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BIOREDUCTION AND FORMATION OF GOLD NANOPARTICLES BY *SOLANUM TORVUM* LEAVES EXTRACT

B.S. NAVEEN PRASAD*[1] AND T.V.N. PADMESH [2]

[1]*Department of Chemical Engineering, Sathyabama University, Chennai – 600119, India*
[2]*Department of Chemical Engineering, Manipal International University, Nilai, Malaysia*

ABSTRACT

Development of biologically inspired experimental processes for the synthesis of nanoparticles might be important in biomedical applications. *Solanum torvum* extract when challenged with chloroauric acid leads to formation of gold nanoparticles. The formations of gold nanoparticles were studied by UV-vis spectra and their size of gold nanoparticles in the colloidal solutions was investigated by HRTEM, the average size of gold nanoparticles nanoparticles was found to be 8.4 nm. The rapid reduction of $AuCl_4^-$ ions highlights the possibility of green pathways to produce technologically important nanomaterials.

KEYWORDS: ***Solanum torvum;*** **biomaterials; gold nanoparticles; electron microscopy**

B.S. NAVEEN PRASAD
Department of Chemical Engineering, Sathyabama University, Chennai – 600119, India

***Corresponding author**

INTRODUCTION

Synthesis of nanoparticles with well-defined shape, size and composition is a big challenge in nanotechnology[1]. Metal nanoparticles have received considerable attention in recent years due to their enormous applications in different fields of science. Further, there is a growing need to develop an eco-friendly process for nanoparticles synthesis and hence the focus turned towards “green” chemistry. The synthesis of metal nanoparticles has in particular, received considerable attention and potential applications in single electron tunneling[2], non-linear optical devices[3], DNA sequencing[4], biomedical devices[5], detection of genetic disorders[6,7], gene therapy[8], biological labeling[9,10], biosensing[5,10], antimicrobial activity[11,12], anticancer[13] and effective drug delivery[14]. Various chemical and physical synthetic protocols, aimed at controlling the physical properties of the particles, are presently employed in the production of metal nanoparticles. Biological synthesis of nanoparticles using plants, seaweeds and microorganisms proves to be biocompatible and hence used for biomedical applications. Plant based synthesis of gold nanoparticles is more advantageous over other biological processes as it is best suited for large-scale synthesis of nanoparticles[15]. Gold nanoparticles from the medicinally useful plant *Adhatoda vasica Nees* which has anti-allergic properties and can be used for various therapeutic applications[16]. Extracellular shape selective formation of single crystalline triangular gold nanoparticles was observed using the extract of the lemongrass plant (*Cymbopogon flexosus*)[15]. A number of different microorganisms including bacteria, yeast and fungi are involved in the reduction of gold ions and formation of gold nanoparticles intra and extracellularly[1,17]. Seaweed mediated synthesis of gold nanoparticles has also played a major role in therapeutic applications. Recently, *Sargassum myriocystum*, pharmaceutically important seaweed has been used in the synthesis of AuNPs which possess heparin like compounds used in the treatment of cardiovascular diseases. Size controlled synthesis of gold nanoparticles is challenging as it is one of the major strategies in biological applications. In this consideration, cyanobacteria *Spirulina platensis* have been used for the synthesis of Au nanoparticles which resulted in particles of size in the range of 6–12 nm[18]. *S. torvum* is used vastly in traditional medicine to cure diseases like cough, liver and spleen enlargement[19]. It is intensively used worldwide in the treatment of fever, wounds, tooth decay, arterial hypertension etc[20]. It also possesses antimicrobial, antiviral, anti-inflammatory, anti-diabetic and nephroprotective properties. Compounds isolated from *Solanum* species have anticancer potential and is used in the treatment of eye diseases[21, 22]. As traditional herb possesses various pharmacological applications, it has been chosen for the study to synthesize AuNPs for biomedical applications. In the present study, AuNPs have been synthesized from the potent plant *S. torvum* and the physico-chemical characteristics have been studied.

