International Journal of
Emerging Research in Management &Technology
ISSN: 2278-9359 (Volume-4, Issue-12)

Research Article December 2015

Plant and Plant Products for Silver Nanoparticles Synthesis: A Green Revolution in Nanobiotechnology

Neh Satsangi, Shabad Preet
Department of Zoology, Faculty of Science,
Dayalbagh Educational Institute, Agra 282005, India

Abstract—

Plants have been of great value throughout human history. Many of the herbs and spices used by humans to season food also have the capacity to produce compounds which are not only of medicinal importance but also have the catalytic activity in certain chemical and biological reactions. This green nanotechnology includes the use of plant products which are easily biodegradable thus curtailing potential environmental and human health risks. India herbal technology is in use since prehistoric time leading to the fundamentals of Ayurveda. Nowadays plants and their products are used in green chemistry to produce metallic nanoparticles. Plants have certain metabolites which act as reducing and stabilizing agents thus helping in the reduction of aqueous silver. Metallic silver in the form of silver nanoparticles (AgNPs) has made a remarkable comeback due to its diverse medical applications. The AgNPs fabricated using plants are less hazardous more biodegradable compared to the AgNPs synthesized using convection physical and chemical methods. In our study we have screened 40 different plants which includes trees, weeds, biowaste, Indian spices, herbs, shrubs, etc which are found in Agra city and can be exploited for the synthesis of AgNPs. The change in color signifies the production of AgNPs and growth of nanoparticle was monitored by surface plasmon behavior using UV-Vis Spectroscopy between the range 300nm and 700nm. Majority of the spectral peaks were between the 420 to 430nm. The selection of the plants was done on the basis of incubation time. The plants which show fastest color change tend to reduce silver nitrate more. Hitherto, this is the first report on the synthesis of AgNPs using 40 different plants and plants product.

Keywords*— Silver nanoparticles, biofabrication, plants, green chemistry, nanobiotechnology*

I. INTRODUCTION

Plants have the ability to synthesize a wide variety of chemical compounds that are used to perform important biological functions and hence used throughout human history. Chemical compounds in plants mediate their effect on the human body through processes identical to those already well understood for the chemical compounds and thus used in every branch of modern science. Presently they are been widely used in green chemistry and nanotechnology. Nanotechnology is one of the most extensively studied areas in the 21st century. It is thus the science of materials dealing with very small dimension materials usually in the range of 1 to100 nm. These particles have a high specific surface area and a high fraction of surface atoms due to which they attain entirely new and improved properties [1]. Metal nanoparticles; have unique physicochemical characteristics including catalytic activity, optical properties, electronic properties, antibacterial properties and magnetic properties [2,3] hence they have been applied to various fields ranging from medical to physical fields . The most effectively studied nanoparticles in the recent past are those made from the noble metals such as silver [4] and gold [5]. The synthesis of these nanoparticles has been done using active physical and chemical methods. Nanoparticles synthesized using chemicals show undesirable effect to the environment and existing organisms, whereas physical methods are exclusive and requires high energy. Thus, Green nanotechnology has been described as the development of clean technologies, to minimize potential environmental and human health risks associated with the manufacture and use of nanotechnology products, and to encourage replacement of existing products with new nano-products that are more environmentally friendly throughout their life cycle.

Since the last decade, nanoparticle biosynthesis is the active area of research. Different biological entities such as plant, plant extracts, bacteria, fungi, and yeast have been explored for metal nanoparticle synthesis. Green AgNPs have been produced using various natural products like *Azadirachta indica* [6], *Glycine max* [7], *Cinnamon zeylanicum* [8], and *Camellia sinensis*[9]. Using plant materials for the synthesis of nanoparticles could prove to have an enormous impact in immediate future, because it eliminates elaborate process like preservation of microbial cell cultures and tiresome down-stream processing [10]. Silver nanoparticles (AgNPs) are reported to possess anti-fungal [11], anti-inflammatory [12], and anti-viral activity [13]. As a result of which the development of reliable green process for the synthesis of silver nanoparticles is an important aspect of current nanotechnology research.

II. MATERIALS AND METHOD

A. Preparation of aqueous extract of plants and their products

Known weight (25 g) of freshly collected, taxonomically authenticated plant products were taken and washed thoroughly in flush of tap water in the laboratory for 10 min in order to remove the dust particles. After that they were cut into small pieces and rinsed briefly in milli-Q water. In 250 mL beaker containing 100 mL of milli-Q water, 25 gms of plant product was added and heated in the microwave for 5 minutes. The extract was cooled to room temperature, pressed and filtered firstly through Whatman filter paper No. 1 and then by Millipore 0.45 µm syringe filter.

