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SILVER NANO – A MAGIC WORLD (A SMALL REVIEW ON BIOMEDICAL APPLICATIONS)

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ABSTRACT

Here we report a small review on synthesis of silver nanoparticles by plant materials. Different materials like leaves, flowers, fruits etc. which are ecofriendly were used for the production of silver nanoparticles is became essential. Silver nanoparticles are found to be very effective against bacteria, fungi and viruses. Vast literature is available which shows evidence that silver nanoparticles can directly attack and destroy the cell membrane of bacteria and kills. Depending upon their size, shape, structure and other properties like PH, temperature and organic molecules present in the plant extracts increases the stability of the particle. The components of the plant materials help in the size reduction which increases the surface area of the particle and leads to enhance the antibacterial activity.

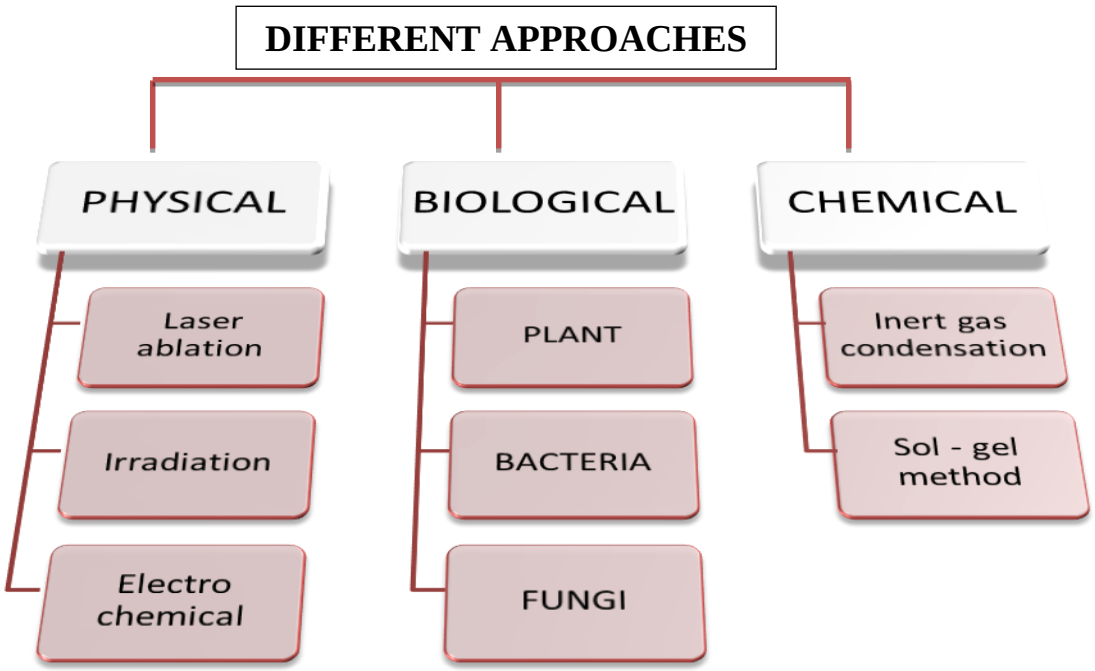
KEYWORDS: Broad spectrum antibacterial, biomedical applications, UV-VIS Spectroscopy, XRD, FTIR.

INTRODUCTION

Applications of silver nanoparticles have been extended and it is most commonly used in consumer products (Rejeski D 2009).[1] The broad spectrum activity helps its usage in biomedical applications water and air purification, food production, cosmetics, clothing, water filters, contraceptives, detergent, sox, shoes and numerous household products (C.Marabio – Jones et. Al 2010).[2]

Methods for synthesis of nanoparticles

There are three types of approaches for the synthesis of nanoparticles.



