International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 8
August 2017

Green synthesis of Nano Zerovalent Iron using *Glycine Max* Leaf Extracts

Ch Chandra
Department of Chemistry, National Institute of Technology, Raipur, Chhattisgarh, India
Dr. (Mrs.) Fahmida Khan
Department of Chemistry, National Institute of Technology, Raipur, Chhattisgarh, India

ABSTRACT

In this study, the nano-zerovalent iron is synthesized through green synthesis pathway with the help of leaf extracts of Glycine max. Green synthesis method is simple, cost-effective and environmental friendly technique for synthesis of nZVI particles. The FTIR studies shows that the polyphenols and carbonyl groups present in the leaf extract of Glycine max are responsible for the reduction and acts as capping agents too providing the stabilization of the nanoparticle during and after the synthesis.

KEYWORDS : Green Synthesis, nanoparticle, ecofriendly, polyphenols, capping agents

INTRODUCTION

Nanomaterials have superior properties and greater functional versatility, e.g. nanoparticles, nanowires and nanotubes. The size of nanoparticle is in the range of 1-100 nm[1]. Due to the small size, nanoparticles have unique characteristics in regards to their electrical, magnetic and optical response[4].

An important impact in all spheres of human life is attained by nanotechnology. Chemical synthesis like reduction in solutions, photochemical reactions in reverse micelles, physical methods of synthesis like thermal decomposition and radiation assisted, microwave assisted, electrochemical methods are in practice for the formation of nanoparticles[2][3].

Recently, nanoparticles are being prepared by green chemistry route or biological synthesis using plants, bacteria, fungi, etc. The use of plant leaf extract, bacteria, fungi and enzymes for the synthesis of nanoparticles is an ecofriendly way[7][8]. It is compatible to pharmaceutical and biomedical applications. This route is simple, low cost and does not require elaborated equipments. Also, plant extracts are nontoxic and environmentally friendly as compared to other methods of nanoparticles synthesis. Polyphenols present in the plant extracts were considered to be responsible for the stabilization of nZVI and serving as the reducing and capping agent[8].

So, this study aims at the synthesis of nano zero valent iron from the leaf extracts of *Glycine max* (soyabean) plant which is a rich source of isoflavones. Previous studies showed that glycine max leaves consist mostly of isoflavones such as genestein, glycetein and daidzein and they also contain kaempferol glycoside.[12][13]. Isoflavones contains polyphenols which acts as reducing as well as capping agents for the synthesis and stabilization of nZVI.

MATERIALS AND METHODS

Reagents and Chemicals

All the chemicals used in this synthesis are of analytical reagent grade and are obtained from Merck, Germany. All the chemicals are used without further purification. Various solutions in this synthesis are made with Merck Millipore water.

Preparation of Plant Extract

Leaves of Glycine max were collected from Rajnandgaon District of Chhattisgarh. Leaves are washed several times with Millipore water to remove dust particles and then dried at room temperature. Leaves are then crushed in to fine powder with mortar and pestle and then used for preparing its extract. 3 g of dried powdered leaves of glycine max were takenin RB Flask with 50 ml Millipore water and then heated at 70°C with stirring at 500 rpm for 1 h in Tarson's Digital Spinot. After cooling at room temperature, solution was filtered with Whatmann filter paper no. 42. The filtrate obtained was stored at 4°C overnight for further synthesis of nanoparticles.

Green Synthesis of nZVI from Glycine max

0.1 M $FeCl_3.6H_2O$ solution was prepared by adding 1.35 g of solid $FeCl_3.6H_2O$ in 50 ml of Millipore water. 0.1 M $FeCl_3.6H_2O$ solution prepared was then added to glycine max plant extract in the ratio of 1:1 turning the solution from light green to black, the solution was then further heated at 70°C with stirring at 500 rpm for half an hour in Tarson's Digital Spinot. The solution obtained was then centrifuged at 10000 rpm for 30 minutes in Sigma 3-30 KS high speed centrifuge. The supernatant liquid was then removed and the precipitate was washed with Millipore water and then with ethanol and then dried in hot air oven.

RESULTS AND DISCUSSION

Characterization of the synthesized Nanoparticles

Reduction of Fe(III) to Fe(0) immediately leads to the change in the color of solution from light green to black along with the reduction in pH which indicates the formation of nanoparticle. During the synthesis, it was seen that the pH of the solution of plant extract changes from lower acidic pH 6.2 to higher acidic pH 1.7 on reduction of $FeCl_3.6H_2O$ solution.

