

Green Synthesis of Gold Nanoparticles: A Novel, Environment-Friendly, Economic, Safe Approach

Niladry Sekhar Ghosh^{1*}, Ekta Pandey², Madan Kaushik¹,
Jai Prakash Kadian¹, Bhupendra Chauhan¹, Ajeet Yadav³ and Ranjit Singh¹

¹Shobhit University Gangoh, Saharanpur, UttarPradesh-247341, India.

²Bundelkhand Institute of Engineering and Technology Jhansi, UP- 284128, India.

³Department of Pharmaceutical Sciences. J.S University, UP, India.

*Corresponding Author E-mail: niladry_chem@yahoo.co.in

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Nanoparticles can be synthesised using a variety of methods. These approaches, on the other hand, are connected with the development of undesired byproducts that are both harmful and expensive. As a result, several attempts are being undertaken to develop unique, cost-effective, safe, and dependable "green" techniques for producing desirable nanoparticles. To develop a novel, environment-friendly, economic, safe approach to the synthesis of gold nanoparticles via the biological entity. Addition of aqueous gold chloride solution to the microwave-exposed aqueous extracellular Cassia tora leaf extract yielded poly shaped gold nanoparticles. The UV-vis. spectroscopic investigations are led to notice and affirm the formation of nanoparticles. FTIR studies are performed to affirm the role of a biomolecule in stabilizing the nanoparticles. X-beam diffraction study is utilized to affirm the crystalline nature of nanoparticles. The elemental characterization of the samples is regulated by EDX studies. The size and morphology of the synthesized nanoparticles are explored using HR-TEM analysis and FESEM. It is seen that the flavonoids which are separated during microwave warming of extracellular solution of the cassia tora leaves are liable for the biosynthesis of gold nanoparticles. The nanoparticle was noted to be well dispersed and polyshaped with a 20-60 nm range. The leaf extract based preparation of AuNP is more gainful since leaf is used instead of microorganism as many of the issues like pathogenicity, procedural maintenance of hygiene of cell culture and labor efforts can be overcome. The presence of flavonoids in the leaf was discovered by the examination of produced nanoparticles, suggesting that they may have fulfilled both reduction and stabilisation activities. The presented approach can be inferred to be cost-effective, environmentally friendly, and capable of manufacturing nanoparticles with desired physical and pharmacological properties.

Keywords: Cassia tora leaf Extract; Environment Friendly; Gold Nanoparticles; Poly Shaped.

Nano sized gold nanoparticles are extensively used in the fields of nanobiotechnology¹. The exceptional properties offered by them carry much potential for their widespread biomedical applications²⁻⁴. These particles with different

dimensions are used for the detection of biological molecules⁵. Biological molecule & cancer cells can be easily adsorbed on the surface of gold nanoparticles and the surface plasmon resonance of bio capped AuNP causing them to have better

photon capture cross-sections than those of photothermal dye⁶. Colloidal solutions of AuNP are being used in a homogeneous form for DNA sequences detection and signal based mutations⁷. The synthesis of the gold nanoparticles through the green process is a highly brought after area to develop systems for detection and destruction of the cancer cells in the early stage itself. The size and shape of the nanoparticles play a significant part in choosing the level of sensitive detection of nanoparticles. These nanoparticles can be synthesized with varying properties using a variety of methods via physical, chemical & biological. The advantages of biological methods include their environment, less time consumption, production of negligible waste & toxic substances and safety⁸. The other methods are comparatively unsafe, expensive & hazardous. Thus there is more emphasis on green methods of synthesis which use a natural resources such as plants or microbes. To prepare metal nanoparticles with stability & controlled size and shape, there has been looking for a modest, safe, rapid and “green” approach. Plants give a superior stage to nanoparticles synthesis as they are nontoxic as well as contain natural reducing agents⁹. Among various plants, we have chosen cassia tora leaves extract for the present study since it has several pharmacological effects such as anti-Cancer, anti-diabetic, anti-hyperlipidemia, antioxidant, and hypotensive activities¹⁰⁻¹¹. The plant-based synthesis of AuNP is more advantageous since parts of the plants are utilized rather than organisms as a significant number of the issues like pathogenicity, procedural support of cleanliness of cell culture and labor efforts can be overcome¹²⁻¹³. This procedure is more suitable for industrial scaling as well. The main goal of this research was to come up with a simple, time-saving, cost-effective, and environmentally friendly green approach for synthesizing metal nanoparticles. As a result, efforts were made to investigate biological pathways for nanoparticle synthesis while keeping a close eye on composition and dimensions. Based on a thorough understanding of bioactive nanomaterials, efforts were made to develop novel green-technology-based nanoparticle synthesis methods. The nanoparticles were made in an aqueous solution by reducing metal ions with a natural catalyst.

