Volume-5, Issue-03, March 2018 ISSN: 2349-7637 (Online)

RESEARCH HUB – International Multidisciplinary Research Journal (RHIMRJ)

Research Paper

Green Synthesis for Sustainable Production of Zinc oxide Nanoparticles using *Mukia maderaspatana* (L.) M. Roem. Plant Extracts

Naresh Panwar

Department of Botany, Government M. S. College, Bikaner, Rajasthan, India

Abstract:* *The stable zinc oxide nanoparticles (ZnO NPs) were synthesized using the bioactive compounds present in Mukia maderaspatana whole plant extracts which acted as reducing and stabilizing agents. The onset of ZnO NPs synthesis was confirmed by the visual colour change in the reaction mixture. Further confirmations of the synthesis of ZnO NPs in the solutions were validated using UV-visible spectroscopy characterization. The UV-Vis spectrum of colloidal solutions of ZnO NPs synthesized using M. maderaspatana plant extracts exhibited absorbance peaks between 292-322 nm, which were the characteristics of metallic ZnO. Thus, based on this report, it is apparent that an effective eco-friendly, nontoxic, and multipotential ZnO NPs synthesized using M. maderaspatana plant extracts.

Keywords:* *Zinc oxide nanoparticles, Green synthesis, Mukia maderaspatana, Spectroscopy

1. Introduction

Biomolecules of plant extracts are used as reducing agents in the green synthesis of nanoparticles (Villasenor-Basulto et al. 2018). The requirement for the production of eco-friendly nanoparticles, paved the way for the exploration of biological materials for the biogenic synthetic methods of precious nanoparticles and their applications in agriculture and pharmaceuticals. The biogenic reduction of metal ions is accepted by various researchers due to its rapidness and can be conducted at room temperature and pressure (Mirzaei and Darroudi, 2017). The synthesis mediated by plant extracts is environmentally benign. The reducing agents involved include the various water-soluble plant metabolites (e.g. alkaloids, phenolic compounds, terpenoids, etc.) and co-enzymes. Commercial production of zinc oxide (ZnO) is attractive due to its nontoxic, having 60 meV exciton-binding energy, 3.37 eV spot wide gap, distinct optic and electrical properties, and industrial application in UV-light emitting devices (Huang et al. 2001). ZnO nanoparticles (ZnO NPs) are reported to be non-toxic, compatible with the skin, antimicrobial, antibacterial, UV-blocker, anticancer, bio-imaging properties, and have immense utilization in pharmaceutical and cosmetic industries (Shirgholami et al. 2015).

ZnO nanoparticles are efficiently used in drug delivery systems to selectively act on cancerous cells (Taylor and Webster, 2011). Multifunctional properties of plants-mediated ZnO nanoparticles are reviewed by many researchers. The evaluation of eco-friendly synthesis of ZnO NPs from the whole plant is dealt in *Passiflora foetida* (Shekhawat et al. 2014), *Melia azedarach* (Manokari et al. 2016), etc. ZnO NPs of *Passiflora caerulea* leaf extracts are reported to possess antibacterial properties and fight against pathogens of urinary tract infection (Santhoshkumar et al. 2017). ZnO NPs synthesized using *Eucalyptus globulus* extracts are found to possess photocatalytic properties in organic dye degradation (Siripireddy and Mandal 2017). Zinc oxide NPs prepared from *Lagenaria siceraria* pulp extract are evaluated for antidandruff, antimicrobial, and antiarthritic properties (Kalpana et al. 2017). Leaf-mediated ZnO NPs of *Cassia alata* are also found to possess antibacterial activity against *Escherichia coli* (Happy et al. 2019).

Plants have already been explored for the synthesis of silver, gold, and chromium (III) oxide nanoparticles. An aqueous extract-mediated synthesis of silver NPs from *Mukia maderaspatana* was reported to be active against the malarial vector *Culex quinquefasciatus* and *Aedes aegypti* – a malarial vector (Chitra et al. 2015). The silver and gold nanoparticles synthesized from *M. maderaspatana* plant extracts were reported to possess efficient effects against MCF7 breast cancer cell lines using an MTT assay (Devi and Sathishkumar 2016). Chromium (III) oxide NPs of *M. maderaspatana* plant extracts were reported to have antibacterial activity against *E. coli* (Rakesh et al. 2013). Subha et al. (2016) reported that the phytochemicals present in *M. maderaspatana* root extracts were responsible for the reduction of silver nitrate into silver nanoparticles.

