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PLANT EXTRACT MEDIATED SYNTHESIS OF GOLD NANOPARTICLES: A MINI-REVIEW

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ABSTRACT

Nanoparticles are an important field of research due to their unique properties as compared to their bulk structures and the diverse applications arising from these properties. The major synthesis methods available involve physical and chemical methods which are expensive and use toxic chemicals. There is hence a need for an eco-friendly synthesis route which is in par with the chemical methods. Green synthesis or biosynthesis is a good alternative where plants or microbes are used to assist nanoparticle synthesis, thereby reducing toxicity. Usually, biosynthesis is done for metallic nanoparticles, especially gold. In this paper, plant extract mediated synthesis of gold nanoparticles and the factors affecting the synthesis are discussed.

KEYWORDS: Plant extract, Green synthesis, Gold nanoparticles, Phytochemistry.

INTRODUCTION

Nanoparticles are gaining wide importance owing to their unique electrical, optical, magnetic and mechanical properties which can be exploited for diverse applications. Synthesis of nanoparticles is hence a major field of research. Common synthesis techniques involve physical methods such as ball milling, evaporation etc. and chemical methods such as chemical reduction, electrochemical reduction etc. [1]. However, these methods have the disadvantage that they are expensive, utilize toxic chemicals and also lead to wastage of chemicals. The toxicity factor is especially significant in the case of application of nanoparticles in medicine wherein they interact with living cells. Therefore, there is a need for an alternative synthesis route which is environment-friendly. Biosynthesis is a promising field which involves microbes (bacteria, virus, fungi) or plants to mediate the synthesis process. Microorganism-mediated synthesis however requires preparing several cultures which is time-consuming. Plant-mediated synthesis is faster, simple to perform and can be scaled up easily [2].

Green synthesis usually focuses on metal nanoparticles, especially gold and silver. Gold nanoparticles (GNP) have tunable optical and electrical properties. They exhibit the phenomena of Surface Plasmon Resonance (SPR) which is used in diagnostic probes, drug delivery and sensors. They also have applications in optoelectronics and catalysis. The main advantage of their use in biological systems is the excellent biocompatibility and non-toxicity. Anti-microbial effects of gold nanoparticles have also been studied. They may exist in different shapes such as spherical, nanotriangles, nanoplates, nanoprisms, nanowires hexagons etc. The shape and size highly influence properties, especially optical properties [3].

Plants: An effective source

As mentioned earlier, plant extract mediated synthesis is fast and simple. It avoids the presence of toxic or redundant chemicals and is in keeping with principles of Green synthesis. The phytochemicals present in plants are responsible for reducing the metal ions. This process is called bioreduction. In the case of GNPs, reduction of chloroauric acid is done by the biomolecules in plants. The plant extract may be from the leaves, bark, flower, seed or any other part of the plant. The extract may act as both reducing and stabilizing agent in some cases.

Factors affecting biosynthesis

One of the major factor affecting the size and morphology of the resultant GNPs is temperature. It also controls dispersion of particles. For instance, GNPs synthesized using cumin seed powder extract were found to have nanoplatelet structure when synthesised at 20°C, spherical structure at 100°C and polydispersed at room temperature synthesis with pH=3. All particles had size around 1-10 nm. Varying the temperature can hence tune the shape, size and morphology of GNPs [4].

Other factors affecting synthesis are pH, concentration of salt, concentration of the extracts and presence of ions such as chloride, iodide etc. In one study using *Cinnamomumzeylanicum*, at lower extract concentrations gold nanoprisms dominated whereas at higher concentrations of extract, spherical particles dominated [5].pH variations for shape control have also been extensively studied [2,24].

Plants used for biosynthesis of GNP

The phytochemistry and medicinal properties are usually considered while selecting the plant. Researches on different plants for biosynthesis are going on so as to improve the yield, size distribution, dispersion, etc. of the particles and reaction rate. Some plants used in the synthesis of gold nanoparticles were show in Table 1**.**

