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A review on synthesis of silver nanoparticles using chirata (*Swertiaperennis*) extract

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Abstract
In Indian pharmacopoeia, a number of *Swertia* plants are used as crude drugs. Plants are readily available and can be used to manufacture metal nanoparticles, especially AgNPs. Plants convert metal ions to metal nanoparticles at a far faster rate than microorganisms. Plant-based nanoparticle synthesis is also superior to microorganism-based nanoparticle synthesis in terms of biosafety. Nanoparticles made from plant extracts are cost-effective, provide healthy work environments and societies, protect human health and the environment, and result in less waste and safer goods. They have unique properties that aid in molecular diagnostics, therapies, and devices which can be used in a variety of medical procedures. The physical and chemical methods are the most commonly used for the synthesis of silver nanoparticles. For morphological studies of nanoparticles, microscopic techniques such as scanning electron microscopy, transmission electron microscopy, and atomic force microscopy are commonly used. FTIR spectroscopy, on the other hand, is a chemical analytical technique that measures infrared intensity versus light wavelength (wavenumber). Antibacterial activity is one of the most important applications for such nanoparticles (Kumar *et al*. 2012b; Khan *et al*. 2015). The medicinal plant *Swertia chirata* has been researched for its ability to synthesize poly shaped gold nanoparticles (Au NP). Au NPs have been linked to significant scientific contributions as a result of their use in a variety of fields, including cosmetics, bio molecular imaging, cancer treatment, and drug delivery. Crop defense and agriculture are two areas where nanoparticles are being used. Antimicrobial silver nanoparticles are already widely used in commercial medical and consumer products. By various methods Nanoparticles synthesized have been used in diverse in vitro diagnostic applications silver, silica, and platinum nanoparticles. Leaf extracts to aqueous silver nitrate solution, the color of the solution changed from faint light to yellowish brown and finally to colloidal brown indicating formation of silver nanoparticles. The process is simple and can be done at room temperature, making it a feasible and environmentally friendly way to make benign nanoparticles without a lot of energy or waste. Nanomaterials have different types such as copper, zinc, titanium, gold.

Keywords: plant extract, silver nanoparticles, antibacterial activity, plant microbes, India, green synthesis

Introduction

For thousands of years, *Swertia* plants have been used as medicinal plants to treat a variety of ailments. In the clinic, seventy species of the genus *Swertia* were used, with approximately forty species present in China (Liu *et al*. 2011) [15]. Swertiaperennis as shown in fig 1 is a long-lived, iteroparous, herbaceous perennial found in calcareous fens and extremely wet grasslands (Hegi, 1906) [1]. It has a broad, but irregular distribution that stretches from Central Europe to western North America, with a centre in the European Alps (Hulten and Fries, 1986).It is considered endangered worldwide (Ja'ger and Hoffmann, 1997) [11]. Despite the fact that it can be abundant locally. The plant *Swertia* belongs to Gentianaceae family, which is a tropical family of small trees, consists of 180 species of which 40 species occur in Indian subcontinent (Hooker, 1885; Clarke 1885; Kirtikar and Basu, 1984) [13]. This plant is only found in the Himalayas at elevations above 4000 feet, from Kashmir to Bhutan (Bhattacharjee, 1980) [13]. Geographical distribution of Chirata as shown in fig 2.

Taxonomical classifications

Scientific name: *Swertiaperennis*
Botanical description:
Kingdom: Plantae
Order: Gentianales
Family: Gentianaceae
Genus: *Swertia*
Species: *S. perennis*

Fig 1: Chirata (*Swertiaperennis*)

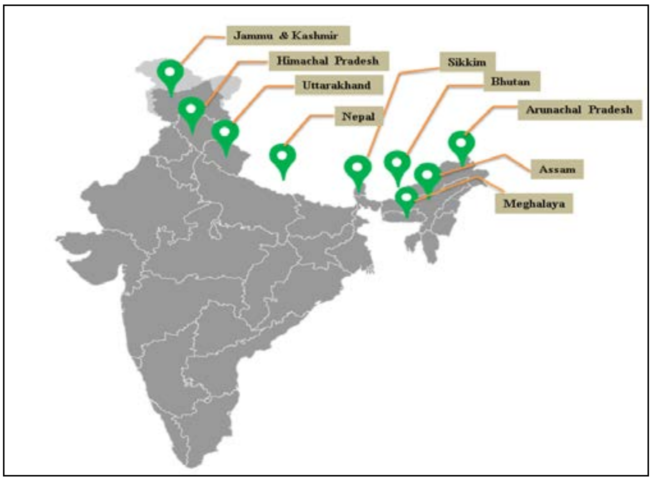


Fig 2: Geographical distribution of *Swertia* species in India showing by the green location icon on map

