



Zinc oxide nanoparticles synthesis from *Moringa oleifera* Lam. Extracts and their characterization

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ABSTRACT

The enormous applications of metal nanoparticles urged to find new biologically hazard free methods for huge synthesis. The green synthesis approaches are acknowledged by many scientists due to its cost effective, simple, eco-friendly and resourceful move. The present investigation deals with the bio-production and characterization of zinc oxide (ZnO) nanoparticles using leaf, stem, flowers and fruit pods of the medicinal plant *Moringa oleifera*. The synthesis of ZnO nanoparticles from the aqueous extracts were mediated by Zinc Nitrate Hexahydrate as precursor. Various parameters like time periods, concentration of plant extracts and different temperatures were influenced the synthesis of ZnO nanoparticles. The stability and reduction of zinc ions to ZnO nanoparticles were characterized by UV-Visible spectroscopic analysis. The reaction medium from the leaves and flowers showed strong absorption at 308nm. The stem and fruit pods reaction medium existed absorption peak at 293nm.

Keywords: Zinc oxide nanoparticles; *Moringa oleifera*; UV-Visible spectroscopy; Reaction medium

1. INTRODUCTION

The precise surface area and elevated fraction of surface atoms of metal nanoparticles gained enormous attention in the field of drug discovery, biotechnology and agriculture. The

metal NPs are reported to possess distinctive physicochemical uniqueness including catalytic activity, optical, electronic and antibacterial properties (Catauro et al., 2004). Green synthesis of nanoparticles and their applications in food processing, production of antimicrobials, cosmetics, health care products have been acknowledge by number of researchers (Begum et al., 2009). The utilization of plants in synthesis of zinc oxide nanoparticles (ZnO NPs) is quite novel technique and does not require consent with the preparation, which leads to eco-friendly green chemistry approach. The biological methods of nanoparticles synthesis were reported to have advancement over chemical and physical methods (Prasad and Elumalai, 2011).

Recently the medicinal plant species exploited for the synthesis of zinc oxide nanoparticles are *Hybanthus enneaspermus* (Shekhawat et al., 2014), *Camellia sinensis* (Shah et al., 2015), *Ficus benghalensis* (Shekhawat et al., 2015), *Zingiber officinale* (Raj and Jayalakshmi, 2015), *Hemidesmus indicus* (Manokari and Shekhawat, 2015), *Azadirachta indica* (Bhuyan et al., 2015), *Adhatoda vasica* (Shekhawat, 2016) etc..

Moringa oleifera belongs to the family Moringaceae. It is a medium sized tree grows to the height of 5-12 m. Its leaves are bi- and tripinnate with entire oval shaped leaflets (Muhl et al., 2011). Stem is soft and the flowers are creamy white. The fruits (pods) are 20 to 30 cm long, green in color and change to brown when mature. Seeds are numerous, round or triangular in shape with three papery wings (Arbonnier, 2002). The plant is endowed with various life giving medicinal properties. Its different parts are employed in treating anemia, blindness, arthritis, hyperthyroidism, rheumatism, epilepsy, Crohn's disease, antiherpes-simplex virus, gout and sexually transmitted diseases (Mulh et al., 2011; Monera and Maponga, 2012; Dao and Kabore, 2015).

M. oleifera is loaded in nourishment owing to the presence of essential phytochemicals. The phytochemical profile of its leaves showed the presence of essential minerals, vitamins, sterols, anthraquinones, alkaloids, terpenoids, flavonoids, tannins and saponins (Kasolo et al., 2010). The immature pods and flowers are reported to contain linolenic, linoleic, palmitic and oleic acids (Mbikay, 2012; Berkovich et al., 2013). These phytoconstituents leads to the anti-inflammatory, antiulcer, antidiabetic (Divi et al., 2012), anticancer (Nair and Varalakshmi, 2011), antimicrobial, antioxidant and antifungal properties (Ijarotimi et al., 2013).

Due to these evidences about the medicinal values and phytochemistry of this plant, the present study applied biomimetic approach for the green synthesis of eco-friendly zinc oxide nanoparticles from panacea *M. oleifera* through bioreduction and UV-Visible spectroscopic characterization.

