



A modern review of silver nanoparticles mediated plant extracts and its potential bioapplications

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Abstract

The development of eco-friendly technology for the biosynthesis of nanoparticles has emerged as a notable step in the field of nanotechnology and also branch of science that deals with the framing of materials at atomic level to achieve distinctive properties and bio applications. Of all the metal nanoparticles, silver nanoparticles attract the most attention owing to its distinctive physical, chemical and biological properties. Green chemistry has emerged as an alternative to the range of conventional methods used to synthesis of nanoparticles. Of all the available green methods, the use of plants in the synthesis of nanoparticles is considered to be the most suitable method because of the broad variation of the bio-molecules in them which not only reduce but also act as stabilizing, capping agents, thus increasing the rate of reaction. Unlike microbial culture they are easy to handle, broadly distributed and easily available. The current review examines the different types of plants that should be used for the rapid and one-step protocol for the synthesis of silver nanoparticles and describes its antibacterial, antifungal, antioxidant, antiviral, anticancer and anti-diabetic agent.

Keywords: silver nanoparticles, antimicrobial, antioxidant, antiviral, diabetic, anticancer

Introduction

Nanoscience and nanotechnology are the greatest interdisciplinary branches that measured at the nanoscale 1 to 100 nm. Physicist Richard Feynman conveyed a speech on December 29, 1959 entitled "There is a plenty of Room at the Bottom" in the meeting of American Physical Society Phnom Penh R.P. at the California Institute of Technology. There is plenty of room at the bottom: Invitation to enter a new field of physics (Feynman *et al.*, 2012) ^[1]. In his keynote speech, Feynman described the technology of manipulation at the atomic level. A decade later, in his journey to ultraprecise, fabrication, Professor Norio Taniguchi coined the term nanotechnology. In current years nanotechnology has become an important and major innovation. Nanotechnology refers to the NPs as nuclear or atomic aggregates explained with the size of under 100nm. Nanotechnology refers to the terms manufacturing, illustration, control and uses of structures to control nanoscale size and shape at the nanoscale (Rafique *et al.*, 2017) ^[2].

About 5000 years ago, numerous Egyptians, Persians, Greeks and Romans used silver in many structures to store nutrients (Srikar *et al.*, 2016) ^[3]. In ancient times, silverware was used in everyday household activities due to its antimicrobial activity. There are records of treatments method for silver in the literature as early as 300 BC. Until the invention of antimicrobials by Alexander Fleming, silver was commonly used as an antimicrobial expert. In Hinduism, to this day, silverware is preferred to create "panchamrit" using the *Ocimum sanctum*, curd and various other ingredients. The restorative properties of various metals are mentioned in the old Indian book of Ayurvedic Medicine Charak Samhita (Galib *et al.*, 2011) ^[4].

In the past, AgNPs have attracted considerable attention from researchers. Owing to the unusual properties of AgNPs, they are used in a wide variety of applications, such as biomedical (rapid diagnosis, imaging, tissue regeneration

and drug delivery, and development of new medical products, biology, coatings, antimicrobial activities (Balamurugan *et al.*, 2017; Sivakumar *et al.*, 2015; Senthil Kumar and Sivakumar, 2014; Senthil Kumar *et al.*, 2016; Sivakumar, 2019) ^[5-9]. Furthermore, owing to the broad range of protection against microorganisms and medicinal properties, AgNPs are used as anti-infective agents, tranquilizer conveyance agents, water purifiers, agriculture (Chaloupka *et al.*, 2010) ^[10].

Presently, the plant-mediated green synthesis of silver nanoparticles has grown into a new and important branch of nanotechnology. It has gained prominence due to its eco-friendly and cost effective, lesser toxicity when associated with chemical hazards (Chanel *et al.*, 2017) ^[11]. In the physical and chemical nanoparticles synthesis, the green synthesis has many benefits. For example (1) less toxic and hazardous substances and environmentally benign solvents, (2) easy, quick and inexpensive, (3) uses less energy and operates under moderate operating conditions, (4) combines the energy of both silver nanoparticles and the plant phytochemicals. In this respect, plant-mediated silver nanoparticles are said to have higher biological functions than nanoparticles synthesized by chemical methods (Choudhury *et al.*, 2016) ^[12].

