Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2021; 10(6): 274-278
Received: 13-09-2021
Accepted: 15-10-2021

Neetusha Chal Ravendran
B.Tech Biotechnology, Karpagam Academy of Higher Education, Singanallur, Coimbatore, Tamil Nadu, India

L Sivashankari
Department of Nano Science and Technology, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

R Helen Rani
Department of Nano Science and Technology, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Corresponding Author:
Neetusha Chal Ravendran
B.Tech Biotechnology, Karpagam Academy of Higher Education, Singanallur, Coimbatore, Tamil Nadu, India

Plant-mediated synthesis of zinc oxide nanoparticles using *Costus pictus* D. leaf extract and its physio-chemical properties

Neetusha Chal Ravendran, L Sivashankari and R Helen Rani

DOI: https://doi.org/10.22271/phyto.2021.v10.i6d.14298

Abstract
Plant-mediated method of nanoparticle synthesis has many advantages over conventional methods including the elimination of chemical reductants that makes it eco-friendly and cost-effective technique and the synthesized nanoparticles has tremendous scope for packaging, cosmetics, biomedical and agricultural applications. The bioactives and secondary metabolites present in the leaf extracts involve in redox reactions to synthesize ZnO nanoparticles from its bulk counterpart. In this study we have attempted to synthesize zinc oxide nanoparticles using leaf extract of *Costus pictus D.* which is commonly known as insulin plant. The synthesized zinc oxide nanoparticles were characterized for various physio-chemical properties using UV-Vis Spectroscopy, FTIR, TEM, EDAX, Dynamic light scattering and Zeta potential. The particle size analysis revealed that the ZnO-NPs formed was distributed between 50-130 nm and a sharp absorption peak at 301 nm was detected in the UV-vis region that corresponds to an optical band gap of ZnO NPs. TEM shows that the ZnO-NPs exhibit a near-hexagonal shape.

Keywords: zinc oxide nanoparticles, *Costus pictus* D., seed germination

1. Introduction

Zinc oxide nanoparticles are known for their versatile physical and chemical properties that is the result of their large surface area. The diameters less than 100 Nano meters contributes to its potential catalytic activity that promotes its application in sunscreens, UV protective garments and it also serves as a better choice of antimicrobial agent in packaging industry (Barzinjy *et al.*, 2020) [6]. In terms of agriculture, zinc is the most widespread deficient micronutrient in the soil world over and in India, 40-42 per cent cultivated lands show Zn deficiency which is causing considerable reduction in yield. Thus, there is need for zinc supplement and that when given in nano-form could ensure better nutrient use efficiency. As well, adequate Zn content in seeds can ensure higher germination, boost plant development, and enhance protection against pathogens. But ZnO nanoparticle to be more economical and cheap, an eco-friendly way of synthesis is inevitable. Apart from being economical the method of synthesis also influences the properties of ZnO NP and the real challenge comes in stabilizing the synthesized ZnO nanoparticles. Number of physical and chemical methods including laser ablation, sol-gel, hydrothermal, solvothermal, chemical and physical vapor deposition are well-established once (Darshita and sood, 2021) [14]. Though these methods are significant they have a negative edge of clinical toxicity as they involve use of toxic chemical reductants thus, in recent past, the plant-mediated green synthesis of nanoparticles are gaining importance. The green-synthesis technique offers an advantage of increased life span of NPs as the plant metabolites facilitates capping of NPs and thus resulting in enhanced chemical and physical properties. The plant sources are readily available round the year in abundance and are cost effective (Raveendran *et al.*, 2003) [20].

Extensive research work have been reported for synthesize of zinc oxide nanoparticles using leaf extracts of *Azadirachta indica* (Madan *et al.*, 2016) [13], *Agathosma betulina* (Thema *et al.*, 2015) [25], Aloe vera (Ali *et al.*, 2016) [2], *Parthenium hysterophorus* L. (Rajiv *et al.*, 2013) [19], *Vitex negundo* L. (Fu *et al.*, 2015), *Plectranthus amboinicus* (Ambika *et al.*, 2015) [4], *Pongamia pinnata* (Sundrarajan *et al.*, 2015) [4], *Dysphania ambrosiodes* (Chimal *et al.*, 2021) [3], *Tridax procumbens* (Jabeen *et al.*, 2020) [11], *Camillia sinensis* L. (Aprilly *et al.*, 2021) [5], *Justicia adhatoda* (Pachaiappan *et al., 2021), Cinnamomum tamala (Prasad et al.*, 2019), *Costus igneus* (*Nandhini et al.*, 2018) [15], *Eucalyptus globulus (Siripireddy et al.*, 2016) [23], and many more.