Mukia madaraspatana (Cucurbitaceae) commonly known as Madras pea pumpkin, is distributed throughout the tropics, subtropics, and all over India. It is a climbing annual herb with bristle hairs over aerial parts. Leaves are triangular, tendrils simple, and flowers are small and yellow in color. Fruits are ellipsoid berries, have cream stripes, and possess numerous seeds (Fig. 1). The species is employed in indigenous medicines of India, Africa, Asia, and Australia (Petrus, 2013).

This plant contains several biologically active molecules such as amino acids (L-glutamic acid, D- and L-alanine, L-arginine, L-glycine, D, and L- valine), reducing sugars, triterpenes, alkaloids, phenols, flavones, catechins, glycosides, steroids, and saponins (Gomathy et al. 2012). The aerial parts are endowed with minerals and vitamins (Kavitha et al. 2013).

Fig. 1. *Mukia maderaspatana* plant growing in the natural conditions.

The phytoactives of this plant species have been screened for various bioactivities. Quercetin and phloroglucinol contents of the plant are responsible for antidiabetic effects (Srilatha and Ananda 2013). Various parts of the plants are reported to possess antioxidant (Veeramani et al. 2011), vasoprotective (Petrus, 2012), antidiabetic, hepatoprotective, immunomodulatory, antihyperglycaemic, antihyperlipidemic (Pandey et al. 2010), antimicrobial, antiulcer (Gomathy et al. 2015), anxiolytic, antihypertensive, anti-inflammatory, and mosquito larvicidal properties (Chitra et al. 2015).

The continuous search for the substrates of the sustainable production of nanomaterials leads to the experimentation of almost 50% of the plant species, hence the present study aimed to evaluate the multipotent medicinal plant *Mukia maderaspatana* (L.) M. Roem. for the synthesis of ZnO nanoparticles, which could provide sustainable, non-toxic source material in the field of drug discovery.

Though this plant is medicinally potent, it has not yet been explored for the synthesis of zinc oxide nanoparticles. Hence, the present work aims at evaluating the plant extracts of *M. madaraspatana* on biogenic and sustainable production of zinc oxide nanoparticles for continuous supply. This is the first report on the synthesis of zinc oxide nanoparticles using whole plant parts of *M. madaraspatana* using zinc nitrate.

2. Materials and Methods

Collection of plant material

The plant material was collected from the desert areas of Rajasthan, India. The plant parts such as leaves were excised and washed thoroughly with distilled water to remove the dust particles. The materials were allowed to shade dry at room temperature for about 1 hr (Fig. 2).

Fig. 2. Fresh eaves used in the study.

Preparation of plant extracts

Ten grams of healthy and fresh plant materials were made into small pieces and boiled separately each for 20 min with 100 ml of sterilized distilled water. After boiling the extracts were filtered using Whatman filter paper (No.1) and the aqueous extracts were used for the synthesis of ZnO nanoparticles. The plant extracts were prepared following Shekhawat et al. (2014).

Preparation of precursors

The aqueous stock of Zinc nitrate hexahydrate [$Zn (NO_3)_2.6H_2O$] (Merck, Mumbai) solution was used as a precursor in the present study. One mM solution of Zinc nitrate was prepared using double distilled water and stored using amber bottles in a refrigerator at 4 ^{o}C temperature for further use (Shekhawat et al. 2014).

Synthesis of ZnO NPs

The fresh aqueous solutions of *M. maderaspatana* were used to reduce the zinc metal ions into metallic zinc oxide nanoparticles. Three boiling tubes were used to synthesize ZnO nanoparticles, one containing 20 ml of 1.0 mM Zinc nitrate solution as reference, and the second one containing 20 ml of aqueous plant extract. The third tube contained various concentrations of (1.0, 2.5, 5.0, and 10.0 ml) plant extracts and made up to 20 ml with a 1.0 mM Zinc nitrate solution. The mixtures were allowed to stir continuously using a magnetic stirrer for uniform mixing at room temperature (Fig. 3). To observe the visual color change into yellow, the reaction medium was boiled for 20 min at 30 °C to 60 ^{o}C temperatures. The test solution from the third tube was centrifuged at 5000 rpm for 20 min to obtain the pellet. The supernatant was discarded and the pellet was dissolved in double distilled water and used for further studies.

