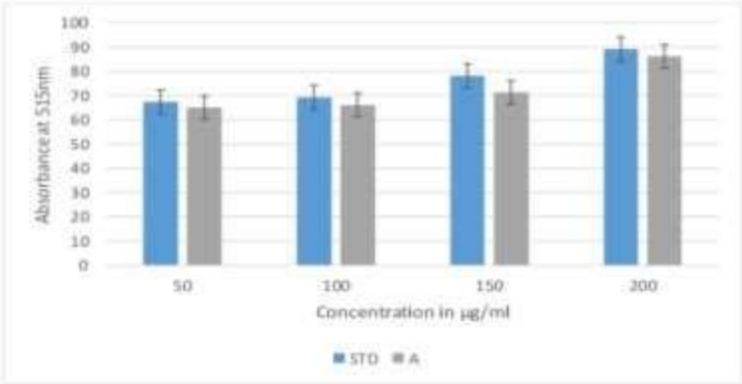

Fig 3.7 DPPH free radical scavenging activity of the IONPs

Table 3.1 Antioxidant activity of iron oxide nanoparticles

Samples in %	Concentration in µg/ml			
	50	100	150	200
Standard sample	67.41±0.05	69.32±0.01	78.2±0.01	89.1±0.01
IONPs	65.13±0.11	66.12±1.05	71.27±0.15	86.15±1.05

Reactive oxygen species (ROS), which can result in oxidative damage, are defended against by antioxidants in cells. The antioxidant activity was calculated using the IC50 value. The IC50 value shows the antioxidant concentration required to reduce free radicals by 50%. The lower the IC50, the better the scavenging activity of antioxidant samples [18-20]. Fig 3.7 shows the antioxidant activity of various concentrations of IONPs (1.05–86.15 µg/ml). At the highest concentration (86.15 µg/ml), IONPs showed the potent DPPH radical scavenging of 72%, while standard ascorbic acid showed 76% antioxidant activity.

The results show the DPPH scavenging ability of biosynthesized IONPs showed IC50 values of 70.17µg/ml. Previous studies supported that IONPs has excellent anti-oxidant activities [20-23]. As a result, it was suggested that IONPs scavenge free radicals by giving DPPH radicals electrons or transferring hydrogen atoms. As a result, it can halt the oxidation process and prevent oxidative damage on proteins, nucleic acids, carbohydrates and lipids [24-25]. Therefore, IONPs' potential antioxidant action may prove beneficial in the future as agents against cancer and other harmful illnesses.

Conclusion

Green synthesis of iron oxide nanoparticles using brown seaweed extract of*Turbinaria Ornata* is a promising method for obtaining environmentally friendly. Iron oxide nanoparticles were synthesized using brown seaweed extract of *Turbinaria Ornata* as a reducing and stabilizing agent. The synthesized iron oxide nanoparticles were characterized by UV spectroscopy, FTIR spectroscopy and morphology and size of the iron oxide nanoparticles were studied using SEM and XRD techniques. FTIR measurements confirmed the functional group of the iron oxide nanoparticles. The synthesized Iron oxide NPs were tested for antibacterial activity against human pathogens such as *S.aureus* and *proteus*. The antioxidant activity of iron Oxide nanoparticles were determined. The synthesized iron oxide nanoparticles are therefore a promising alternative treatment for pharmaceutics and biological applications. To employ the environmentally friendly manufacturing of nanoparticles as nano medicine, more research is required.

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