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Analysing Metallic Nanoparticles in Plant Extract

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Abstract

Metal nanoparticles (MNPs) Medical imaging, bioengineering, photoelectricity, antibacterial, anticancer, and catalysis are just a few of the many areas where their unique physical and chemical properties have been extensively utilized. In the conventional MNP synthesis method, toxic chemicals are typically used as reducing and stabilizing agents. This method is extremely harmful to the environment and takes a long time. Because of this, environmentally friendly MNPs synthesis has recently received a lot of attention. Utilizing plant extracts as reductants and stabilizers enables MNP synthesis to be simple, cost-effective, and long-lasting. In addition, unlike their conventional counterparts, the as-synthesized MNPs are uniform in size, less toxic, and more stable. Green preparation methods are becoming an increasingly important focus in MNPs synthesis research. This systematic review provides a summary of the most recent developments in the utilization of plant extracts as reductants and stabilizers in the green synthesis of MNPs. The potential applications of MNPs made from plant extracts have also been studied in greater detail.

Keywords:Metal NanoParticles (MPs), silver Nanoparcticle (AgNP), Gold NanoParticle (AgNPs), etc

I. Introduction

Numerous Nanotechnology has changed several research areas, such as industrial manufacturing, photoelectricity, medicine, and catalysis. In 2020, 58,000 tonnes of nanomaterials are expected to be produced industrially [1]. Metal nanoparticles (MNPs) have been extensively utilized in a number of fields, including catalysis [2, 3], electronics, optoelectronics, medicine, sensing, and information storage [4, 5] due to their distinct biological and physicochemical properties. Some of them include high electrical conductivity, high catalytic activity, high chemical stability, and biomedically important antibacterial and anticancer actions. As depicted in Figure 1, "top-down" and "bottom-up" methods are frequently employed in the synthesis of MNPs. In this method, mechanical grinding, laser ablation, and thermal decomposition, among other physical and chemical processes, are used to produce MNPs from bulk metallic materials [6].

"Bottom-up" synthesis, also known as chemical synthesis and biosynthesis, piles the metal atoms associated with MNPs [7,8]. Polyvinylpyrrolidone, formaldehyde, alkyl mercaptan, thioanthracenol, dimethylformamide, Tween 80, and formaldehyde are frequently used as stabilisers and reducing agents in chemical synthesis to produce MNPs [9]. Because hazardous chemicals are frequently utilised along this route, it is extremely detrimental for the environment. Because of the strong reduction reaction, stabilisers are frequently used when manufacturing MNPs using

conventional chemical reducing agents. The majority of the time, the costly, hazardous, and poisonous chemical reduction agents utilised in this process placed the experimenters' safety and the safety of their surroundings at jeopardy [10]. Consequently, a mild stabiliser that is also a green reducing agent with and has a mild reaction is highly desired [24- 27]

Figure 1 demonstrates that, due to their low energy consumption, low cost, and favourable environmental effects, biosynthetic techniques are substantially more environmentally friendly than chemical synthesis methods [12, 13]. However, the microbial-based synthesis is rarely utilized due to its disadvantages of being time-consuming, costly, and susceptible to biosafety concerns [14].

On the other hand, the plant-mediated synthesis of MNPs has received a lot of attention from researchers all over the world [11] due to its many benefits, such as being faster, less expensive, and easier to use with more resources. Additionally, plant extracts are friendly to the environment, inexpensive, provide MNPs with a stable protective layer, are biocompatible and biodegradable [15]. They additionally stop MNP aggregation. Nanogold, silver, copper, platinum, and palladium are just a few of the MNPs that have been the subject of recent study on the synthesis of MNPs utilising plant extracts. A brief summary of the uses of related MNPs has also been provided, which could serve as a basis and a source of ideas for future studies on the environmentally responsible synthesis of MNPs.

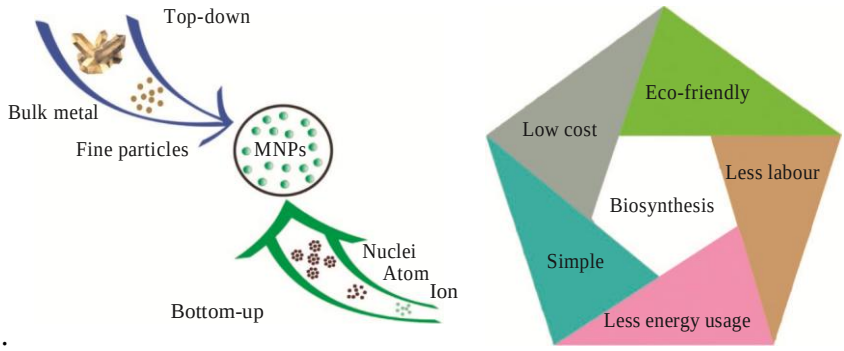

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Figure 1- An Bottom up approach for Analyzing Nanoparticle in plant

