

Research Article



Green Synthesis of Gold Nanoparticles Using *Argemone mexicana* L. Leaf Extract and its Characterization

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ABSTRACT

In recent years, green synthesis of gold nanoparticles (AuNPs) has gained much interest from researchers. In this concern, Indian flora has yet to reveal numerous sources of cost-effective non-hazardous reducing and stabilizing compounds utilized in preparing AuNPs. This study investigates an efficient and sustainable route of AuNPs preparation from 1 mM HAuCl₄ using leaf extracts of *Argemone mexicana*, due to their wide availability and medicinal property. AuNPs were prepared by the reaction of 1 mM HAuCl₄ and 10% leaf extract. The AuNPs were duly characterized. The optical properties and purity of biosynthesized gold nanoparticles were analysed by UV-Vis, XRD and SEM. Analysis revealed that green synthesized gold nanoparticles were around 26nm in size and spherical in shape. Functional groups such as poly phenolic groups, carboxylic and amine groups were associated with the *A. mexicana* mediated gold nanoparticles which were confirmed using FTIR. Chemical composition of *A. mexicana* mediated gold nanoparticles was determined by EDX. On whole, the AuNPs obtained by the biogenic syntheses have potential biological and medical applications.

Keywords: Green synthesis, *A. mexicana*, Gold nanoparticle, SEM, FTIR, Characterization.

INTRODUCTION

Particles smaller than tens of nanometers in primary particle diameter (nanoparticles) are of interest for the synthesis of new materials because of their special optical properties, low melting point, high catalytic activity, and unusual mechanical properties compared with their bulk material^{1,2}. Biosynthesis of nanoparticles is budding into a significant approach in nanotechnology^{3,4}. Green chemistry approach method highlights the usage of natural organisms as nontoxic, eco-friendly, reliable and simple^{5,6}. Synthesis of nanoparticles by using microorganisms, enzyme and plant extract, have been proposed by several researchers^{7,8}. Gold nanoparticles play a vital role in nano biotechnology as biomedicine for convenient surface bio conjugation with bio molecular probes and remarkable plasmon resonant optical properties⁹⁻¹¹. Gold nanoparticles have a significant function in the delivery of proteins, nucleic acids, *in vivo* delivery, gene therapy and targeting¹². Green synthesis of gold nanoparticles using plants extract such as *Neem*¹³, *Alfalfa*¹⁴, *Emblica officinalis*¹⁵, and *Cinnamomum camphora*¹⁶ have been reported. In biological methods, it is found that the extracts of living organisms act both as reducing and stabilizing agent in the synthesizing process of the nanoparticles¹⁷. *A. mexicana* belongs to Papaveraceae family, glabrous, prickly, branching herb with yellow juice and attractive yellow flowers. Phyto constituents such as alkaloids (chelerytherine, sarguinarine, protopine, optisine and berberine) and oil are predominantly present in *A. mexicana* leaves. Leaves, roots and seeds are used for curing skin-diseases, leprosy, bilious fevers and inflammations^{18,19}. Aqueous extract of *A. mexicana* leaf has been already reported for its anticancer activity²⁰.

Arokiyaraj et al.¹⁹ synthesized iron oxide magnetic nanoparticles using *A. mexicana* leaves and assessed its antibacterial activity. In this research paper we have reported biosynthesis and characterization of gold nanoparticles using aqueous extract of *A. mexicana* leaf.

MATERIALS AND METHODS

Materials

Fresh and healthy *Argemone mexicana* L. leaves have been collected from Coimbatore district, which belongs to Tamil Nadu, India. It was identified (code number is 1399) by Botanical Survey of India, Coimbatore. All glass wares were washed with distilled water and dried in oven before use. All the chemicals and solvents used in this experiment were of analytical grade and were purchased from Sigma-Aldrich Chemicals, India.

Preparation of extract

Collected leaves were washed thoroughly using distilled water. Five gram of leaves were ground well by mortar and pestle using de-ionized water. The mixture of the plant extract was heated at 60 °C for 10 min. After cooling the solution was filtered using filter paper (Whatman No. 42, Maidstone, England) and stored in freezer for further investigations.

