e-ISSN: 2455-667X

Annals of Natural Sciences

(Peer Reviewed and UGC Approved International Journal)

Vol. 3(4), December 2017: 42-47

Journal's URL: http://www.crsdindia.com/ans.html

Email: crsdindia@gmail.com

Annals of Natural Sciences

ORIGINAL ARTICLE

An Overview of Various Methods of Preparation of Green Nanoparticles and their Therapeutic Applications

Neelam Yadav

Centre for Biotechnology, Maharshi Dayanand University, Rohtak, Haryana, India

Email: neelamindia12@gmail.com

ABSTRACT

Recently, the development of effective green chemistry methods for preparation of metal nanoparticles has attracted the interest of researchers. They have been scrutinized to find an eco-friendly technique for production of well-characterized nanoparticles. A number of lant species have been used for the synthesis of these green nanoparticles as plants are suitable for large-scale biosynthesis of nanoparticles. These green nanoparticles are more stable and the rate of synthesis is faster as compared to microorganisms. Furthermore, the plant based nanoparticles have exhibited various shape and size than those produced by other organisms. Research has been carried out to understand the possible mechanism of metal ions uptake and bioreduction by plants derived materials during biosynthesis of metallic nanoparticles. In this review, most of the plants used in metal nanoparticle synthesis are shown. Hence, future research should be focused to explore the use of green nanoparticles in pharmaceutical sciences for the diagnosis and treatment of various fatal diseases and the approach used for therapeutics should be reliable, non toxic and inexpensive.

Key word: *Green nanoparticles, pharmaceutical, therapeutics, Non-toxic, Biosynthesis, Medical applications*

Received: 3rd Sept. 2017, Revised: 21st Oct. 2017, Accepted: 25th Oct. 2017

How to cite this article:

Yadav N. (2017): An Overview of Various Methods of Preparation of Green Nanoparticles and their Therapeutic Applications. Annals of Natural Sciences, Vol. 3[4]: December, 2017: 42-47.

INTRODUCTION

Nanoparticles has arouse the interest among researchers due to their unique properties such as small size and large surface to volume ratio, mechanical properties, biological and sterical properties, catalytic activity, thermal and electrical conductivity, optical absorption and melting point (Matson and Wilson, 2010)**.** As a result, fabrication and production of materials with novel applications can be achieved by controlling shape and size at nanometre scale. Nanoparticles have been used in diverse applications including biosensing and catalysts to optics, antimicrobial activity, computer transistors, electrometers, chemical sensors, and wireless electronic logic and memory schemes. These have several other applications in diverse fields like medical imaging, nanocomposites, filters, drug delivery, and hyperthermia of tumors (Lee, *et al.,* 2008; Pissuwan, *et al.,* 2006). Metal nanoparticles have contributed in the field of in medicine and pharmacy. Among metallic nanoparticles gold and silver nanoparticles are widely used in biomedical applications and in emerging interdisciplinary field of nanobiotechnology. For example; oligonucleotide capped gold nanoparticles have been used for polynucleotide or protein detection using various detection/characterization methods, including atomic force microscopy, gel electrophoresis, scanometric assay, surface plasmon resonance imaging, amplified voltammetric detection, chronocoulometry, and Raman spectroscopy (Cai, *et al.,* 2008; Sperling, *et al*., 2008), immunoassay (Liu, *et al.,* 2008), protein assay (Tang, *et al.,* 2007), cancer nanotechnology (Medley, *et al.,* 2007) and capillary electrophoresis (Tseng, *et al.,* 2005). In the field of medicine, gold nanoparticles are acting as markers for biological screening test. When these nanoparticles are cellularly uptaken they precisely targeted and powerful heaters for killing the cancerous cells (El-Sayed, *et al.,* 2006). Besides, gold nanoparticles are also responsible for inducing apoptosis in B cell-chronic lymphocytic (Mukherjee, *et al.,* 2007). Silver nanoparticles have also attracted the attention of scientific communities as they have exhibited various applications in areas like integrated circuits (Kotthaus, *et al.,* 1997), sensors (Cao, 2004), biolabelling, filters, antimicrobial deodorant fibres (Zhang and Wang, 2003), cell electrodes (Klaus-Joerger, *et al.,* 2001) and antimicrobials (Kalaichelvan and Mohan, 2010). Antimicrobial properties of silver nanoparticles have been exploited in different fields of medicine, industries, animal husbandry, packaging, accessories, cosmetics, health and military. Silver nanoparticles have showed significant antimicrobial activities against infectious agents including *Escherichia coli*, *Bacillus subtilis*, *Vibria cholera*, *Pseudomonas aeruginosa*, *Syphillis typhus*, and *Staphylococcus aureus* (Dura'n, *et al,* 2007).