MATERIALS AND METHODS

Chemical & Reagents

Fresh leaves of *Cassia tora* was collected from the Botanical garden Dr. YS Parmar University of Horticulture and Forestry, Solan, India. All the chemicals and reagents utilized in this investigation were of analytical grade. Gold nanoparticles were obtained from HI media Chemicals.

Biosynthesis of Gold nanoparticles using *Cassia tora* leaf extract

Gold chloride solutions of a 10-3 M concentration analytical grade were prepared. Freshly collected & cut leaves of *Cassia tora* were taken in a flask and washed properly using deionized water. Then 200 mL of double distilled water was put into the flask containing the leaves and the flask was heated in a microwave for 3 minutes to inactivate the enzymes and proteins which may interfere in the process. The solution was then filtered in hot conditions to remove the solid fibrous residues. The clear filtrate was the extracellular extract of the leaf is used for the nanoparticles synthesis. 50 ml of gold chloride solution was made to interact with the 10 ml extracellular extract of the leaf at 27°C in a rotary shaker at 120 rpm. Immediately after the addition of plant extract to gold chloride aqueous solution, a light golden color appeared which changed to dark purple color within 5 min. The color change indicated that the formation of gold nanoparticles has taken place.

RESULTS

UV-Visible Spectra

The progression of the reaction of the mixture of leaf extract and gold chloride solution in water as a function of time is given in fig 1. A change in color of the reaction mixture from light golden to dark purple within few minutes indicates the formation of gold nanoparticles, which was further confirmed by UV-Vis spectroscopy. Further darkening of color to dark purple indicates the enhanced growth of gold nanoparticles. It is well supported by the fact that gold NPs exhibit dark purple color in water due to SPR. The spectrum of synthesized AuNPs was noted to have a maximum absorption band in the wavelength range of 550-575 nm, due to the SPR of AuNPs.

X-ray powder diffraction (XRD) & Energy Dispersive X-Ray (EDX) Analysis

XRD studies carried out to assess crystallinity of the synthesized Gold nanoparticles and results are depicted in figure 2 a). Gold nanoparticles displayed four particular peaks at $2\theta = 38.1, 44.3, 64.5,$ and 77.7 . This indicates the presence of pure gold

The results of EDX analysis are shown in Fig2 b). The graph indicates presence of elemental Gold. This suggested the reduction of gold ions to elemental Gold. Carbon and Oxygen presence confirms that organic moiety is protecting on the surface of gold nanoparticle