Synthesis of gold nanoparticles

An innovative method was employed for the synthesis of gold nanoparticles. Gold chloride was used as a precursor for the synthesis of gold nanoparticles. 10% of leaf extract was prepared with de-ionized water. Analytical grade aqueous gold chloride solution (90 mL of 1 mM) was prepared using de-ionized water. Later, the gold chloride solution was mixed in the leaf extract under constant



stirring using magnetic stirrer. This mixture of the solution was kept under vigorous stirring at room temperature for 30 min. Finally, a reddish brown color solution was obtained. Solid product was obtained by centrifugation process and particles were washed twice with de-ionized water and dried at room temperature. Dried powder samples were stored in properly labelled containers and used for further analysis.

Characterization of gold nanoparticles

The optical properties of green synthesized gold nanoparticles were analyzed by Ultra Violet–visible spectroscopy (UV-2450, Shimadzu) at 200–800 nm wave length range. Synthesized gold nanoparticle's purity and grain size were characterized by X-ray diffraction (Perkin-Elmer) Cu-K α radiations ($\lambda = 0.15406$ nm) in 2θ range from 20° to 80° . Further FTIR analysis was also done to identify the functional groups in gold nanoparticles. The FTIR spectrum was verified in the range $4000\text{--}400$ cm^{-1} (Perkin-Elmer 1725x) by KBr pellet method. The morphology and size of the synthesized green gold nanoparticles was characterized by scanning electron microscope (SEM) (Model JSM 6390LV, JOEL, USA). The synthesized gold nanoparticles were analysed for chemical composition by energy dispersive X-ray spectrometer (RONTEC's EDX system, Model Quan Tax 200, Germany).

RESULTS AND DISCUSSION

Characterization of AuNPs

UV- Vis analysis

UV- Visible absorption spectrum of AuNPs is shown in Figure 1, which reveals that gold nanoparticles are mono dispersed. Green synthesized nanoparticles showed a broad absorption peak at 545 nm. The band gap of AuNPs was calculated by using formula $E = hc/\lambda$, where h = plank's constant, c = velocity of light and λ = wavelength. The band gap of gold nanoparticle has been stated earlier²¹.

XRD analysis

X - ray diffraction pattern was done to confirm the phase of AuNPs. The peaks at 2θ values of 38.2° , 44.5° , 64.7° and 77.6° correspond to crystal planes of (111), (200), (220) and (311) of gold nanoparticles. The diffraction peaks denote as crystalline phase, which was assessed with the data from JCPDS card No. 89-7102. The narrow and strong peak represents that the particle has well crystalline nature (Figure 2). The particle average size was calculated by the Scherrer formula and found to be in the range of 22-26 nm. Similar report of XRD for gold nanoparticles synthesized using plant extract was found in an earlier work¹³.

FTIR analysis

The FTIR spectrum of green synthesized AuNPs. FTIR spectral analysis was carried out for functional molecules or phyto constituents in the *Argemone* mediated gold

nanoparticles. The AuNPs synthesized from *Argemone* leaf extract have more of bio active molecules which may be responsible for medicinal applications. The spectrum showed bands at 1735 , 1550 and 1365 cm^{-1} corresponding to aromatic compounds. The band at 3441 cm^{-1} can be attributed to free NH stretching vibrations. The synthesized Au NPs have peaks at 3842 cm^{-1} which shows phosphorous compounds. This is similar to *A. indica* mediated gold nanoparticles which have amine, poly phenols and carboxylic functional groups¹³.

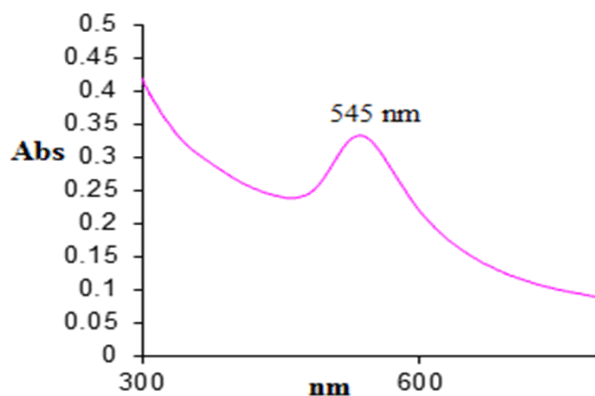


Figure 1: UV–vis absorption spectrum of gold nanoparticles synthesised from *A. mexicana* leaf extract after 30 min reaction time.