Costus pictus D. Don generally called as spiral ginger are well-known for their anti-diabetic properties and so referred as insulin plant (Hedge *et al*., 2014). With this broad outline, in this study we have attempted to synthesize zinc oxide nanoparticle using *Costus pictus D.* leaf extract and characterize it for various physical and chemical properties.

2. Materials and Methods

All the raw materials including Zinc sulphate [$ZnSO_4$ Himedia, India] used as a precursor was maintained at a high purity level (>99%). Another raw material used for the study was leaves of *Costus pictus D.* collected from in and around Coimbatore district (11.0168° N, 76.9558° E).

2.1 Synthesis of zinc oxide nanoparticles

Initially, the collected *Costus pictus D.* leaves were washed thoroughly using deionized water to remove any dirt and other undesirable matter. Then, it was shade dried for 30 minutes to remove the excess moisture. Then, the leaves were chopped into small pieces. 10 gm of chopped leaves (wet weight) were weighed and added with 100 ml of distilled water. This was then boiled for 1 hour at 50 to 65° C using hot water bath. A greenish-yellow aqueous extract was obtained that was filtered using a filter paper.

100 ml of 0.1M zinc sulphate solution was prepared in beaker to which 10 ml of leaf extract was added dropwise with continuous stirring for 20 minutes and the zinc oxide nanoparticles were found to be reduced as precipitates. The precipitated nanoparticles were centrifuged to obtain ZnO NP which was in the form of white paste. This paste was then transferred to silica crucible and heated at high temperature of 400 º C for two hours in a muffle furnace and cooled. The white powdered ZnO nanoparticle was obtained.

The synthesized ZnO nanoparticle was analysed for particle size and visual confirmation using dynamic light scattering (Model: HORIBA-SZ-100) and Transmission Electron Microscope (FEI Technai Sprit) respectively. The stability of the nanoparticle was confirmed via zeta potential (Model: HORIBA-SZ-100) estimation. The spectroscopic confirmation was also performed using UV Vis Spectroscopy (Specord 210/plus) and Fourier Transform Infrared spectroscopy (Jasco Model: R- 3000-QE). The elemental analysis were done using EDAX (FEI, Quenta 250).

3. Results and Discussion

3.1 Particle Size Analyzer (PSA)

The analytical data of particle size analyzer indicated that ZnO NPs obtained with *Costus pictus D* leaf extract was of 128.1 nm and the distribution was found between 50 and 130 nm with a polydispersity index of 0.524 (Fig. 1). NPs synthesized from *Vitex negundo* leaf and flower showed the similar size of 38.17 nm confirmed by XRD analysis calculated through Debye-Scherrer equation (Agarwal *et al.*, 2017) [1]

