Gold Nanoparticles Detection by Plants Extracts – A Review

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ABSTRACT

Many efforts have been employed for gold nanoparticles (AuNPs) green synthesis by utilizing various plant extracts. Nanotechnology treats with the materials usage and production with nanoscale dimension. Nanoscale dimension provides nanoparticles with large surface area to volume ratio and thus very specific properties. Gold nanoparticles (AuNPs) had been in recent study attribute to its high exciton binding energy, large bandwidth and potential applications such as antifungal, antibacterial, anti-inflammatory, wound healing, antioxidant, optic properties and anti-diabetic. Attribute to the toxic chemicals large rate and extreme environment used in the chemical and physical production of NPs. This review is overall synthesis study of and applications using for AuNPs green synthesis with various biological sources.

Keywords: *gold nanoparticles; green synthesis; plants extract; applications*

INTRODUCTION

Nanotechnology in health provides challenging environment for the cancer treatment, mostly in drug delivery out of nanoparticles in the targeted therapy case [1]. The increasing interest for inorganic nanoparticles in oncology and medical diagnostic shows the concentrate of the research area on the new method of treating cancer, instead of the vectorized molecules toxicity claim [2]. Nanomaterials are particles having nanoscale dimension, small size particles with enhanced thermal conductivity, catalytic reactivity, chemical steadiness and non-linear optical performance due to its large surface area to volume ratio [3]. NPs have started being treated as nano antibiotics because their antimicrobial activities [4]. Nanoparticles have been incorporated into different health, industrial, feed, food, chemical, space and cosmetics industry of consumers which calls for a green and environment-friendly method to their synthesis [5]. Nanotechnology is a mixing of two words; nano and technology. The term ‘nano’ creates from ‘nanos’. It is a Greek word that denotes ‘very small or dwarf’ and refers to one billionth part (10^{-9}). In 2006, American Society for Testing and Materials (ASTM) explained the term ‘nanoparticles’ as particles having at least two or more dimensions size ranging from 1 to 100 nm [6]. Thus, nanotechnology is the science application that controls matter at molecular level [7]. According to a recent definition put forward by British Standards Institution, nano-particles (NPs) are the particles with one or more dimensions at nanoscale (with dimensions of the order of 100 nm or less) [8]. At this scale, particles properties are different from their properties at either molecular or atomic levels. Because of atomic properties changes are controlled by the law of quantum mechanics and molecular properties controlled by the classical physics laws. Therefore, nanoparticle size (1–100 nm) relates as an intermediate state between the molecular (bulk) and atomic states. This intermediate state thus acts a critical role in deciding its fate in such a way that not only the synthesized nanomaterial makes differently from its bulk material but also, it detects certain unpredicted physical and chemical properties. Such change in the behavior of these nanomaterials is still unexplained by classical physics laws [9]. The aforementioned changes in chemical and physical properties of the synthesized NPs provides them with characteristic melting point, sterical, catalytic, biological, thermal conductivity, electrical, optical and mechanical properties [10].

Several techniques designed to produce eco-friendly products (NPs) with less hazardous effects [11]. One of the emerging fields of nanotechnology is referred as nano-biotechnology. Nano-biotech-nology engrosses biological standards with the chemical procedures and physical techniques to produce NPs for specified uses. Nano-biotechnology utilized as an umbrella term that encompasses the synthesis and tailoring subsequent exploitation of small particles that are less than 100 nm in size [12]. Nanotechnology is an important emerging area of research that has been expanding interest which focusses on the synthetic development and biological approaches of engineering nanoparticles across the globe with huge momentum in forming nano revolution attribute to their wide applications [13]. Due to completely new or improved properties of nanoparticles, their applications are growing rapidly on different fronts such as biomedical, pharmaceutical, catalysis, drug delivery, and antimicrobial, etc. [14]. Attribute to miniaturization, the change in the physicochemical properties shows the novel functional attributes development of nanomaterials [15,16].

