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Green Synthesis of Different Sized Antimicrobial Silver Nanoparticles using Different Parts of Plants – A Review

S. Rajeshkumar*

School of Bio-Sciences and technology VIT University, Vellore, TN, India

Abstract: Majorly nanoparticles are produced in the form of polymers, semi conductors and metal nanoparticles. The most applicable metal nanoparticles are silver nanoparticles and gold nanoparticles synthesized using various green methods. In that bacterium, fungus and plants are playing a major role. The plants are very important green chemical factories producing valuable phytoconstituents were play a vital function in the synthesis of silver nanoparticles. Silver is the very ancient antimicrobials using from thousand years ago. This review will having lots of information about various plants with scientific name and its parts used for silver nanoparticle synthesis in various sizes and antibacterial activity against various microbes.
Key words: Silver nanoparticles; plants; green synthesis; antimicrobials.

Introduction

Nanotechnology is the very broad area having lots of applications in various fields such as electronics, mechanics, chemical engineering, bioengineering, environmental sciences and engineering, biotechnology, bio-pesticides production, aqua culture technology, cosmetics, paints, sensor applications, biomedicals like diagnostics, therapeutics, drug delivery etc, controlling of plant and animal pathogens in the form of antimicrobials, antioxidants, anticancer drugs and anticancer drug carriers, cardio vascular diseases, blood brain barriers, etc. Bascically plants are the very major resources used for various biological applications such as Anticancer activity [1,2], Antidiabetic and Anti-hyperglycemic activity [3-5], antimicrobial activity [6,7], protection of liver and antioxidant and hepatoprotective action [7-12], cardio-protective effect [13,14], nephro-protective activity [15-17]. The different types green resources are used for the silver nanoparticles synthesis such as bacterial strains of marine bacteria *vibrio alginolyticus* [18], *Enterococcus* sp. [19], *Klebsiella planticola* (MTCC 2277) [20], *Bacillus* sp. [21], *Serratia nematodiphila* **[22],** Bacillus subtilis MTCC 3053 [23] and Planomicrobium sp [24], fungal strain *Aspergillus niger* [25], marine macro algae like *Padina tetrastromatica* [26], *Turbinaria conoides* [27] and *Sargassum longifolium* [28]. The various parts of plants used for nanoparticles synthesis is shown in figure 1 and table 1. The various parts of the plants have been used for the silver nanoparticles synthesis like leaves are majorly used [29-32,34], stem [33,34], fruits [35,36], flower [37] and root [38].

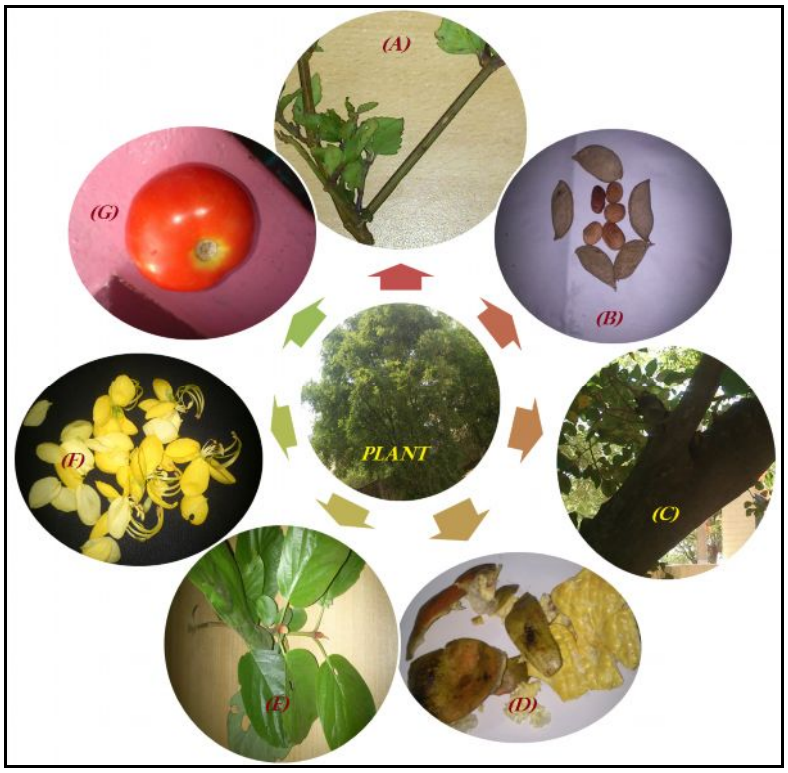

Figure 1: Synthesis of silver nanoparticles using various parts of plants (A) Stem, (B) Seeds, (C) Bark, (D) Peel, (E) Leaves, (F) Flowers and (G) Fruits

The leaf, stem and fruit assisted silver nanoparticles and characterization using UV-vis spectrophotometer, Scanning Electron Microscope, X-ray Diffaraction assay, Transmission electron Microscope and Fourier transform infrared spectroscopy are shown in figure 2 and 3.