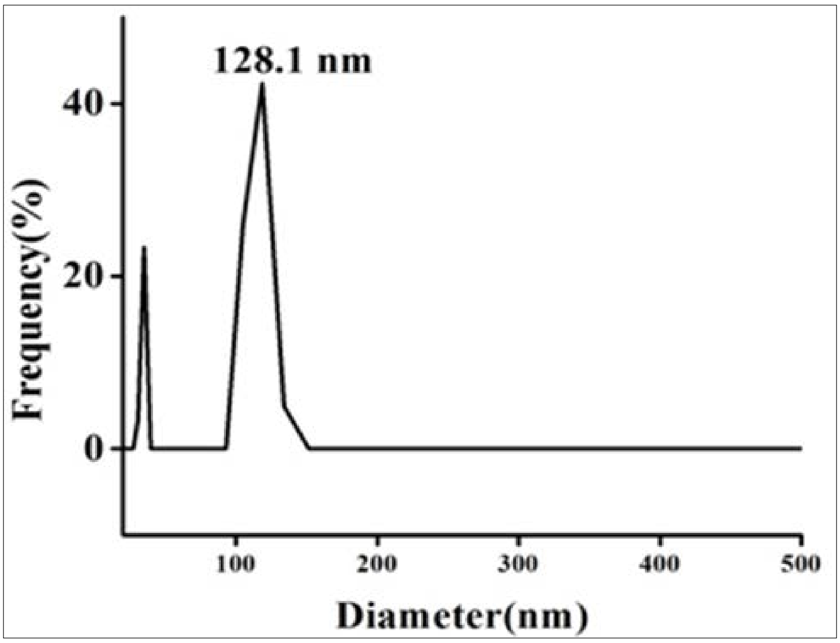

Fig 1: Particle size distribution of ZnO NP synthesized

3.2 Transmission Electron Microscope (TEM)

Electron microscopy of plant-based ZnO nanoparticles determined the morphology (size and shape) of synthesized nanoparticles. ZnO NPs synthesized from the leaf extract were near hexagonal in shape and were seen distributed between the range from 10-30 nm (Fig. 2). Number of scientific evidences witness the formation of hexagonal and flower shaped ZnO NP synthesized by various physical, chemical and biological methods (Suresh *et al* 2018).

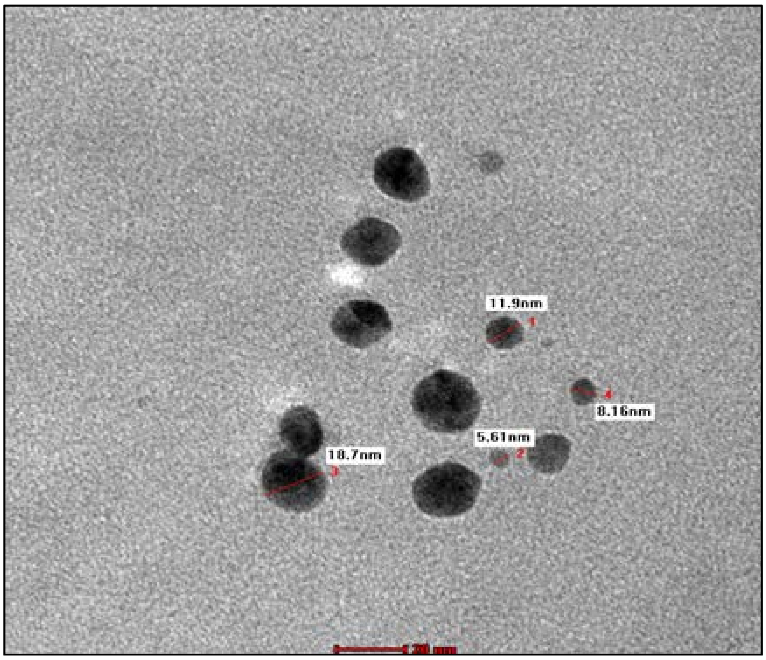

Fig 2: Transmission Electron Microscopy image showing Size distribution and Morphology of Synthesized ZnO NP

3.3 Energy Dispersive Atomic X-ray Analysis (EDAX)

The elemental composition of green synthesized nanoparticles was determined using EDAX (Fig. 3). ZnO NPs synthesized with neem leaf extract was found to have purity of 39% while rest of sample weight was occupied with carbon, oxygen and other foreign elements (trace in amount) present in the leaf extracts.

Table.1: Chemical composition of ZnO nanoparticles reduced using *Costus pictus D.* leaf extract

Element	Wt%	At%
CK	32.06	54.99
NK	03.67	03.93
OK	22.72	32.53
ZnL	39.49	00.43
NaK	00.48	00.31
MgK	00.50	00.31
AlK	00.61	00.34
ClK	00.11	00.50
CaK	00.38	00.52
Matrix	Correction	ZAF

3.4 Zeta Potential

The measures of dispersion stability were measured using the nano particle size analyzer instrument (Model: HORIBA-SZ-100), in which the zeta potential/electrostatic forces were measured between -200 mV to +200 mV. The zeta potential obtained was +64mV and this confirms the stability of synthesized ZnO nanoparticle.