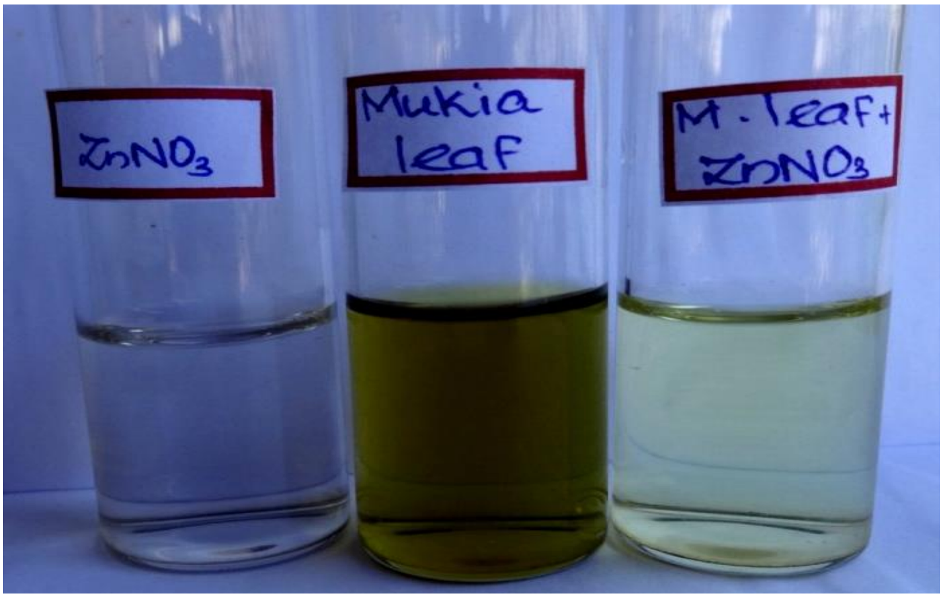

Fig. 3. Reaction mixtures and biosynthesis of ZnO nanopaticles.

Characterization of ZnO NPs by UV-visible spectroscopy

Synthesis of nanoparticles was confirmed through UV-visible spectroscopic readings after the visual color change. The bioreduction of synthesized ZnO nanoparticle solutions was recorded periodically at room temperature in a quartz cuvette (1 cm path length) using a double beam UV-Vis spectrophotometer (Model 2202, Systronics Ltd.) in diffuse reflectance mode and scanned in the range of 200 to 700 nm and recorded at a scanning speed of 1 nm intervals. One mM zinc nitrate solution was used as a reference.

3. Results and Discussion

In general, two substrates were used to prepare biogenic ZnO NPs namely Zinc acetate and Zinc nitrate (Shekhawat et al. 2014; Fatimah et al. 2016). Plant extracts are reported to play as reducing as well as stabilizing agents in the synthesis of nanoparticles (Kumar and Yadav 2008). The main components in the leaves of *M. maderaspatana* are dichloroacetic acid, 4-methylpentyl ester, 2-butyn-1-ol, 4-methoxy, flavonoids, saponins, carbohydrates, tannins, and phenolic compounds (Gomathy et al. 2012).

Synthesis of ZnO nanoparticles

Synthesis of nanoparticles in the reaction mixtures was envisaged through visual observation of color change in the solution from colorless to yellow. Further, confirmation was done using UV-visible spectroscopy. Gradual increase and decrease of zinc nitrate and plant extracts were used to optimize the synthesis of ZnO NPs.

Optimization of ZnO nanoparticles

Initially, the standardization of ZnO NPs synthesis using various parts of *M. maderaspatana* was done with the volume of reaction the mixture, zinc nitrate, incubation time, and temperature. There was an increase and sharp absorption peak when the volume of plant extract increased from 1 to 5 ml. However, an additional increase in volume to 10 ml resulted in the decline of absorption peak. It was also observed that further increase or decrease in this volume of plant extracts resulted in the decline of absorption peak. This is in agreement with the available report on ZnO NPs synthesis from *Nyctanthes arbor-tristis*. The increased concentration of the solution was reported to decrease the synthesis of zinc oxide nanoparticles using flower extracts of *N. arbor-tristis* (Jamdagni et al. 2018).

UV-visible spectroscopic characterization of ZnO NPs

UV-visible readings were recorded in the wavelength range of 200–700 nm. The reduction of zinc metal ions to zinc oxide nanoparticles by the plant extracts was observed by periodical recording of the absorption spectra. The confirmation of ZnO NPs synthesis was done by evaluating the absorption spectral range from 292 to 322nm. The maximum absorption was detected with the leaf reaction mixture at the range of 310-340 nm and a strong peak was found at 322 nm (Fig. 4). The initial spectra of the leaf reaction mixture showed strong surface plasmon resonance at 302 nm which intensified and stable at 322 nm in an hr, it clearly depicted that the enzymatic reduction of zinc nitrate completes within an hr and synthesis of ZnO NPs taken place. Similar reports of ZnO NPs synthesis were reported using leaf extracts of *Passiflora caerulea* (Santhoshkumar et al. 2017), flower extracts of *Cassia auriculata* (Ramesh et al. 2014), leaves of *Moringa oleifera* (Matinise et al. 2017) and whole plants of *Passiflora foetida* (Shekhawat et al. 2014).