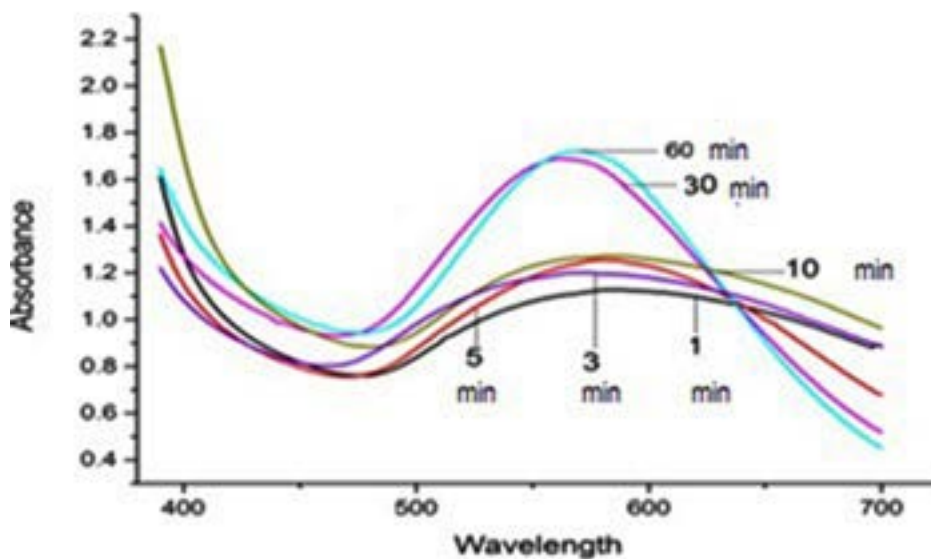


Fig. 1. UV-vis Spectra of plant mediate gold nanoparticles

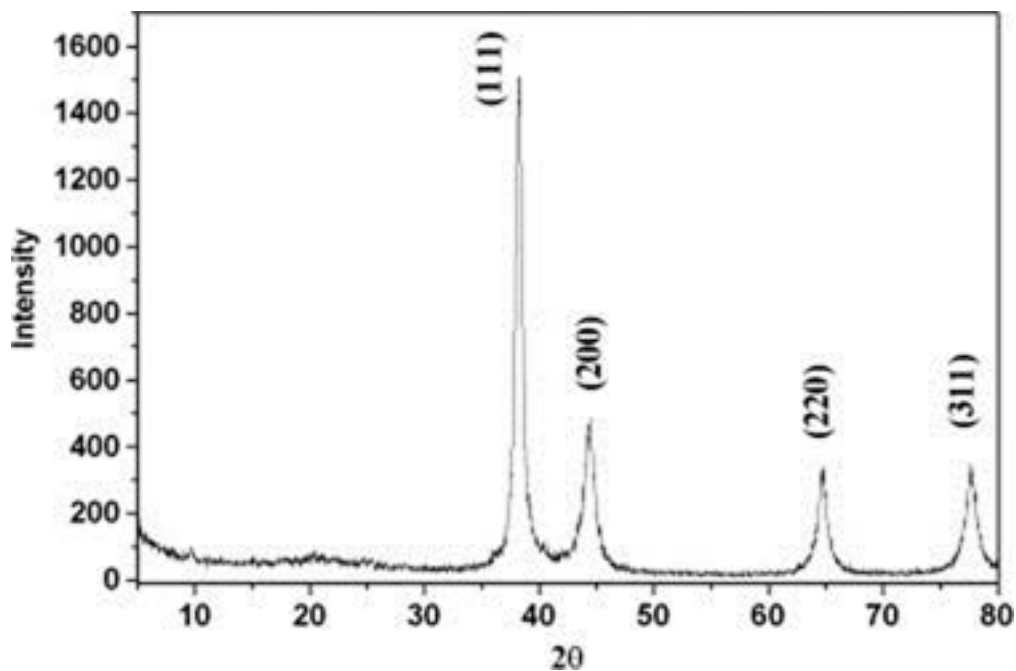


Fig. 2a. XRD studies of gold nanoparticles

Field Emission Scanning Electron Microscopy (FESEM)

FESEM images at different resolutions are shown in figure 3. A careful observation indicates the presence of bio moiety covering the metal surface of all nanoparticles (AuNP). The nanoparticle was noted to be well dispersed and poly shaped. Most of the particles are spherical in shape

Fourier Transform Infrared Spectroscopy (FTIR)

The FTIR analysis of the nanoparticles is given in (Figure 4). The interpretation of IR spectra shows bands at 3433, 2921, 2846, 1628, 1396, 1043 and 591 cm⁻¹. The peaks at 3433 cm⁻¹ is cm⁻¹

corresponds to O-H stretch vibration alcohol and The band at 2921 cm⁻¹ showed O-H stretching in carboxylic acid group while adsorbed bond at 2846 cm⁻¹ can be assigned to C-H stretch vibration of aldehyde. The peak at 1628 cm⁻¹ mention to amide group. The peak at 1396 cm⁻¹ cm⁻¹ refers to C-O stretch, which is due to stretching vibration of carboxylic acid group.