II. Literature Review

1. Plant-Extract-Mediated Synthesis of Metal Nanoparticles

2.1. Synthesis of Gold Nanoparticles. Due to their stability, size controllability, biocompatibility, high adsorption capacity, high catalytic activity, and biocompatibility, gold nanoparticles (AuNPs) are a hot topic in research on nanomaterials [16]. Medicine [17], drug and gene delivery [18], biosensors [19], tomography [20], photocatalysis [21], environmental sensing [22], and water purification [23] are just a few of the many applications for AuNPs. Reducing the metal ions to metal atoms, assembling the metal atoms into nuclei through coprecipitation, sol-gel, and atomic condensation, and then growing the metal nuclei into MNPs is one of the most common "Bottom-up" synthesis techniques (Figure 1). Utilization of AuNPs in fields like biology and medicine is restricted as a result of the harmful chemicals that adsorb on their surface during their current chemical production. Consequently, green and innovative. As a result, new, environmentally friendly, and

efficient synthetic methods must immediately replace harmful chemical synthesis. It has attracted a lot of attention in this context because it is successful at creating AuNPs and because the as-prepared AuNPs are more biocompatible without containing harmful compounds [26].

By reducing chloroauric acid with ethanol extracts of powdered dried vine tea leaves, AuNPs were created ($HAuCl_4$). Extracts from leaves were used to create AuNPs. Additionally, they looked at the effects of reaction variables including temperature, pH, and extract dosage on the physicochemical characteristics of AuNPs. They found that vine tea extracts or alkaline circumstances caused AuNPs to aggregate excessively; smaller AuNPs could be easily synthesised at higher temperatures, whereas larger AuNPs were more stable at lower temperatures. Smaller AuNPs were easier to synthesis at higher temperatures, while larger AuNPs were more stable at lower temperatures. According to Tao and colleagues, $HAuCl_4$ was reduced with aloe vera leaf aqueous extracts to create spherical, highly crystalline AuNPs with particle sizes between 20 and 60 nm (28).

AuNPs were made from flower extracts; Ghosh and coworkers (29) discovered that Gnidia glauca flower aqueous extracts reduced $HAuCl_4$ and AuNPs in less than 20 minutes. There were three distinct shapes in the final AuNPs: spherical, triangular, and hexagonal, with a size of approximately 10 nm on average. The reduction of 4nitrophenol with $NaBH_4$ demonstrated that the AuNPs had a significant catalytic effect on 4-aminophenol synthesis. Zangeneh and Zangeneh [30] reduced $HAuCl_43H_2O$ to produce spherical AuNPs with a particle size range of 15-45 nm by utilizing water extracts from Hibiscus sabdariffa flowers. The as-synthesized AuNPs were able to significantly reduce proinflammatory cytokines while simultaneously increasing anti-inflammatory cytokines. AuNPs, like daunorubicin, did not appear to have any effect on endothelial cells.

The biological effects of the as-obtained AuNPs were examined by Baldea and colleagues along with the viability of synthesising AuNPs from aqueous extracts of Cornusmas fruit. Fruit or fruit shell extraction was used to create AuNPs. It was discovered that HAuCl4 could be transformed into AuNPs at a pH of 7.5, which were fatal to hypertrophic keratinocytes. Because the AuNPs were biocompatible with common gingival fibroblasts, they might be used to treat problems related to oral dysplasia. After a 60-minute reaction at 70 °C, pH 7, 1 mM substrate, and 5 mL of fruit extracts from Couroupita guianensis, Sathishkumar and colleagues [31,32] produced nanogold.

The resulting AuNPs were grouped together, had a negative charge, and were coated in polyphenolic compounds. They were also negative in charge and averaged 26 11 nm in size. In addition, it was demonstrated that the as-prepared AuNPs possess exceptional hemocompatibility and anti-oxidant properties. Chen [33] produced hydrophilic AuNPs with sizes ranging from 9 to 23 nm by reducing and stabilizing them with mangosteen polyphenols from the aqueous extracts of Garcinia mangostana L. pericarp. He discovered that varying the extract concentration resulted in a variety of AuNP forms, including a variety of AuNP types formed.