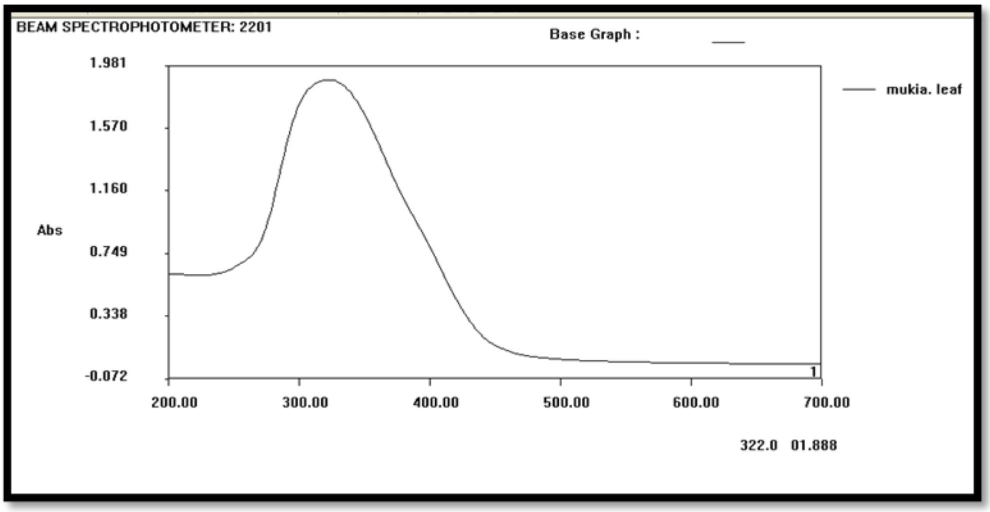

Fig. 4. Absorption spectra of the reaction mixture.

The properties of synthesized ZnO NPs were characterized generally by UV-visible spectrophotometer, FTIR, photoluminescence, XRD, SEM, and TEM analysis (Sangeetha et al. 2011). The biogenic ZnO NPs were further explored for various pharmacological activities. Antibacterial activity of ZnO nanoparticles synthesized from *Cassia alata* (Senthilkumar et al. 2013), *Catharanthus roseus* (Savithramma et al. 2014), *Coptidis rhizoma* (Nagajyothi et al. 2014). *Solanum nigrum* (Ramesh et al. 2015), *Cassia fistula* (Suresh et al. 2015), *Trifolium pretense* (Dobrucka, 2015), *Pongamia pinnata* (Rajeshkumar 2016), *Ceropegia candelabrum* (Murali et al. 2017) were reported.

Change in reaction time and temperature

Among the various concentrations/volume (1-10 ml) of plant extracts with zinc nitrate, reaction temperature (30 °C to 60 °C) and reaction time (48 hr) experimented, 5 ml of plant extract with 15 ml of zinc nitrate solution and stirring at 45 °C for 60 min were observed optimum conditions to get a narrow peak at the characteristic wavelength (322 nm) with maximum absorbance with the UV-visible spectrophotometer.

4. Conclusion

Green synthesis of zinc oxide nanoparticles using fresh plant extracts of *Mukia maderaspatana* provided an eco-friendly, rapid, simple, non-toxic, and efficient means for the synthesis of nanoparticles. The formation of yellow color in the reaction mixtures was observed within two hr. Synthesized ZnO NPs were further characterized using UV–Vis absorption spectroscopy. UV–Visible spectra suggested the presence of a strong peak at 322 nm confirming the nanoparticles synthesis. The ZnO NPs synthesized could be explored further for pharmaceuticals, antimicrobials, and in agricultural applications.