BIOSYNTHESIS OF NANOPARTICLES FROM PLANTS

Very firstly, metallic green nanoparticles i.e. gold and silver were synthesized from plant *Medicago sativa* (alfalfa). Table 1 shows the myriads of plants species have been used for the synthesis of green nanoparticles (Baker, *et al.,* 2013).

Table 1: Plant species used for preparation of nanoparticles (Baker, *et al.,* 2013)

Acalypha indica	Gliricidia sepium
Artocarpus Heterophyllus	Camellia sinensis
Boswellia ovalifoliolata	Psidium guajava
Brassica juncea	Syzygium aromaticum
Cardiospermum helicacabum	Aloe vera
Cassia fistula	Azadirachta indica
Catharanthus roseus	Emblica officinalis

Methods of preparation of green nanoparticles:

At present, varied physical, chemical, biological, and hybrid methods have been used for the preparation of nanoparticles (Fig. 2) (Chung, *et al.,* 2016). Traditional synthesis of nanoparticles depends on two approaches i.e. physical and chemical. These approaches are based on ion sputtering, solvothermal synthesis, reduction, and sol-gel techniques. Nanoparticle synthesis methods can also be classified as bottom-up and top-down. Chemical practices of nanoparticles synthesis involve the reduction of chemicals (Guzmán, *et al.,* 2009), electrochemical procedures (Rodríguez-Sánchez, *et al.,* 2000), and reduction of photochemicals (Sharma, *et al.,* 2009). Synthesis of plant-based nanoparticles is safe, light in weight, ability to do works at low temperatures, and rapid (Goodsell, 2004). Recently, nanoparticles prepared from plants have attracted more attention due to growing interest in environmentally conscious products. Furthermore, synthesis of plant based nanoparticles have offered many advantages including use of safer solvents, minimized use of harmful/toxious reagents, milder response conditions, viability and their use in medicinal, surgical, and pharmaceutical applications (Abdel-Halim, *et al.*, 2011).

There are some important aspects which should be considered during preparation of highly stable and well-characterized nanoparticles which are given below:

i. Selection of the Best Organisms:

For the synthesis of metal nanoparticle researchers should focused on the essential intrinsic properties of the organisms like enzyme kinetics and metabolic pathways. For instance, plants which can accumulate heavy metals and detoxification ability are the paramount entrant for nanoparticle synthesis.

ii. Optimal Conditions for Cell Growth and Enzyme Activity:

Before synthesis of nanoparticles optimum growth conditions should also be considered like nutrients, inoculum size, light, temperature, pH, mixing speed, and buffer.

1. Characterization of Nanoparticles:

Plant based nanoparticles have been characterized to know about size, shape, surface area, and dispersity (Jiang, *et al.,* 2009). The most commonly used techniques of characterizing nanoparticles includes UV–visible spectrophotometry, dynamic light scattering (DLS), scanning electron microscopy (SEM), transmission electron microscopy (TEM), Fourier transform infrared spectroscopy (FTIR), powder X-ray diffraction (XRD) and energy dispersive spectroscopy (EDS) (Shahverdi, *et al.,* 2011).