Previous studies have suggested the use of various plant components such as leaf, root, stem, bark, fruit, seed, bud and latex for the synthesis of silver nanoparticles. A plant-mediated synthesis of silver nanoparticles is preferred over a micro-mediated synthesis. The latter is not feasible and requires more aseptic conditions, a time-consuming process and a longer incubation period. Moreover, the reduction properties of the secondary metabolites of plants are said to be due to the more ability of plant extracts to synthesis nanoparticles with enhanced properties (Kharissova *et al.*, 2013) ^[13].

Past few decades, some reviews focusing on the green synthesis of AgNPs have been published (Ghaffari-

Moghaddam *et al.*, 2014) ^[14]. Most of them are found in a few plants cherry fruit extract, aloe leaf, *Coffea arabica* seeds, *Macrotyloma uni-forum*, *Trianthema decandra*, *Rosa rugosa*, biopolymers, Chitosan, microbial sources (Kumar *et al.*, 2015; Yadav *et al.*, 2016; Dhand *et al.*, 2016; Vidhu *et al.*, 2011; Geethalakshmi and Sarada, 2012; Dubey *et al.*, 2010; Leung *et al.*, 2010; Futyra *et al.*, 2017; Tho *et al.*, 2013; Kannan and Subbalaxmi, 2010) ^[15-24] for a synthesis of AgNPs. Numerous characterization procedures (UV-Vis, FTIR, XRD, SEM, TEM -EDX and DLS,) have been employed to inspecting information regarding the source, shape, size and properties of AgNPs with respect to various applications. The present review, in contrast to previous reviews, focuses on synthetic methods, parameters, characterization techniques, Bio medical applications, biosensor, antibacterial, anticancer activity components expected from various green ways for the synthesis of AgNPs. Modern applications of nanoparticles and nanomaterials are developing rapidly at different fronts owing to their absolutely new or improved properties in terms of size, their distribution and morphology. It is rapidly updating in many areas such as healthcare, biomedical, pharmaceutical-genetic distribution, cosmetics, food and fodder, environment, kinetics, optics, electronics, aerospace, energy science, catalysis chemical industries, non-linear optical devices, light emitters, single electron transistors, catalytic activity, photo-electrochemical applications and many more to count on. The greatest development in these

expanding technologies opened up application frontiers and novel basics. This includes the production of nanoscale materials for investigating or using their mysterious physicochemistry and optoelectronic properties (Khalil *et al.*, 2013; Kaviya and Viswanathan, 2011) ^[25-26].

Green syntheses of silver nanoparticles using plant extracts

The use of plants as a production gathering of silver nanoparticles has attracted attention because of its rapid, eco-friendly, non-pathogenic, economical protocol and allowing one-step techniques for biosynthetic processes Figure 1. Reduction and stabilization of silver ions by the incorporation of biological molecules such as proteins, enzymes, amino acids, polysaccharides, alkaloids, phenolics, tannins, saponins, terbinoids and vitamins are already established in plant extracts with medicinal values and are environmentally friendly chemically complex structures (Kulkarni and Muddapur, 2014) ^[27]. The protocol for nanoparticle syntheses includes: collection of herbal leaves part of the plant of interest from available sites and then rinsing well two/ three times in tap water to remove dust and soil particles; Follow with sterile distilled water to remove any associated debris. These are clean and fresh leaves are dried in the shade for 5-7 days and then powdered using a domestic blender. To prepare the plant broth, about 10g of dried powder is boiled with 100ml of distilled water.

