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Potential Applications of Plants for the Synthesis of Gold and Silver Nanoparticles: A Review

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Abstract: ***Nanoparticles are widely used in biotechnology and biomedical fields such as in diagnosis and therapy. Recently, synthesizing metal nanoparticles using plants has been extensively studied and has been recognized as a green and efficient way for further exploiting plant parts as convenient nanofactories. The importance of nanotechnology is highly increased in last years.***
Gold and silver nanoparticles are significant in the process due to their many peculiarities such as surface Plasmon absorption and the surface accessibility for further functionalization. As gold and silver nanoparticle are proved to be safest for drugs applications they are considered very important and used in several applications. Synthesis of gold and silver nanoparticle can be done through three methods like Physical, Chemical reduction and Biological or Green methods. Present work have been presented to focus on the green method of its synthesis.
The biosynthesis of nanoparticles has many advantages over tedious, toxic and expensive physical and chemical methods of synthesis.
The goal, was to develop a reliable, ecofriendly and easy process for the synthesis of gold and silver nanoparticles. The size and shape of nanoparticle are the key to their biomedical property.
Green synthesis of nanoparticle is feasible way for the future and this review provides gold and silver nanoparticle synthesis by green method because in recent years' efficient green chemistry methods for the synthesis of metal nanoparticle has become major focus of researchers.
Keywords: Nanotechnology, Nanoscience, physical methods, chemical reduction methods, green synthesis, silver nanoparticle, gold nanoparticle, Reducing agent and capping agent.

I. INTRODUCTION

Now a day's nanotechnology is rapidly growing field for manufacture of new materials on the nanoscale level. Nano scale material have different property such as electrical, magnetic, optical physical and chemical property due to its surface to volume ratio [1]. Nanoparticle have been extensively studied for applications in various fields due to the unique property that arise as a result of their dimensions [2].

Nanotechnology is the combination of principle which involved physical, chemical and biological factor that cerate nano size particle with a particular function [3]. Nano particle can be defined as a particle ranging in size from 1-100 nm and their size may be differing from bulk materials [11].

II. NANOTECHNOLOGY

The application of science to control matter at a molecular level is an interdisciplinary field which involved physics, chemistry, biology and engineering is called nanotechnology [60].

In 1959 physicist Richard Feynman gives the concept of nanotechnology in his talk "There's plenty of room at the bottom." The term nanotechnology was first used by Norio Taniguchi in 1974 through it was not widely known.

A more accurate definition of nanotechnology presented in 1981 by Drexler such as the production with dimensions and precision between 0,1 and 100 nm. In medium term nanotechnology involve the study at microscopic scale (1nm = 1 x 10^{-9}m) [12].

Many benefits of nanotechnology depend on the fact that it is possible to tailor the structure of material at extremely small scales to achieve specific properties. Using nanotechnology, materials can efficiently be made stronger, lighter and even better electrical conductor.

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III. NANOPARTICLES

According to IUPAC nanoparticle is the particle of any shape with dimension in the 1 x 10^{-9} and 1 x 10^{-7} m range. There are two groups of nanoparticles, Organic group and inorganic groups. The organic group is comprised of carbon Nanoparticles and fullerenes while the inorganic group consist of noble metal (Ag and Au) and semiconductor (Titanium oxide and Zinc oxide) nanoparticles. Inorganic nanoparticle shows important novel chemicals physicals and biological characteristic as well as good functionality owing their nano scale size. The color difference between metallic gold is yellow whereas Au NPs that are Wine red [60].

IV. CLASSIFICATION OF NANOPARTICLES

A. *On The Basic Of Dimensional Structure*

On the basic of dimensional structure nanoparticle are classified into four types:

1) *Zero Dimensional Nanoparticle:* The nanomaterial which are measured in the nanoscale level are i.e. no dimensional are larger than 100 nm. Most commonly 0D nanomaterial are nanoparticles.
2) *One Dimensional Nanoparticle:* The nanoscale material which are one dimensional like structure. Examples include - Nano roads, nanowires.
3) *Two Dimensional Nanoparticle:* The nanoscale material which are two dimensional like structure. Examples include Graphene, Nano films.
4) *Three Dimensional Nanoparticles:* These are the material which are not confined to the nanoscale in any dimensions. Some examples are bulk powder, dispersion material, bundles of nano wires etc.