Gold Chemistry & Nanoparticles

Gold nanoparticles have been mostly studied attribute to their individual surface plasmon resonance (SPR) and their applications in biomedical science including drug delivery [2] photothermal therapy and tissue/tumor imaging [17]. Gold is one of the biocompatible metals also having different effective properties against many diseases. From history, it is known that colloidal gold solutions were utilized to cure different types of infections [10]. Well engineered AuNPs are considered to be of more importance as they offer some individual properties such as being, provide more surface reactivity, more compatible with living tissues/systems, diverse range of shapes, very small size and readily oppose oxidation [18]. Gold exists in six oxidation states with high electronegativity; 1, 0, +1, +2, +3 and +4. Generally, Au forms complexes in auric [Au(III)] and aurous [Au(I)] oxidation states [19]. In an aqueous solution, Au can dissolve bycollective oxidation action and complex formation processes. In the presence of a complex forming ligand, Au(I) and Au(III) can readily form stable complexes. While in the absence of any complex forming ligand in the solution, the solution decreases Au(I) and Au(III) to metallic state [Au(0)].

Not only the complex forming ligand but also the donor atom of the ligand bonded to Au atom is responsible for the stability of the gold complex formed. Nicol et al., reported two rules for the gold complexes stability. First rule states that donor atom electronegativity increases as the gold complex stability decreases in such a manner that stable gold halide complexes follows the order as: I > Br > Cl > F. Second rule proposes that Au(III) binds with hard ligands while Au(I) favors the complexes formation with soft ligands. Thus, Au(I) forms linear complexes with an oxidation state of 2 while Au(III) forms square planar complexes with an oxidation state of 4. As such, the common precursors utilized for synthesis of AuNPs are Au(I) thiosulfate and Au(III)–chloride complex [20].

Gold nanoparticles (AuNPs) are being widely dealt by researchers because of their smaller size, higher surface area to volume ratio, magnetic, chemicals and electronic properties [21]. AuNPs hold an important position among all other metallic nanoparticles attribute to their long history of medical utilize like cancer treatment and excellent biocompatibility [22]. Conventionally, AuNPs are being synthesized over physical and chemical approaches with well-defined morphology and size. However, these synthesis protocols have been reported to contain different drawbacks like the toxic chemicals use, expensive multifaceted system and harsh reaction conditions [23].

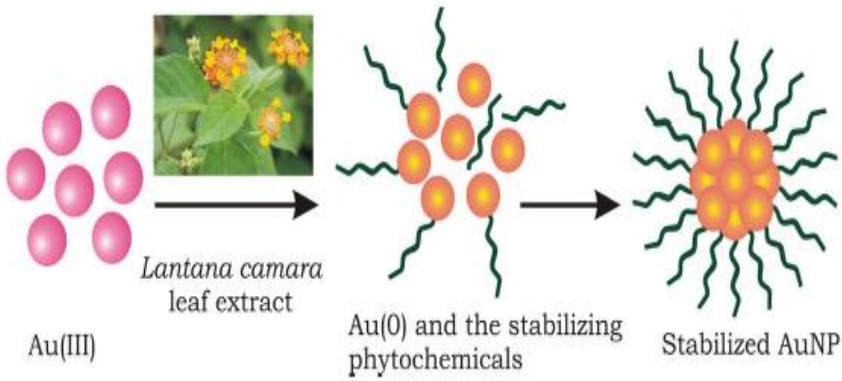

Figure 1: Mechanism of the formation and stabilization of AuNPs by the phytochemicals present in the leaf extract of *L. camara* [72]

