International Journal of Chemistry and Pharmaceutical Sciences

Journal Home Page: www.pharmaresearchlibrary.com/ijcps

Research Article **Open Access**

Green Synthesis of Zinc Nanoparticles using Punica granatum Fruit Extract and their Structural and Optical Properties

R. Rajakumari[*1], [1]S. Kalaiarasi, [2]L.Parimala

[1]*PG and Research Department of Physics, Queen Mary's College (Autonomous), Chennai, Tamil Nadu, India*
[2]*Annai Violet College of Arts & Science, Chennai, Tamil Nadu, India*

A B S T R A C T

The Zinc nanoparticles were prepared with the fruit extract of *Punica granatum* via green synthesis. Though physical and chemical methods are more popular for nanoparticle synthesis, the biogenic production is a better option due to eco-friendliness. The structural and optical properties of the synthesized sample were characterized by XRD, UV-absorption, Photoluminescence (PL) and FTIR analysis. XRD analysis put forward that the particles were crystalline in nature. The UV-visible analysis showed band around 256.5 – 276 nm which was identified as "surface Plasmon resonance band" and this band is ascribed to excitation of valence electrons of Zn arranged in the nanoparticles (nanocrystal /nanosphere). The PL spectrum showed green emission of the synthesized sample. FTIR analysis identified the possible functional groups in biomolecules responsible for the reduction of Zn^{2+} and capping agent of bioreduced Zn nanoparticles through particular bond vibrations peaks coming at defined wave numbers.

Keywords: Green synthesis, Zn nanoparticles, *Punica granatum*

A R T I C L E I N F O

CONTENTS

Article History: Received 18 May 2016, **Accepted** 15 June 2016, **Available Online** 27 August 2016

***Corresponding Author**
R. Rajakumari
PG and Research Department of Physics,
Queen Mary's College (Autonomous),
Chennai, Tamil Nadu, India
Manuscript ID: IJCPS3017

PAPER-QR CODE

Citation: R. Rajakumari, *et al.* Green synthesis of Zinc nanoparticles using *Punica granatum* Fruit Extract and their Structural and Optical properties. *Int. J. Chem, Pharm, Sci.*, 2016, 4(8): 395-398.

1. Introduction

The widespread practical application of metal nanoparticles (particles less than 100 nm) is attributable to a number of their unique properties [1-4]. Different physical and chemical processes are currently widely used to synthesize metal nanoparticles, which allow one to obtain particles with the desired characteristics [5-8]. However, these production methods are usually expensive, labor-intensive, and are potentially hazardous to the environment and living organisms [9,10]. Thus, there is an obvious need for an alternative, cost-effective, safe and environmentally sound method of nanoparticle production [11-13]. During the past decade, it has been demonstrated that many biological systems, including plants and algae [14], diatoms [15,16], bacteria [17], yeast [18], fungi [19], and human cells [20] can transform inorganic metal ions into metal nanoparticles via the reductive capacities of the proteins and metabolites present in these organisms. It is significant that the nanoparticle production using plants described in various studies display the advantages over other biological systems.

The low cost of cultivation, short production time, safety make plants an attractive attractive platform for nanoparticle synthesis [21]. It has long been known that plants are able to reduce metal ions both on their surface and in various organs and tissues remote from the ion penetration site. In this regard, plants (especially those which have very strong metal ion hyper accumulating and reductive capacity) have been used for extracting precious metals from land which would be economically unjustifiable to mine; an approach known as phytomining.

The metals accumulated by the plants can be recovered after harvesting via sintering and smelting methods. Interestingly, study of the metal bioaccumulation process in plants has revealed that metals are usually deposited in the form of nanoparticles. In the present study, synthesis of Zinc nanoparticles has been reported, reducing the Zinc ions present in the Zinc nitrate solution by the aqueous extract of *Punica granatum* fruit extract. Further, these biologically synthesized nanoparticles were found to be potential candidate in the field of optoelectronics.

2. Experimental

Materials

Chemicals used in the present study were of highest purity and purchased from Merck (Mumbai, India). *Punica grantanum* fruits (Kabul variety) were purchased from local market Chennai, Tamil Nadu, India.

Preparation of plant extract and the synthesis of Zinc nanoparticles: *Punica grantanum* fruit, weighing about 200 g was thoroughly washed in distilled water. The arils were taken out, and then gently squeezed without causing any damage to the core of the seeds. Zinc nitrate (0.5 g) was added with 5 ml of fruit extract and stirred magnetically for 2 hours at room temperature. When Zinc nitrate was added to fruit extract, an immediate colour change was observed, that is the mixture turned into deep pink in colour (Figure 2.1). The mixture was repeatedly centrifuged without adding alcohol & distilled water into it. The resultant solution was filtered and dried in an oven for an hour at 100^{o}C to get Zinc nanoparticles.