Leaf extracts

The leaf extract of *Azadirachtaindica*, commonly known as Neem, is widely used for reducing gold ions. It involves a simple procedure. Leaves are finely cut and boiled in water. A small quantity of the broth is then incubated with 1mM hydrogen tetra chloroaurate solution at room temperature for 1-2 hrs. The gold nanoparticle solution thus obtained is purified by repeated centrifugation at 15,000 rpm for 20 min. Supernatant is discarded and the pellet is dissolved in deionised water. The GNPs thus formed showed a broad size distribution [6].Coriander leaf extract assisted reduction resulted in GNPs with average size of 6.75-57.91 nm. But the reaction time was long, about 1-2 hours [7].Aqueous leaf extract of *Cassia auriculata*assisted in synthesis of stable triangular and spherical GNPs with size of 15-25 nm. The plant possesses antidiabetic potential and hence anti-hyperglycemic effects may be promoted by these particles [8].The effects of *Artocarpusheterophyllus* Lam leaf extract on the morphology of obtained GNPs were investigated in a study. The GNPs present included 64 ± 10 nm nanospheres, 131 ± 18 nm nanoflowers, and 347 ± 136 nm (edge length) nanoplates [9].*Gymnemasylvestra*leaf extract produced 1-90 nm spherical GNPs. Their anticancer and antioxidant properties for application in nanomedicine were evaluated [10].Bioreduction with the aqueous extract of the seaweed, *Sargassammyriocystum,* lead to spherical GNPs with average size of 10-23 nm. Due to its heparin-like activity, it has potential application in cardiovascular systems [11].Apart from these, leaf extracts of several other plants such as Aloe vera [12], *Rosa rugosa*[13] and others [14-24] have been utilized for bioreduction.

Table 1: Some plants used in the synthesis of gold nanoparticles

Extract	**Plant**	**Average Size of GNPs (nm)**	**Shape**	**Reference**
Leaf	*Azadirachtaindica*	2-100	-	6
	Coriander	6.75-57.91	Spherical	7
	Cassia auriculata	15-25	Triangular, spherical	8
	Artocarpusheterophyllus	64 ± 10, 131 ± 18, 347 ± 136 resp.	Nanospheres, nanoflowers, nanoplates	9
	Gymnemasylvestra	1-90	Spherical	10
	Sargassammyriocystum	10-23	Spherical	11
	Aloe vera	-	Nanotriangle	12
	Rosa rugosa	11	-	13
	Phyllanthusamarus	65-99	Spherical	14
	Jasminumnervosum	2-20	-	15
	Coleus amboinicus	4.6-55.1	Spherical, triangle, truncated triangle, decahedral, hexagonal	19
	Dalbergiasissoo	5-55	Triangular, spherical	22
	Centellaasiatica	9.3-10.9	Spherical	23
	Achyranthesaspera	50-80	Spherical	24
	Ocimum sanctum *Cinnamomumzeylanicum*	30 -	Hexagonal Nanoprisms, nanospheres	17 5
Fruit	*Citrus limon*	32.2	Polyshaped	25
	Citrus reticulate	43.4	Polyshaped	25
	Citrus sinensis	56.7	Polyshaped	25
	Ananascomosus	5-15	Spherical	26
Bark	*Saracaindica*	15-23	Polyshaped	27
Flower	*Mirabilis jalapa*	60-70	Multishaped	28
	Rosa hybrida	10	Spherical, triangular, hexagonal	29
	Nyctanthesarbortristis	14.8-24.8	Spherical	30
Seed	Cumin	1-10	Nanoplatelets, spherical	4

Fruit extracts

Citrus fruits have also been effectively used to reduce gold ions from $HAuCl_4$. Juice extracts from *Citrus limon, Citrus reticulata and Citrus sinensis*were utilized. They also stabilize the nanoparticles formed. The average sizes of the GNPs were 32.2 nm, 43.4 nm and 56.7 nm respectively. Various shapes and sizes (polymorphic GNP) were obtained by altering the ratio of extract to $HAuCl_4$ [25].*Ananascomosus*(pineapple) fruit extract mediated synthesis produced GNPs with spherical morphology and average size range of 5-15 nm. The reduction reaction was slow and took about 3-4 hours for completion [26].

Bark extract

An efficient green synthesis method for GNP was done using the bark extract of *Saracaindica*. It required no additional stabilizing or capping agent. The polyphenolic compounds present in the bark extract were responsible for the reducing effect. Polyshaped GNPs with size range of 15-23 nm were obtained [27].

Flower extracts

Flower extract of *Mirabilis jalapa*was used to synthesize GNPs with multi shaped morphology. However they had a broad size distribution and the reaction took 1-2 hours to get completed [28].Green synthesis using aqueous extract of *Rosa hybrida*petals gave GNPs with polydispersed morphologies (spherical, triangular and hexagonal) with an average size of 10 nm. The reaction time was only 5 min [29].The strong reducing and capping potential of *Nyctanthesarbortristis*flower extract have been explored. The GNPs synthesized had dominant spherical morphology with an average diameter of 14.8-24.8 nm. The particles were also found to be stable upto 6 months [30].

CONCLUSION

In this paper, the process of plant-extract mediated synthesis of gold nanoparticles, the factors affecting synthesis and various plant sources used have been discussed. Green synthesis is the preferred methodspecifically for applications in medicine, as it is biocompatible and less toxic. Mostly leaf extracts are used for reducing gold ions. The reaction time depends on the reducing power of the extracts,varying from 10 mins with cypress leaf extract to few hours with coriander leaf extract. Some extracts can also stabilize the particles formed. GNPs obtained from medicinal plants or herbs have potential in the field of nanomedicine.

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