2. Applications of Nanoparticles:

Nanoparticles prepared by using various methods and used in several *in vitro* therapeutic applications (Chen, *et al.,* 2012). Nanoparticles of gold and silver have shown broad spectrum antimicrobial activity against human and animal pathogens (Kandasamy, *et al.,* 2012). Silver nanoparticles are already widely used as antimicrobial agents in commercial medical and consumer products (Ravindra, *et al.,* 2010). General applications of metal nanoparticles in biological field are shown in Fig. 3.

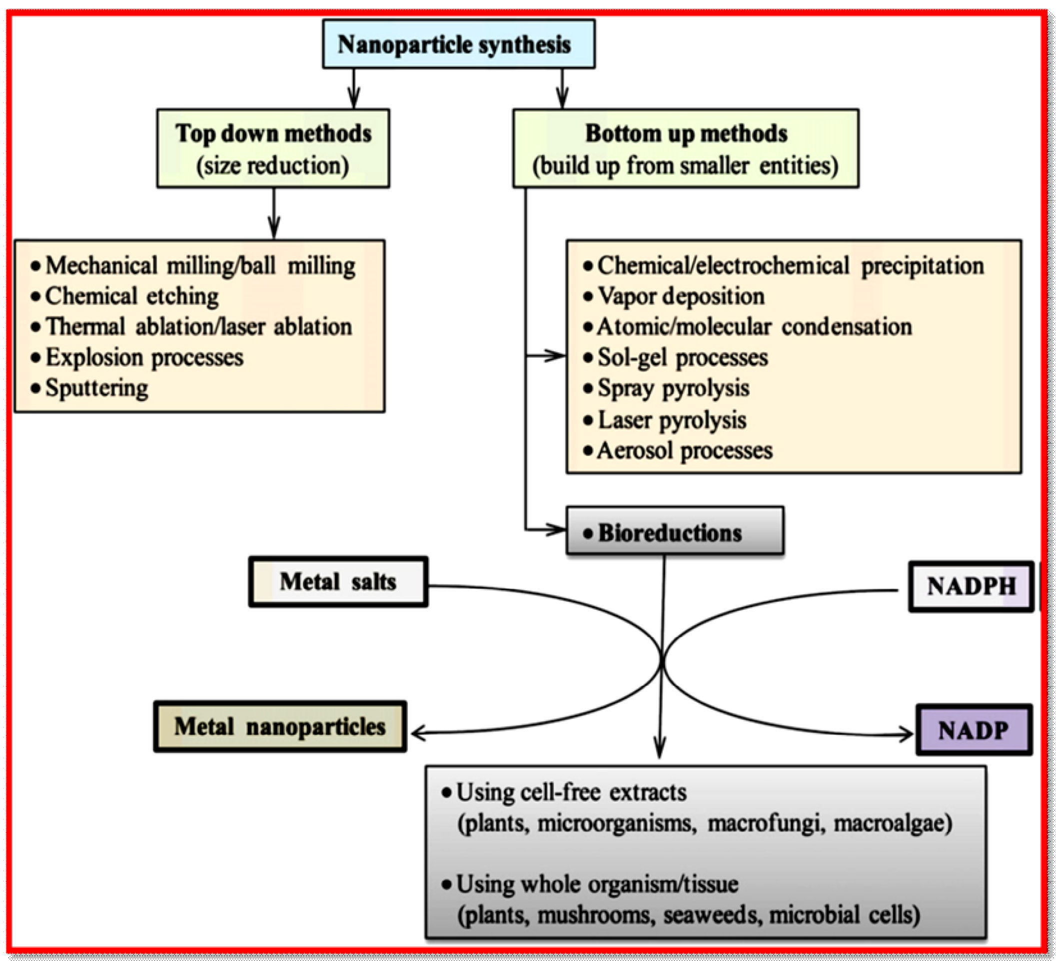

Fig. 1: Various approaches for making nanoparticles and cofactor dependent bioreduction (Source: Mittal, *et al.,* 2013)

