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# GREEN SYNTHESIS OF IRON NANOPARTICLES USING PLANT EXTRACTS

**Sneha Shah[1], Sumita Dasgupta[1],* Mousumi Chakraborty[2], Raji Vadakkekara[2], Murtaza Hajoori[1]**

[1]Bhagwan Mahavir College of M. Sc. Biotechnology, Surat – 395 007, Gujarat, India.
[2]Department of Chemical Engineering, S. V. National Institute of Technology, Surat – 395 007, Gujarat, India.

**ABSTRACT**

Iron nanoparticles (Fe NPs) are gaining importance for their uses in environmental remediation technologies. In the present investigation Fe NPs were synthesized by green route using extracts of different parts of plants like *Euphorbia milii, Tridax procumbens, Tinospora cordifolia, Datura innoxia, Calotropis procera* and *Cymbopogon citratus* (lemon grass tea). Fe NPs were generated by reaction of ferric chloride ($FeCl_3$) solution with plant extracts. The reductants present in the plant extracts act as reducing and stabilizing agent. The sizes of NPs were measured using dynamic light scattering (Malvern Zetasizer). Synthesized nanoparticles were characterized using particle size analyzer, UV-vis absorption spectrophotometer, transmission electron microscopy (TEM) and dynamic light scattering (DLS). Dispersion destabilization of NPs was detected by Turbiscan**.** Fe NPs synthesized from the stem extracts of *Euphorbia milii*, *Tridax procumbens* and flower extracts of *Tinospora cordifolia* was found to be of considerable low size and that produced from the stem extracts of *Euphorbia milii* was of the least size ranging from 13-21nm . These ecofriendly, cost effective, stable nanoparticles synthesized from plants can therefore be used as an economic and valuable alternative for the large-scale production of Iron nanoparticles.

**Key Words**: Iron Nanoparticles**,** *Euphorbia milii*, *Tridax procumbens*, *Tinospora cordifolia*, surface plasmon resonance (SPR).

## INTRODUCTION

Nanoparticles are ultrafine particles with their size ranging from 1-100nm. Nanoparticles (NP) have attracted considerable attraction due to their unusual and fascinating properties, with various applications, over their bulk counterparts (Daniel and Astruc, 2004**;** Kato, 2011). Although chemical and physical methods may successfully produce pure, well-defined nanoparticles but these are quite expensive and potentially dangerous to the environment. Use of biological organisms such as microorganisms, plant extract or plant biomass is an alternative to chemical and physical methods for the production of nanoparticles in an eco-friendly manner (Sastry *et al*., 2004; Bhattacharya *et al*., 2005**;** Mohanpuria *et al*., 2008**)**. Synthesis of metal NPs using plant extracts is very cost effective, so can be used as an economic and valid alternative for the large-scale production of metal nanoparticles (Huang *et al*., 2007). The bioreduction of metal NPs by combinations of biomolecules found in plant extracts such as enzymes, proteins, amino acids, vitamins, polysaccharides, typically obtained by contact of a broth of plant with metal salts, has been intensively investigated in recent years (Iravani, 2011**)**. Iron, as a nanoparticle has been somewhat neglected. This is unfortunate, but understandable, extreme reactivity has traditionally made iron nanoparticles difficult to study and inconvenient for practical applications. Iron however has a great deal to offer at the nanoscale, including very potent magnetic and catalytic properties. Recent work has begun to take

Corresponding Author

**Sumita Dasgupta**
Email: sumitarup@gmail.com

advantage of iron's potential, and work in this field appears to be blossoming (Huber, 2005). In the present investigation, the aqueous extracts of leaves, stem and flower of *Euphorbia milli*, *Datura innoxia, Calotropis procera* , *Tinospora cordifolia* , *Tridax procumbens* and leaves of *Cymbopogon citratus* were studied to evaluate their potential in the synthesis Fe NPs .

## MATERIALS AND METHODS

The plants selected for the study were collected from different regions of South Gujarat.

