

# Alhagi maurorum Flower Extract Mediated Novel Synthesis of Gold Nanoparticles

Jain Preeti<sup>1</sup>, Malik Ashish<sup>2</sup>, Sharma Swati<sup>2</sup>, Sehrawat R. Anita<sup>2</sup>

<sup>1</sup>Department of Biochemistry, Maharshi Dayanand University, Rohtak, Haryana, India, <sup>2</sup>Department of Botany, Maharshi Dayanand University, Rohtak, Haryana, India

## Abstract

**Aim:** The aim of this study is to synthesize gold nanoparticles (AuNPs) from flower extract of *Alhagi maurorum* and aqueous gold chloride through a simple green route. **Materials and Methods:** AuNPs were synthesized by the reaction mixture containing freshly prepared flower aqueous extract and HAuCl<sub>4</sub> solution. The reduction of Au<sup>3+</sup> ions to AuNPs was monitored at different time intervals (0-180 min), at different concentration of chloroauric acid (0.1-2.0 mM), and at varying content of flower extract (1.0-25.0 ml). Characterization and storage stability of synthesized AuNPs were also noticed in this study. **Results and Discussion:** Optimization studies showed that 0.5 mM of chloroauric acid and lower amount (5.0 ml) of flower extract in 1:5 ratio facilitated maximum synthesis of AuNPs at an incubation period of 20 min. Transmission electron microscopic study revealed a size range of 12-24 nm and crystalline nature of biosynthesized AuNPs. The possible involvement of biomolecules in the formation of AuNPs was confirmed by Fourier transform infrared spectroscopy (FTIR) study. Stability of synthesized AuNPs showed only some microaggregates in the reaction mixture after 120 days which indicates the formation of highly stable AuNPs by a novel, simple, non-toxic, and eco-friendly route. **Conclusions:** Flower extract of *A. maurorum* could be used as an efficient green material for the rapid and consistent synthesis of AuNPs and their use as an antimicrobial agent in drug delivery system and in pharmaceutical and medical industry for the human welfare.

**Key words:** *Alhagi maurorum*, flower extract, Fourier transform infrared spectroscopy, gold nanoparticles, transmission electron microscope

## INTRODUCTION

Particles with spatial dimension <100 nm are termed as nanoparticles. Gold nanoparticles (AuNPs) are considered to be the extensively studied materials due to their easy and rapid synthesis, intense surface plasmon resonance characteristics, and high chemical as well as thermal stability.<sup>[1]</sup> A variety of gold structures including rods, triangles, hexagons, octagons, cubes, and nanowires can be synthesized using various physical and chemical synthetic methods, but synthesis of AuNPs with the help of biological reduction method proves to be an eco-friendly, biocompatible, and cost-effective approach in the present scenario.<sup>[2]</sup> Plant parts (leaves, stem, shoots, and flowers) extract mediated synthesis of nanoparticles further advantageous over other biosynthetic method as it does not require an elaborate process of maintaining cell culture and showed great reducing properties which reduces ions to elemental nanoparticles.<sup>[3]</sup> Along with this, studies on the morphological behavior

of gold nanostructures are significant because of their wide use in catalysis, optics, optical electronics, microelectronics, biodiagnostics, imaging, biological, and chemical sensing techniques.<sup>[4]</sup>

Many reports have been found on biogenesis of AuNPs using flower extract of many plants as *Gnidia glauca*, *Mirabilis jalapa*, *Achillea wilhelmsii*, *Nyctanthes arbor-tristis*, *Rosa hybrida*, *Syzygium aromaticum*, etc.<sup>[5-7]</sup> *Alhagi maurorum* (Syn. *Alhagi camelorum*, *Alhagi pseudalhagi*) is a small (60-100 cm), green, thorny, branched perennial medicinal herb distributed very well in the semiarid zone of Asia (Pakistan and India), Europe, Russia, and Africa.<sup>[8]</sup> It shows

### Address for correspondence:

Sehrawat R. Anita, Department of Botany, Maharshi Dayanand University, Rohtak, Haryana, India. Phone: +91-8950503301. E-mail: anitarsehrawatbotany@gmail.com

**Received:** 22-02-2017

**Revised:** 04-03-2017

**Accepted:** 04-03-2017

antirheumatic, analgesic, antiasthmatic, antipyretic, diuretic, anti-inflammatory, antiulcer activity.<sup>[9]</sup> Here, in the present study, we have investigated the biosynthesis of AuNPs by *A. maurorum* flower extract. This proves to be a newer novel green chemistry-based approach for synthesizing biocompatible, stable, cost-effective, and eco-friendly AuNPs under different reaction conditions.