REFERENCES

1. Villasenor-Basulto D, Pedavoah MM, Bandala ER. Plant materials for the synthesis of nanometerials: Green sources. In: Martínez L., Kharissova O., Kharisov B. (eds) Handbook of Ecomaterials. Springer, Cham, 2018, https://doi.org/10.1007/978-3-319-48281-1_88-1.
2. Mirzaei H, Darroudi M. Zinc oxide nanoparticles: Biological synthesis and biomedical applications. Ceramics International, 2017; 43: 907-914.
3. Huang MH, Mao S, Feick H, Yan HQ, Wu YY, Kind H, Weber E, Russo R, Yang PD (2001) Room-temperature ultraviolet nanowire nanolasers. Science 292:1897.
4. Shirgholami M, A. Nazari, M. Mirjalili, Statistical optimization of self-cleaning technology and color reduction in wool fabric by nano zinc oxide and eco-friendly cross-linker, Clean. Technol. Environ. Policy 17 (2015) 905–919.

5. Taylor E, T.J. Webster, Reducing infections through nanotechnology and nanoparticles, Int. J. Nanomed. 6 (2011) 1463–1473.
6. Shekhawat MS, Ravindran CP, Manokari M (2014) Biosynthesis of Zinc oxide nanoparticles from *Passiflora foetida* L. Extracts and their characterization. International Journal of Green and Herbal Chemistry, 3(2): 518-523.
7. Manokari M, Ravindran CP, Shekhawat MS (2016) Biosynthesis of zinc oxide nanoparticles using *Melia azadarach* L. extracts and their characterization. International Journal of Pharmaceutical Science and Research, 1(1): 31-36.
8. Santhoshkumar J, Kumar SV, Rajeshkumar S. Synthesis of zinc oxide nanoparticles using plant leaf extract against urinary tract infection pathogen. Resource-Efficient Technologies, 2017; 3: 459-465.
9. Siripireddy B, B. K. Mandal, "Facile green synthesis of zinc oxide nanoparticles by Eucalyptus globulus and their photocatalytic and antioxidant activity," Advanced Powder Technology, vol. 28, no. 3, pp. 785–797, 2017.
10. Kalpana V. N., C. Payel, V. Devi Rajeswari, "*Lagenaria siceraria* aided green synthesis of ZnO NPs: anti-dandruff, Anti-microbial and Anti-arthritic activity," *Research Journal of Chemistry and Environment*, vol. 21, no. 11, pp. 14–19, 2017.
11. Happy A, Soumya M, Kumar SV, Rajeshkumar S, Sheba RD, Lakshmi T, Nallaswamy VD. Phyto-assisted synthesis of zinc oxide nanoparticles using Cassia alata and its antibacterial activity against Escherichia coli. Biochem Biophys Rep. 2019; 17: 208-211.
12. Chitra, G., Balasubramani, G., Ramkumar, R., et al.: 'Mukia maderaspatana (Cucurbitaceae) extract-mediated synthesis of silver nanoparticles to control *Culex quinquefasciatus* and *Aedes aegypti* (Diptera: Culicidae)', Parasitol. Res., 2015, 114, (4), pp. 1407–1415
13. Devi GK, Sathishkumar K. Synthesis of gold and silver nanoparticles using Mukia maderaspatana plant extract and its anticancer activity. IET Nanobiotechnology, 2016; doi: 10.1049/iet-nbt.2015.0054.
14. Rakesh, Ananda S, Gowda NMM. Synthesis of chromium (III) oxide nanoparticles by electrochemical method and *Mukia maderaspatana* plant extract, characterization, KMnO4 decomposition and antibacterial study. Modern Research in Catalysis, 2013; 2: 127-135.
15. Subha V, Kirubanandan S, Renganathan S. Green synthesis of silver nanoparticles from a novel medicinal plant source roots extract of *Mukia maderaspatana*. Colloid and Surface Science, 2016; 1: 14-17.
16. Petrus AJA. Ethnobotanical and pharmacological profile with propagation strategies of *Mukia maderaspatana* (L.) M. Roem. – A concise review. Indian Journal of Natural Products and Resources, 2013; 4: 9-26.
17. Gomathy G, Vijay T, Sarumathy K, Gunasekaran S, Palani S. Phytochemical screening and GC-MS analysis of *Mukia maderaspatana* (L.) leaves. Journal of Applied and Pharmaceutical Science, 2012; 2: 104-106.
18. Kavitha M, Srinivasan PT, Priya SL, Jayakumar LV. Evaluation of nutrient composition and antibacterial potential of leaf and stem of *Mukia maderaspatana* L. International Journal of Pharmaceutical Research & Allied Sciences, 2013; 2: 68-76.
19. Srilatha BR, Ananda S. Antidiabetic effects of *Mukia maderaspatana* and its phenolics: An in vitro study on gluconeogenesis and glucose uptake in rat tissues. Pharmaceutical Biology, 2013; 52: 597-602.
20. Veeramani C, Aristatile B, Pushpavalli G, Pugalendi KV. Effects of Melothria maderaspatana leaf extract on antioxidant status in shamoperated and uninephrectomized DOCA-salt hypertensive rats. Saudi J Biol Sci 2011;18(1):99-105.
21. Petrus AJ. Mukia maderaspatana (Linn.) M. Roemer. A potentially antidiabetic and vasoprotective functional leafy-vegetable. Pharmacogn J 2012;4(34):1-12.
22. Pandey D, Pandey S, Hemalatha S. Hypolipidemic activity of aqueous extract of Melothria maderaspatana. Pharmacol Online 2010;3:76-83.
23. Gomathy G, Venkatesan D, Palani S. Gastroprotective potentials of the ethanolic extract of Mukia maderaspatana against indomethacininduced gastric ulcer in rats. Nat Prod Res 2015;29:2107-11.
24. Fatimah I, Pradita RY, Nurfalinda A. Plant extract mediated of ZnO nanoparticles by using ethanol extract of *Mimosa pudica* leaves and coffee powder. Procedia Eng. 2016; 148: 43-48.
25. Kumar V, Yadav SK. Plant-mediated synthesis of silver and gold nanoparticles and their applications. Journal of Chemical Technology and Biotechnology, 2008, 84: 151-157.
26. Jamdagni P, Khatri P, Rana JS. Green synthesis of zinc oxide nanoparticles using flower extract of *Nyctanthes arbor-tristis* and their antifungal activity. Journal of King Saud University – Science, 2018; 30: 168-175.
27. Ramesh P, Rajendran A, Meenakshisundaram M. Green synthesis of zinc oxide nanoparticles using flower extract of *Cassia auriculata*. Journal of NanoScience and Nano Technology, 2014; 2: 41-45.
28. Matinise N, Fuku XG, Kaviyarasu K, Mayedwa N, Maaza M. ZnO nanoparticles via *Moringa oleifera* green synthesis: Physical properties & mechanism of formation. Applied Surface Science, 2017; 406: 339-347.