Plants Extracts

Lantana camara L. (Verbanaceae) is an ornamental and notorious herb found in subtropical and tropical countries. It has large traditional claims for different illness treatment [24]. Its leaves are rich in essential oil [25]. Metal nanoparticles synthesis using plant extracts is cost effective, so it can be utilized as an economic and valuable alternative for the large-scale production. Synthesis of gold nanoparticles using Lemon grass [26], *Aloe vera* leaf [27], *Neem* leaf [28], *Tamarindus indica* leaf extract [29], synthesis of gold and silver nanoparticles utilizing *Murraya koenigi* leaf extract [30], Piper betle leaf extract [31], *Plumbago zeylanica* leaf extract [32] and utilizing *Neolamarckia cadamba* flower extract as previously reported [33]. Ankamwar et al. [34] used the biosynthesized Ag nanoparticles gained from *Neolamarckia cadamba* plant extract as an effective SERS active substrate and pathogens such as bacteria and viruses were found rapidly from culture free clinical sample. Recently, Ankamwar et al. [31] reported the morphology dependent catalytic activity of biosynthesized gold and silver nanoparticles obtained from Piper betle plant extract.

Plant parts like leaves, roots, seeds, fruits, stems have also been used for the NPs synthesis as their extract is rich in phytochemicals which play as both stabilization and reducing agent [35]. Plants are most preferred NPs synthesis source because they due to large-scale production and production of stable varied in shape and size NPs [36]. Bio-reduction includes reducing metal ions or metal oxides to 0 valence metal NPs with the help of phytochemicals such as polyphenolic compounds, alkaloids, polysaccharides, amino acids, vitamins, terpenoids secreted from the plant [36].

AuNPs Synthesis by utilizing plants as natural source has provided a better, environmental friendly method [27]. For example, the plant extract of *Aloe vera* has been utilized to get size ranges gold nanotriangles (20-50) nm [37]. Similarly, *Nyctanthes arbortristis* flower extract has been used to prepare spherical AuNPs of diameter approximately 20 nm [38]. AuNPs synthesis of different shapes have been reported such as quasispherical, triangular, spherical, decahedral, cubic hexagonal, rod shaped and isosahedral utilizing different of plant sources like *Anacardium occidentale* [39], *Camelia sinesis* [40], *Cymbopogon sp* [41], *Geranium* [42], *Vitex negundo L.* [43], *Memecylon edule* [44], and *Cinnamomum camphor* [45].

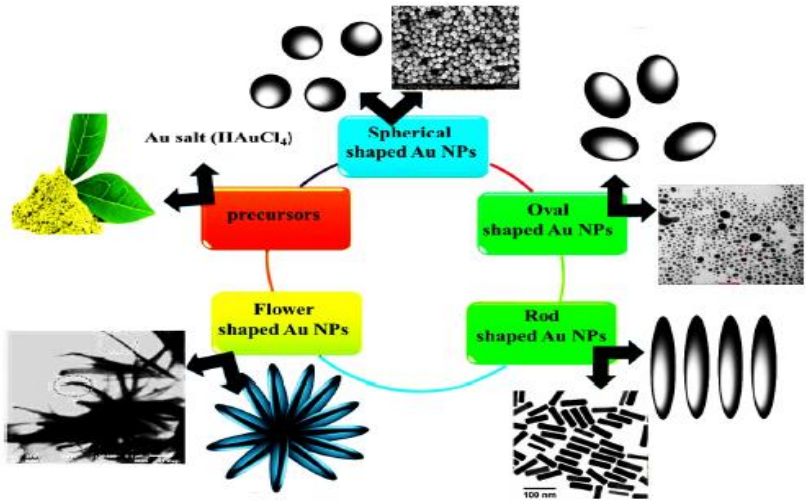

Figure 2: Phytochemicals employ from different plant extracts as reducing and capping agents for Au nanosynthesis acts vital roles to regulate the size and shape of the synthesized nanomaterial [73]

Recent studies have investigated the plants role and their extracts as an excellent candidate for metallic nanoparticles green synthesisattribute to their nontoxicity, renewability features and low cost. Different plant sources like *Camellia Sinensis* extract [46], seed coat of *vigna mungo* [47] *cumin seeds* [48] *filicium decipiens* leaf extract [49] *cynometra ramiflora* leaf extract [50] have been successfully used for metallic nanoparticles green synthesis. Plants constituents like amino acids, organic acids, flavonoids and phenols are assumed to play as reducing and stabilizing agents [51]. *Elaeis guineensis* (oil palm) leaves have been successfully utilized for spherical shaped silver nanoparticles green synthesis [52].