2. MATERIALS AND METHODS

2. 1. Collection of plant materials

Healthy *Moringa oleifera* trees were selected in the local provinces of Puducherry (Pondicherry, India) and its different parts namely fresh leaves, stem segments, flowers and fruit pods were collected (**Fig. 1A-1D**) during March-June 2014. These parts were initially washed under running water to remove dirt and other foreign particles and followed by rinsing in double distilled water and dried at room temperature. These materials were chopped into fine pieces (**Fig. 2A-2D**).



Fig. 1. Plant parts of *M. oleifera* used for the synthesis of ZnO nanoparticles.

A - Leaves, **B** - Stem segments, **C** - flowers and **D** - fruit pods

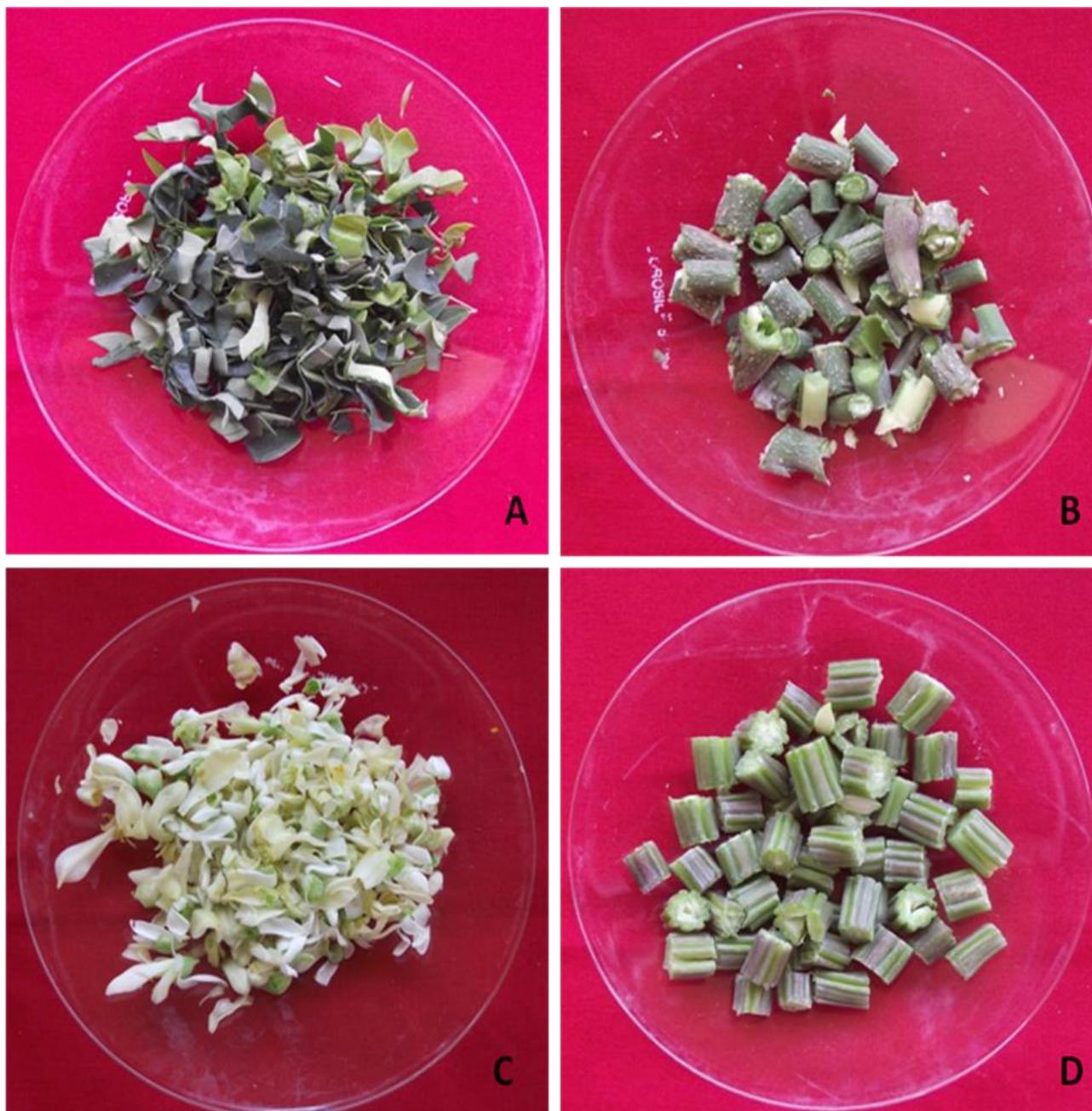


Fig. 2. Five grams of plant materials chopped into fine pieces for the preparation of aqueous extracts.