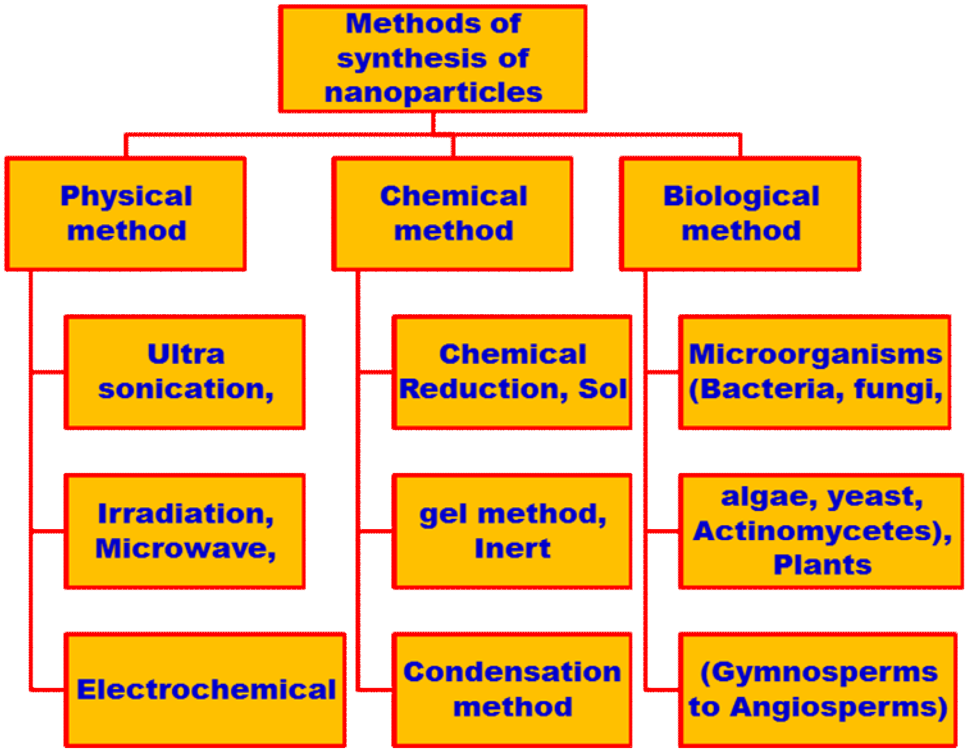

Fig. 2: Methods involved in nanoparticle synthesis (Source: Chung, *et al.*, 2016)