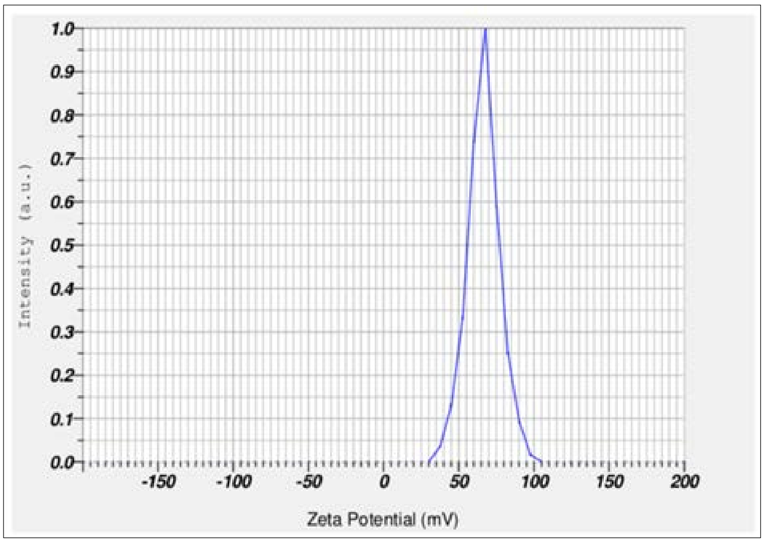

Fig 3: Zeta Potential (stability) of Synthesized ZnO NP

3.5 UV Vis–spectroscopy
UV-Vis spectrophotometer was used for the preliminary confirmation of ZnO nanoparticles synthesized. Using ultra sonication, 1mg of Zinc oxide NPs was dispersed in 10ml of distilled water and then the optical density of the sample was recorded between the wavelengths of 280-375 nm. The spectrum revealed a characteristic absorption peak of ZnO at 301 nm and this can be assigned to the intrinsic band-gap absorption of ZnO due to the electron transitions. A study reported a blue shifted absorption peak of ZnO NPs at 325 nm and their average size was 16 nm (Senthil kumar and Sivakumar, 2014) [21].

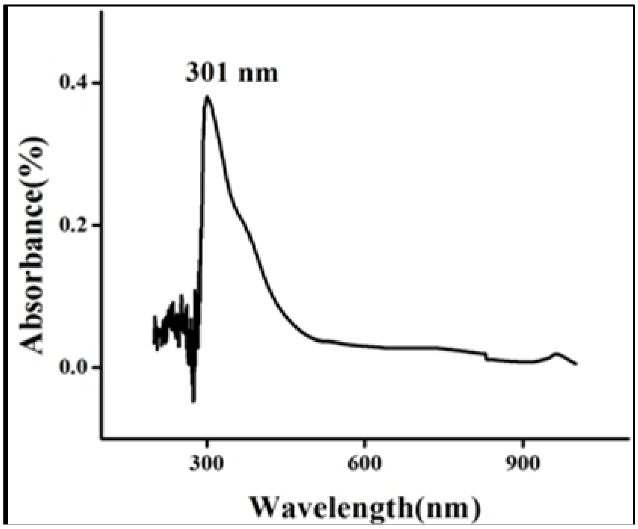

Fig 4: UV Absorbance Spectra of Synthesized ZnO NP

3.6 FTIR spectroscopy
FTIR analysis was performed to identify the adsorption bands that are associated with vibrations of unique functional groups or "fingerprint". A pinch of sample was placed on the sample port and the spectra were recorded over the wavelength range of 4000-400 cm^{-1}. The FTIR spectrum of zinc oxide nanoparticles was absorbed at 543 cm^{-1}. The O–H stretch appeared in the spectrum as a very broad band extending from 3100 cm^{-1} (Suresh *et al.*, 2018). The FTIR results proved the purity of the obtained ZnO-NPs.