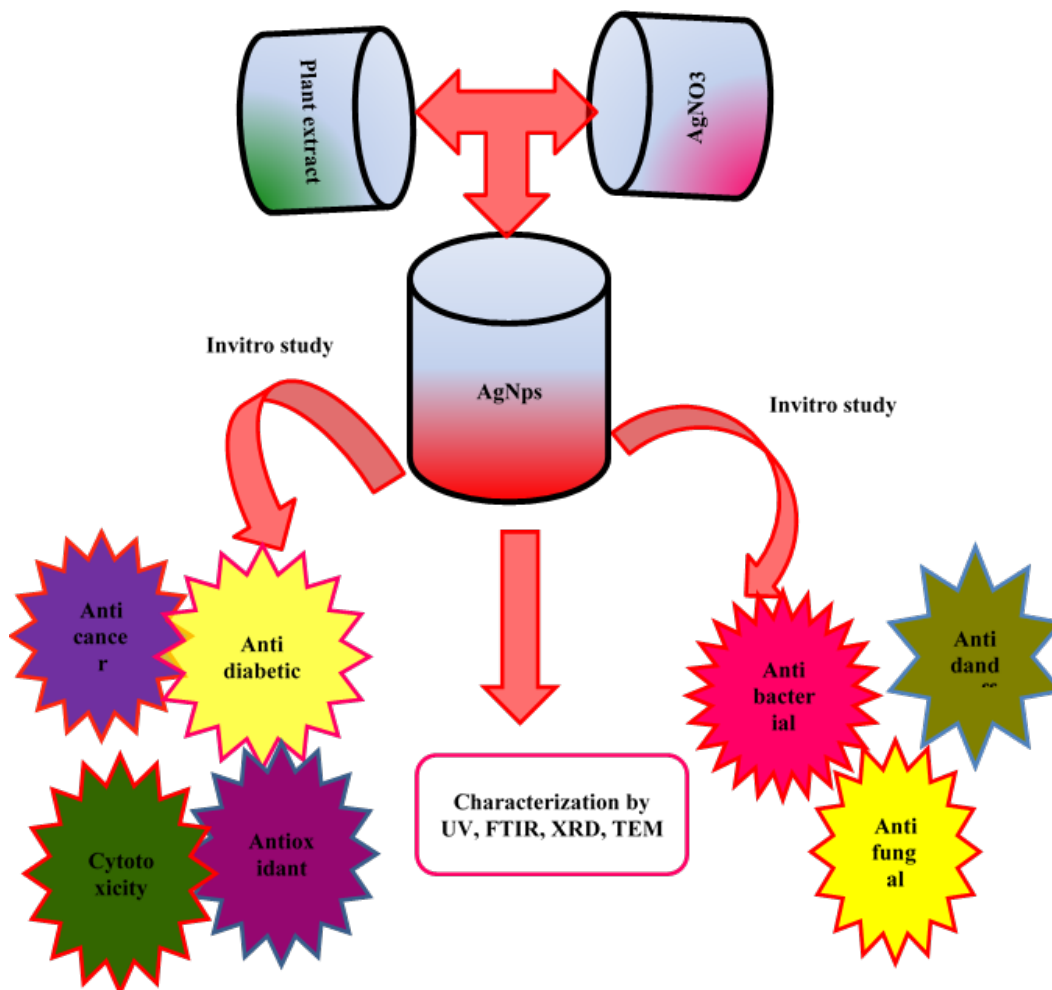


Fig 1: Various approaches for silver nanoparticles synthesis

The resulting infusion is filtered completely until no insoluble substance appears in the broth. For 10^{-3} M AgNO₃ solution, in addition to few mL of plant extracts, the reduction of pure Ag (I) ions to Ag (0) can be followed, which can be monitored by measuring the UV-visible spectrum of the solution at regular intervals (Sahayaraj and Rajesh, 2011) [28]. Green rapid syntheses of spherical shaped silver nanoparticles with dimensions of 50–100nm were found using herbal leaves extract. The reduction of silver ions into silver nanoparticles by this extract was completed within 10-30min. External silver nanoparticles in plant extract combine a rapid, simple, economical process comparable to chemical and biological methods. This review articles focus on the investigating the potential of silver nanoparticles for important use in antibacterial, antifungal, antioxidant, antiviral, anticancer, anti-diabetic.

Biological applications

Antibacterial and Antifungal Activity

Currently, struggle to a lot of well-known antibiotics of bacteria of the genera Escherichia, Streptococcus, Salmonella, Pseudomonas etc. is an important medical problem that compulsory to be resolved as well as possible. AgNPs have been found to be the most promising part in the fight against pathogens in the search for novel bio drugs. The capability of silver nanoparticles to inhibit growth and to induce the death of pathogenic microorganisms that cause a different types of worldwide human diseases are agreed by the enormous majority of the research. As indicated above, the ability of AgNPs to bind to different biomolecules in microorganisms provides their continuous antibacterial