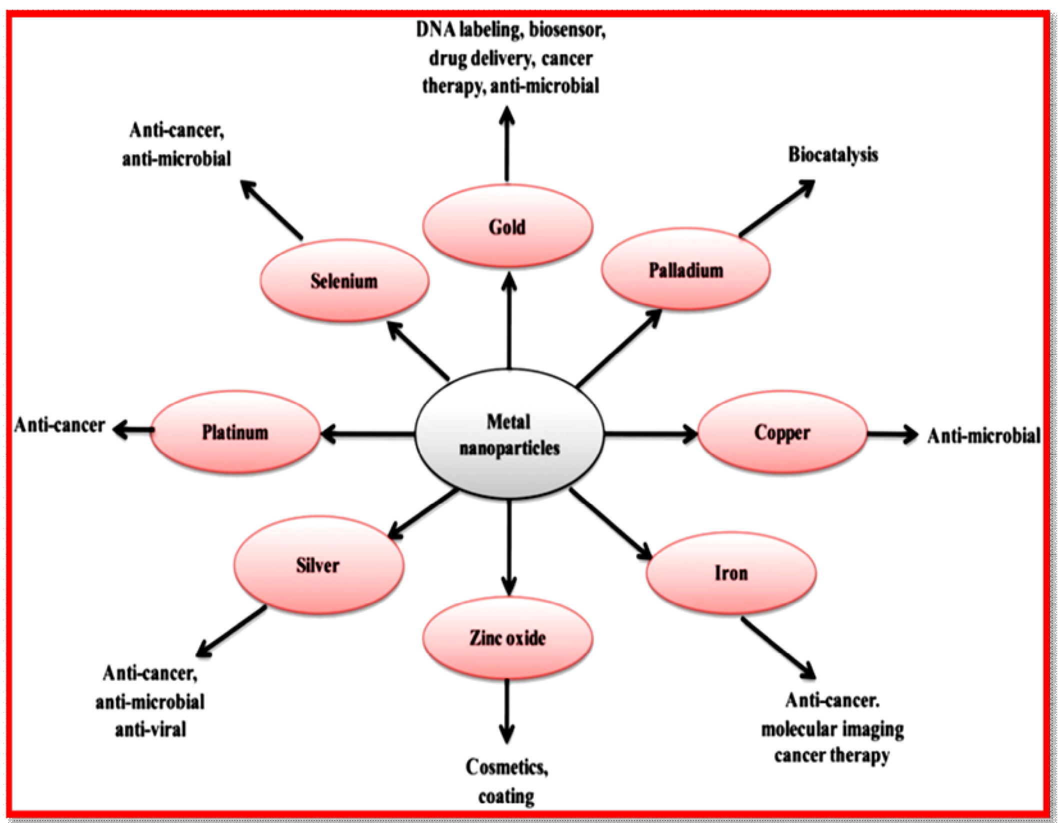

Fig. 3: Types of metal nanoparticles and their applications in biotechnology

Silver nanoparticles have been found to be larvicidal against filariasis and malaria vectors (Rajakumar and Abdul Rahuman, 2011) and also active against plasmodial pathogens (Ponarulselvam, *et al.,* 2012) and cancer cells (Subramanian, 2012). They also showed antifungal activity (Vivek, *et al.,* 2011) and found to be highly toxic to a number of microbes (Jung, *et al.,* 2008). Mechanism antimicrobial action of these AgNPs is slow release of silver ions through oxidation within or outside the cell and interrupt the permeability of membranes of microbial and other cells (Li, *et al.,* 2010). These nanoparticles also inactivate the proteins and interfere with the replication of DNA (Chaloupka, *et al.,* 2010). Table 2 shows the various applications of metallic nanoparticles synthesized from plant extracts.

Table 2: Applications of nanoparticles synthesized from plant extracts

Metal nanoparticles	Application	References
Silver	Anti-microbial, anti-cancer, anti-protozoal	Rajkumar and Abdul, 2011
Gold	Anti-microbial	Ghosh et al, 2011
Palladium	Anti-bacterial	Amarnath et al., 2012
Copper	Anti-microbial, anti-cancer	Lee et al, 2001
Selenium	Anti-cancer	Prasad et al, 2012

Green nanoparticles based practices have reduced the risk of crop damage in agriculture system (Khot, *et al.,* 2012). Espitia, *et al.* (2012) reported the significance of zinc oxide nanoparticles in antimicrobial food packaging (Perez Espitia, *et al.,* 2012). A number of nanoparticles have been used to minimize the microbial loads in treated wastewater effluent (Duran, *et al.,* 2007).

CONCLUSION

Increasing consciousness towards green chemistry and biological processes has influenced the synthesis of environment-friendly non-toxic nanoparticles. The present biosynthesis method for making metallic nanoparticles is a green, cost-effective, easily scaled up and environmentally benign. Plant based nanoparticles are free from toxic contaminants which is required in medicinal applications as these green nanoparticles are in controlled size and morphology. In medicine, nanoparticles are being used as antimicrobial agents in bandages, for example. Research is going on to explore the applications of these nanoparticles in targeted drug delivery and clinical diagnostics. Due to the huge biodiversity of plants, nanoparticle synthesis has become an interest across the world. Consequently, different plant species are being rapidly explored and analysed for preparation of nanoparticles. These plant based nanoparticles have offered several human benefits. Harvesting of endangered species of plants reduces the risk to the plant biodiversity which should be focused in the future. Future research on green synthesis of nanoparticles will exhibit numerous fascinating properties such as optoelectronics, physicochemical and electronic properties that will be significant applications in the field chemistry, electronics, medicine and agriculture.