A - Finely cut leaves, **B** - Finely cut stem segments, **C** - Finely cut flowers and **D** - fruit pods

2. 2. Preparation of aqueous extracts from various plant parts

Five (5) gm in each of leaf, stem, flowers and pod samples were challenged with 50 ml double distilled water and boiled for 15 min. After boiling period all the samples were filtered using Whatman filter paper (No.1) and the aqueous extracts were used for the synthesis of ZnO nanoparticles.

2. 3. Preparation of precursor

Zinc Nitrate hexahydrate [$\text{Zn}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$] (Merck, Mumbai) was used as a precursor for the synthesis of ZnO nanoparticles from *M. oleifera* plant parts. 1mM Zinc nitrate solution was prepared using double distilled water and stored in refrigerator at 4 °C for further use.

2. 4. Synthesis of ZnO nanoparticles

The plant extracts were used to reduction of metal ions in to metallic oxide nanoparticles. Three boiling tubes were used to synthesize ZnO nanoparticles, one containing 10 ml of 1mM Zinc nitrate solution as reference, and the second one containing 10 ml of aqueous plant extract and the third tube contained 5 ml of 1 mM Zinc nitrate solution and 5 ml of plant extracts as reaction medium and incubated at room temperature. To observe the visual color change, the reaction medium was boiled for 20 min at the temperature of 60 °C (Fig. 3A-3D). The test solution from the third tube was centrifuged at 5000 rpm for 20 min to obtain the pellet. Supernatant is discarded and the pellet is dissolved in double distilled water.

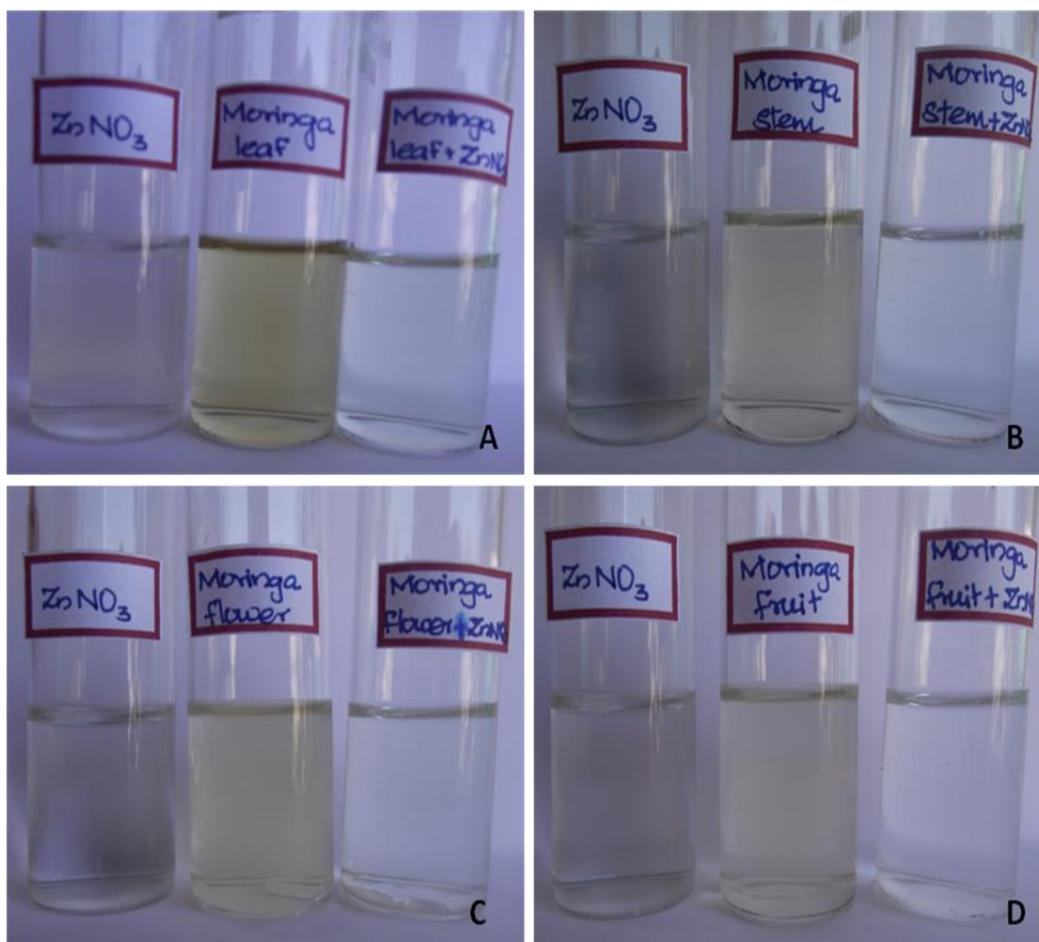


Fig. 3. Color change in the reaction medium.