Table 1. Change in color and pH during the synthesis of nanoparticle

Plant Extract		Plant Part	Color and pH Change		Result
			Before	After	
Binomial Name	Common Name	Leaves	Light Green	Black	Positive
Glycine max	Soyabean		6.2	1.7	Positive

UV Visible Spectral Analysis

UV Visible Spectral analysis of synthesized nanoparticle was done through Labtronics Double Beam UV-Visible spectrophotometer at a range of 200 to 400 nm for monitoring the reduction of Fe(III) to Fe(0) nanoparticle. Excitation of surface Plasmon vibrations in Fe nanoparticle solutions results in the absorption peak at 290 nm.

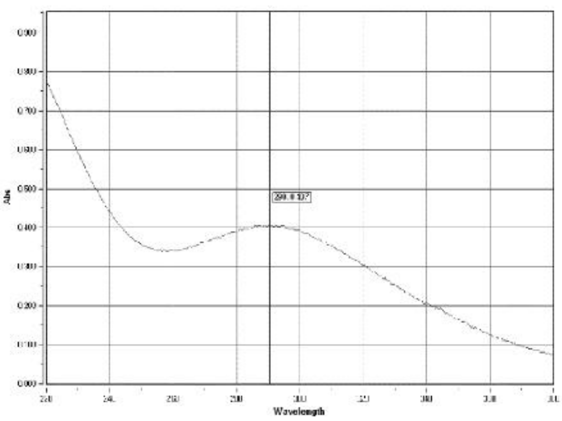

Fig.1: UV-Visible spectra of green synthesized GM-Fe Nanoparticle

FTIR Analysis

FTIR Analysis is done to determine the functional groups responsible for the reduction and acting as capping agents in the nanoparticle for providing the stability. There is a prominent peak in the range of 3200-3550 corresponding to the polyphenols and it is seen that these phenolic groups are responsible for reducing Fe(III) to Fe(0). Delocalization of unpaired electrons takes place in these phenolic groups which is responsible for the radical scavenging nature of any plant extract. Hence, the antioxidant activity of any plant extract depends upon the number of phenolic -OH groups present in the plant extracts.

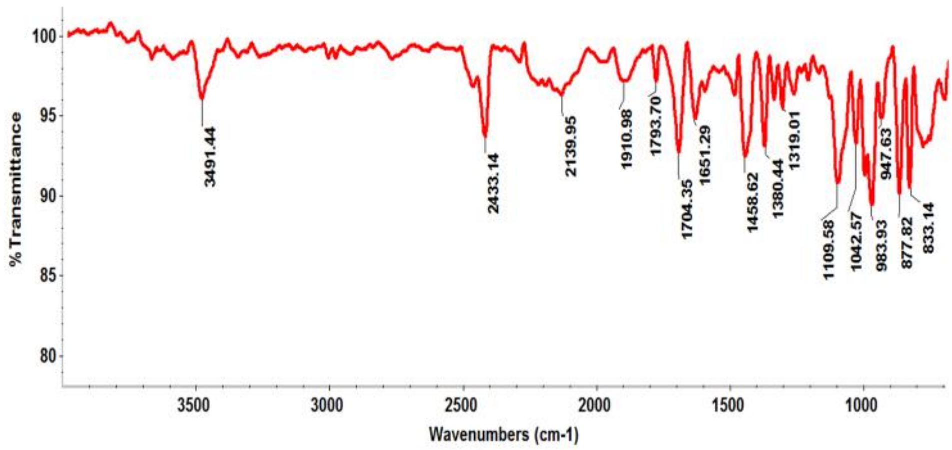

Fig.2: FTIR Spectra of synthesized GM-Fe Nanoparticle

Another strong peak occurs in the range of 1700-1800 cm^{-1} corresponding to the carbonyl group which is heterocyclic group in plant extracts. Carbonyl groups are also known to be responsible for reduction during the synthesis and also providing stability to the nanoparticle by acting as capping agents.

Peaks between 850-950 cm^{-1} corresponds to –C=H and $–CH_2$ bending in the aromatic groups present in the plant extract which are being adsorbed by the nanoparticle in the form of polyphenols during its synthesis. All these groups present in the surface of nanoparticle acts as stablizing agents after its synthesis.