B. *On The Basic Of Pore Size*

On the basic of pore size nanomaterials are classified into three types

1) *Microporous Materials:* Such type of material have very narrow pores. Such type of materials has diameter less than 2 nm. Examples Na-Y and naturally occurring clay metal.
2) *Mesoporous Materials:* The materials which are having diameter ranges between 2 nm to 50 nm are generally known as mesoporous materials. Examples are carbon mesoporous material.
3) *Macroporous Material:* The material having diameter greater than 50 nm are called as macro porous nanomaterials. These materials are generally used as a metrics to store functional molecules. Examples are carbon micro tubes , porous glasses.

V. SILVER NANOPARTICLES

Silver has been in use since the time immemorial in the form of metallic silver , silver nitrate , silver sulfadiazine for the treatment of burns, wounds , and several bacterial infections.in the year of 1700 silver nitrate was used in its solid form to treat venereal disease, abscesses and several other diseases [13]. In the 19^{th} century $AgNO_3$ was used in various concentration for the treatment of fresh burn wounds[60].

As silver nanoparticles are most effective due to its good antimicrobial efficiency against bacteria, virus, and several other micro-organisms. They are used as an antimicrobial agent. For treatment of water in textile industry[11]. Silver nanoparticle can be synthesized by green method using plants such as Azadirachta Indicia, Capsicum annum and Carica papaya.

VI. GOLD NANOPARTICLE

Gold nanoparticle are considering to be the most stable nanoparticles and have various application in optical and electronic property in the field of biology [60].

Gold nanoparticle is used as a lab tracer in DNA finger print to detect presence of DNA sample. Aminoglycoside antibiotic like streptomycin, gentamycin and neomycin are being used for detection.

Gold nanorods being used detect cancer stem cells [11]. Gold nanoparticles are now being considered as perfect antigenic compounds since they are easy to synthesize, characterize and able to easily bind thiols which wound in turn inhibit or denature the function of angiogenesis inducer in proteins. Various disease such as cancer, arthritis, etc. depends on angiogenesis thus Au NPs could lead to new therapeutic measure for the diseases [60].

VII. PROPERTY OF GOLD AND SILVER NANOPARTICLE

As we know that there are large number of property have silver and gold nanoparticle but some of the general property of gold and silver nanoparticles are discussed as follows in the given table 1.1 [60]

Table 1.1 Property of Gold and Silver nanoparticle

Sl.No	Property	Silver	Gold
1	Atomic Number	47	79
2	Atomic Weight	107.87	196.87
3	Electronic Configuration	$[Kr]4d^{10}5s^{1}$	$[Xe]\ 5d^{10}6s^{1}$
4	Density	$10.50 g\ cm^{-3}$	$19.28\ g\ cm^{-3}$
5	Lattice	f.c.c	f.c.c
6	Electronic density	$5.56 \times 10^{28}\ m^{-3}$	$5.90 \times 10^{28}\ m^{-3}$
7	Ionization energy	7.57 eV	9.22eV
8	Melting temperature	1253K	1338K
9	Boiling temperature	2495K	3243K
10	Standard potential	+0.80 V	+1.69 V
11	Electronegativity	1.9	2.4

VIII. REDUCING AGENT AND CAPPING AGENT IN THE SYNTHESIS OF NANOPARTICLES

The role of reducing agent is giving electrons to ions to form atoms. Then these atoms will develop a particle by combining together. The capping agent / stabilizing agent is the responsible to prevent uncontrollable growth of particles, prevent particle aggregations, control the growth rate, control the particle size. These possibilities can be achieved by both electrostatic stabilization and steric stabilizations.

Some examples which are used both as reducing as well as capping agent in the synthesis of nanoparticle are as follows: -

1) *Sodium Borohydride($NaBH_4$):* it has dual role to act as reducing agent as well as capping agent in the synthesis of silver nanoparticles formations. First it reduces the metal ion into the zero valent metal nanoparticles and stabilized by being adsorbed. However, a higher concentration may result in aggregations of Ag nanoparticle due to an increased ionic strength.
2) *Polyvinyl Polymer (PVP):* is a polymer that act as a Capping or stabilizing agent in silver nanoparticle synthesis it prevents the particles agglomerations even in the presence of electrolyte or ionic salt.

IX. METHODS FOR THE SYNTHESIS OF NANOPARTICLES

Nanoparticle can be synthesized by various methods such as physical, chemical and biological methods [9]. Basically there are top-down (physical) and bottom-up (chemical methods and via green pathway) approaches. The various methods for the synthesis of metal nanoparticle are discussed as follows.