effect. Today, plant extract are an indescribable source of AgNP production. Often having their own therapeutic properties and forming AgNPs in particular capping, plants are the chief object of research in this area. Table 1 shows only a minor fraction of the established anti-bacterial effect of silver nanoparticles from different plant extracts, sometimes superior to antibiotics. Consequently, an inhibitory effect has been exhibit against *C. kefir* (Elumalai *et al.*, 2010) [29], *Vibrio parahaemolyticus* (Latha *et al.*, 2016) [30], *F. oxysporum*, *Alternaria brassicicola* (Vankar and Shukla, 2012) [31], *E. aerogenes*, *B. bronchiseptia* (Phull *et al.*, 2016) [32] *Fusarium sp.*, *Rhizopus sp.* (Rao and Savithamma, 2010) [33], *A. niger*, *A. flavus* (Pasupuleti *et al.*, 2013) [34], *S. typhimurium*, *S. enteritidis* (Loo *et al.*, 2018) [35], *K. pneumoniae*, *Acinetobacter baumannii* (Alharbi and Alarfaj, 2020) [36], *Str. aureus*, *E. coli* (Ruiz-Baltazar *et al.*, 2017) [37], *St. aureus*, *Str. Pyrogenes* (Siddiqi *et al.*, 2018) [38], *Aeromonas hydrophila*, *Pseudomonas fluorescens* (Vijaykumar *et al.*, 2014) [39], *E. coli* (Zhang *et al.*, 2010) [40], *M. tuberculosis* (Agarwal *et al.*, 2013) [41], *P. aeruginosa*, *S. aureus* (Govindaraju *et al.*, 2010) [42], *Vibro cholera*, *protus mirabilis* (Sivakumar *et al.*, 2015) [6], *Klebsiella pneumoniae*, *Pseudomonas aeruginosa* (Senthilkumar and Sivakumar, 2014) [7] *Bacillus subtilis*, *Escherichia coli*, *Staphylococcus aureus* and *streptococcus pyogenes* (Senthilkumar *et al.*, 2016) [8], *S. typhi*, *E. coli*, *S. aureus* and *B. subtilis* (Sadeghi *et al.*, 2015) [43], *P. aeruginosa*, *P. mirabilis*, *Shigella flexneri*, *S. somenei* and *Klebsiella pneumoniae* (Kumarasamyraja and Jeganathan, 2013) [44], *Pseudomonas aeruginosa*, (Khandelwal *et al.*, 2010) [45].

Table 1: Antibacterial activity of silvernanoparticles from different plant extracts.

<i>C. albicans</i> , <i>C. kefir</i>	<i>Euphorbia hirta</i> leaf extract	29
<i>V. parahaemolyticus</i>	<i>Adathoda vasica</i> leaf extract	30
<i>F. oxysporum</i> , <i>Alt. brassicicola</i>	<i>Citrus limon</i> leaf extract	31
<i>A. fumigatus</i> , <i>F. solani</i> , <i>A. niger</i> , <i>A. flavus</i> , <i>S. aureus</i> , <i>E. aerogenes</i> , <i>B. bronchiseptia</i>	<i>Bergenia ciliate</i> leaf extract	32
<i>Fusarium</i> , <i>Rhizopus</i> , <i>Proteus</i> , <i>A. flavus</i> , <i>A. niger</i>	<i>Svensonia hyderabadensis</i> leaf extract	33
<i>St. aureus</i> , <i>B. subtilis</i> , <i>Ps. aeruginosa</i> , <i>E. coli</i> , <i>K. pneumoniae</i> , <i>A. niger</i> , <i>A. flavus</i>	<i>Rhinacanthus nasutus</i> leaf extract	34
<i>E. coli</i> , <i>K. pneumoniae</i> , <i>S. typhimurium</i> , <i>S. enteritidis</i>	pu-erh tea leaves	35
<i>K. pneumoniae</i> , <i>Acinetobacter baumannii</i>	<i>Neurada procumbens</i> leaf extract	36
<i>S. aureus</i> , <i>Escherichia coli</i>	<i>Melissa officinalis</i> leaf extract	37
<i>St. aureus</i> , <i>Str. Pyrogenes</i> , <i>Str. Viridans</i> , <i>Corynebacterium xerosis</i>	<i>Usnea longissima</i> extracts	38
<i>Aeromonas hydrophila</i> , <i>Pseudomonas fluorescens</i> and <i>Flavobacterium branchiophilum</i>	<i>Boerhaavia diffusa</i>	39
<i>E. coli</i>	<i>Aloe vera</i>	40
<i>M. tuberculosis</i>	<i>Cucumis sativus</i> plant extract	41
<i>S. aureus</i> , <i>Escherichia coli</i>	<i>Vigna radiata</i>	9
<i>P. aeruginosa</i> , <i>S. aureus</i> , <i>A. flavus</i> and <i>Aspergillus niger</i>	<i>Solanus torvum</i>	42
<i>Vibro cholera</i> , <i>protus mirabilis</i>	<i>Ipomea patatas</i>	6
<i>Klebsiella pneumoniae</i> , <i>Pseudomonas aeruginosa</i>	Green tea	7
<i>Bacillus subtilis</i> , <i>Escherichia coli</i> , <i>Staphylococcus aureus</i> and <i>streptococcus pyogenes</i>	Green tea	8
<i>S. typhi</i> , <i>E. coli</i> , <i>S. aureus</i> and <i>B. subtilis</i>	<i>Abutilon indicum</i>	43
<i>P. aeruginosa</i> , <i>P. mirabilis</i> , <i>E. coli</i> , <i>Shigella flexneri</i> , <i>S. somenei</i> and <i>Klebsiella pneumoniae</i>	<i>Cymbopogon citratus</i>	44
<i>Escherichia coli</i> ; <i>Pseudomonas aeruginosa</i> ; <i>Aspergillus flavus</i>	<i>Argimone mexicana</i>	45