H. Sutan [45] demonstrated that HAuCl4 could be used to reduce ethanol extracts of Aconitum toxicum Reichenb roots for three hours at room temperature, resulting in the production of AuNPs with diameters ranging from 9 to 15 nm. AuNPs were produced as a result of this method. At a pH of 6.65, water extracts of Ulva intestinalis L. could, according to Gonzalez-Ballesteros and Associates [34], reduce chloroauric acid for four hours. At a pH of 6.65, AuNPs were made by reducing chloroauric acid for four hours. AuNPs were synthesized as a result of this. The average zeta potential and diameter of the AuNPs were 17.8 2.7 nm and 22.30 0.24 mV, respectively, and the antioxidant activity of the AuNPs was determined to be between 78% and 84.32%, with a total

polyphenol content of 1.49 percent and an aconitine content of 4.891 mg/mL. In a systematic investigation into their biocompatibility, AuNPs were found to be biocompatible, low in hemolytic toxicity, and capable of promoting cell proliferation.

Water, n-butanol, chloroform, and n-hexane were the four polarity solvents used to extract Ocimum sanctum's active ingredient. The extracts were then used by Lee and colleagues to convert $HAuCl_4$ into AuNPs. They discovered that the majority of the AuNPs produced by the water extracts were thin flakes with clean edges, while the majority of the AuNPs produced by the n butanol extracts were spherical tiny particles measuring approximately 20 nm and nanosheets measuring approximately 1 m. The majority of the AuNPs produced by the hexane extracts were nanospheres measuring less than 10 nm. The majority of the AuNPs that were produced by chloroform extracts were rough-edged nanosheets.

The green synthesis of AuNPs was made by reducing and stabilizing flavonoids, polyphenols, and amino acids from plant leaves, flowers, seeds, roots, and fruits using $HAuCl_4$ as a precursor (Table 1). Research on extract concentration, reaction temperature, pH, and reaction time has extensively examined AuNP morphology. Colour dye detection, antibacterial activity, and catalytic dye degradation were the most frequently utilized applications for AuNPs produced through green synthesis. The development of AuNP synthesis from plant extracts in the future looks very promising. Both the method for synthesising AuNPs on the surface of other materials through in situ reduction and research into the synthesis mechanism for establishing a precise and controllable morphology for AuNPs are crucial.

2.2. Synthesis of Silver Nanoparticles. Silver One of the nanoparticles most frequently utilized in the biomedical field is nanoparticles (AgNPs), which are an essential component of nanotechnology. AgNPs have been used in biomolecular detection, drug administration, food production, and agriculture due to their exceptional chemical stability, electrical conductivity, catalytic powers, and antibacterial properties [32]. Due to their remarkable antibacterial properties, AgNPs have emerged as one of the most promising materials for combating drug-resistant bacteria. Due to their low toxicity and biocompatibility, AgNPs made from plant extracts are better suited for use in biomedical and other fields [35].

The best reaction conditions were 60°C, 10 mL of AgNO3 (0.005 mol/L), 60 mL of yellow quail leaf extracts (material ratio of 15 g/L), and a 40-minute reaction time when making AgNPs from Youngia japonica leaf extract [36]. Due to their spherical shape and average size of 20 nm, the produced AgNPs are anticipated to be used in the freshness treatment of cut flowers following the reaction, which effectively reduced the bacteria that were detached from cut lilies' stem ends. By reducing silver nitrate with water-soluble green tea extracts, Wang and his colleagues (37) produced spherical AgNPs with a range of particle sizes between 30 and 40 nm.

Table 1- Green synthesis of silver nanoparticles by different researchers using plant extracts.

Plants	Size (nm)	Plant's part	Shape

Alternanthera dentate	50–85	Leaves	Spherical
Acorus calamus	31.86	Rhizome	Spherical
Boerhaavia diffusa	24	Whole plant	Spherical
Tea extract	20–80	Leaves	Spherical
Tribulus terrestris	16–27	Fruit	Spherical
Cocous	23	Inflorescence	Spherical
Abutilon indicum	8–17	Leaves	Spherical
Pistacia atlantica	11–50	Seeds	Spherical
Ziziphora tenuior	9–40	Leaf	Spherical
Ficus carica	14	Leaf	–
Cymbopogan citratus	33	Leaf	–
Acalypha indica	0.7	Leaf	–
Premna herbacea	11–30	Leaf	Spherical
Calotropis procera	18–45	Plant	Spherical
Centella asiatica	32–50	Leaf	Spherical
Argyreia nervosa	22–50	Seed	–
Psoralea corylifolia	80–110	Seed	–
Brassica rapa	17.4	Leaf	–
Coccinia indica	11–20	Leaf	–
Vitex negundo	5 & 10–30	Leaf	Spherical & fcc
Melia dubia	35	Leaf	Spherical
Portulaca oleracea	<60	Leaf	–