IR spectroscopic investigation affirmed that proteins along with carbohydrates bind the metal, and reduce gold ions to gold nanoparticles. These outcomes recommend that the biomolecule perform double action by formation of Gold nanoparticles and stabilized them in aqueous solution. We can assume that the proteins which

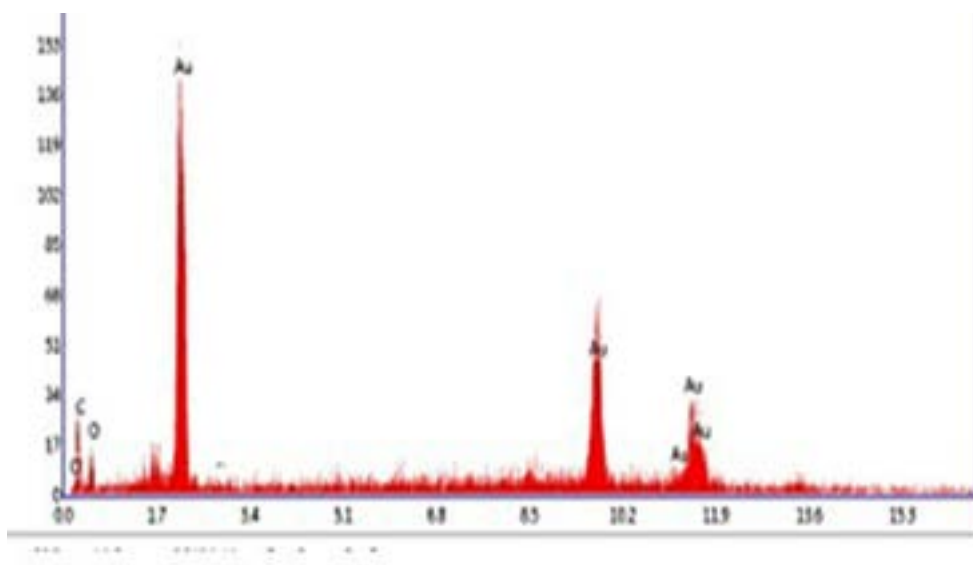


Fig. 2b. EDX studies of gold nanoparticle

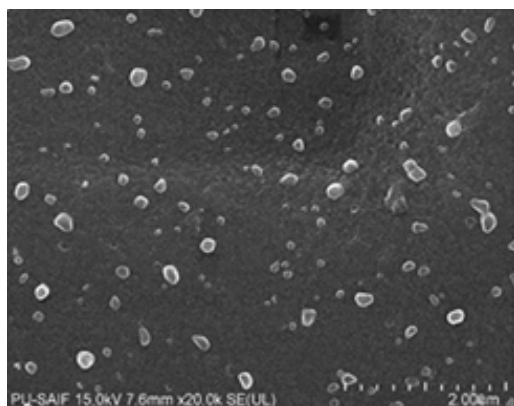


Fig. 3. FESEM images of gold nanoparticles

are available in large quantities in cassia tora leaves show typical peaks which could be to be responsible for reduction and capping process. The proteins present over the gold nanoparticle surface may played an important role in reduction of gold ions to Gold nanoparticles and stabilization of nanoparticles.

High-resolution transmission electron microscopy (HRTEM) & Size distribution histogram

From Fig no 5(a) and (b) indicates that, it is observed that above 62 % of the particles are in 20-60 nm size range. The particles are generally spherical in shape with a few rod shapes, hexagonal

and square. The rod shape particles are noted to be in the size range of 7-12 nm.

DISCUSSION

A new, simple, cost-effective microwave-assisted rapid extracellular manufacturing technique of spherical gold nanoparticles was proposed and developed using plant extract. The flavonoids in *Cassia tora* leaf extract were found to cover the surface of gold nanoparticles. Chemical

and physical processes, which typically produce harmful byproducts, have an advantage with this new revolutionary technology. Plant-mediated silver nanoparticle synthesis is industrially practicable, as opposed to microbe-mediated procedures, which require strict aseptic conditions.