29. Sangeetha G, S. Rajeshwari, and R. Venckatesh, “Green synthesis of zinc oxide nanoparticles by aloe barbadensis miller leaf extract: Structure and optical properties,” *Materials Research Bulletin*, vol. 46, no. 12, pp. 2560–2566, 2011.
30. Senthilkumar R.P., Malayaman V., Sindhuja S. Phytochemical screening and antibacterial evaluation of the leaf, flower and seed coat extracts of Cassia alata L. J. Chem. Pharm. Res. 2013;5:740–744.
31. Savithramma N., Bhumi G. Biological Synthesis of zinc oxide nanoparticles from C atharanthus roseus (l.) G. Don. leaf extract and validation for antibacterial activity. Int. J. Drug Dev. Res. 2014;6:208–214.
32. Nagajyothi P.C., Sreekanth T.V.M., Tettey C.O., In Y., Heung S. Characterization, antibacterial, antioxidant, and cytotoxic activities of ZnO nanoparticles using coptidis rhizoma. Bioorg. Med. Chem. Lett. 2014;24:4298–4303.
33. Ramesh M., Anbuvannan M., Viruthagiri G. Green synthesis of ZnO nanoparticles using Solanum nigrum leaf extract and their antibacterial activity, Spectrochim. Acta Part A Mol. Biomol. Spectrosc. 2015;136:864–870.
34. Suresh D., Nethravathi P.C., Rajanaika H. Green synthesis of multifunctional zinc oxide (ZnO) nanoparticles using Cassia fistula plant extract and their photodegradative, antioxidant and antibacterial activities. Mater. Sci. Semicond. Process. 2015;31:446–454.
35. Dobrucka R. Biosynthesis and antibacterial activity of ZnO nanoparticles using Trifolium pratense flower extract. Saudi J. Biol. Sci. 2015
36. Rajeshkumar S. Synthesis of silver nanoparticles using fresh bark of Pongamia pinnata and characterization of its antibacterial activity against gram positive and gram negative pathogens. Resour. Technol. 2016;2:30–35.
37. Murali M., Mahendra C., Rajashekar N., Sudarshana M.S. antibacterial and antioxidant properties of biosynthesized zinc oxide nanoparticles from Ceropegia candelabrum L. – An endemic species. Spectrochim. Acta Part A Mol. Biomol. Spectrosc. 2017;179:104–109.