Literature survey reveals - biological approaches are single pot, easy to handle and safe method for the production of silver nanoparticles (Table – 1). The biochemical reaction of $AgNo_3$ with plant extract (Fig. 1) leads to the formation of AgNPs (Tripathy et al, 2010).[3]

Plant extract + $Ag^{+}No_3^{-}$ →AgNPs + Byproducts (hazardless)

Fig.1 – Mechanism of synthesis of nanoparticles with silver

Table – 1. Literature on nanoparticle production using green nanotechnology

S. NO	TITLE	SOURCE/METHOD	PARTICLE SIZE & APPLICATION	YEAR	REF. NO
1.	Fabrication of silver nanoparticles and their antimicrobial mechanisms	Silver nitrate + PVP + Formaldehyde	>10 nm Antimicrobial activity	2006.	[18]
2.	Does the antibacterial activity of silver nanoparticles depend on the shape of the NP? A study of the gram negative bacterium *E.coli*		40 nm Antibacterial activity	2007.	[19]
3.	Extracellular biosynthesis of silver nanoparticles by some bacteria	Bacteria	2-100 nm-	2008.	[20]
4.	Investigation of antibacterial properties of silver NP – loaded poly grafted cotton fabric	Silver nitrate	12.5 nm Antibacterial activity	2008.	[21]
5.	Rapid biosynthesis of silver nanoparticles using culture supernatant of bacteria with microwave irradiation	Bacteria	5-60 nm	2009.	[22]
6.	Stable silver nanoparticle synthesizing methods and its applications	Chemical method	>5 nm Applications of silver nanoparticles	2010.	[23]
7.	Extracellular synthesis of silver nanoparticles using leaves of *Euphorbia hirta* and their antibacterial activities	*Euphorbia hirta*	40-50 nm Antibacterial activity	2010.	[24]
8.	Biomimetic synthesis of silver NP'S by *Citrus Limon* (lemon) aqueous extract and theoretical prediction of particle size	Lemon	Below 50 nm Particle size prediction	2010.	[25]
9.	Phytofabrication of silver NP'S using pomegranate seeds	Pomegranate fruit seeds	30 nm Phytofabrication	2011.	[26]
10.	Extracellular synthesis of silver nanoparticles using leaf extract of *Cassia auriculata*	*Cassia auriculata*	20-40 nm Antibacterial activity	2011.	[27]
11.	Extracellular biosynthesis of silver NP'S using the *Mycorrhiza mushroom tricholoma crissum* (Bark). SACC: Its antimicrobial activity against pathogenic bacteria and fungus, including multidrug resistant plant and human bacteria	Mushroom	21-91 nm Antimicrobial activity	2011.	[28]
12.	Antimicrobial activity of silver nanoparticles synthesized by using medicinal plants	*Boswellia Shorea Svensonia*	Antimicrobial activity	2011.	[29]
13.	Synthesis of silver nanoparticles using albumin as a reducing agent	Albumin		2011.	[30]
14.	Green fruit of Chili (Capsicum annum) synthesizes nanosilver	Chili (Capsicum annum)	2-6 nm Played the pivotal role in fabrication of AgNP'S	2011.	[31]
15.	Silver nanoparticles synthesis from *Lecanicillium lecenii* and evolutionary treatment on cotton fabrics by measuring their improved antibacterial activity with antibiotics against *staphylococcus aureus & E.coli*	*Lecanicillium lecenii*	45-100 nm Prevents pathogen infection.	2011.	[32]
16.	Extracellular fabrication of silver nanoparticles using pseudomonas aeruginosa and its antimicrobial assay	*Pseudomonas aeruginosa*	20–50 nm antimicrobial assay	2012.	[33]