Antioxidant Activity

Many researcher studied the free radical scavnging activity of plant extract mediated synthesized silver nanoparticles at various time. Nanoparticles formed using plant extracts have enhanced antioxidant activity and it's may be owing to the excellent absorption of antioxidant from plant extracts on the surface of nanoparticles. The antioxidant properties of a silver phyto-nanosystem make them beneficial in the cure of disease. Hence, silver phyto-nanoparticles acquired

from extracts of plants extracts were found to have high antioxidant activity (Bunchez *et al.*, 2012) [46]. Salari *et al.* explained the AgNPs synthesized using an aqueous *Prosopis farcta* fruit extract were excellent free radical cleaners (Salaria *et al.*, 2019) [47] the similar effect was shown in vitro for an aqueous extract of apple extract (Nagaich *et al.*, 2016) [48], *Indigofera hirsuta* (Netala *et al.*, 2018) [49], leaf extracts of *Elephantopus scaber* (Kharat and Mendhulkar, 2016) [50]. Therefore, high indicators of the activity of

antioxidant phyto-nanoparticles may be related to the specific capping of AGNPs, especially for medicinal plants, whose extracts contain a variety of antioxidants (polyphenols, flavonoids, etc.).

Antiviral Activity

In current human history, viruses have been identified as one of the most deadly human pathogens. The pathogenic nature of viruses involves attachment and penetration into the host cell. In this case, the virus binds to the ligands and proteins on the cell membrane surface using its own protein components. Preventing such binding appears to be the best route to avoid cell infection. Silver nanoparticles were found to stimulate the apoptotic pathway by creating free oxygen radicals that showed antitumor, antiproliferative and antiangiogenic effects *in vitro* (Gurunathan *et al.*, 2009) [51]. Silver nanoparticles disturb normal cellular function and affect the influence of membranes by persuade various apoptotic signaling genes in mammalian cells, leading to planned cell death (Sanpui *et al.*, 2011) [52]. As in the antioxidant activity, the most common biofactory plants for the production of AGNPs, mainly the anti-cancer properties are already known. Therefore, other organisms are also used for the synthesis of nanoparticles, for example, the fungus, bacteria, *A. Fumicatus* (Nilavukkarasi *et al.*, 2020; Othman *et al.*, 2019) [53-54]. With vigour anti-cancer properties and very low toxicity, AgNPs are the most promising anticancer drugs. Further research into the antiviral activity of AgNPs may open up new possibilities in the fight against various virus-induced diseases.

Anti-Diabetic Activity

Since alpha-amylase and glucosidase are important enzymes in carbohydrate metabolism, their prevention is one of the most key strategies in the treatment of diabetes. Amylase and glucosidase inhibitors prevent the breakdown of carbohydrates into monosaccharides, which is the main reason for the increase in blood glucose levels. An amylase inhibitor, in combination with starchy foods, reduces the regular rise in blood sugar. AgNPs are referred to as alpha-amylase inhibitors in several studies *in vitro* and *in vivo* (Bagyalakshmi *et al.*, 2017; Saratale *et al.*, 2018; Prabhu *et al.*, 2018) [55-57].

Conclusion

Green biosynthesis of silver nanoparticles mediated plant extracts have numerous advantages over other methods because they are environment friendly, cost effective. It is highly suitable for the production of nanoparticles free of toxic contaminants required in bioapplications. Green biosynthesized silver nanoparticles have significant features of nanotechnology through incomparable applications and the synthesis of nanoparticles using plants is more beneficial than other biological methods because plant materials are easy to handle, safe, widely distributed and readily available. The present review by conferring different literatures reported newly has showed the significant of plant extract mediated biosynthesis of silver nanoparticles and describe them as a good antibacterial, antifungal, antioxidant, antiviral, anticancer and anti-diabetic agent.

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