Silver nanoparticles

Silver nanoparticles are mostly with sizes ranging from 1 to 100 nm. They have unique properties that aid in molecular diagnostics, therapies, and devices which can be used in a variety of medical procedures involved (Prabhu &Poulose, 2012) [22]. Silver nanoparticles can be synthesized using microorganisms such as bacteria, fungi, and plants (Ahmed *et al*. 2016). Plant extracts is more preferable to microorganisms (Kalishwaralal *et al*. 2010) [3]. The physical and chemical methods are the most commonly used for the synthesis of silver nanoparticles. The issue with chemical and physical methods is that synthesis is costly and can result in toxic substances being absorbed onto them. To address this, the biological method offers a viable alternative. Bacteria, fungi, and plant extracts are the main biological systems involved (Prabhu &Poulose, 2012) [22]. Different type of nanomaterials like Copper, zinc, titanium. (Retchkiman-Schabes *et al*. 2006) [25] and silver nanoparticles have all been produced, but silver nanoparticles have proven to be the most effective because they have strong antimicrobial efficacy against bacteria, viruses, and other eukaryotic microorganisms (Gong *et al*. 2007) [9]. For morphological studies of nanoparticles, microscopic techniques such as scanning electron microscopy (SEM), transmission electron microscopy (TEM), and atomic force microscopy (AFM) are commonly used. FTIR spectroscopy, on the other hand, is a chemical analytical technique that measures infrared intensity versus light wavelength (wavenumber) (Kumar *et al*. 2012b).

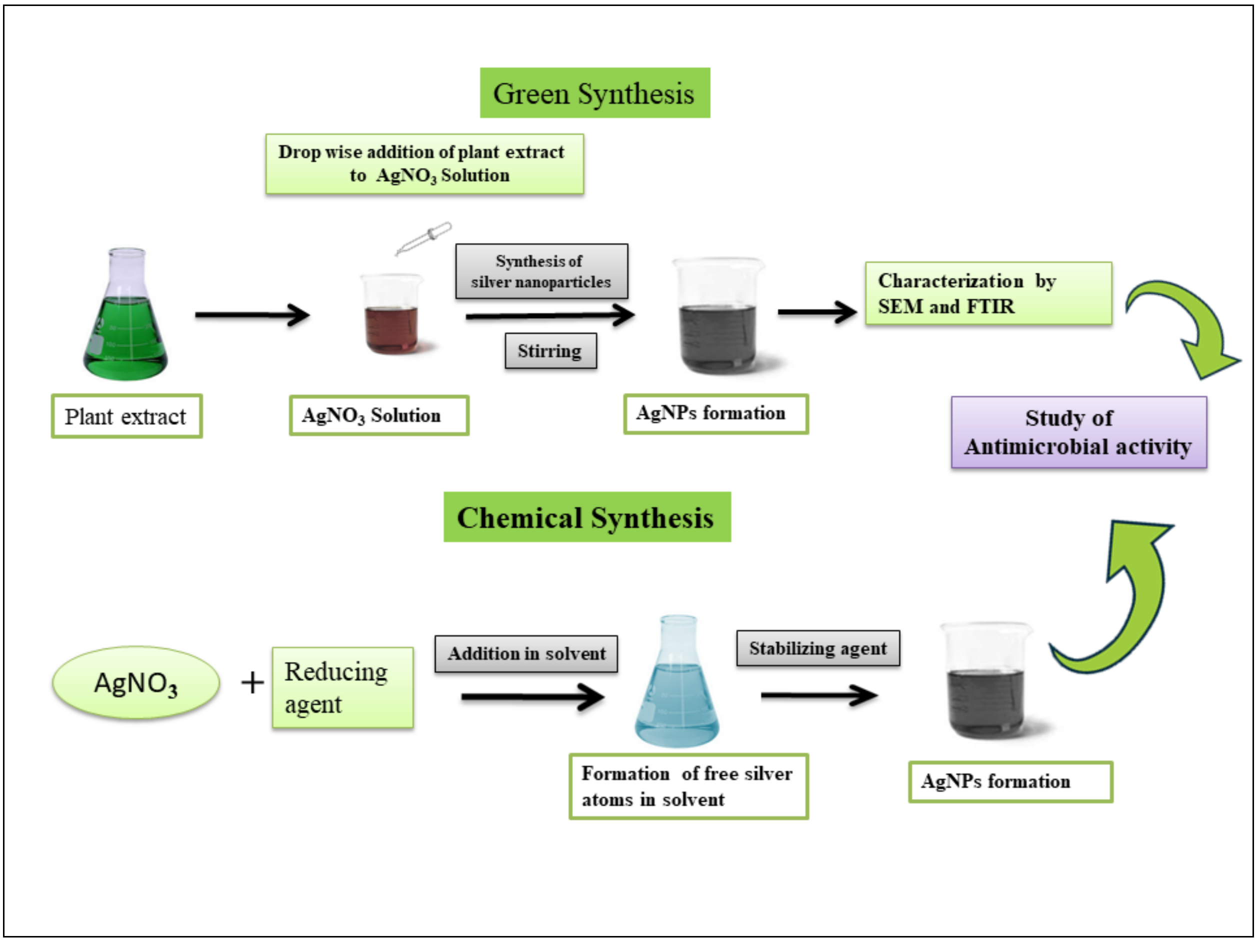
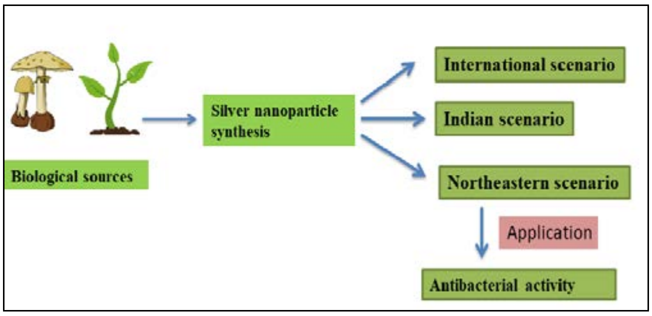