17.	Silver nanoparticles ecofriendly synthesis by two medicinal plants	*Punica granatum* *Rosa damascena*	21 nm	2012.	[34]
18.	Biosynthesis of silver nanoparticles from *Glycyrrhiza glabra* root extract	*Glycyrrhiza glabra*	19 nm	2012.	[35]
19.	Synthesis of silver nanoparticles using *Klebsiella pneumonia* and its Bio-medical applications	*Klebsiella pneumonia*	21±8.9 nm	2013.	[36]
20.	Synthesis and characterization of silver nanoparticles using *cannonball* leaves and their cytotoxic activity against MCF – 7 cell line	*Cannonball* leaves	5-35 nm Cytotoxic activity	2013.	[37]
21.	Silver nanoparticles ecofriendly green synthesis by using two medicinal plant extract.	*Jasminium grandifolium* *Cymbopogan citrullus*	206 nm 199 nm	2013.	[38]
22.	Green synthesis of nanoparticles and its application in treatment of Rheumatoid arthritis.	*Night jasmine (nyctanthes arbor tristis)*	46-80 nm Treating Rheumatoid arthritis	2013.	[39]
23.	Cationic antimicrobial peptides and biogenic silver nanoparticles kill mycobacteria without eliciting DNA damage and cytotoxicity in mouse macrophages.	*Cationic antimicrobial peptides* *Mycobacteria*	177 nm 97.65 nm DNA damage and cytotoxicity	2013.	[40]
24.	Biological synthesis of silver nanoparticles using *Raphanus sativus* VAR.LONGIPINNATUS leaf extract and evaluation of their antioxidant and antibacterial activity.	*Raphanus sativus*	22 nm antioxidant and antibacterial activity	2013.	[41]
25.	Leaf extract mediated green synthesis of silver nanoparticles from widely available Indian plants: synthesis, characterization, antimicrobial property and toxicity analysis.	*Musa balbisiana* *Azadirachta indica* *Ocimium tennflorum* *Vigna radiate* *Chick pea*	80.2 nm antimicrobial property and toxicity analysis	2014.	[42]
26.	One pot light assisted green synthesis, storage and antimicrobial activity of dextran stabilized silver nanoparticles.	*$AgNO_3$+Dextran sol*	50-70 nm antimicrobial activity	2014.	[43]
27.	Bioreduction based synthesis of silver Nano coats and their application in development of nanoembeded medical fabrics.	*Phyllanthus amarus* *Calotropisgigantea* *Vitexnegundo* *Acalyphaindica* *Cardiospermum helicacabrium Polygala chinensis Ponganiasp* *Aegle marmelos Vincarosea*	- development of nanoembeded medical fabrics	2014.	[44]
28.	Green synthesis, characterization and antimicrobial properties of silver nanowires by aqueous leaf extract of piper betle.	Piper betle	40-60 nm antimicrobial properties	2014.	[45]
29.	Biofabrication and extraction of silver nanoparticles using leaf extract of Azadirachta indica.	*Azadirachta indica*	104.8 nm Biofabrication	2014.	[46]
30.	Bioreduction based synthesis of silver Nano coats and their application in development of nano embedded medical fabrics.	*Polygala chinensis*	development of nano embedded medical fabrics.	2014.	[47]
31.	Biogenic synthesis, characterization of silver nanoparticles *Tabernaemontana divaricata* and *Polyanthus tuberosa* flower extract and evaluation of their antibacterial activities.	*Tabernaemontana divaricata* *Polyanthus tuberosa*	32 nm 17 nm	2014.	[48]
32.	Efficacy of green synthesis of silver nanoparticles using flowers of calendula officinalis.	*Calendula officinalis*	2-20 nm	2014.	[49]
33.	Green synthesis and characterization of	*Basella alba*	22.6-25 nm	2014.	[50]

	silver NP's from aqueous extract of *Basella alba* and their in-vitro antioxidant potentials.		antioxidant potentials		
34.	Green synthesis of plant mediated silver NP's and evaluation of their antimicrobial activities.	*Morinda tintoria* *Michelia champaca*	< 100 nm antimicrobial activities	2014.	[51]
35.	Green synthesis of silver NP's from marigold flower and its synergistic antimicrobial potential.	*Marigold flower*	10-90 nm synergistic antimicrobial potential	2014.	[52]
36.	Biosynthesis of silver NP's using flower extracts of Catharanthus roseus and evaluation of its antibacterial efficacy.	*Catharanthus roseus*	11-15 nm antibacterial efficacy	2014.	[53]
37.	Biosynthesis and characterization of silver nanoparticles using Ficus benghalensis leaf extract.	*Ficus benghalensis*	10-50 nm	2014.	[54]
38.	Synthesis and characterization of silver nanoparticles using Tabernaemontana Divaricata and its cytotoxic activity against MCF – 7 cell line.	*Tabernaemontana Divaricata* (common garden plant)	22.85 nm cytotoxic activity	2014.	[55]
39.	Leaf extract mediated green synthesis of silver NP's from widely available Indian plants: synthesis, characterization, antimicrobial property and toxicity analysis.	*Seeds of Moong bean and Chick pea*	80.2 nm antimicrobial property and toxicity analysis	2014.	[56]
40.	Syntheses of silver nanoparticles using the vegetable extract of Raphanus sativus (Radish) and assessment of their antimicrobial activity.	*Raphanus sativus (Radish)*	30-60 nm antimicrobial activity	2015.	[57]
41.	Green synthesis of silver NPs using Brassica oleracea (Cauliflower) and Brassica oleracea capitata (Cabbage) and the analysis of antimicrobial activity.	*Brassica oleracea (Cauliflower)* *Brassica oleracea capitata (Cabbage)*	36-42 nm antimicrobial activity	2015.	[58]
42.	Biological synthesis of silver nanoparticles using Colocassia extract and their antimicrobial activity.	*Colocassia*	10-30 nm antimicrobial activity	2015.	[59]
43.	Evaluation of bactericidal and fungicidal properties of silver NP's fabricated using Jasminium sambac.	*Jasminium sambac*	14-17 nm bactericidal and fungicidal properties	2015.	[60]
44.	Biosynthesis, characterization and antimicrobial applications of silver nanoparticles.	*Brevibacterium frigoritolerans DC2*	97 nm antimicrobial applications	2015.	[61]
45.	Synthesis of silver nanoparticles using Muntingia calabura leaf extract.	*Muntingia calabura*	- Screening of secondary metabolites	2015.	[62]
46.	Antibacterial and anticancer activity of silver nanoparticles synthesized from Cynodon dactylon leaf extract.	*Cynodon dactylon*	- Antibacterial and anticancer activity	2015.	[63]
47.	Bactericidal paper trays doped with silver nanoparticles for egg storing applications.	*Gelatin* *chitosan*	37.35 nm Antibacterial activity	2016.	[64]
48.	Green Synthesis and Characterization of Silver Nanoparticles Using *Mimusops elengi* Flower Extract and Its Synergistic Antimicrobial Potential.	*Mimusops elengi*	- Antibacterial agent	2016.	[65]
49.	Green Synthesis of Silver Nanoparticles Using Apple Extract and Its Antibacterial Properties.	Apple Extract	Antibacterial Properties	2016.	[66]
50.	Rapid green synthesis of silver nanoparticles by aqueous extract of seeds of *Nyctanthes arbor-tristis.*	*Nyctanthes arbor-tristis*	Biomedical applications	2016.	[67]