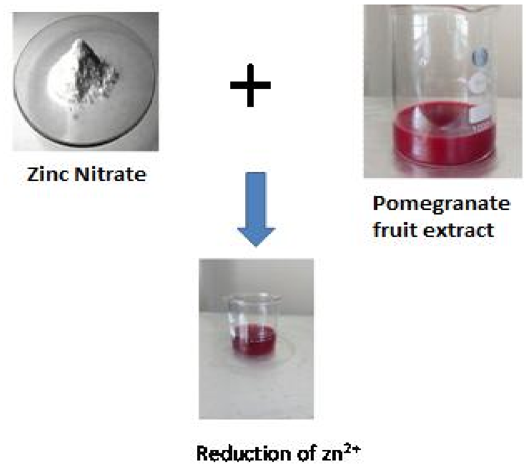

Figure 2.1: Schematic illustration of reduction of Zinc using *P.granatum*

3. Results and Discussion

3.1 X-ray diffraction analysis:

The XRD pattern of dried mixture of Zinc nanoparticles was taken by X-ray diffract meter with CuKα radiation in a θ - 2θ configuration. Figure 1 shows the XRD pattern of green synthesized Zinc nanoparticles. Figure 1 shows the XRD spectrum of purified sample of Zinc nanoparticles. The peaks observed in the XRD pattern at 2θ values of 18.71^{o}, 22.57^{o}, 30.20^{o}, 35.06^{o}, 40.49^{o},43.43^{o} and 48.35^{o} corresponds to (101), (102), (110), (112), (202), (203) and (211) planes of Zinc respectively. Some unidentified peaks were also observed near the characteristic peaks. A peak at 27.79^{o} is possibly due to crystalline nature of the capping agent. This clearly shows that the Zinc nanoparticles are crystalline in nature due to reduction of Zn^{2+} ions by *Punica grantanum* fruit extract. XRD pattern coincides with the hexagonal crystal structure of Zinc with lattice parameters, a = b = 2.670A^{o}, and c = 4.966 A^{o}. The crystallite size calculated from the prominent peaks using Scherer formula is 45 nm.

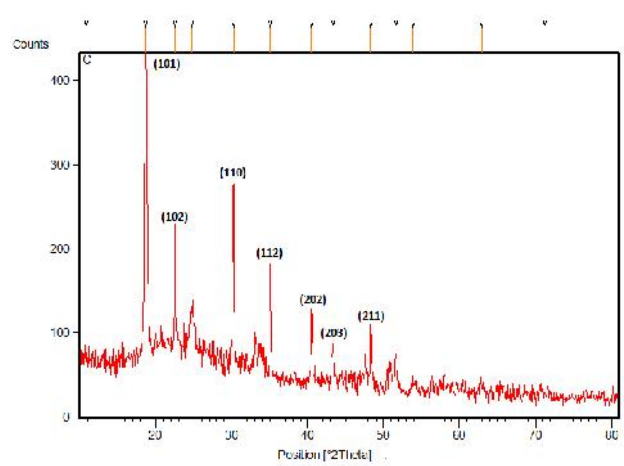

Figure 3.1: Shows the XRD spectrum

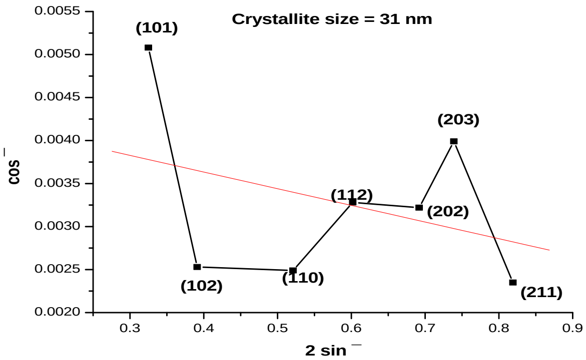

Figure 3.1.1: W-H plot of green synthesized Zinc nanoparticles

3.1.1 Williamson Hall Plot

Williamson and Hall proposed a method for deconvoluting size and strain broadening by looking at the peak width as a function of 2θ. W-H plot is shown in Figure 3.1.1. It is plotted with 2 sinθ on the x-axis and β cos θ on the y-axis (in radians). The W-H plot shows anisotropy in broadening due to anisotropy in shape and size of the nanoparticles. The crystallite size extracted from W-H plot in 31 nm and the strain is 0.001.