CONCLUSION

The green synthesis method for the preparation of gold nanoparticles using plant

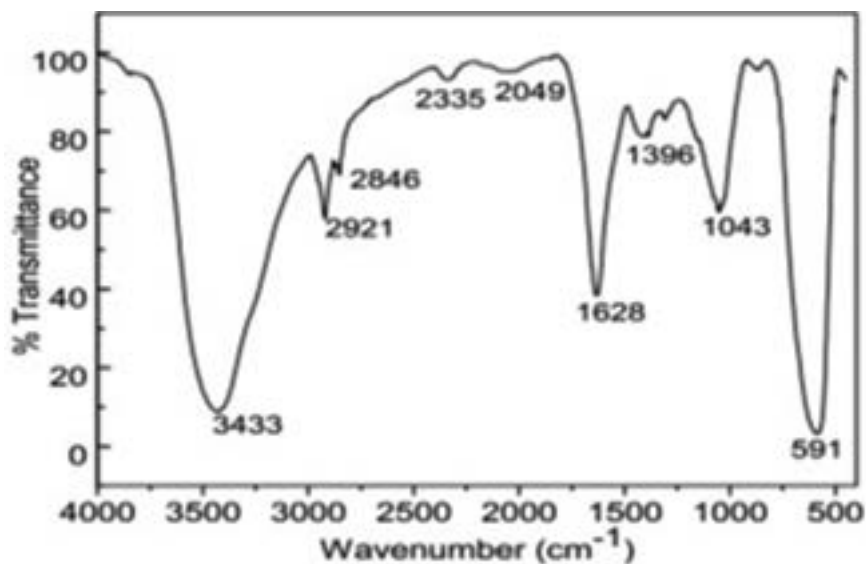


Fig. 4. FTIR analysis of biosynthesized gold nanoparticles

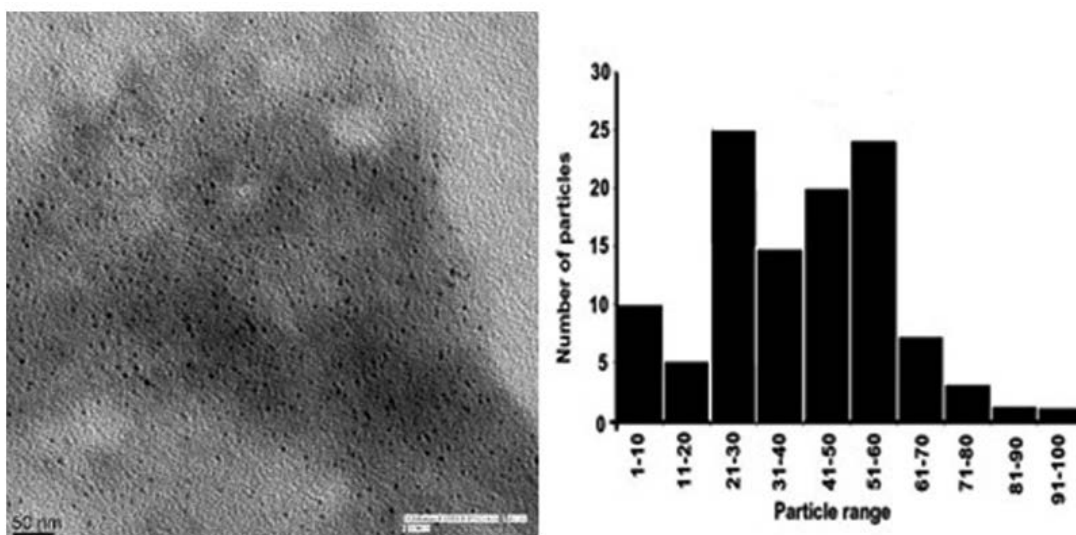


Fig. 5. (a) HR-TEM IMAGE of gold nanoparticles and (b) size distribution histogram gold nanoparticle

leaf extract was found to be rapid, environment-friendly and cost effective. The nanoparticle was noted to be well dispersed and polyshaped with 20-60 nm range. The analysis of synthesized nanoparticles indicated presence of flavonoids in the leaf which possibly performed dual functions of formation and stabilization. It can be concluded that the developed method is cost effective, eco-friendly and capable of producing nanoparticles with desired physical & pharmacological properties.

Conflicts of Interests

There is no Conflict of Interest.

Funding Source

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Authors Contributions

All authors have contributed equally in this work.

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