B. Synthesis of silver nanoparticles
For the synthesis of AgNPs, 10 ml of 25% aqueous extract was added to 90ml of 1mM aqueous $AgNO_3$ solution with constant stirring for half an hour and left at room temperature till the color change was observed. The reduction of Ag+ was observed by measuring the UV–Vis spectra of the solution.

C. UV Spectrophotometric analysis
The formation of plant mediated silver nanoparticles was confirmed by the spectral analysis. The UV spectra of the biosynthesized silver nanoparticles was recorded using Systronics double beam spectrophotometer 2203 by continuous scanning from 300nm to 700nm and the Milli Q water was used as the reference for the baseline correction.

III. RESULTS AND DISCUSSIONS
A. Preparation of aqueous extract
Plants and their products are used for the biological reduction of silver nitrate. Plants which are used for the study are given in Table 1. The formation of silver nanoparticles were initially been monitored by colour change. The colourless silver nitrate solution changes to brownish or dark yellow colour signifying the formation of AgNPs.

Table 1 showing plants screened along with parts used for biosynthesis of silver nanoparticles

S.No	Name	Category	Part used	Wavelength (nm)
1	*Azadirachta indica*	Evergreen Tree	Leaves	426.4nm
2	*Eucalyptus*	Flowering Tress	Bark	439.2nm
3	*Millettia pinnata*	Tree	Leaves	426.4nm
4	*Polyalthia longifolia*	Tree	Leaves	426.4nm
5	*Neolamarckia cadamba*	Evergreen Tree	Leaves	464.8nm
6	*Thuja occidentalis*	Evergreen Tree	Leaves	567.2nm
7	*Cymbopogon*	Perennial Grass	Leaves	426.4nm
8	*Calendula officinalis*	Perennial Herb	Leaves	-
9	Asafoetida (Hing)	Spice	Latex	426.4nm
10	*Mace (Javitri)*	Spice	Aril	426.4nm
11	*Resin*	Hydrocarbon	Secretion from plant	522.4nm
12	*Ricinus communis*	Flowering plant	Leaves	426.4nm
13	*Nerium oleander*	Shrub	Leaves	-
14	*Nyctanthes arbor-tristis*	Shrub	Leaves	426.4nm
15	*Citrus aurantium*	Biowaste	Fruit peel	426.4nm
16	*Beta vulgaris*	Biowaste	Leaves	490.4nm
17	*Tamarind seeds*	Biowaste	Seed	420nm
18	*Nutmeg (Jaifal)*	Spice	Seed	426.4nm
19	*Pisum sativum*	Biowaste	Peel	426.4nm
20	*Argemone mexicana*	Weed	Leaves	-
21	*Sida acuta*	Weed	Leaves	439.2nm
22	*Sonchus arvensis*	Weed	Leaves	490.4nm
23	*Gnaphalium purpureum*	Weed	Leaves	-
24	*Artemisia absinthium*	Weed	Leaves	426.4nm
25	*Oxalis cernua*	Weed	Leaves	464.8nm
26	*Achyranthes aspera*	Weed	Leaves	-
27	*Agave angustifolia*	Monocots	Leaves	-
28	*Averrhoa carambola*	Woody plant	Fruit	439.2nm
29	*Bougainvillea glabra*	Shrub	Leaves	426.4nm
30	*Callistemon citrinus*	Shrub	Leaves	426.4nm
31	*Berberis aristata (Rasaut)*	Tree	Bark extract	333.6nm
32	*Brassica oleracea*	Biowaste	Leafy peel	-
33	*Musa acuminate*	Biowaste	Fruit peel	426.4nm
34	*Bryophyllum pinnatum*	Succulent herb	Leaves	490.4nm
35	*Lantana camara*	Perennial shrub	Leaves	452nm
36	*Datura inoxia*	Annual shrub	Leaves	-
37	*Jasminum officinale*	Deciduous shrub	Leaves	-
38	*Tropaeolum majus*	Flowering herb	Leaves	-
39	*Clerodendrum paniculatum*	Semi-woody shrub	Flower	452nm
40	*Hibiscus rosa-sinensis*	Shrub	Leaves	416.8nm