REFERENCES

1. Abdel-Halim E.S., El-Rafie M.H. and Al-Deyab S.S. (2011): Polyacrylamide/guar gum graft copolymer for preparation of silver nanoparticles. Carbohydr Polym, 85: 692.
2. Amarnath K., Kumar J., Reddy T., Mahesh V., Ayyappan S.R. and Nellore J. (2012): Synthesis and characterization of chitosan and grape polyphenols stabilized palladium nanoparticles and their antibacterial activity. Colloids Surf B Biointerfaces, 94: 254–261.
3. Baker S., Rakshith D., Kavitha K.S., Santosh P., Kavitha H.U., Rao Y. and Satish S. (2013): Plants: Emerging as Nanofactories towards Facile Route in Synthesis of Nanoparticles. *BioImpacts*, 3(3): 111-117.
4. Cao G. (2004): Nanostructures and Nanomaterials: Synthesis, Properties and Applications, Imperial College Press, London.

5. Chaloupka K., Malam Y. and Seifalian A.M. (2010): Nanosilver as a new generation nanoproduct in biomedical applications. Trends Biotechnol, 28: 580–588.
6. Chen X.J., Sanchez-Gaytan B.L., Qian Z.X. and Park S.J. (2012): Noble metal nanoparticles in DNA detection and delivery. Wiley Interdiscip Rev Nanomed Nanobiotechnol, 4: 273–290.
7. Chung I.M., Park I., Hyun K.S., Thiruvengadam M. and Rajakumar G. (2016): Plant-Mediated Synthesis of Silver Nanoparticles: Their Characteristic Properties and Therapeutic Applications. Nanoscale Research Letters, 11:40, 1-14.
8. Dura'n N., Marcato P.D., De S., Gabriel I.H., Alves O.L. and Esposito E. (2007): *J. Biomed. Nanotechnol.*, 3: 203-208.
9. Duran N., Marcato P.D., De Souza G.I.H., Alves O.L. and Esposito E. (2007): Antibacterial effect of silver nanoparticles produced by fungal process on textile fabrics and their effluent treatment. J Biomed Nanotechnol, 3: 203–208.
10. El-Sayed I.H., Huang X. and El-Sayed M.A. (2006): *Cancer Lett.*, 239: 129-135.
11. Ghosh S., Patil S., Ahire M., Kitture R., Jabgunde A., Kale S., *et al.,* (2011): Synthesis of gold nano-anisotrops using Dioscorea bulbifera tuber extract. J. Nanomater.
12. Goodsell D.S. (2004): Bionanotechnology: lessons from nature. Wiley, Hoboken
13. Guzmán M.G., Dille J. and Godet S. (2009): Synthesis of silver nanoparticles by chemical reduction method and their antibacterial activity. Int. J. Chem. Biomol. Eng., 2: 3.
14. Iravani S. (2011): Green synthesis of metal nanoparticles using plants. *Green Chem.*, 13: 2638–2650.
15. Jiang J., Oberdörster G. and Biswas P. (2009): Characterization of size, surface charge, and agglomeration state of nanoparticle dispersions for toxicological studies. J. Nanopart Res., 11: 77–89.
16. Jung W.K., Koo H.C., Kim K.W., Shin S., Kim S.H. and Park Y.H. (2008): Antibacterial activity and mechanism of action of the silver ion in Staphylococcus aureus and Escherichia coli. Appl Environ Microbiol., 74: 2171–8.
17. Kalaichelvan and Mohan N. (2010): *Colloids Surf., B*, 76: 50–56.
18. Kandasamy K., Alikunhi N.M., Manickaswami G., Nabikhan A. and Ayyavu G. (2012): Synthesis of silver nanoparticles by coastal plant Prosopis chilensis (L.) and their efficacy in controlling vibriosis in shrimp Penaeus monodon. Appl. Nanosci.