Fig 3: Silver nanoparticles

Plants used for synthesis of silver nanoparticles

The use of plant extracts for the development of silver nanoparticles appears to be the best option for researchers and scientists because the process is fast, environmentally friendly, cost-effective, and only requires one stage (Husain *et al*. 2016). Plant extracts from live alfalfa, lemongrass broths, geranium leaves, and other green reactants have been used to make Ag NP (Shankar *et al*., 2003b; Gardea-Torresdey *et al*., 2003) [7]. *Capsicum annum* L., a vegetable, was also used to make Ag NPs (Li *et al*., 2007). *O. tenuiflorum, S. tricobatum, S. cumini, C. asiatica, and C. sinensis* extracts were used to make the silver nanoparticles, which is a cost-effective, safe, and environmentally friendly process (Logeswari *et al*. 2015) [16]. It is important to investigate the geographic distribution of plants, as well as whether they grow all year or only during certain seasons. Plant parts such as leaves, buds, fruits, stems, barks, and roots have all been found to be useful in the production of AgNPs. For AgNPs synthesis, plant extracts containing proteins, enzymes, alkaloids, tannins, phenolics, quinines, and oils may be used (Patil *et al*. 2012; Bar *et al*. 2009; Lukman *et al*. 2011; Ankamwar *et al*. 2005). *Micrococcus luteus* and *Staphylococcus aureus* shows that AgNPs synthesized with plant extract from *Mimusopselengi* leaf have enhanced antibacterial activity against multidrug-resistant clinical isolates (Prakash *et al*. 2013) [23]. Bioactive compounds found in plant extracts that are involved in the reduction of silver ions, which serve as capping agents for AgNPs, have been shown to have bacteriostatic effects against Gram-positive and Gram-negative human pathogenic bacteria (Ahmed *et al*. 2015).



Biosynthesis of silver nanoparticles from fungi

Many fungi have been used to successfully synthesize silver nanoparticles, including *Fusariumacuminatum*, *Fusariumsolani*, *Aspergillusniger*, *Phomaglomerata*, *Alternariaalternata*, *Fusariumculmorum*, and others. These studies confirmed that fungi are more effective candidates for fabricating metal nanoparticles both intracellular and extracellular than other biological agents. As opposed to chemical and physical approaches, extracellular biosynthesis of silver nanoparticles using fungi has advantages such as being more simple and eco-friendly (Ingle *et al*. 2008) [10]. *Trichodermaviride* developed AgNPs with sizes ranging from 1 to 50 nanometers (Abdallah *et al* 2016) [31]. Both pathogenic bacteria studied were significantly inhibited by the biogenic AgNPs. The biosynthesis of AgNPs (with an average size of 15.5 nm) using extracellular filtrate of *Aspergillusversicolor* ENT7 as a reducing agent has been documented, and these nanoparticles have shown to have excellent antioxidant and antimicrobial activity (Netala *et al* 2016) [32].