MATERIALS AND METHODS

Solanum torvum (Solanaceae) leaves collected from Chennai (latitude 13.0839° N and longitude 80.2700° E). 100g of fresh leaves of *Solanum torvum* were washed three times with deionized water. It was grinded to juice in a glass mortar. The extracts were filtrered using whatman filter paper No.1 and the filtrates of 1 mL extract was added to 100 mL of deionized water incubated at room temperature. For reduction of chloroaurate ions 1 mL of aqueous $AuCl_4^-$ ions in solution was monitored by periodic sampling of aliquots (2 mL) of the aqueous component and measuring the UV-vis spectrum of the solution. UV-vis spectra of these aliquots were monitored as a function of time of reaction on a Schimadzu spectrophotometer (model 1601) operated at a resolution of 2 nm. TEM analysis was performed using a JEOL 3010 instrument operated at an accelerating voltage at 120 kV. Samples for high resolution transmission electron microscopy analysis were prepared by drop coating Au nanoparticles solutions onto carbon-coated copper TEM grids. The films on the TEM grids were allowed to stand for 2 min, following which the extra solution was removed using a blotting and the grid was allowed to dry prior to measurement.

RESULTS AND DISCUSSION

It is known that the physical properties of biologically synthesized nanoparticles may vary according to the bioreductive natural resources. In the present investigation polydispersed gold nanoparticles were observed to occur when the concentration of $HAuCl_4$ increased. (Fig. 1a) shows the before immersion $HAuCl_4$ solution the green colour of the plant extract (*S. torvum*) can clearly be seen. (Fig.1b) shows the formation of ruby red color by the increased concentration of aqueous $AuCl_4^-$ ions indicates the formation of gold nanoparticles in solution. Gold nanoparticles absorb radiation in the visible region of the electromagnetic spectrum (ca. 520 nm) because of excitation of surface plasmon vibrations giving gold nanoparticles the striking ruby red colours in various media[23]. UV-vis spectra show no evidence of absorption in the range of 400-800 nm for the plant extract, the plant extract solution exposed to $AuCl_4^-$ ions show a distinct absorption at around 528 nm of nanoparticles obtained (Fig.2). The absorbance is close to that observed for thin films of gold nanoparticles grown by different techniques[24]. It is observed that the gold surface plasmon resonance band occurs initially at ca 523 nm after completion of the reaction, the wavelength of the surface plasmon band stabilizes at 528 nm. Reduction of the $AuCl_4^-$ ions are completed after 45 min of reaction, in both nanocrystals and nanoparticles formation.

Figure 1
(a) S.torvum leaf extract,(b) Ruby red color indicating the formation of gold nanoparticles by reduction of the aqueous metal ions during exposure to the S.torvum.

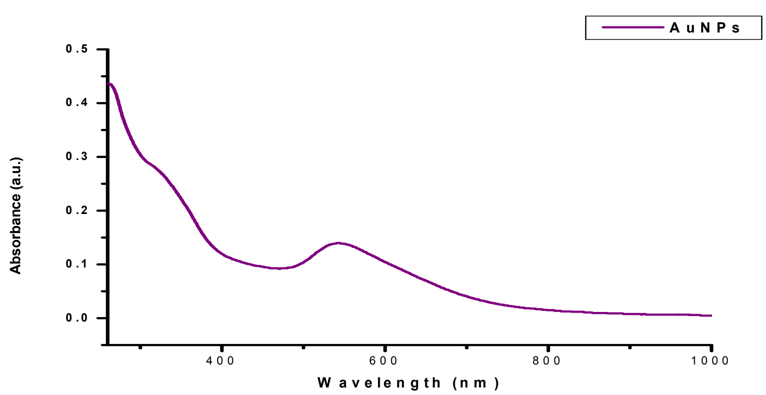

Figure 2
UV-vis spectra recorded as a function of time of reaction of aqueous solutions of chloroauric acid with S. torvum.