Various plant parts were used to synthesize silver nanoparticles (Fig. 2) such as stem, root, fruit, seed, callus, leaves and flower (Palaniselvam Kuppusamy et al, 2014).[4]

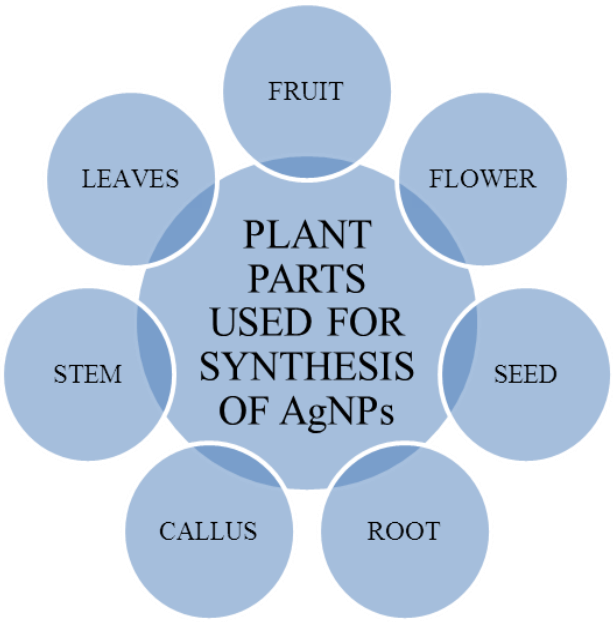


Fig. 2 - Various plant parts used for the production of AgNP

CHARACTERIZATION

Various methods are employed to know the size, shape, structure of surface and other characteristics. Mainly used techniques are UV – VIS Spectroscopy, XRD, EDS, SEM, AFM, FTIR and TEM.

UV- VISIBLE Spectroscopy of silver nanoparticles shows an absorption peak is usually in between 400 and 450 nm (Devika R et al. 2012, Poinern G E J et al. 2013).[5,6] The elemental composition of nanoparticles can be determined by EDS whereas XRD technique identifies size, structure and orientation of crystal (Klug H P et al. 1974, Barrett C S et al. 1986).[7, 8] FTIR Spectroscopy used to identify the functional groups and surface chemistry (Poinern G E J et al. 2014).[9] SEM and TEM techniques reveal the morphology and size of the stabled nanoparticles.

Silver nanoparticles – Applications

There are several applications for silver nanoparticles. The major applications are mentioned in the fig. 3.