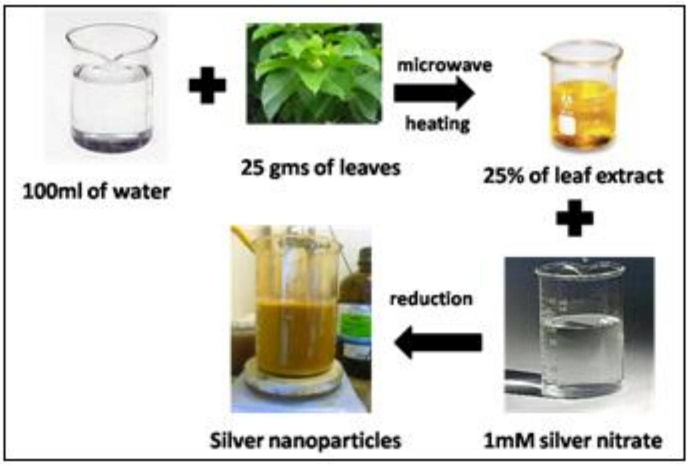


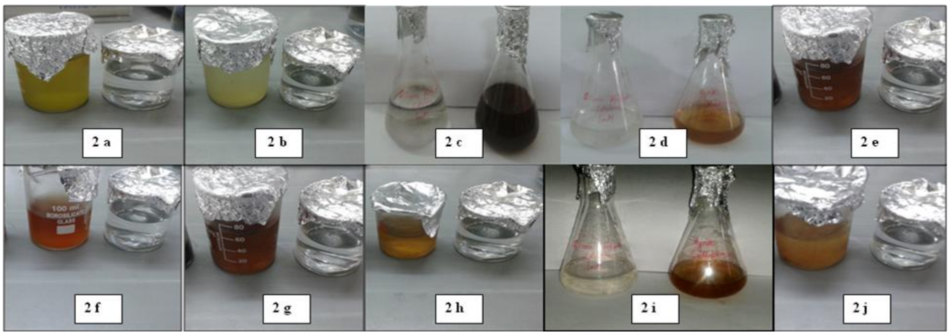
Fig 1 shows diagrammatical preparation of silver nanoparticles (AgNPs)

B. Synthesis of silver nanoparticles

UV–vis spectroscopy is one of the frequently used techniques for structural studies of silver nanoparticles. The production of the silver nanoparticles synthesized from plants and plant products were evaluated through spectrophotometer in a range of wavelength from 300 to 700 nm. This revealed that most of the peaks were at the range from 420-430nm. Out of these 40 plants, the plants with gave the best spectral peaks are shown in table 2. Figure 2(a-j) shows the formation of the dark brownish color which might be due to the excitation of the surface Plasmon vibration of the synthesized silver nanoparticles [14].

Table 2 showing plants which gave the best result for biosynthesis of silver nanoparticles

S.No	Plants	Wavelengths (nm)	Incubation time
1	*Azadirachta indica*	426.4nm	2-3 hrs
2	*Cymbopogon*	426.4nm	3 hrs
3	*Musa acuminata*	426.4nm	6 hrs
4	*Tamarind seed*	420nm	1 hr
5	*Sida acuta*	439.2nm	4-5 hrs
6	*Artemisia absinthium*	426.4nm	3.30-4 hrs
7	*Neolamarckia cadamba*	464.8nm	30mins
8	*Nyctanthes arbortristis*	426.4nm	2hrs
9	*Callistemon citrinus*	426.4nm	30mins
10	Asafoetida (Hing)	426.4nm	5-6 hrs



Figures 2(a) shows color change in *Azadirachta indica*, 2(b) shows color change in *Cymbopogon*, 2(c) shows color change in *Musa acuminate*, 2(d) shows color change in *Tamarind* seed, 2(e) shows color change in *Sida acuta,* 2(f) shows color change in *Artemisia absinthium*, 2(g) shows color change in *Neolamarckia cadamba*, 2(h) shows color change in *Nyctanthes arbortristis,* 2(i) shows color change in *Callistemon citrinus* and 2(j) shows color change in Asafoetida (Hing).

C. UV-vis analysis

The UV visible spectroscopy of the synthesized nanoparticles was in the range of 420-470 nm. Among 40 plants extracts, 30 were showed to synthesize the silver nanoparticles by the indication of suitable surface Plasmon resonance (SPR) with high band intensities and peaks under visible spectrum. There were 10 plants extract which did not produce any results. The extracts which showed the best result are demonstrated along with their spectral peaks in Figure 3(a-j).