High resolution transmission electron microscopy has provides further insight in the morphology and size details of the gold nanomaterials. A representative HR-TEM image recorded from the gold nanoparticles is shown in (Fig 3a). In general, the particles are isotropic (i.e low aspect ratio) in shape and reasonably spherical in structure. All the nanoparticles are well separated and no agglomeration was noticed. From the HR-TEM images we obtained the average size of gold nanoparticles of 8.4 nm. The histogram of the nanoparticles size distribution (Fig 3b) is obtained by measuring the size of about 10 nanoparticles.Synthesis and characterization of nanocrystals of materials have become an area of intense research over the last few ears. Several materials scientist have been reported for the preparation of nanocrystals of metals such as Au, Ag, CdS and CdSe using chemical and physical methods[25-29]. Presently, nanocrystals of metals are finding a variety of applications starting from biological tagging to electronic devices[30]. A key challenge in application of these materials is to prevent agglomeration of nanomaterials to overcome in the present study and it may be due to the surface function utilization/ stabilization of the *S. torvum* extract. Recently, biosynthetic methods employing either biological microorganisms or plant extracts have emerged as a simple and viable alternative to chemical synthetic procedures and physical methods. Many reports on synthesis of metals (Au, Ag) and semiconductor nanoparticles (CdS, Pt and Pd) using various microorganisms[31-34] have been appeared.

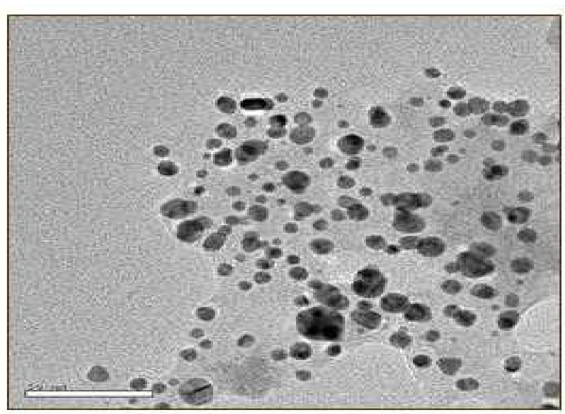

Figure 3a
HR-TEM image of gold nanoparticles synthesized using Solanum toruvum

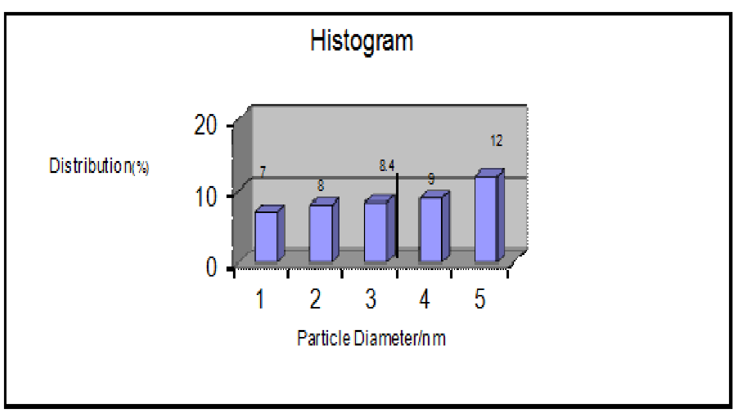

Figure 3b
Shows the histogram of gold nanoparticles size distribution

CONCLUSION

A process for the rapid synthesis of stable gold nanoparticles using *S. torvum* leaf extract and to develop a simple and efficient route for the synthesis of nanomaterials, within 45 min has been proposed. The ability to synthesis gold nanoparticles rapidly with morphology control by eco-friendly biological methods is exciting and represents an important advance in making them a viable alternative to the more popular chemical methods. The production of nanoparticles highlights the possibility of green pathway to produce nanomaterials also easily amenable for large-scale production.

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