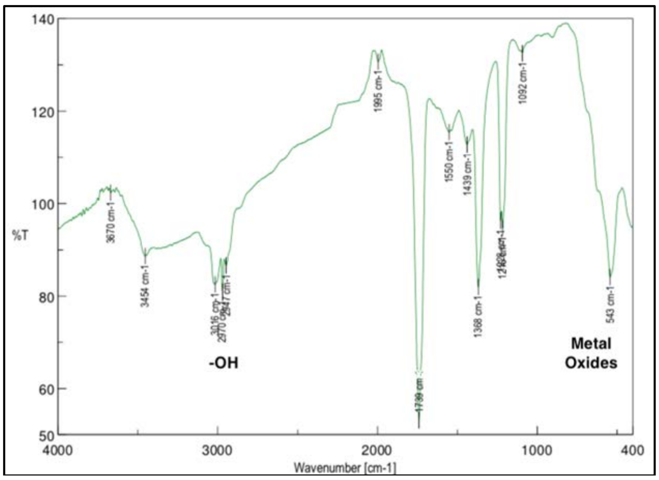

Fig 5: FTIR Spectra of Synthesized ZnO NP

4. Conclusion
In this study, ZnO NPs was synthesized using *Costus pictus D.* leaves aqueous extract using zinc sulphate as precursor. UV–Visible spectrum showed a distinct peak around 301 nm, which is distinct for Zinc Oxide Nanoparticle. The average size of synthesized zinc nanoparticle was found to be distributed between 50-130 nm and its morphology were confirmed as near-hexagonal using Transmission Electron Microscope. EDAX results confirmed the presence of zinc and FT-IR spectra indicated the formation of ZnO. Our results confirm the potential *Costus pictus D.* for the synthesis of ZnO NPs in a simple, fast and eco-friendly way. Further, different precursors can be used in green synthesis as it has major influence in size and morphology of final product.

5. Acknowledgement
I sincerely thank Department of Nano Science and Technology, TNAU, Coimbatore for helping me in characterizing the synthesized nanoparticle.

6. References
1. Agarwal H, Kumar SV, Rajeshkumar S. A review on green synthesis of zinc oxide nanoparticles–An eco-friendly approach. Resource-Efficient Technologies 2017;3(4):406-413.
2. Ali K, Dwivedi S, Azam A, Saquib Q, Al-Said MS, Alkhedhairy AA. Aloe vera extract functionalized zinc oxide nanoparticles as nanoantibiotics against multi-drug resistant clinical bacterial isolates. Journal of colloid and interface science 2016;472:145-156.
3. Álvarez-Chimal R, García-Pérez VI, Álvarez-Pérez MA, Arenas-Alatorre JÁ. Green synthesis of ZnO nanoparticles using a Dysphania ambrosioides extract. Structural characterization and antibacterial properties. Materials Science and Engineering: C 2021;118:111540.
4. Ambika S, Sundrarajan M. Green biosynthesis of ZnO nanoparticles using Vitex negundo L. extract: spectroscopic investigation of interaction between ZnO nanoparticles and human serum albumin. Journal of Photochemistry and Photobiology B: Biology 2015;149:143-148.
5. Aprilly J. Study of green synthesis of zinc oxide nanoparticles using dried and used green tea *(Camellia sinensis* L.) extracts (Doctoral dissertation, Universitas Pelita Harapan), 2016.
6. Barzinjy Azeez, Hamad Samir, Azeez Himdad. Structure, Synthesis and Applications of ZnO Nanoparticles: A Review. Jordan Journal of Applied Science 2020;13:123-135.
7. Datta A, Patra C, Bharadwaj H, Kaur S, Dimri N, Khajuria R. Green synthesis of zinc oxide nanoparticles using parthenium hysterophorus leaf extract and evaluation of their antibacterial properties. J Biotechnol. Biomater 2017;7(3):271-276.
8. Elumalai K, Velmurugan S. Green synthesis, characterization and antimicrobial activities of zinc oxide nanoparticles from the leaf extract of Azadirachta indica (L.). Applied Surface Science 2015;345:329-336.
9. Fu L, Fu Z. *Plectranthus amboinicus* leaf extract–assisted biosynthesis of ZnO nanoparticles and their photocatalytic activity. Ceramics International 2015;41(2):2492-2496.
10. Hegde PK, Rao HA, Rao PN. A review on Insulin plant (*Costus igneus* Nak). Pharmacognosy reviews 2014;8(15):67.
11. Jabeen S. Facile green synthesis of silver doped ZnO nanoparticles using Tridax Procumbens leaf extract and