3.2 UV-Vis spectral analysis:

Electromagnetic radiation such as visible light is commonly treated as a wave phenomenon, characterized by a wavelength or frequency. UV–Vis spectroscopy is an important technique to establish the formation and stability of metal nanoparticles in aqueous solution. The relationship between UV-visible radiation absorbance characteristics and the absorbate's size and shape is well-known. Consequently, shape and size of nanoparticles in aqueous suspension can be assessed by UV-visible absorbance studies. The UV-Vis absorption spectrum of as-synthesized sample of Zinc nanoparticles is shown in Figure 3.2. The absorption wavelength at about 274 nm of Zinc nanoparticles suggested the excitonic character at room temperature. The less intense absorption peat at 529 nm is due to pink coloring of the synthesized sample. As postulated by Mie's theory, spherical nanoparticles results in a single Surface Plasmon Resonance (SPR) band in the absorption spectra. On the other hand, anisotropic particles provide two or more SPR bands depending on the particle shape. In the present study, a reaction mixture confirms two SPR bands disclosing anisotropic particles present in Zinc.

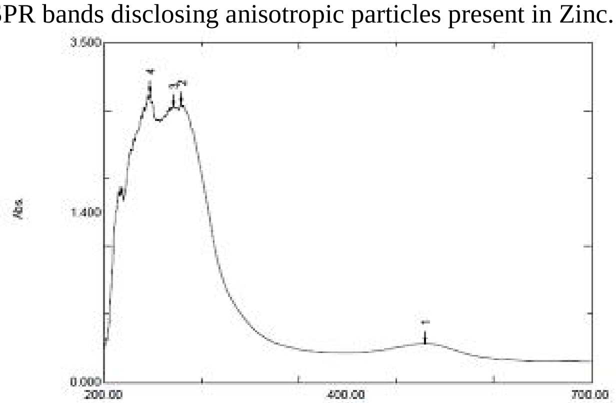

Figure 3.2: UV-Vis absorption spectrum of Zinc nanoparticles

3.3 Photoluminescence Analysis:

Photoluminescence (PL) study was performed to emphasize its emission properties. The PL spectrum of Zinc is shown in Figure 3.3. Green emission at 549 nm is observed for Zinc, when it is excited with the wavelength of 300 nm. The emission peak in the in the visible range is a good indication that the synthesized sample is luminescent and also shows its potential application in the field of optoelectronics.

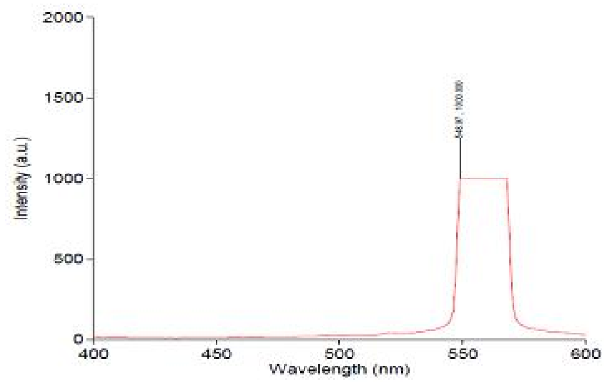

Figure 3.3: Photoluminescence spectrum of Zinc nanoparticles

3.4 FTIR Analysis:

FTIR Spectrum of Zinc nanoparticles prepared from the *Punica granatum* fruit extract was carried out to identify the possible biomolecules responsible for capping and efficient stabilization of the metal nanoparticles synthesized by fruit extract (Figure 3.4). Various modes of vibration are observed at different regions of FTIR spectrum. The peaks at 4,000 and 500 cm^{-1} observed in the spectrum indicate the presence of –OH and C=O groups. The stretching at the wave number 3390 cm^{-1}shows the presence of O-H functional group with H bonded and the bending at wave number indicates the presence of NH functional groups in *punica grananum.* T*he* FT-IR spectrum suggests that the hydroxyl and carbonyl groups present in the fruit extract stabilizes the nanoparticles.