A. Geen Synthesis Of Nanoparticles

The methods involved are typically simple, environmentally friendly and naturally compatible one-pot processes. It has been proved by various studies that the reductive abilities of the proteins and metabolites that are present in these biological systems can change inorganic metal ions into metal NPs [63]. These green NPs synthesized are employed in various areas of Nano medicine, chemistry and related fields for use in drug carriers for targeted delivery, antimicrobial agents, DNA investigations, biosensors, catalysts, separation science, cancer treatment, gene treatment and magnetic resonance imaging. [63].

B. Chemical Reduction Methods of Nanoparticle

Nanoparticle are also synthesised by using chemical reduction methods. By this method we take mainly three important components i.e. metal salt, reducing agent and Capping agent. Here first the reducing agent will reduce the metal salt into metal nanoparticle but these nanoparticles formed are highly unstable in nature so they are made to join together to form agglomeration. So to make nanoparticle stable and to prevent agglomeration we have to add some capping agent or stabilizing agent.

X. VARIOUS APPROACH FOR THE SYNTHESIS OF METAL NANOPARTICLES:

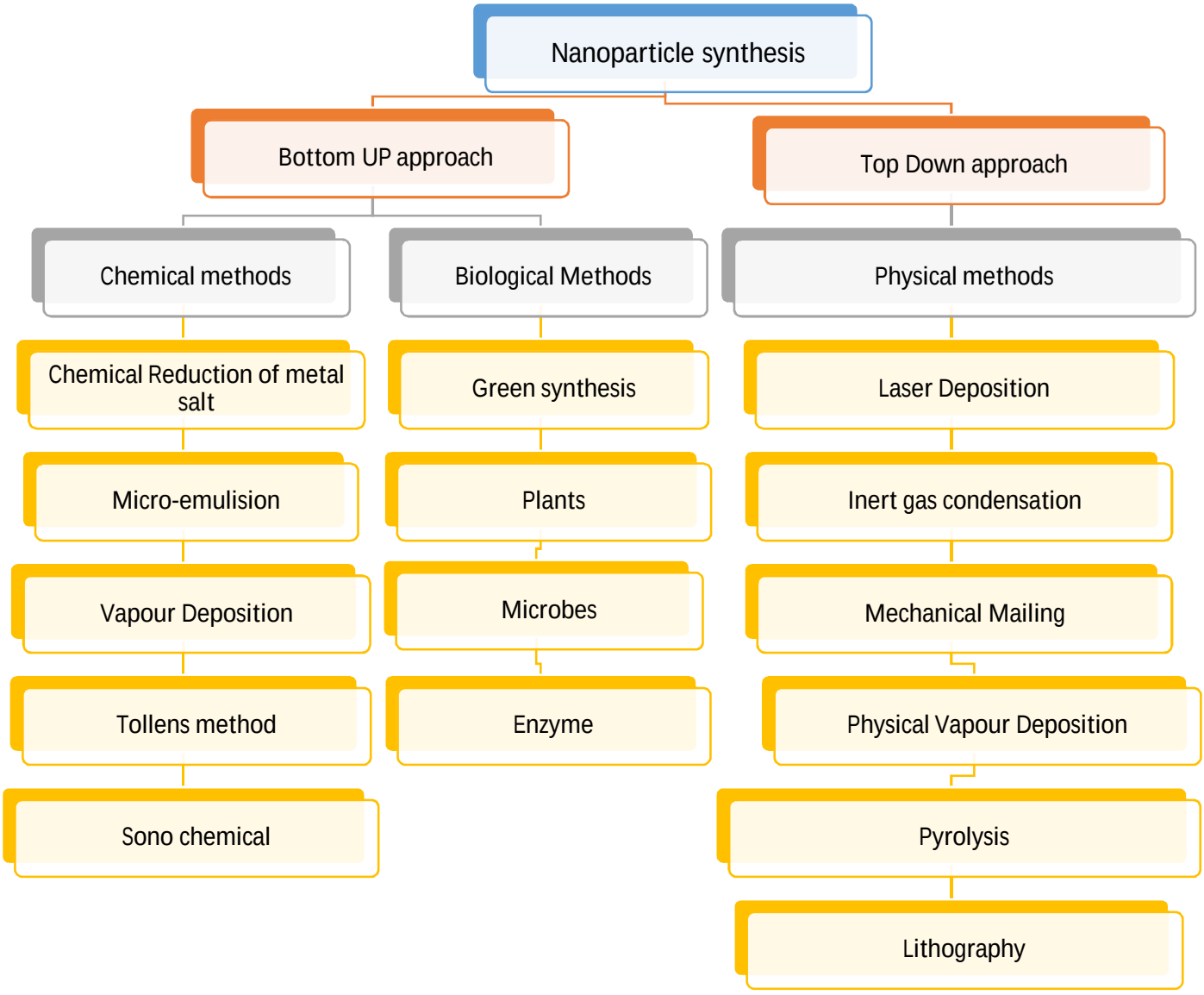

Fig- 1.1 Systematic representation of various approaches for synthesis of metal nanoparticle