### *Biosynthesis of Nanoparticles using Plant Extract*

20gms of leaves, 10 gms of stem and 2 gms of flower were thoroughly washed with running water to remove the dust particles present on the plant and then with double distilled water. They were dried using blotting paper, cut into fine pieces using a sterilized blade and crushed in a mortar with pestle. The crushed materials were then boiled with 100 mL distilled water at $80^0$C for 5-10mins, cooled and filtered using Whatman No. 1 filter paper. 5mL of the prepared plant extract was added to 5 ml of 0.001 M Ferric Chloride at a temperature of about 50-$60^o$C (Pattanayak and Nayak,2013) . A change in colour from faint yellow to brownish yellow and finally dark blue after certain time period indicates the formation of Fe NPs.

### *Characterization of Nanoparticles*

The size distribution and average particle size of Fe NPs were obtained using particle size analyzer. The sizes of NPs were measured using dynamic light scattering (Malvern Zetasizer, Nano ZS 90, U.K.).The absorption spectra of Fe NPs were analyzed at different time interval by UV-Vis spectrophotometer (HACH, Germany). TEM images were obtained with a Philips Tecnai – 20, which at 200 kV provides 0.27 nm point resolution. The stability of the NPs was analysed by turbiscan. The stability of dispersion can be viewed in terms of the propensity for aggregation and in redispersibility of the final particles. Iron nanoparticles were scanned from bottom (0 mm) to the top of the vial (~70 mm) for a period of 20 min. Scanning was performed at different time intervals upto 48 h.

## RESULT AND DISCUSSION

The stem extracts of *Euphorbia milii, Tridax procumbens* and flower extracts of *Tinospora cordifolia* was found to be the most suitable for generation of Fe NPs with lesser size. The size distribution and average particle size of Fe NPs were obtained using particle size analyzer. It was observed that the size of Fe NPs were within a range of 13-342nm [Table 1]. Fe NPs generated from the stem extract of *Euphorbia milli* was found to be having the least size ranging between 13-21nm [FIG. 3]. The stem and leaf extracts of *Calotropis procera* did not produce nanoparticles of appreciable size. Leaf extract of *Euphorbia milli*, flower and leaf extract of *Datura innoxia* failed to produce Fe NPs (Table 1). The time required for the bio-reduction of the metal ions varied from few minutes as in *Euphorbia milli* to about 24 hours as in Lemon grass tea.

Colour change was observed from yellowish brown to finally dark blue almost blackish blue colour indicating the formation of Fe NPs. More or less similar type of change in colour was noticed during the synthesis Fe NPs in previous work using Neem Plant Leaves extract (Pattanayak and Nayak,2013) .Change in colour was due to excitation of surface plasmon resonance (SPR) which is characterized by UV-VIS spectroscopy indicating formation Fe NPs ( Song and Kim, 2009). UV-VIS spectrum, known as the surface plasmon absorption band, of the individual nanoparticles is different from that of nanoparticles aggregate. The SPR of a nanoparticle aggregate is shifted to a longer wavelength as compared with SPR of the individual particles (Masarovičová and Kráľová, 2013).

In the present study the absorption peak of Fe NPs generated from the stem extracts of *Euphorbia milii, Tridax procumbens* and flower extracts of *Euphorbia milii* and *Tinospora cordifolia* as shown in FIG 1 was found to be ranging between 190 and 202 nm. The shorter UV absorption wavelength indicated that the NPs did not form aggregation.

Relatively identical UV visible spectrum was recorded by metallic iron nano particles (Alqudami and Annapoorni, 2007).

### *Stability of iron nanoparticles*

Stability test by turbiscan indicated that Fe NPs maintained a stable peak position and intensity of absorbance were not changing up to 24 h (FIG. 2).

The morphology of Fe NPs was studied by Transmission electron microscopy (TEM). TEM image of Fe NPs obtained from stem extract of *Euphorbia milli*, which were of the least size is shown in FIG. 3. It was observed that particles are distinct and scattered in distribution. They were spherical in shape with an average size of 17.11 nm.