A - Leaf reaction medium, **B** - Stem reaction medium, **C** - flower reaction medium and **D** - Fruit pods reaction medium.

2. 5. Characterization of ZnO nanoparticles (UV-VIS spectra analysis)

The bioreduction of ZnO nanoparticles using *M. oleifera* aqueous extracts were monitored by measuring the UV-Visible spectroscopy. The UV-Visible absorption spectra of the reaction media were recorded at room temperature in a quartz cuvette (1 cm path length) and at the wavelength ranging from 200 to 700 nm using a Systronics Double Beam Spectrophotometer (Model 2202, Systronics Ltd.) in diffuse reflectance mode using Zinc nitrate as reference.

3. RESULTS AND DISCUSSION

The present study involves various parts of medicinal plant species *M. oleifera* for the synthesis of ZnO nanoparticles. The plant is endowed with immense secondary metabolites and astonishing nutritive properties. The different parts of the plants have already been exploited for the synthesis of various metal nanoparticles with valuable bioactive mechanisms. This report aimed on synthesis of ZnO nanoparticles using extracts of various parts of *M. oleifera*.

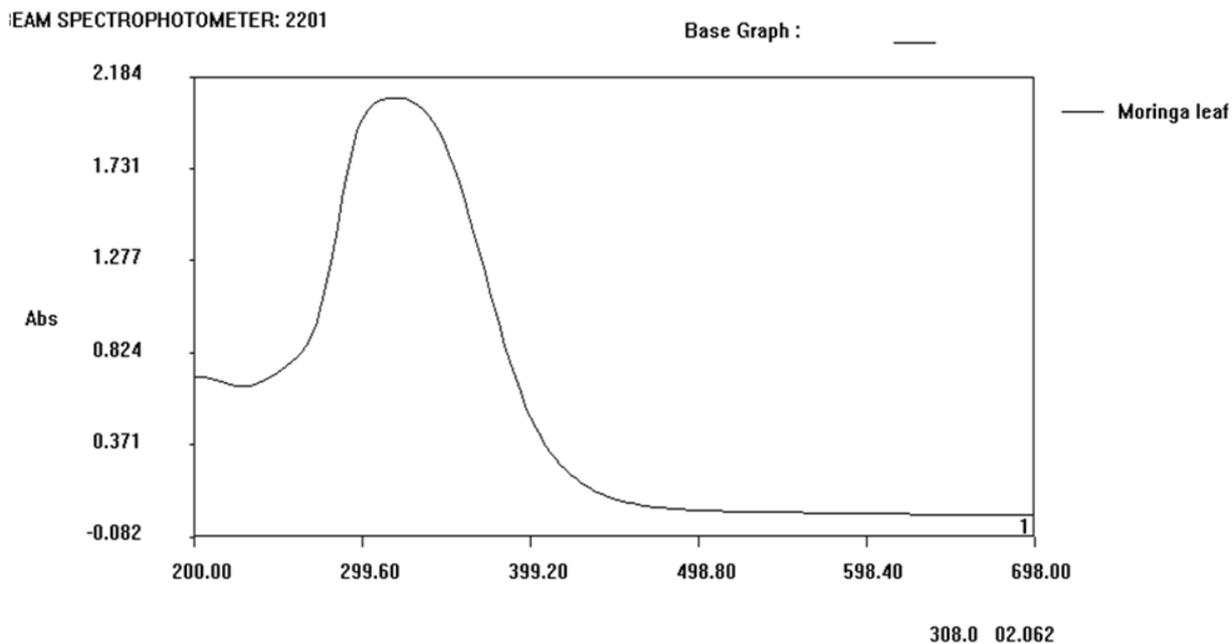
Prasad and Elumalai (2011) reported the synthesis of silver nanoparticles (AgNPs) from aqueous leaf extracts of *M. oleifera*. Sathyavathi et al. (2011) proposed that the leaf mediated Ag nanoparticles from *M. oleifera* are used in optical limiting. The AgNPs from *M. oleifera* leaves have been reported to possess significant antifungal activity against *Candida albicans* (Vibhute et al., 2014). Silver nanoparticles from *M. oleifera* have been reported to induce apoptosis of human cervical carcinoma cells (Vasanth et al., 2014). The silver nanoparticles reduced by the gum of *M. oleifera* was reported to exhibit antibacterial activity against *Staphylococcus aureus*, *E. coli* and *Pseudomonas aeruginosa* (Kudle et al., 2013). Silver nanoparticles from the seeds of *M. oleifera* are reported to control major dengue vector *Aedes aegypti* and against dengue serotype DEN-2 (Sujitha et al., 2015).