XI. VARIOUS PLANT EXTRACT USED FOR THE SYNTHESIS OF SILVER AND GOLD NANOPARTICLE

Sl.No	Plants extract	Nanoparticle	Reference
1	Aervalanata	Ag	18
2	Alternanthera sessilis	Ag	19
3	Ananascomosus	Ag	20
4	Annona squamosa	Ag	21
5	Artemisia nilagirica	Ag	22
6	Artocarpus heterophyllus lam seed	Ag	23
7	Banana peel	Ag	24
8	Basil roots	Ag	25
9	Basil stem	Ag	25
10	Biophytum sensitivum	Ag	18
11	Carica papaya	Ag	26
12	Callus	Ag	27
13	Catharanthus roseus	Ag	28
14	Cocos nucifera	Ag	29
15	Coriandrum sativum	Ag	30
16	Crataegusdouglasii Fruit	Ag	31
17	Dalbergiaspinosa	Ag	32
18	Emblicaofficinalis Fruit	Ag	33
19	Eucalyptus leaf	Ag	34
20	Ficuscarica	Ag	35
21	Hibiscus rosa sinensis	Ag	36
22	Lakshmi tulasi	Ag	37
23	Mangiferaindica	Ag	39
24	Maple leaf	Ag	40
25	Mushroom extract	Ag	41
26	Neem	Ag	42
27	Papaver somniferum	Ag	43
28	Sacha inchi	Ag	44
29	Tea leaf	Ag	45
30	Abelmoschus Esculentus	Au	46
31	Aervalanata	Au	18
32	Curcuma pseudomontana	Au	47
33	Eucommiaulmoides	Au	48
34	Grape waste	Au	49
35	Magnolia Kobus	Au	50
36	Maple leaf pine Needle	Au	51
37	Menthapiperita	Au	52
38	Morindacitrifolia	Au	53
39	Pistaciaintegerrima	Au	54
40	Solanumnigrum	Au	55
41	Terminalia arjuna	Au	56
42	Zingiberofficinale	Au	57
43	Stachys lavandulifolia vahl	Au	58
44	Krishna tulsi	Au	59

XII. OVERVIEW IN THE RECENT DEVELOPMENT

Now a days many research and review articles are been published in different journals for the green synthesis of gold and silver Nanoparticles. Some of them are discussed as follows:

A. In 2018 synthesis of gold nanoparticle using leaf extract of ziziphuszizyphus and their antimicrobial activity was published in this article antimicrobial activity of gold nanoparticle such as zone of inhibition, microdiluation and plate spotting were discussed[62].
B. In 2017 green synthesis of gold nanoparticle by different plant extract was published which explain the various plant taken in the synthesis of nanoparticles[5].
C. In 2006 Controllable synthesis of silver nanoparticle using neem leaves and their antimicrobial activity was published [10].
D. In 2011 green synthesis of silver nanoparticle using ocimum leaf extract and their characterization paper was published [7].
E. In the year of 2011 evolution of green synthesis of silver nanoparticles against parasites was published [8].
F. In 2002 some recent advance in nanostructure preparation from gold and silver particles: a short topical review published[6].

XIII. CONCLUSION

Metal nanoparticles produced by nanotechnology have received global attention due to their extensive applications in the biomedical and biofabrication fields. We have focused on simple method for the preparation of Au and Ag NPs using the botanical extracts derived from various plant parts as a eco-compatible method of inorganic nanoparticle synthesis. Furthermore, we highlight recent milestones achieved for the biogenic synthesis of nanoparticles for use in medicines. In this review, the target has been to explore the wide applications of the synthesized nanoparticles, thus showing scope for application in functional hygiene products and in future medicines. Studies are underway to expand the scope of these botanical extracts of Au and Ag nanoparticles and to explore their ap-plications as functional nanomaterial and biomedicines.

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