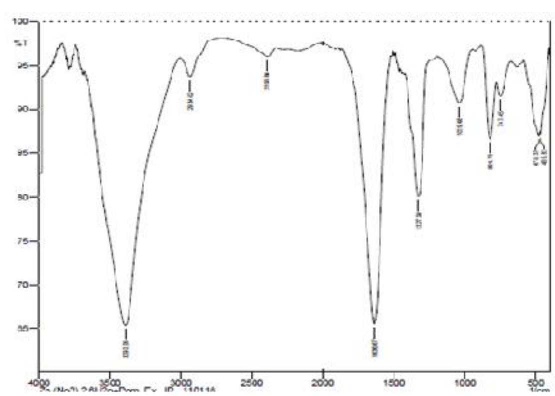

Figure 3.4 FTIR: spectrum of Zinc nanoparticles

4. Conclusion

The present study represents a simple, non-toxic as well as eco-friendly procedure for synthesizing Zinc nanoparticles. The capping around each particle provides regular chemical environment formed by the bio-organic compound present in the *Punica grantanum* fruit extract, which may be chiefly responsible for the particles to become stabilized. This technique gives us a simple and efficient way for the synthesis of nanoparticles with tunable optical properties governed by particle size. From the nanotechnology point of view, this is a noteworthy development for synthesizing Zinc nanoparticles economically. In conclusion, this green chemistry approach toward the synthesis of Zinc nanoparticles possesses several advantages viz, easy process by which this may be scaled up, economic viability, etc.

5. Acknowledgements

The first author (R.R.) acknowledges UGC (University Grants Commission), Government of India, New Delhi, India for providing financial assistance in the form of Minor Research Project. We sincerely thank Department of Physics, Alagappa University, Karaikudi, FIST, Queen Mary's College, Chennai and Department of Physics, Ethiraj College, Chennai for XRD analysis, UV, FTIR and PL analysis.

6. References

[1] D Bhattacharya, RK Gupta, Crit. Rev. Biotechnol. 2005 (25), 199.
[2] N Savithramma, ML Rao, PS Devi, J. Biol. Sci. 2011 (11), 39.
[3] M Sathishkumar, K Sneha, SW Won, CW Cho, S Kim, YS Yun, Colloids Surf. B 2009 (73), 332.
[4] A Tripathi, N Chandrasekaran, AM Raichur, AJ Mukherjee,. Biomed. Nanotechnol. 2009(5), 93.
[5] TC Prathna, N Chandrasekaran, AM Raichur A Mukherjee, Colloids Surf. B 2011(82),152.
[6] SK Sivaraman, I Elango, S Kumar, V Santhanam, Curr. Sci. 2009 (97), 1055.
[7] JY Song, BS Kim, Bioproc. Biosyst. Eng. 2009 (32), 79.
[8] A Ahmad, P Mukherjee, S Senapati, D Mandal, MI Khan, R Kumar, M Sastry, Colloids Surf. B 2003 (28), 313.
[9] A.R Shahverdi, S Minaeian, HR Shahverdi, H Jamalifar, AA Nohi, Proc. Biochem. 2007 (2), 919.
[10] SS Shankar, A Ahmad, M Sastry, Biotechnol. Prog. 2003 (19), 1627.
[11] SS Shankar, A Rai, A Ahmad, M Sastry, J. Colloid Interf. Sci. 2004 (75), 496.
[12] SS Shankar, A Rai, A Ahmad, M Sastry, Chem. Mater. 2005 (17), 566.
[13] SP Chandran, M Chaudhary, R.Pasricha, A Ahmad, M Sastry, Biotechnol. Prog. 2006(22), 577.
[14] J Huang, Q Li, D Sun, Y Lu, Y Su, X Yang, H Wang, Y Wang, W Shao, N He, J Hong, C Chen, Nanotechnology 2007(18), 105104.
[15] A Tripathy, AM Raichur, N Chandrasekaran, TC Prathna, A Mukherjee, J. Nanopart. Res. 2010 (12), 237.
[16] P Raveendran, J Fu, SL Wallen, J. Am. Chem. Soc. 2003(125), 13940.
[17] UK Parashar, PS Saxena, A Srivastava,. Dig. J. Nanomater. Bios. 2009 (4), 159.
[18] LS Nair, CT Laurencin, J. Biomed. Nanotechnol. 2007 (3), 301.
[19] YW Zhang, HS Peng, W Huang, YF Zhou, DY Yan,J. Colloid Interf. Sci. 2008 (325), 371.
[20] VK Sharma, RA Yngard, Y Lin, Adv. Colloid Interf. Sci. 2009(145), 83.
[21] El Abou - MM Nour, A Eftaiha, Al-Warthan , RAA Ammar. Arab J. Chem. 2010(3: 182), 135.