Green synthesis of nanoparticles

Green nanoparticle synthesis is a revolutionary method of synthesising nanoparticles from biological sources. It is gaining popularity because to its low cost, environmentally beneficial nature, and large-scale production capabilities. Researchers are interested in silver nanoparticles because of their evocative physical and chemical properties (Singha *et al*. 2014). Natural polymers such as starch, leaf extracts, root extracts, fruit extracts (Ankamwar *et al*. 2005) [5] and other natural polymers have been widely used for the synthesis of green nanoparticles in recent years because plants are widely available, safe to handle, and contain a variety of metabolites that serve as reducing agents in nanoparticle synthesis (Rokade *et al* 2017) [24].

Advantages of green synthesis	Disadvantages of green synthesis
• Easily scale up for large scale nanoparticle synthesis.	• Plant cannot be used as a source of nanoparticle through genetic technology synthesis.
• There is no requirement for high temperature, pressure, energy, or toxic chemicals.	• Plant produce a poor yield of secreted proteins, slowing the rate of synthesis.
• Less complicated culture maintenance process is more advantageous than using microorganism.	• Become more accessible.
• Reducing the cost of microorganism isolation and the media's culture.	• Health risks have increased as a result of nanotechnology.

Antibacterial activity

Antibacterial activity is one of the most important applications for such nanoparticles (Kumar *et al*. 2012b; Khan *et al*. 2015) [12]. Since Gram positive and Gram negative bacteria have different cell wall compositions, silver nanoparticles have a higher antibacterial activity against *E. coli* than against *S. aureus*. (Ali *et al*. 2011). Gram positive bacteria *Staphylococcus aureus* and Gram negative bacteria *Escherichia coli* were used to test the antibacterial activity of the synthesized NPs. On S. aureus, both Au and Ag NPs had significantly higher activity than on *E. coli* (Dhar *et al*. 2016).

Synthesis of silver nanoparticles

International Scenario

The first plant-based production of silver nanoparticles was announced by Gardea-Torresdey *et al*. (2003) [7]. Plant extracts from a wide variety of plants have been successfully used to make nanoparticles. Live plants, in addition to plant extracts, can also be used. Nanoparticles can be created using either a "top down" or a "bottom up" approach (Sepeur, 2008). Top-down synthesis produces nanoparticles by reducing the size of a suitable starting material (Meyer *et al*. 2006) [18]. Various factors affects the synthesis of silver nanoparticles such as pH, tempeatures etc. AgNP synthesis occurs in plants at all pH levels, depending on the plant species (Veerasamy *et al*. 2011) [28]. Lower temperatures produce sharp peaks, which represent uniform-sized AgNPs, while higher temperatures (40 °C or above) produce broad peaks, which represent uniform-sized AgNPs. (Zhang *et al*. 2013) [29] Several studies have found a general pattern of increased nanoparticle synthesis as temperature rises. Temperature is a critical factor in increasing the activation energy required to complete a reaction (Ghosh *et al*. 2012; Antony *et al*. 2011; Song *et al*. 2009) [8].

Indian Scenario

It has been reported that the leaf extract of *Azadirachtaindica* (commonly known as neem), a Meliaceae plant, was used to bioconvert silver ions to nanoparticles. This plant is widely available in India, and each part of the tree has been used as a home remedy for various human ailments and for the treatment of viral, bacterial, and fungal infections since antiquity (Omoja *et al*. 2011). Without using any other hazardous chemical or physical processes, silver nanoparticles can be made from a low concentration of leaf extract. Natural polymers such as starch, leaf extracts, root extracts, fruit extracts (Ankamwar *et al*. 2005) [5] and other natural polymers have been widely used for the synthesis of green nanoparticles in recent years because plants are widely available, safe to handle, and contain a variety of metabolites that serve as reducing agents in nanoparticle synthesis (Rokade *et al* 2017) [24].