III Antimicrobial property of silver nanoparticles and its mechanism

All civilizations have made substantial use of silver for a number of purposes. Fine cutlery, decorations, and jewellery are all made out of silver in various societies. It was believed that wearing silver jewellery, handicrafts, and silverware was healthy. Silver has been utilised as an antibacterial since the Phoenicians employed it as a natural biocide to protect milk bottles against microorganism infection. 650 distinct types of microorganisms, including viruses, fungi, gram-positive and gram-negative bacteria, and others, can all be killed by the well-known antibiotic silver. An application for the metal that is still relatively new is in silver nanoparticles. Silver has been mentioned as a therapy for several illnesses in the traditional Ayurvedic medicine of ancient India. Applying drops of aqueous silver nitrate to new borns' eyes during childbirth to stop the spread of Neisseria gonorrhoea from infected moms became standard procedure [41-43]. Silver has been discovered to be the least hazardous to animal cells and the most effective antibacterial agent of all the metals possessing antimicrobial capabilities. Since more than 2,000 years ago, silver nitrate has been used to treat infections. However, when silver nanoparticles are used, the surface area to which microbes can be exposed increases significantly. For instance, during the World War, silver was frequently employed in the medical care of injured soldiers. Numerous plant extracts from different sources have been examined for their antibacterial capabilities. Plant extracts from a variety of sources have been used in analyses of the antimicrobial properties of silver nanoparticles against various microbes[38, 39]

The antimicrobial properties of silver nanoparticles depend on:

1. Capping agent and environmental conditions (size, pH, and size).

2. The precise antibacterial or toxicological processes of silver nanoparticles are still the subject of extensive research and discussion.

. The positive charge of the Ag ions is thought to be essential for the antibacterial properties. Silver must be ionised in order to possess any antibacterial effects. Silver is inert while it is not ionised, but when it comes into contact with moisture, silver ions are released. Ag+ ions can form complexes with nucleic acids and prefer to bind with nucleosides over phosphate groups. All silver-containing compounds and silver-containing compounds with known antibacterial activities result in the formation of silver ions (Ag+).

These silver ions can be produced by ionizing the surface of a solid silver particle in the case of silver nanoparticles. They are also able to be incorporated into silver sulfadiazine and released gradually over time. Positively charged nanoparticles and negatively charged bacterial cells electrostatically attract each other, making them the ideal bactericide, according to some published studies.

It has been demonstrated that these nanoparticles accumulate within the membrane before entering the cell and causing damage to the membrane or cell wall. Silver atoms are thought to bind to enzyme thiol groups (ASH) and form stable SAAg bonds with thiol-containing molecules, deactivating enzymes that transport ions and generate trans membrane energy. As a result of the breakdown of the hydrogen bonding between the two anti-parallel strands, it was anticipated that the DNA molecule would denaturate once the Ag(I) ion entered the cell and intercalated between the purine and pyrimidine base pairs(40)

Bacterial cell lysis may account for its antibacterial properties. Nanoparticles altered the phosphotyrosine profile of the bacterial peptide, which interfered with signal transduction and prevented microbial growth. The emergence of bacteria that are resistant to antibiotics has no impact on the antibacterial action, which is dose-dependent. Following treatment, it was discovered that silver nanoparticles accumulated in the bacterial membrane of E. coli cells, causing the cell to die and become more permeable.

Conclusion

The utilisation of green chemistry and a green approach to create metal nanoparticles has increased interest in creating ecologically friendly processes. The production of silver nanoparticles using plant extracts has the benefit of being economical, cost-effective, and energy-efficient. It also makes communities and workplaces healthier while simultaneously preserving consumer safety, environmental protection, and human health. Silver nanoparticles made using green synthesis have significant nanotechnology features that can be applied in ways that are unmatched by other materials. Silver nanoparticles made using green synthesis have significant nanotechnology features that can be applied in ways that are unmatched by other materials. Due to the time-consuming process of using microorganisms and maintaining their culture, which can limit their potential for the production of nanoparticles, plants may be a better choice than other biological entities for this purpose. The use of plant extract in synthesis may therefore have a significant impact in the future.

The manufacture of silver nanoparticles utilising plant extracts, such the ones mentioned before, has been the subject of numerous reports. There hasn't been any research on how to economically and environmentally uncover the natural reducing constituent's capacity to make silver nanoparticles. Lab results may vary because plant extracts from the same species gathered in various parts of the world have chemical compositions that range greatly from one another. When employing

plant extracts as reducing and stabilising agents to make silver nanoparticles, this is the main problem that appears, and it needs to be fixed. A simple and quick fix for the aforementioned issue could be provided by identifying the plant biomolecules that mediate the creation of nanoparticles give green syntheses of silver nanoparticles a new lease on life.

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