Gold nanoparticles synthesized from the pods of *M. oleifera* was reported to possess antibacterial activity against gram positive and gram negative bacteria such as *Bacillus subtilis*, *Escherichia coli*, *Klebsiella pneumonia* and *Staphylococcus aureus* (Belliraj et al., 2015).

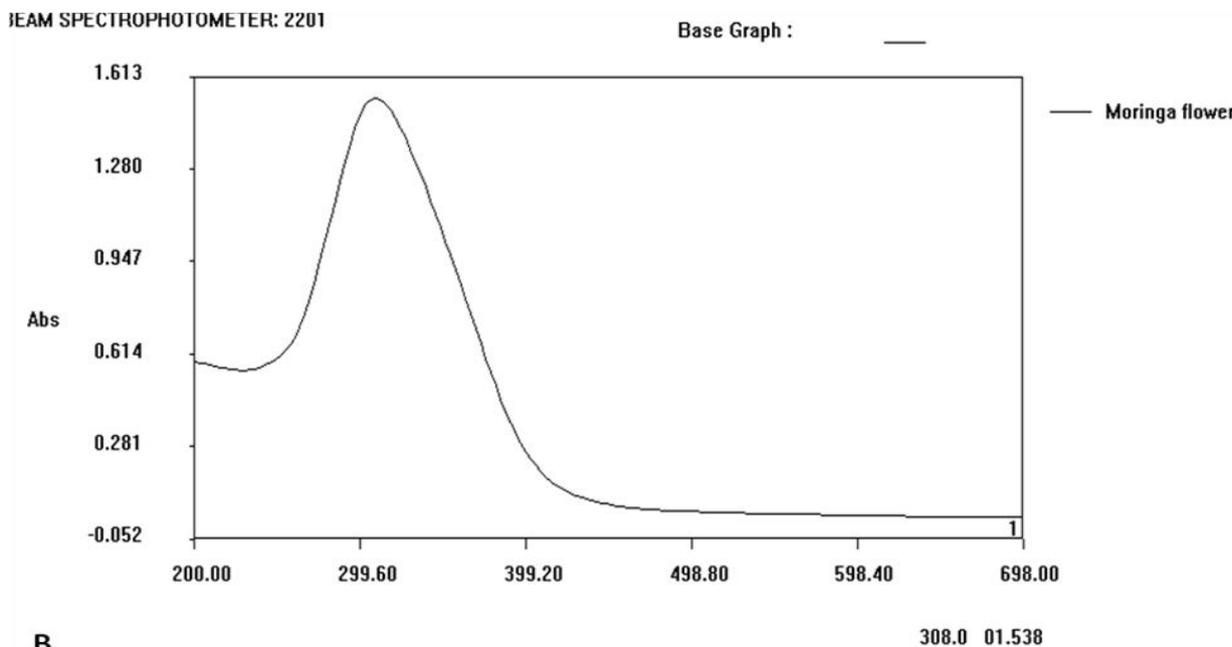
The porous activated carbons derived fruit shells were employed in the synthesis of highly dispersed and stable ruthenium nanoparticles (RuNPs) and exploited for supercapacitor applications (Lou et al., 2016).

Elumalai et al. (2015) synthesized ZnO nanoparticles from the leaves of *M. oleifera*, and these nanoparticles at the concentration of 200 µg/ml exhibits antibacterial activity against gram positive and gram negative bacteria such as *Staphylococcus aureus*, *Bacillus subtilis*, *Pseudomonas aeruginosa*, *Proteus mirabilis*, *Escherichia coli* and antifungal activity against *Candida albicans* and *Candida tropicalis*.