Table 2. Prominent peaks and corresponding functional groups in FTIR spectra of GM-Fe Nanoparticle

GM-Fe Peaks(cm^{-1})	Intensity	Functional Groups	Compounds Indicated
3491.44	Str	O-H(H-bonded) stretch	Polyphenols
1910.98	Str	C=C asymmetric stretch	Alkenes
1793.70	Str	C=O stretch	Carbonyl Compounds
1704.35	Str	C=O (H-bonded)	Carbonyl Compounds
1651.29	Var	C=C(Symmetric)	Alkenes
1458.62	Med	CH_2 and CH_3 deformation	Alkanes
1380.44	Med	O-H bending (in plane)	Polyphenols
1319.01	Med-str	O-C stretch	Ethers
1109.58	Str	C-O stretch	Carbonyl Compounds
1042.57	Str	C-O stretch	Carbonyl Compounds
983.93	Str	C-O stretch	Carbonyl Compounds
947.63	Str	$=C-H$ and $=CH_2$ bending	Aromatics
877.82	Str	$=C-H$ and $=CH_2$ bending	Aromatics
833.14	Str	$=C-H$ and $=CH_2$ bending	Aromatics

CONCLUSION

Green synthesis of iron nanoparticle through *Glycine max* leaf extract is not only an environmental friendly process but also cost effective way for the synthesis of nanoparticles with efficient stability as polyphenols in extracts themselves acts as capping and stabilizing agents and no other external capping agents are required. Also the green synthesis process does not require much use of chemical reagents and complex equipments for the synthesis.

References

[1] Environmental Protection Agency, "Nanotechnology white paper," USEPA 100/B-07/001, 2007.
[2] K. N.Thakkar, S. S. Mhatre, and R. Y. Parikh, "Biological synthesis of metallic nanoparticles," Nanomedicine, vol. 6, no. 2, pp. 257–262, 2010.
[3] S. Panigrahi, S. Kundu, S. K. Ghosh, S. Nath, and T. Pal, "General method of synthesis for metal nanoparticles," Journal of Nanoparticle Research, vol. 6, no. 4, pp. 411–414, 2004.
[4] The Energy and Resources Institute, "Nanotechnology development in India: building capability and governing the technology," Briefing Paper, TERI, 2010
[5] V. Madhavi, T.N.V.K.V. Prasad, A.V.B. Reddy, B. Ravindra Reddy, G. Madhavi, Application of phytogenic zerovalent iron nanoparticles in the adsorption of hexavalent chromium, Spectrochim. Acta Part A Mol. Biomol. Spectrosc. 116 (2013) 17–25.
[6] T. Shahwan, S. Abu Sirriah, M. Nairat, E. Boyacı, A.E. Erog˘lu, T.B. Scott, K.R. Hallam, Green synthesis of iron nanoparticles and their application as a Fenton-like catalyst for the degradation of aqueous cationic and anionic dyes, Chem. Eng. J. 172 (2011) 258–266.
[7] K.S. Prasad, P. Gandhi, K. Selvaraj, Synthesis of green nano iron particles (GnIP) and their application in adsorptive removal of As(III) and As(V) from aqueous solution, Appl. Surf. Sci. 317 (2014) 1052–1059.
[8] X. Weng, L. Huang, Z. Chen, M. Megharaj, R. Naidu, Synthesis of iron-based nanoparticles by green tea extract and their degradation of malachite, Ind. Crops Prod. 51 (2013) 342–347.
[9] L. Huang, X. Weng, Z. Chen, M. Megharaj, R. Naidu, Green synthesis of iron nanoparticles by various tea extracts: comparative study of the reactivity, Spectrochim. Acta Part A Mol. Biomol. Spectrosc. 130 (2014) 295–301.
[10] S. Machado, W. Stawin´ ski, P. Slonina, A.R. Pinto, J.P. Grosso, H.P.A. Nouws, J.T. Albergaria, C. Delerue-Matos, Application of green zero-valent iron nanoparticles to the remediation of soils contaminated with ibuprofen, Sci. Total Environ. 461–462 (2013) 323–329.
[11] T. Wang, J. Lin, Z. Chen, M. Megharaj, R. Naidu, Green synthesized iron nanoparticles by green tea and eucalyptus leaves extracts used for removal of nitrate in aqueous solution, J. Clean. Prod. 83 (2014) 413–419.
[12] J.H. Lee, T.J. Ha, I.-Y. Baek, J.-M. Ko, K.M. Cho, M.-H. Im, M.-G. Choung, J. Korean Soc. Appl. Biol. Chem. 52(2), 139–143 (2009)
[13] Y. Murai, R. Takahashi, F.R. Rodas, J. Kitajima, T. Iwashina, Nat. Prod. Commun. 8(4), 453–456 (2013)