Green Synthesis & Methods

Eco-friendly and cost effective procedures for the nanoparticles synthesis represent interesting topics for biologists, chemists and materials scientists, especially in light of the efforts to find greener approaches of inorganic material synthesis. The plants usage as traditional medicine is very widespread among the local people. Therefore, these two criteria would also let to discover several plants with interesting properties [53].

Nanomaterials preparation by means of green biosynthetic protocols is the familiar tendency in current era among researchers. Nanomaterials particularly, metal and semiconductor nanoparticles can be synthesized utilizing several natural resources like, fruit, plant and microorganisms extracts also animal tissues as probable resource for stabilizing and reducing agents [54,55].

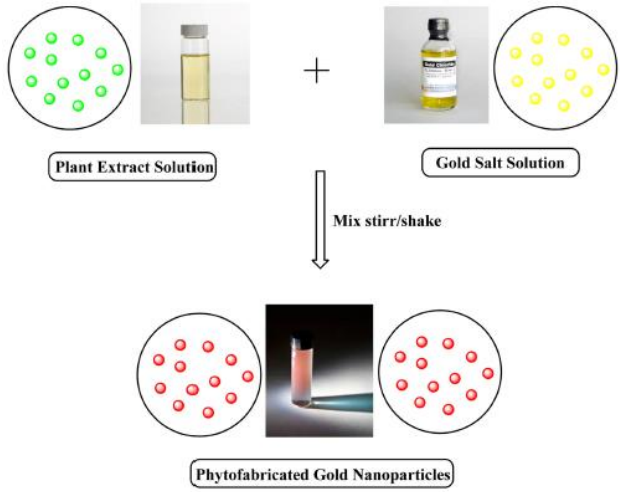

Figure 3: One step AuNPs synthesis from plant's extracts [71]

Two methods have been suggested for nanoparticle synthesis: Bottom up and top down method. The top–down method includes large macroscopic particle milling or attrition. It includes preparing large-scale patterns at first and then decreasing it to nanoscale level over plastic deformation. This technique cannot be used for large scale production of nanoparticles because it is a slow and costly method [56]. The most common technique is Interferometric Lithographic (IL) which uses the role of top–down method for nanomaterial synthesis [57]. This technique includes nanoparticles synthesis of from already miniaturized atomic components through self-assembly. It is a relatively low cost method [58]. It is based on kinetic and thermodynamic equilibrium method. The kinetic method includes MBE (molecular beam epitaxy). This method is cost-effective, environment-friendly, green, safe and biocompatible method [59,64].

In the physical method, physical forces are included in the nanoscale particles attraction and formation of large, stable and well-defined nanostructures. Its example involves synthesis of nanoparticle over colloidal dispersion approach. Also involves basic techniques such as amorphous crystallization, physical fragmentation, vapor condensation and others [60]. The nanoparticle synthesis is mediated by physical, chemical and green approaches [61]. The physical approach includes utilize of costly equipment, high temperature and pressure [62], large space area. The chemical approach includes utilize of toxic chemicals which can prove to be hazardous for the environment and the person handling it. The literature states that some of the toxic chemicals that we utilize in physical and chemical approaches may reside in the NPs created which may confirm hazardous in the domain of their application in the medical domain [63]. Chemical, direct precipitation and microwave assisted combustion [65]. Additional capping and stabilizing agent are needed in chemical and physical approaches [66].

Applications

Nanoparticles (NPs) development these days has become an attribute of development of Richards Feynman laid down concept of nanotechnology. Different metals NPs such as Au, Pb, Pt, Cu, Ag, Ca, etc. have been prepared and estimated for their applications in several fields.