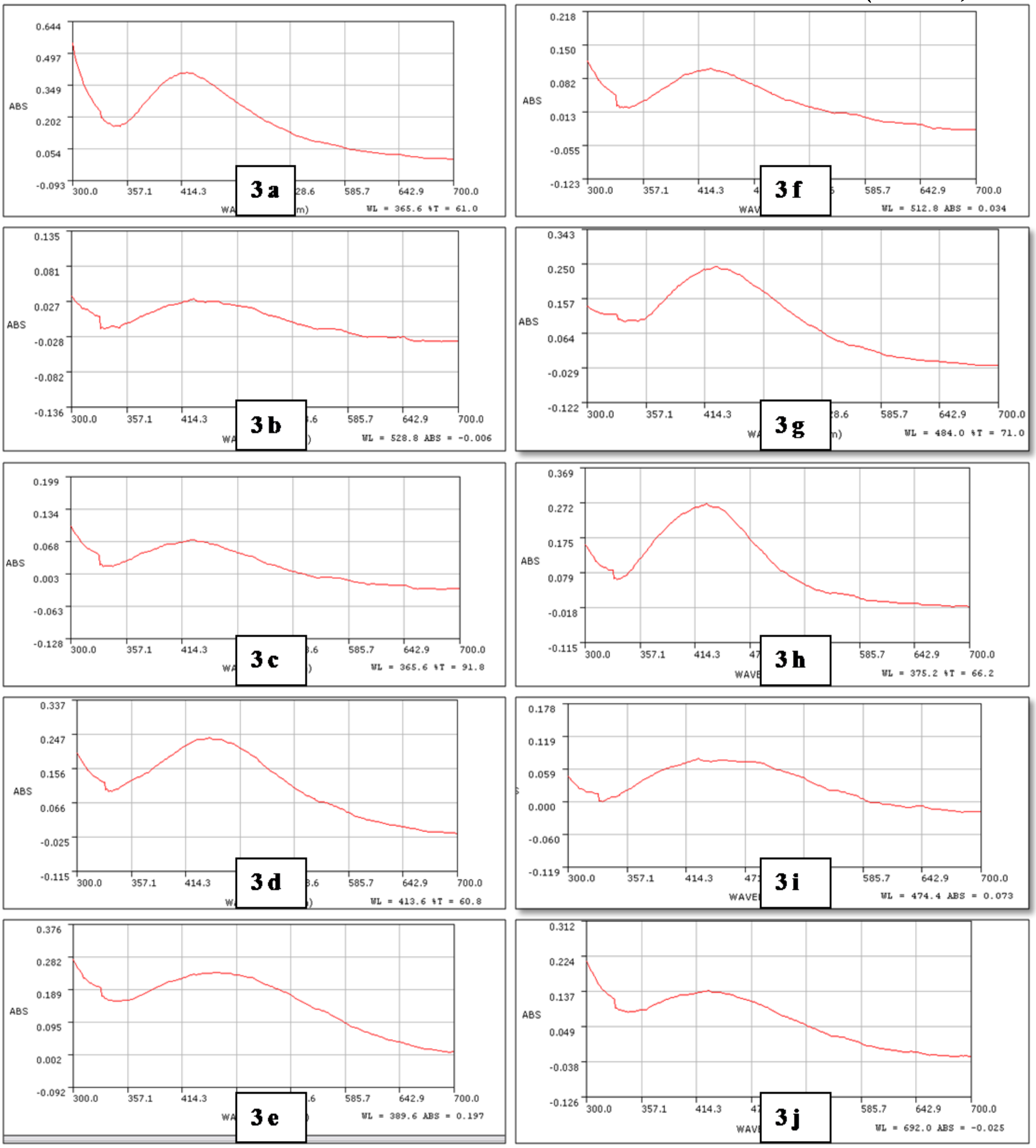


Figure 3(a) shows *Azadirachta indica* peak at 426.4nm, 3(b) shows *Cymbopogon* peak at 426.4nm, 3(c) shows *Musa acuminate* peak at 426.4nm, 3(d) shows *Tamarind* seed peak at 420 nm, 3(e) shows *Sida acuta* peak at 439.2 nm, 3(f) shows *Artemisia absinthium* peak at 426.4 nm, 3(g) shows *Neolamarckia cadamba* peak at 464.8 nm, 3(h) shows *Nyctanthes arbor-tristis* peak at 426.4nm, 3(i) *Callistemon citrinus* peak at 426.4nm and 3(j) shows shows *Asafoetida* peak at 426.4nm

IV. CONCLUSION

In this work, the bio-reduction of aqueous Ag+ ions is done using different plant products. The reduction of the metal ions through plant extracts leading to the development of silver nanoparticles of fairly well-defined dimensions. In conclusion, it has been demonstrated that various extract of plants and spices are competent of producing silver nanoparticles and the nanoparticles shows good stability in solution, under the UV-Visible wavelength nanoparticles shown quiet good surface plasmon resonance behaviour. The formation of these nanoparticles is monitored by their spectral peaks and incubation time at room temperature. Success of such a rapid time scale for synthesis of metallic nanoparticles is an alternative to chemical synthesis protocols and low cost reductant for synthesizing silver nanoparticles.