The reduction of zinc metal ions to zinc oxide nanoparticles in the reaction medium was preliminarily analyzed using UV-Vis Spectrophotometer between 200 to 700 nm. The UV-Visible spectroscopic analysis of ZnO nanoparticles from leaf and flower reaction medium was confirmed by the strong absorption spectra at 308 nm (**Fig. 4A and 4B**). The maximum absorption of stem and fruit pods reaction medium was observed at 293 nm (**Fig. 4C and 4D**).



A

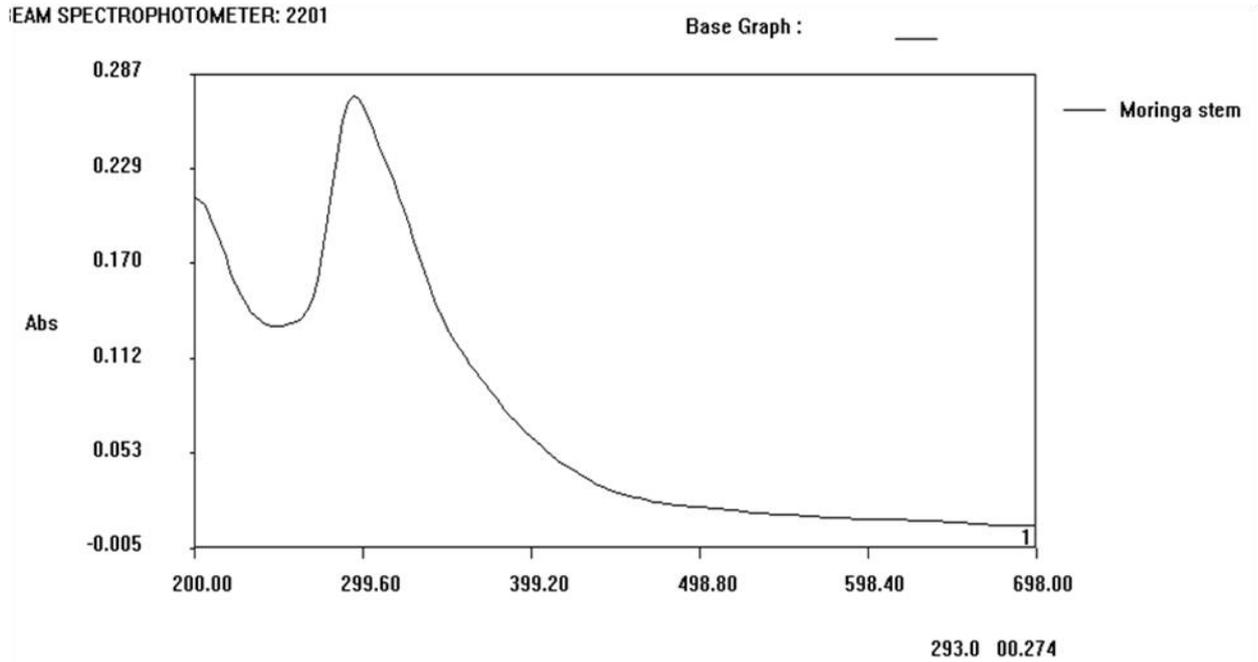


B

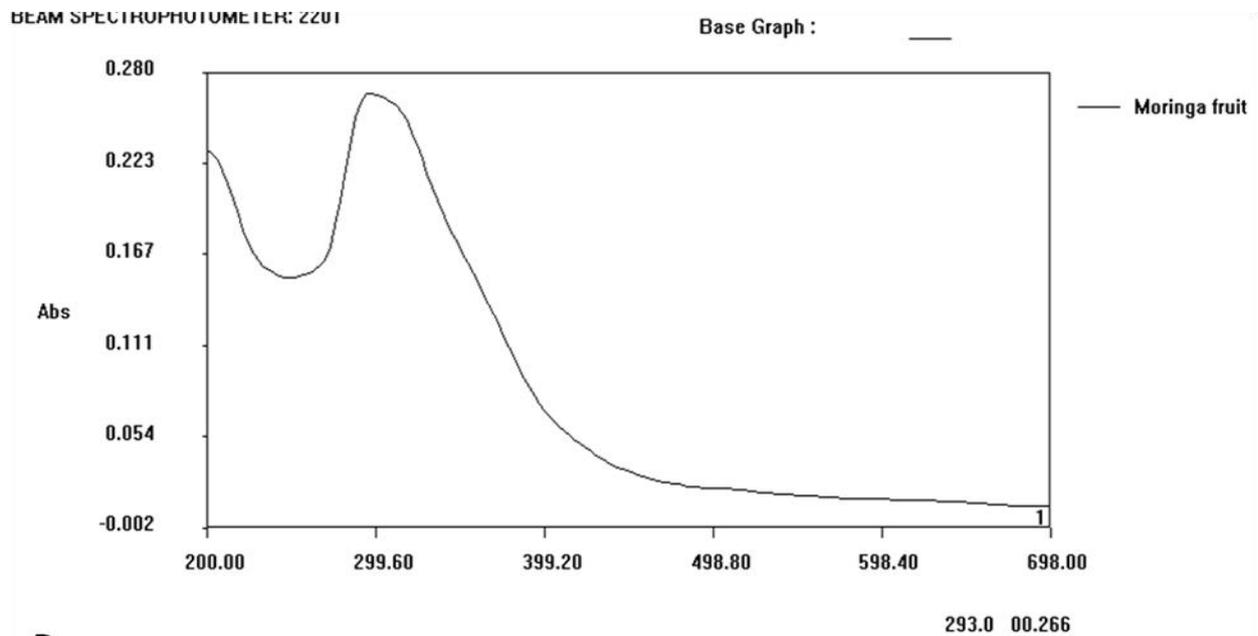
Fig. 4. UV-Visible characterization of ZnO nanoparticles.

A – UV-Visible absorption spectrum of leaf reaction medium,

B – UV-Visible absorption spectrum of flowers reaction medium,



C



D

Fig. 4(continue). UV-Visible characterization of ZnO nanoparticles.

C –UV-Visible absorption spectrum of stem reaction medium,

D – UV-Visible absorption spectrum of fruit pods reaction medium.

Plant extracts at the concentration of 5 ml was found to mediate the ZnO nanoparticles synthesis in less time, whereas the increased and decreased concentrations were less effective when challenged with the precursor. The color change of reaction mediums was observed at different time duration. The pale yellow color development in the leaf reaction medium was observed immediately when the leaf extract is challenged with zinc nitrate solution. Deep yellow color formation was recorded in the stem and fruit pod by heating the respective reaction medium in water-bath for 20 min at 60 °C. Flower extract and precursor changed the color after 12 minutes of incubation at room temperature.