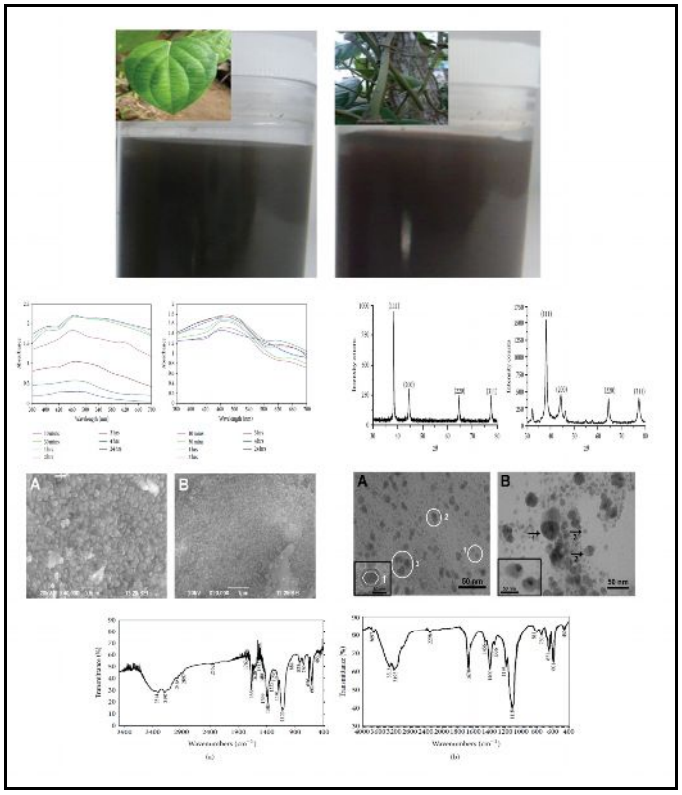

Figure 2: leaf and Stem mediated silver nanoparticles synthesis and its characterization by various techniques (Paulkumar et al., 2014)[34]

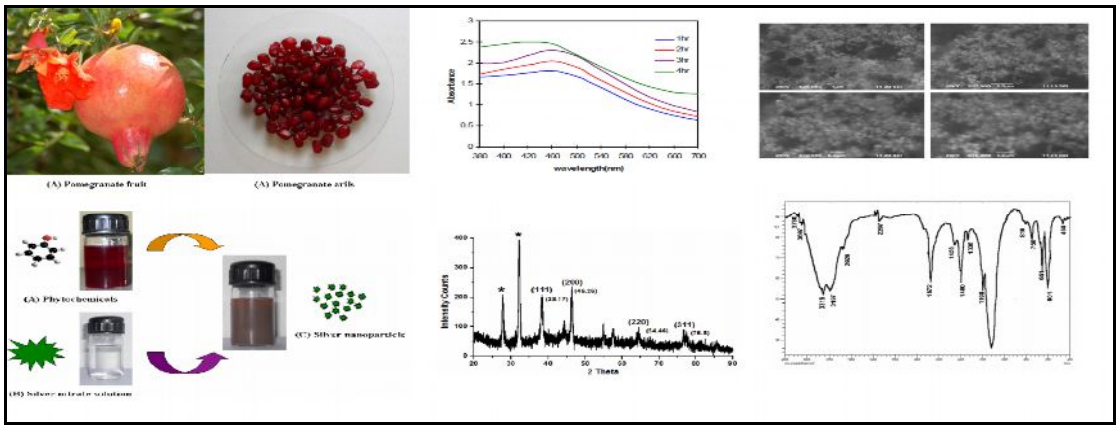

Figure 2: Fruit mediated silver nanoparticles synthesis and its characterization by various techniques (Gnanajobitha et al., 2014) [36]

Table 1: Synthesis of antimicrobial silver nanoparticles by various plants and its parts