ACKNOWLEDGEMENTS

We are thankful to Department of Science and Technology, New Delhi, India for the financial assistance as INSPIRE Fellowship.

REFERENCES

[1] M. Catauro, M.G. Raucci, F.D. De Gaaetano and A. Marotta. "Antibacterial and bioactive silver-containing $Na_2O·CaO·2SiO_2$ glass prepared by sol–gel method" J Mater Sci-Mater Med. 15(7): 831–837, 2004.

[2] J.H. Crabtree, R.J. Brruchette, R.A. Siddiqi, I.T. Huen, L.L. Handott and A. Fishman, "The Efficacy Of Silver-Ion Implanted Catheters In Reducing Peritoneal Dialysis-Related Infections" Perit Dial Int. 23(4):368–374, 2003.

[3] A. Krolikowska, A. Kudelski, A. Michota and J. Bukowska, " SERS studies on the structure of thioglycolic acid mono- layers on silver and gold" J.Surf Sci. 532: 227-232, 2003.

[4] G. Zhao and S.E. Jr Stevens, "Multiple parameters for the comprehensive evaluation of the susceptibility of *Escherichia coli* to the silver ion" Biometals. 11: 27-32, 1998.

[5] S.S.Lal and P.L.Nayak, "Green Synthesis Of Gold Nanoparticles Using Various Extract Of Plants And Spices" International Journal of Science Innovations and Discoveries. 2(3): 325-350, 2012.

[6] A.Tripathi, N. Chandrasekaran, A.M. Raichur and A. Mukherjee, "Antibacterial applications of silver nanoparticles synthesized by aqueous extract of *Azadirachta indica* (Neem) leaves" J Biomed Nanotechnol. 5(1): 93–98, 2009.

[7] S. Vivekanandhan, M. Misra and A.K. Mohanty, "Biological synthesis of silver nanoparticles using *Glycine max* (soybean) leaf extract: an investigation on different soybean varieties" Nanosci Nanotechnol 9(12): 6828–6833, 2009.

[8] M. Sathishkumar, K. Sneha, S.W. Won, C.W. Cho, S. Kim and Y.S.Yun, "*Cinnamon zeylanicum* bark extract and powder mediated green synthesis of nano-crystalline silver particles and its bactericidal activity" Colloids Surf B Biointerfaces 73(2): 332–338, 2009.

[9] Y.Y Loo, B.W. Chieng, Nishibuchi M, Radu S, "Synthesis of silver nanoparticles by using tea leaf extract from *Camellia sinensis*" Int J Nanomedicine.7: 4263-4267, 2012.

[10] C. Jayaseelan, AA Rahuman, G. Rajakumar, A. Vishnu Kirthi, T. Santhoshkumar, S. Marimuthu, A. Bagavan, C. Kamaraj, A.A. Zahir and G. Elango, "Synthesis of pediculocidal and larvicidal silver nanoparticles by leaf extract from heartleaf moonseed plant, *Tinospora cordifolia* Miers" Parasitol Res.109(1):185-194, 2011.

[11] K.J. Kim, W.S. Sung, B.K.Suh, S.K. Moon, J.S. Choi, J.G. Kim and D.G. Lee, "Antifungal activity and mode of action of silver nanoparticles on *Candida albicans*" Biometals 22(2): 235–242, 2009

[12] P.L. Nadworny, J.Wang, E.E. Tredget and R.E. Burrell, "Anti-inflammatory activity of nanocrystalline silver in a porcine contact dermatitis model" Nanomedicine 4(3): 241–251, 2008.

[13] J.V. Rogers, C.V. Parkinson, Y.W. Choi, J.L. Speshock and S.M. Hussain, "A preliminary assessment of silver nanoparticle inhibition of monkeypox virus plaque formation" Nanoscale Res Lett 3: 129–133, 2008.

[14] U.K. Parashar, P.S. Saxenaa and A. Srivastava, "Bioinspired synthesis of silver nanoparticles" Dig J Nanomater Biostruct 4: 159–166, 2009.