The higher surface to volume ratio of nanoparticles are mainly due to excitonic transitions and deep-trap transitions (Shekhawat et al., 2013; Firdhouse et al., 2015). This size dependent property of ZnO nanoparticles were appeared as a clear broad absorption peak through UV-Visible spectral analysis. The spectra from various parts of *M. oleifera* confer the difference in the excitation wavelength. This may be due to presence of secondary metabolites at various fractions in leaves, stem, flowers and fruit pods.

4. CONCLUSION

The biomimetic approach on synthesis of ZnO nanoparticles using various parts of *M. oleifera* is simple, easily scaled up, eco-friendly and quick. The characteristic color changes to yellow in the reaction medium indicate the synthesis of ZnO nanoparticles. The absorption spectral analysis using UV-Visible spectroscopy confirms the reduction of zinc ions in to zinc oxide nanoparticles from herbal extracts of *M. oleifera*. The formation of ZnO nanoparticles from leaves and flowers exhibit absorption peak at 308 nm. The stem and fruit pods showed absorption peak at 293 nm.

References

- [1] M. Catauro, M.G. Raucci MG, F.D. De Gaetano FD, A. Marotta, *Journal of Materials Science: Materials in Medicine* 15 (2004) 831-837.
- [2] N.A. Begum, S. Mondal, S. Basu, R.A. Laskar, D. Mandal, *Colloids and Surfaces B. Biointerfaces* 71 (2009) 113-118.
- [3] T.N.V.K.V. Prasad, E.K. Elumalai, *Asian Pacific Journal of Tropical Biomedicine* 1 (2011) 439-442.
- [4] M.S. Shekhawat, C.P. Ravindran, M. Manokari, *Tropical Plant Research* 1 (2014) 55-59.
- [5] R. K. Shah, F. Boruah, N. Parween, *International Journal of Current Microbiology and Applied Sciences* 4 (2015) 444-450.
- [6] M.S. Shekhawat, C.P. Ravindran, M. Manokari, *International Journal of BioSciences, Agriculture and Technology* 6 (2015) 1-5.
- [7] L. F. Raj, E. Jayalakshmy, *Oriental Journal of Chemistry* 31 (2015), DOI:<http://dx.doi.org/10.13005/ojc/310105>