In plants, the primary and secondary metabolism products, such as flavonoids, flavones, isoflavones, isothiocyanates, carotenoids, polyphenols that have potent biological activities are known as an important natural resource for the synthesis of metallic nanoparticles (Park *et al.*, 2011). In the present investigation the extracts of the parts of those plants yielding NPs of least size are reported to contain several phytochemicals. The plant *Euphorbia milli* is used for ornamental purpose and several secondary metabolites like Terpenoids, Flavonoids, Tannins are reported to be present in the aerial parts of the plant (Qaisar *et al*., 2012). The phytochemical screening of *Tridax procumbens* revealed the presence of alkaloids, carotenoids, flavonoids saponins and tannins (Ikewuchi *et*

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*al*., 2009). Similarly presence of several phytochemicals like phenols, flavanoids, alkaloids, saponins, cardiac glycosides, steroids, carbohydrate and proteins was reported in *Tinospora cordifolia* (Pradhan *et al*., 2013). These biomolecules might be responsible for the reduction of Ferric ions into nano forms.

The biological approach of synthesis of Fe NPs as described in the present paper using plant extracts appears to be ecofriendly and cost effective alternative to conventional chemical and physical methods and would be suitable for developing large-scale production. This Fe NPs may be used in effluent treatment process and in environmental remediation procedure. This simple, low cost and greener method for development of NPs may be valuable in environmental, biotechnological and biomedical application.

**Table 1. Particle size of Fe NPs obtained from different plant extract**

| Sr. No. | Name of Plants | Parts | Size btw (nm) |
|---|---|---|---|
| 1. | *Euphorbia milii* | Stem | 13-21 |
| | | Flower | 37-51 |
| 2. | *Tridax procumbens* | Stem | 15-32 |
| | | Leaf | 50-155 |
| 3. | *Datura innoxia* | Stem | 58-106 |
| 4. | *Tinospora cordifolia* | Stem | 43-95 |
| | | Flower | 13-59 |
| 5. | *Calotropis procera* | Stem | 122-190 |
| | | Leaf | 190-342 |
| | | Flower | 58-91 |
| 6. | Lemon grass | Leaf | 43-342 |

**Fig 1. The absortion peak of Fe NPs. A.** ***Tridax procumbens*** **(stem) B.** ***Tinospora cordifolia*** **(Flower) C.** ***Euphorbia milii*** **(stem) D.** ***Euphorbia milii*** **(flower).**