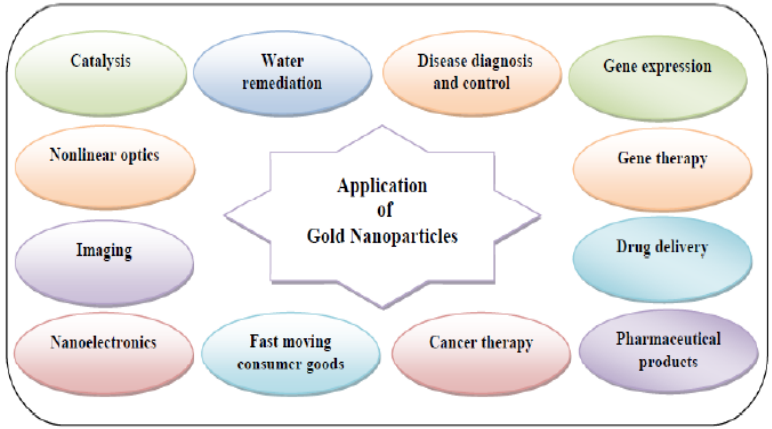

Figure 4: Gold nanoparticles applications [74]

NPs have different applications in different domains such as medicine, energy, environment sciences, agriculture etc. various approaches have been developed for NPs synthesis. Chemical and Physical approaches utilize radiations and/or reductants, harmful to environment and thereby human health; and expensive too. However biological approaches utilize eco-friendly natural resources such as enzymes, microbial cultures and plant extracts [54] on expenditure of less energy [67]. Biological systems like microorganisms (magnetotactic bacteria, diatoms) are capable of fabricating functional superstructures of inorganic nanomaterials like calcite, silica, magnetite and amorphous [68]. In bio systems, shape controlled nanomaterials synthesis has been achieved either by growth in controlled environments like vesicles, membrane or by utilizing different functional molecules like polypeptides which can explicitly bind to definite crystallographic planes or facets of inorganic surfaces [69]. Therefore, advances in the synthesized NPs applications can be completed by controlling both shape and size of the nanoparticles at nanoscale. Such shape and size dependent properties are the main areas to invest for researchers nowadays. These special properties have support scientists in improving novel antimicrobial formulations, biosensors, drug delivery protocols, nanocomposites and filters, medical imaging, catalytic procedures, treatment of cancer, computer transistors, chemical sensors, electrometers, logic schemes and wireless electronic memory [70].

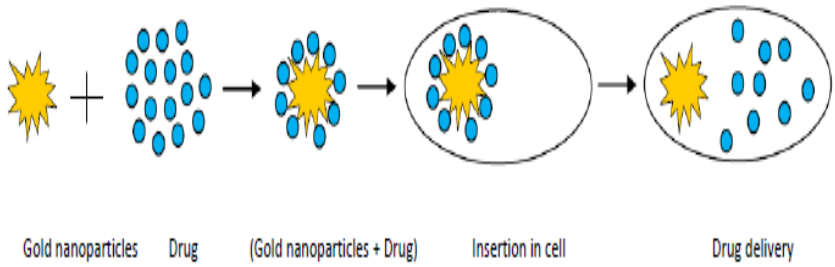

Figure 5: Drug delivery possible mechanism using gold nanoparticles on the target cells [74]

CONCLUSION

Plants extracts mediated synthesis promises eco-friendly method for AuNPs preparation possess large applications in difference fields of science and thereby life. Green sources play as reducing and stabilizing agent for the synthesis of shape and size controlled nanoparticles. Future prospect of plant-mediated nanoparticle preparation involves an expansion of laboratory-based work to industrial scale, clarification of phytochemicals included in the nanoparticles preparation utilizing bioinformatics tools and deriving the exact mechanism included in pathogenic bacteria inhibition. The plant-based nanoparticle possesses wide applications in the domain of pharmaceutical, food and cosmetic industries and thus become a considerable area of research.

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