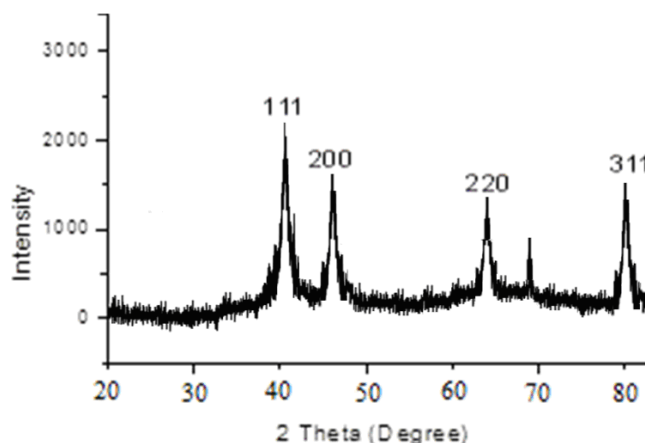


Figure 2: XRD pattern of gold nanoparticles synthesised from *A. mexicana* leaf extract.

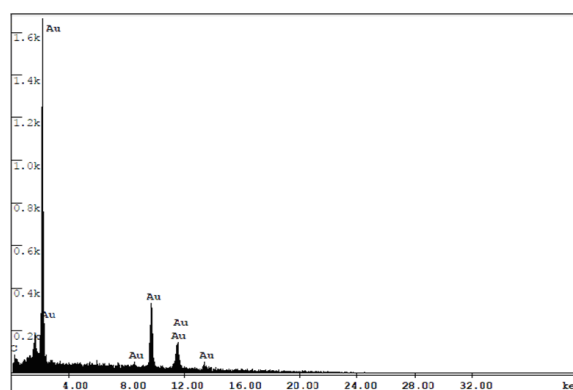


Figure 3: EDX spectra of gold nanoparticles synthesised from *A. mexicana* leaf extract.

EDAX/SEM analysis

Energy dispersive X-ray (EDX) spectrometer analysis confirmed the presence of AuNPs (Figure 3). The vertical axis displays the number of X-ray counts whilst the horizontal axis displays energy in keV. Identification lines for the major emission energies for gold are 90.75 % and carbon 9.25 % these corresponds with peak in the spectrum, thus giving that gold has been correctly identified. The SEM images of biosynthesized AuNPs are shown in Figure 4 and it is a proof that the morphology of gold nanoparticles was spherical shaped and well distributed without aggregation, which is very similar to previous investigation²¹.

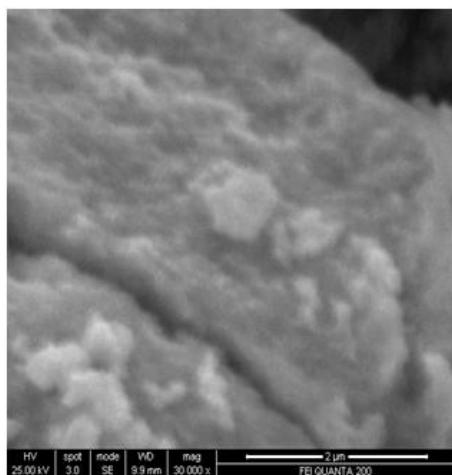


Figure 4: SEM image of gold nanoparticles synthesised from *A. mexicana* leaf extract.

CONCLUSION

Hazardous organic solvents and surfactants which are often employed in chemical synthesis of nanoparticles can be avoided through green synthesis techniques. The present protocol is an eco-friendly and easy way of gold nanoparticles synthesis under laboratory conditions.

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