S. No	Plant	*Scientific name*	Part use	Size	Antimicrobial Activity	Ref
1	Rose	*Catharanthus roseus*	Leaves	67-48nm	*Bacillus cereus.*	**[39]**
2	Yellow-berried Nightshade	*Solanum xanthocarpum*	Fruit	350-450nm	*Pseudomonas sp. Klebsiella sp.*	**[40]**
3	Indian copperleaf	*Acalypha indica*	Leaf	20-30nm	*Escherichia coli and Vibrio cholera*	**[41]]**
4	chilli pepper	*Capsicum annuum*	Extract	10±2		**[42]**
5	Camphor-Tree	*Cinnamomum camphora*	Leaf	5-40nm		**[43]**
6	Cuban oregano	*Coleus aromaticus*	Leaf	44nm	*Bacillus subtilis and Klebsiella planticola*	**[44]**
7	Coriander	*Coriandrum Sativum*	Leaf	26nm		**[45]**
8	creeping tick trefoil	*Desmodium triflorum*	Leaves	10nm	*Escherichia coli Staphylococcus spp Bacillus subtilis*	**[46]**
9		*Five plant (Pine, Persimmon,Ginkgo, Magnolia and Platanus)*	Leaf extract	430nm	*Azadirachta indica*	**[47]**
10	ocimum basilicum	*Ocimum sanctum*	Steam and root	10nm		**[48]**
11	Asthma Weed	*Euphorbia hirta*	Leaves	40-50nm	*B.cereus and S.aureus*	**[49]**
12	Garlic	*Allium sativum*	garlic clove extract	12nm		**[50]**
13	Gliricidia	*Gliricidia sepium*	Leaf	27nm	*Staphylococcus aureus Escherichia coli Pseudomonas aeruginosa*	**[51]**
14	Convolvulacee Asteraceae Onagraceae	*Ipomoea aquatica Enhydra fluctuans and Ludwigia adscendens*	leaves extracts	420-450nm		**[52]**
15	yellow-berried nightshade	*Solanum xanthocarpum*	Berry extract	400-450nm	*H. pylori*	**[53]**
16	edible fig	*Ficus carica*	Leaves and bark	10-20nm		**[54]**
17	Lemon	*Citrus limon*	Leaves extract	>100 nm	*Fusarium oxysporum and Alternaria brassicicola*	**[55]**

18	Herb Louisa	*Lippia citriodora*	leaves aqueous extract	15-30nm		**[56]**
19	*Alhagi maurorum*	*Acanthe phylum bracteatum*	Soap-root extract	40nm		**[57]**
20	prickly pear	*Opuntia ficus*	aqueous extract	23nm		**[58]**
21	Bitterweed	*Parthenium*	Leaf extract	50nm		**[59]**
22	Rose	*Rosa rugosa*	Leaf extract	451-578nm		**[60]**
23	Paederia	*Paederia foetida*	leaf extract	24nm	*Staphylococcus aureus, Klebsella sp., V. cholera, P. aerueginosa and E. coli bacterial*	**[61]**
24	Elaeagnus	*Elaeagnus Indica*	Fresh leaves	30nm	*E. coli, Pseudomonas putida, Bacillus Subtilis, Staphylococcus aureus*	**[62]**
25	Chanca piedra	*Phyllanthus amarus Schum.* & Thonn	Leaf extract	32-53nm		**[63]**
26	Atrazine	*Bacillus thuringiensis*	*Spore crystal mixture*	15nm	*E.coli, Pseudomonas aeruginosa Streptococcus aureus*	**[64]**
27	Caucasus hornwort	*Anthoceros*	Extract	20-50nm	*Pseudomonas aeruginosa*	**[65]**
28	Periwinkl	*Catharanthus roseus*	Leaves	35-55nm	*Euphorbiahirta Nerium indiu*	**[66]**
29	*1.Alstoniascholars* 2.*Calotropisgigaa* 3. *Ficus religiosa* Linn 4. *Hevea brasiliensis* 5. *Musa Paradisiaca* 6. *Achras sapota*	*SIX plant* 1. *Apocynaceae* 2. *Asclepiadaceae* 3. *Moraceae* 4. *Euphor biaceae* 5. *Musaceae* 6. *Sapotaceae*	Leaves Latex	401-434 nm		**[67]**
30	Pomegranate, Anar and Damask rose	*Two plant Punica granatum and Rosa damascena*	peel extract petals extract	21nm		**[68]**
31	Strawberry	*Arbutus unedo*	Leaf extract	9-15nm	*E.coli , Pseudomonas putida Klebsiella pnuemoniae, Bacillus subtilis and Staphylococcus aureus*	**[69]**
32	Onion	*Allium cepa*	Extract	413nm	*Escherichia coli, Klebsiella pneumoniae, Peudomonas*	**[70]**