- [8] M. Manokari, M.S. Shekhawat, *International Journal of Research Studies in Microbiology and Biotechnology* 1 (2015) 20-24.
- [9] T. Bhuyan, K. Mishra, M. Khanuja, R. Prasad, A. Varma, *Materials Science in Semiconductor Processing* 32 (2015) 55-61.
- [10] M.S. Shekhawat, *International Journal of Biological Papers* 1 (2016) 9-15.
- [11] Q.E. Muhl, E.S. du Toit, P.J. Robbertse, *American Journal of Plant Sciences* 2 (2011) 776-780.
- [12] M. Arbonnier, Arbres, arbustes et lianes des zones sèches d'Afrique de l'Ouest. Ed. Quae, 2002, pp. 573.
- [13] T.G. Monera, C.C. Maponga, *Journal of Public Health in Africa* 3 (2012) 6-8.
- [14] M.C.E. Dao, K.H. Kabore, *African Journal of Plant Science* 9 (2015) 401-411.
- [15] J.N. Kasolo, G.S. Bimenya, L. Ojok, J. Ochieng, J.W. Ogwal-okeng, *Journal of Medicinal Plant Research*, 4 (2010) 753-757.
- [16] M. Mbikay, *Frontiers in Pharmacology* 3 (2012) 1-12.
- [17] L. Berkovich, G. Earon, I. Ron, A. Rimmon, A. Vexler, S. Lev-Ari, *BMC Complementary Alternative Medicine* 13 (2013) 212-219.
- [18] S.M. Divi, R. Bellamkonda, S.K. Dasireddy, *Asian Journal of Pharmaceutical and Clinical Research* 5 (2012) 67-72.
- [19] S. Nair, K.N. Varalakshmi, *Journal of Natural Pharmaceuticals* 2 (2011) 138-142.
- [20] O.S. Ijarotimi, O. Adeoti, O. Ariyo, *Food Science and Nutrition* 1 (2013) 452-463.
- [21] R. Sathyavathi, M.B. Krishna, D.N. Rao, *Journal of Nanoscience and Nanotechnology* 11 (2011) 2031-2035.
- [22] S.K. Vibhute, V.S. Kasture, P.N. Kendre, G.S. Wagh, *Indo American Journal of Pharmaceutical Research* 4 (2014) 1581-1587.
- [23] K. Vasanth, K. Ilango, R. Mohan Kumar, A. Agrawal, G.P. Dubey, *Colloids and Surfaces B: Biointerfaces* 117 (2014) 354-359.
- [24] M.R. Kudle, K.R. Kudle, M.R. Donda, M.P.P. Rudra, *Nanoscience and Nanotechnology: An International Journal* 3 (2013) 45-48.
- [25] V. Sujitha, K. Murugan, M. Paulpandi, C. Panneerselvam, U. Suresh, M. Roni, M. Nicoletti, A. Higuchi, P. Madhiyazhagan, J. Subramaniam, D. Dinesh, C. Vadivalagan, B. Chandramohan, A. A. Alarfaj, M. A. Munusamy, D. R. Barnard, G. Benelli, *Parasitology Research* 114 (2015) 3315-3325.
- [26] T.S. Belliraj, A. Nanda, R. Ragunathan *Journal of Chemical and Pharmaceutical Research* 2 (2015) 781-788.
- [27] B. Lou, P. Veerakumar, S. Chen, V. Veeramani, R. Madhu, S. Liu. *Scientific Reports*, doi:10.1038/srep19949.
- [28] K. Elumalai, S. Velmurugan, S. Ravi, V. Kathiravan, S. Ashokkumar, *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy* (2015), 143; 158-164.

- [29] M. S. Shekhawat, P. Anusuya, N. Kannan, M. Manokari, J. Revathi, V. Ilavarasi, *International Journal of Green and Herbal Chemistry* 2 (2013) 1041-1049.
- [30] J. M. Firdhouse, P. Lalitha, P. Vennila, *International Journal of Extensive Research* 2 (2015) 12-20.

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