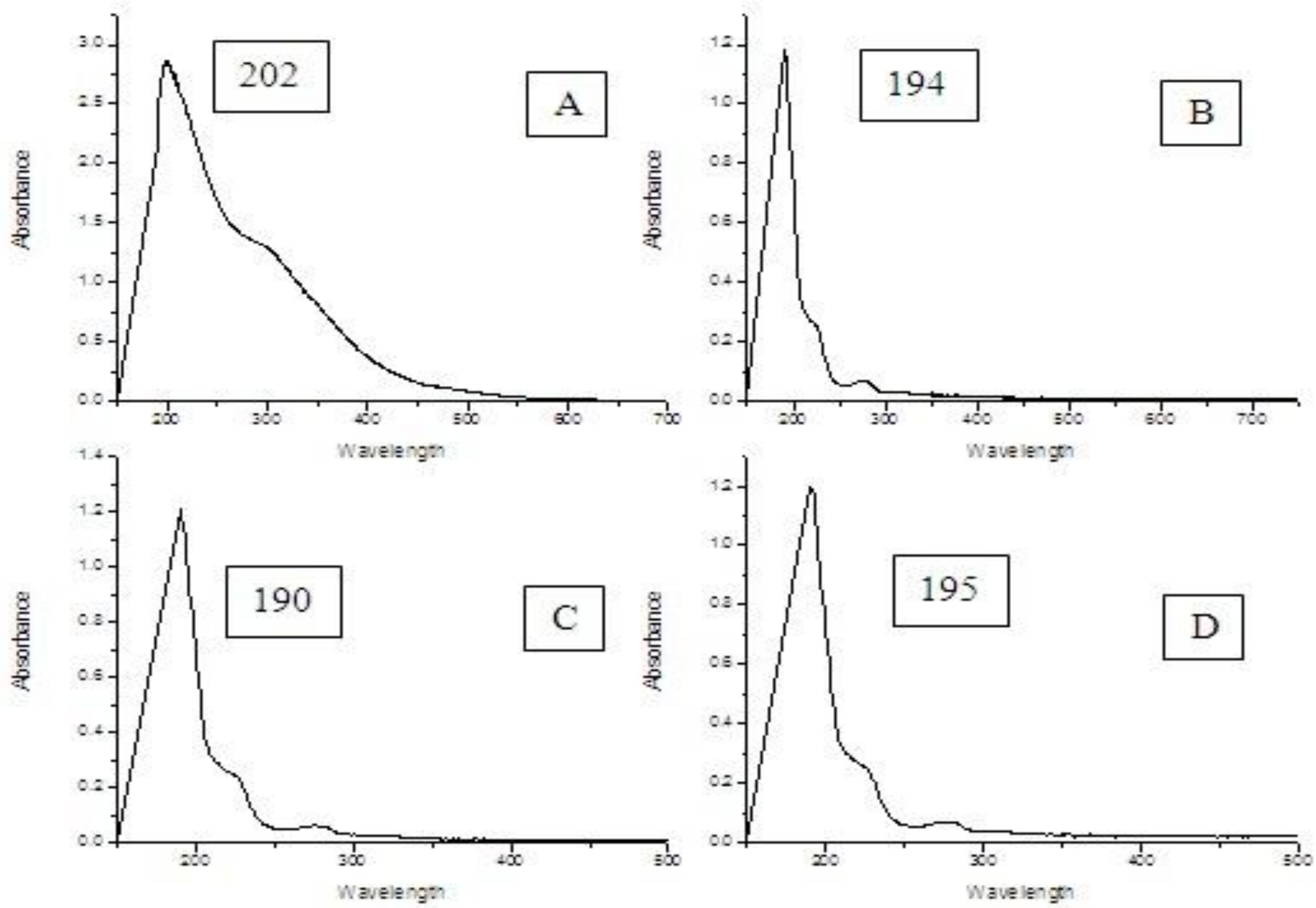


**Fig 2. BS profile of Fe NPs at different time intervals**

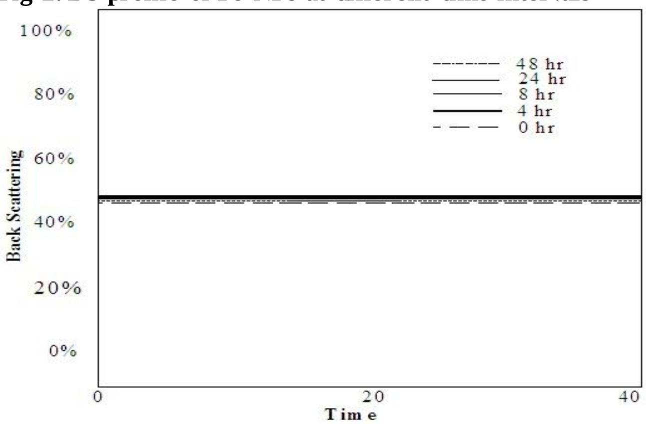
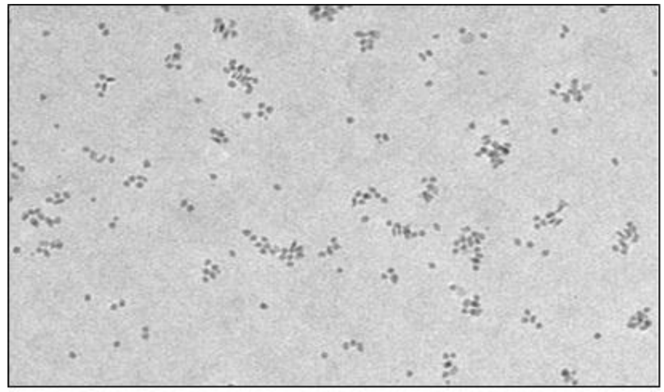



**Fig 3. TEM image Fe NPs obtained from stem extract of *Euphorbia milli***



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