					aeruginosa, Staphylococcus aureus and Streptococcus pyogenes	
33	Achiote	*Bixa orellana*	Leaf extract	35-65nm		**[71]**
34	Flat fork moss	*Fissidens minutes*	Aqueous Extrac		*Escherichia coli, Bacillus cereus, Klebsiella pneumoniae and Pseudomonas aeruginosa*	**[72]**
35	papaya	*Carica papaya L*	aqueous extract	15nm	*Escherichia coli and Pseudomonas aeruginosa*	**[73]**
36	Bastard Oleaster	*Elaeagnus latifolia*	Leaf extract	30-50nm		**[74]**
37	Oleander	*Nerium oleander*	Leaf ectract	48-67nm	*Klebsiella Pseudomonas Alkaligenes except Acinetobacter*	**[75]**
38	Candida lipolytica	*Yarrowia lipolytica*	Melanin	7nm	*Aspergillus*	**[76]**
39	Cauliflower	*Brassica oleracea*	cauliflower extract	42-83nm	*E. coli andS. Aureus*	**[77]**
40	Ocimum	*ocimum Bacillicum*	Leaf extract	58-89nm	*Pseudomonas aeruginosa E.coli Bacillus Subtilis*	**[78]**
41	Wodier	*Odina wodier*	Leaves	5-30nm		**[79]**
42	Axlewood	*Anogeissus latifolia*	Gum	5.7 ± 0.2 nm.	*Staphylococcus aureus Escherichia coli , E. coli , and Pseudomonas aeruginosa*	**[80]**
43	grape fruit	*Vitis vinifera*	Fruit extract		*Bacillus subtilis and Klebsiella planticola*	**[81]**
44	Taxonomic Tree	*Fusarium oxysporum*	Eco-friendly	25-50nm		**[35]**
45	Carob	*Ceratonia siliqua* L.	Leaf extract	5-40nm	*E. coli*	**[82]**
46	Lentil	*Fusarium oxysporum*	Seed	13nm		**[83]**
47	Walnut	*Juglans regia L.*	Leaf extract	10-50nm		**[84]**
48	Sheesham	*Dalbergia sissoo*	Leaf extract	5-55nm		**[85]**
49	asthma plant	*Euphorbia hirta*	Leaves	40-50nm	*B.cereus and S.aureus*	**[86]**
50	Tanner's Cassia	*Cassia auriculata*	Leaf extract	420-435nm	*E.coli, Sarratiamarcascenc Bacillus subtilis Aspergillusniger and Aspergillusflavus*	**[87]**
51	Tropical soils	*Penicillium citrinum*	*Czapek dox broth*	109nm		**[88]**
52	Siam Weed	*Chromolaena Odorata*	Leaf extract	40-70nm		**[89]**

53	Sanskrit	*Cephalandra indica*	Leaves	40-90nm		**[90]**
54	Thistle	*Sonchus asper*	Leaf extract	2-100nm	*Staphylococcus aureus*	**[91]**
55	*Pepper*	*Piper Nigram*	Leaf extract	19.7- 82 nm		**[92]**
56	Potato bush	*Phyllanthus reticulatus*	Leaf and root extract	11-30nm	*Klebsiella pneumoniae, Escherichia coli, Pseudomonas putida and Staphylococcus aureus*	**[93]**
57	Margosa Tree	*Azhadirachta indica*	Leaf extract	21.07 nm	*Salmonella typhi and kleibsiella Pneumonia*	**[94]**
58	White moonflower	*Ipomoea indica*	methonolic extract of flowers	10-50nm		**[95]**
59	edible mushroom	*Rhizoctonia*	Plant extract	25-50nm		**[96]**
60	orange Jessamine	*Murraya paniculata*	Leaf extract	5-50nm		**[97]**
61	Jasmine	*Nyctanthes arbortristis*	Flower and leaf		*Escherichia coli*	**[98]**
62	Frangipani	*Plumeria Alba Linn*	Flower extract	10-50nm	*Aspergillus niger, Aspergillus flavus, E.coli and Streptobacillus sp.*	**[99]**
63	Cork tree	*Millingtonia hortensis*	Flower extract	10-40nm	*B.subtilis, K.planticola*	**[37]**
64	Tanner's Cassi	*Cassia auriculata*	Flower extract	10-40nm		**[100]**
65	Safflower	*Carthamus Tinctorius L*	Flower extract	40-200nm	*Aspergillus niger, Aspergillus flavus, E.coli and Streptobacillus sp.*	**[101]**
66	Balsam Tree	*Gnidia glauca*	Flower extract	5-20nm		**[102]**
67	Olibanum	*Boswellia serrata*	Flower extract	60-84nm	*Pseudomonas aeruginosa, Bacillus subtilis, Klebsiella Pneumoniae, E.coli*	**[103]**
68		*Pediculus capitis*				**[104]**
69	Morning Glory	*Ipomoea indica*	Flower extract	10-50nm		**[105]**
70	Marvel of Peru	*Mirabilis jalapa*	Flower extract	60-70nm		**[106]**

Conclusion

There is no life for living organisms without the plants resources. In this review fully explains about the plants and its various parts such as leaves, stem, bark, seeds, flowers, vegetables, fruits and roots role in the synthesis of various sized nanoparticles synthesis. In that leaves are playing a major role in the biosynthesis of silver nanoparticles because of important phytochemicals presence. Apart from the silver nanoparticles are having very good antimicrobial property against different type of pathogens.

Conflict of Interest

The author declares that there is no conflict of interest.

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