their evaluation of antibacterial activity. Journal of Water and Environmental Nanotechnology 2020;5(4):307-320.
12. Joghee Suresh *et al*. Adv. Nat. Sci: Nanosci. Nanotechnol 2018;9:015008
13. Madan HR, Sharma SC, Suresh D, Vidya YS, Nagabhushana H, Rajanaik H *et al*. Facile green fabrication of nanostructure ZnO plates, bullets, flower, prismatic tip, closed pine cone: their antibacterial, antioxidant, photoluminescent and photocatalytic properties. Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy 2016;152:404-416.
14. MN D. Sood, R. Review on Synthesis and Applications of Zinc Oxide Nanoparticles. Preprints 2021. 2021050688
15. Nandhini G, Suriyaprabha R, Pauline WMS, Rajendran V, Aicher WK, Awitor OK. Influence of solvents on the changes in structure, purity, and *in vitro* characteristics of green-synthesized ZnO nanoparticles from *Costus igneus*. Applied Nanoscience 2018;8(6):1353-1360.
16. Pachaiappan R, Rajendran S, Ramalingam G, Vo DVN, Priya PM, Soto-Moscoso M. Green Synthesis of Zinc Oxide Nanoparticles by *Justicia adhatoda* Leaves and Their Antimicrobial Activity. Chemical Engineering & Technology 2021;44(3):551-558.
17. Prasad AR, Garvasis J, Oruvil SK, Joseph A. Bio-inspired green synthesis of zinc oxide nanoparticles using *Abelmoschus esculentus* mucilage and selective degradation of cationic dye pollutants. Journal of Physics and Chemistry of Solids 2019;127:265-274.
18. Rahimi Kalateh Shah Mohammad G, Karimi E, Oskoueian E, Homayouni-Tabrizi M. Anticancer properties of green-synthesised zinc oxide nanoparticles using *Hyssopus officinalis* extract on prostate carcinoma cells and its effects on testicular damage and spermatogenesis in Balb/C mice. Andrologia 2020;52(1):e13450.
19. Rajiv P, Rajeshwari S, Venckatesh R. Bio-Fabrication of zinc oxide nanoparticles using leaf extract of *Parthenium hysterophorus* L. and its size-dependent antifungal activity against plant fungal pathogens. Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy 2013;112:384-387.
20. Raveendran P, Fu J, Wallen SL. Completely "green" synthesis and stabilization of metal nanoparticles. Journal of the American Chemical Society 2003;125(46):13940-13941.
21. Senthilkumar SR, Sivakumar T. Green tea (*Camellia sinensis*) mediated synthesis of zinc oxide (ZnO) nanoparticles and studies on their antimicrobial activities. Int. J Pharm. Sci 2014;6(6):461-467.
22. Singh K, Singh J, Rawat M. Green synthesis of zinc oxide nanoparticles using *Punica granatum* leaf extract and its application towards photocatalytic degradation of Coomassie brilliant blue R-250 dye. SN Applied Sciences 2019;1(6):1-8.
23. Siripireddy B, Mandal BK. Facile green synthesis of zinc oxide nanoparticles by *Eucalyptus globulus* and their photocatalytic and antioxidant activity. Advanced Powder Technology 2017;28(3):785-797.
24. Sundrarajan M, Ambika S, Bharathi K. Plant-extract mediated synthesis of ZnO nanoparticles using *Pongamia pinnata* and their activity against pathogenic bacteria. Advanced powder technology 2015;26(5):1294-1299.
25. Thema FT, Manikandan E, Dhlamini MS, Maaza M. Green synthesis of ZnO nanoparticles via *Agathosma betulina* natural extract. Materials Letters 2015;161:124-127.