19. Klaus-Joerger T., Joerger R., Olsson E. and Granqvist C.G. (2001): *Trends Biotechnol.*, 19: 15-20.
20. Korbekandi H., Iravani S. and Abbasi S. (2009): *Crit. Rev. Biotechnol.*, 29: 279-306.
21. Kotthaus S., Gunther B.H., Hang R. and Schafer H. (1997): *IEEE Trans. Compon., Packag., Manuf. Technol., Part A*, 20: 15-20.
22. Lee H.Y., Li Z., Chen K., Hsu A.R., Xu C., Xie J., Sun S. and Chen X. J. (2008): Nucl. Med., 49: 1371-1379.
23. Liu X., Dai Q., Austin L., Coutts J., Knowles G., Zou J., Chen H. and Huo Q. (2008): *J. Am. Chem. Soc.*, 130, 2780-2782.
24. Matson M.L. and Wilson L.J. (2010): *Future Med. Chem.*, 2: 491-502.
25. Medley C.D., Smith J.E., Tang Z., Wu Y., Bamrungsap S. and Tan W. (2008): *Anal. Chem.*, 80, 1067-1072.
26. Mittal A.K., Chisti Y. and Banerjee U.C. (2013): Synthesis of metallic nanoparticles using plant extracts. Biotechnology Advances, 31: 346-356.
27. Mukherjee P., Bhattacharya R., Bone N., Lee Y.K., Patra C.R., Wang S., Lu L., Secreto P., Banerjee C., Yaszemski M.J., Kay N.E. and Mukhopadhyay D. (2007): *J. Nanobiotechnol.*, 5: 4.
28. Pissuwan D., Valenzuela S.M. and Cortie M.B. (2006): *Trends Biotechnol.*, 24: 62-67.
29. Prasad K.S., Patel H., Patel T., Patel K. and Selvaraj K. (2012): Biosynthesis of Se Nanoparticles and its Effect on UV-Induced DNA Damage. Colloids and Surfaces B: Biointerfaces, 103: 261–266.
30. Rajakumar G. and Abdul Rahuman A. (2011): Larvicidal activity of synthesized silver nanoparticles using Eclipta prostrata leaf extract against filariasis and malaria vectors. Acta. Trop., 118: 196-203.
31. Ravindra S., Mohan Y.M., Reddy N.N. and Raju K.M. (2010): Fabrication of antibacterial cotton fibres loaded with silver nanoparticles via "green approach". Colloids Surf A., 367: 31-40.
32. Rodríguez-Sánchez M.L., Blanco M.C. and López-Quintela M.A. (2000): Electrochemical synthesis of silver nanoparticles. J. Phys. Chem. B., 104: 9683-9688.
33. Shahverdi A.R., Shakibaie M. and Nazari P. (2011): Basic and practical procedures for microbial synthesis of nanoparticles. In: Rai M, Duran N, editors. Metal nanoparticles in microbiology. Berlin: Springer, 177-197.
34. Sharma V.K., Yngard R.A. and Lin Y. (2009): Silver nanoparticles green synthesis and their antimicrobial activities. Adv Colloid Interf Sci., 145: 83–96.
35. Sperling R.A., Gil P.R., Zhang F., Zanella M. and Parak W.J. (2008): *Chem. Soc. Rev.*, 37: 1896–1908.
36. Subramanian V. (2012): Green synthesis of silver nanoparticles using Coleus amboinicus lour, antioxitant activity and invitro cytotoxicity against Ehrlich's Ascite carcinoma. J. Pharm. Res., 5: 1268–72.
37. Tang D., Yuan R. and Chai Y. (2007): *Biosens. Bioelectron.*, 22: 1116–1120.
38. Tseng W.L., Huang M. F., Huang Y.F. and Chang H.T. (2005): *Electrophoresis*, 26: 3069–75.
39. Vivek M., Kumar P.S., Steffi S. and Sudha S. (2011): Biogenic silver nanoparticles by Gelidiella acerosa extract and their antifungal effects. Avicenna J. Med. Biotechnol., 3: 143-148.
40. Zhang W. and Wang G. (2003): *New Chem. Mater.*, 31: 42-44.