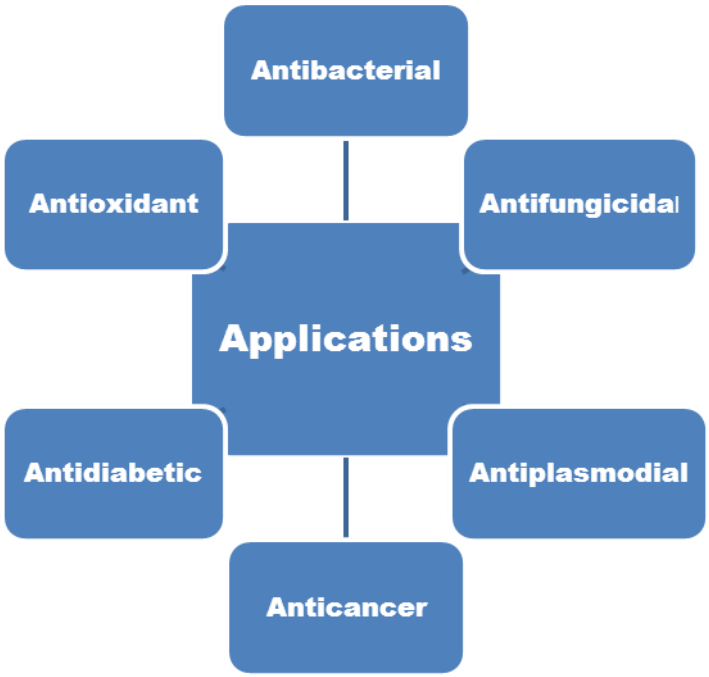


Fig. 3 – Major applications of silver nanoparticles

Applications

1. Antibacterial activity: The double action of AgNPs eventually breaks the cell wall and disturbs the mechanism of protein synthesis in the bacteria (Sondi and Salopek–sondi, 2014).[10]

Silver nanoparticles exhibited good antibacterial properties against *Staphylococcus areus* and *Pseudomonas aeruginosa* (D. Sarvamangala et al. 2014).[11]

2. Antifungicidal activity: Plant mediated AgNPs damage the intercellular components of fungus and destroy the cell function (Logeswari et al. 2012).[12]
3. Antiplasmodial activity: Synthesis of silver nanoparticles from plant extract has been used to suppress the number of malarial productions.

Silver nanoparticles synthesizes rapidly by using the plant medicinal plants *Andrographis paniculata* against the malarial parasites *Plasmodium falciparum* (C. Panneerselvam et al. 2011).[13]

4. Anticancer studies: Synthesized silver nanoparticles using *Abelmoschus esculentus* (L.) pulp extract showed that the IC_{50} dose of AgNPs leads to the increase in intracellular reactive oxygen species and significantly diminished mitochondrial membrane potential, indicating the effective involvement of apoptosis in cell death. (Md. Masud Rahaman Mollick. et al. 2015).[14]
5. Antidiabetic activity: Plant mediated AgNPs contains TAP (Terpenoids in Andrographis Paniculata leaf) shows good Antidiabetic activity which has been investigated by glucose oxidase method (S. Kavitha et al. 2014).[15]
6. Antioxidant activity: Antioxidant activities are attributed to the phenolic contents in plants probably due to their redox properties, which allow them to act as reducing agents, hydrogen donors and singlet oxygen quenchers (S. T. Chang et al. 2001).[16]

The total phenolic compounds and total flavonoids were higher in plant-AgNPs compared to the plant extract alone. Plant-AgNPs showed a higher antioxidant and antimicrobial activity compared to C.murale leaf extract alone or silver nitrate (Mohamed S. Abdel-Aziz et al. 2014).[17]

CONCLUSION

In the last two decades, applications of plant derived silver nanoparticles were extensively studied. Biosynthesis of plant mediated AgNPs is a simple, easy to handle and ecofriendly method with controlled side effects. Applications of silver nanoparticles derived from plant material are tremendous in various fields such as medical diagnosis, pharmaceuticals, cosmetics, medical treatment, electronics, optics and other commercial products.

In future there is a vast scope in this field of Nano science and more things to be explored. Few of them are:

- The active phytochemical compound which helps in the reduction of silver ions to silver nanoparticles is to be explored.
- A particular route of functional mechanism on different pathogenic microorganisms and virus to be explored.
- Implementation of large scale production and action of silver nanoparticles on their target sites have to be studied in depth.
- New pharmaceutical formulations are to be explored from these plant mediated AgNPs i.e., the process in which plant mediated silver nanoparticles including the active drug combined to produce a final medical product.

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