Northeastern Scenario

Nowadays silver nanoparticles are widely used in a variety of antimicrobial applications such ascosmetic products, biosensor materials, optical catalysts, electrometer, medical imaging.drug delivery, Nano composites, memory schemes, bio labeling nanowires.animal husbandry, health industry. Food storage, textile coating and many more (Singha *et al* 2004) [27]. The antibacterial activity of silver nanoparticles was substantial. When applied in conjunction with, their efficacy increased antibiotics that are commercially accessible.As a result, with more testing on experimental animals, such silver nanoparticles could be employed as an antibacterial agent alone or in conjunction with antibiotics (Raheman *et al*. 2011) [33]. The antibacterial properties of the AgNPs as produced were tested against Pseudomonas Fluorescens and Staphylococcus Epidermidis, both gramme negative bacteria (Saikia *et al*. 2015) [34]. Morphologically diverse silver nanostructures were produced employing the leaf extracts of *Symplocosracemosa*.*Symplocos* is a genus of flowering plants comprising over 300 species scattered in Asia and the Americas.*Symplocosracemosa*Roxb.is a tree native to the northeastern hilly regions of India and Burma, whose bark is prized as an old therapeutic herb in the Ayurvedic system. The bark of the Lodh tree (Odia name) is thought to have therapeutic characteristics and is primarily used to treat women's health and liver problems. Its bark is often used to create a natural yellow dye (Panda *et al*. 2021) [38]. *Bryophyllum, Asiatic pennywort, Paederiafoetida, Houttuyniacordata, Bacopamonnieri, Menthaarvensis,* and other edible plants used as ethno-medicines in North East India, particularly Assam, include *Paederiafoetida, Houttuyniacordata, Bacopamonnieri, Menthaarvensis, Bryophyllum* because of its potential medical application, the production of bio-reduced AgNP sutilising locally accessible medicinal plant extracts is a significant area of investigation (Tatsimo *et al*. 2012) [39]. Water mimosa, also known as *Neptuniaoleracea,* is a pantropical nitrogen-fixing perennial legume with delicate leaves and white spongy layers around its stems (Singha *et al*. 2004) [27]. The edible medicinal plant *Neptuniaoleracea* (water mimosa) is used to treat a variety of ailments. Earaches, diarrhoea, syphilis, and tumours are all treated using *Neptuniaoleracea* (Reddy *et al*. 2020) [40]. Advantages of using biological nanoparticles.

The advantages of biological nanoparticle synthesis include fast and environmentally friendly production methods, as well as the cost-effective and biocompatible design of synthesized nanoparticles. Furthermore, it does not need additional stabilizing agents because the constituents of plants and microorganisms serve as capping and stabilizing agents (Makarov *et al*. 2014) [17].

Disadvantages nanotechnology

Nanotechnology has improved people's living standards, but it has also increased emissions, such as water pollution and air pollution. Nano pollution is the term for pollution caused by nanotechnology. This type of pollution is extremely harmful to living things. The drawbacks of nanoparticles are largely unexplored (Parveen *et al*. 2016) [20].

Future prospect

Recent research has focused on answering the following questions: (1) methods for synthesising AgNPs with optimal properties, enhancing their antimicrobial effect while minimizing potential toxic effects on human or animal cells.(2) discovery of prospective targets among bacteria for which AgNPs could be used alone or in combination with conventional antibacterial agents.Many parts of these global goals are yet unanswered, and studies in the near future may improve in the removal of current limitations (Rai *et al*. 2014) [35] Nanoparticles have been widely used in molecular research to investigate nucleic acid architecture and functions in the intact cell. Nanoparticles can also be found in proteins, nucleic acids, hormones, and other biologically active compounds as biological indicators. Nanobiotechnology has emerged as the era's present and future technology, with a wide range of applications spanning quantum dots, optoelectronics, medicine, therapeutics, biosensors, and many other (Prasad, 2014) [36]. SNPs can also be used to improve the characteristics of other materials, such as plasmonic light traps, by integrating them with them. Fuels, solar cells, micro-electronics, medical imaging, and waste management all benefit from these features. SNPs' unique optical, physical, and antibacterial qualities will lead to a wide range of applications in medical and other fields like as healing, food sanitation, and medication delivery. Future research should focus on the development of SNPs aimed at overcoming these problems, as they will improve the level of effective drug delivery agents, the diagnosis and treatment of deadly diseases, as well as assuring greater safety and efficacy (Sanjukta *et al*. 2016) [37].

Conclusion

The method for making nanoparticles on a large scale using readily available plant extracts could be commercially viable, and it could be used to further research in the field of biology and materials science. The key benefit of using plant extracts for silver nanoparticle synthesis is that they are easily available, stable, and nontoxic in most cases, contain a wide range of metabolites that can aid in silver ion reduction, and are faster at synthesis than microbes. Overall, this antibacterial and silver nanoparticles combination appears to be one of the strongest methods for microorganism prevention and therefore therapeutic management in infection control. Acknowledgement: The review article is a part of the dissertation topic of the first author. The authors acknowledge the support received from Department of Biotechnology, Faculty of Science, Assam down town University, India.

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