## MATERIALS AND METHODS

### Preparation of flower extract

*A. maurorum* fresh flowers (10 g) were collected, thoroughly washed in running tap water for 15 min, and surface sterilized by 1% mercuric chloride solution. Shade dried these flowers for 2 days at room temperature and was grounded into a fine powder by surface-sterilized pestle and motor. 0.1 g of this powder was suspended in 10 ml of distilled water and boiled for 15 min before finally decanting it. The extract thus formed was filtered through a cheese cloth, and the filtrate was stored at 4°C which was used further as flower extract for all the experiments.

### Synthesis of AuNPs

AuNPs were synthesized by the reaction mixture containing 5 ml of freshly prepared flower extract and 25 ml of 0.5 mM HAuCl<sub>4</sub> solution. The reaction mixture was allowed to react at room temperature by putting them in an orbital shaker at 35°C for 15 min. The reduction of Au<sup>3+</sup> ions to AuNPs was monitored at different time intervals and was characterized further for determination of various parameters.

The concentration of chloroauric acid was varied from 0.1 to 2 mM by keeping all other reaction conditions constant. Effect of varying content of flower extract (1-25 ml) was also studied while keeping the gold chloride concentration at a level of 0.5 mM. For all experiments, the source of gold was gold chloride (HAuCl<sub>4</sub>) in distilled water and was carried out in triplicate.

### Characterization of AuNPs

AuNPs formed after reduction of Au<sup>3+</sup> ions by the flower extract has been analyzed through ultraviolet-visible (UV-VIS) spectroscopy, transmission electron microscopy (TEM), and Fourier transform infrared spectroscopy (FTIR). UV-VIS spectroscopic analysis was carried out on Spectro 20D Plus Spectrophotometer. The measurements were carried out as a function of reaction time at room temperature. A change in absorbance at different wavelength was also studied for the absorption maxima. The TEM images of synthesized AuNPs were obtained for size and shape determination using TEM, Morgagni<sup>M</sup> 268 D, FEI Company, Eindhoven, at Department of Anatomy, All India Institute of Medical Sciences, New Delhi. FTIR analysis was carried out with the help of

platinum attenuated total reflectance-IR FTIR Alpha (Bruker, Germany) instrument at Department of Genetics, Maharshi Dayanand University, Rohtak, to determine the functional groups in the flower extract and their possible involvement in the synthesis of AuNPs. Flower extract before reaction with HAuCl<sub>4</sub> and after reaction with the gold salt was recorded independently in the range of 400-4000 cm<sup>-1</sup>.

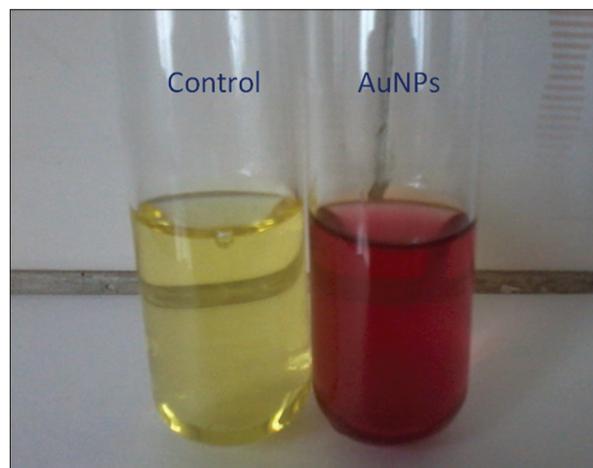
## RESULT AND DISCUSSION

### Biosynthesis of AuNPs

The reaction mixture having flower extract and 0.5 mM gold chloride in 1:5 ratio changed into ruby red color from initial yellow color after an incubation period of only 20 min [Figure 1]. The change was not observed in control sample (without gold salt) postulating the involvement of biomolecules present in the flower extract in synthesizing AuNPs through a simple, non-toxic route. A single peak was observed at 540 nm when absorption at different wavelength has been studied at different time intervals which confirmed the synthesis of AuNPs as it is in agreement with previous reports.<sup>[10]</sup> Initially, there was no significant peak at 2 min, but after 5 min, the building of peak at 540 nm marked the initiation of synthesis of AuNPs. The subsequent rise in the peak with a maximum at 20 min supported that the reported route of AuNPs synthesis is novel as well as rapid as compared to *M. jalapa* flower wherein the synthesis was reported to be completed in 2 h.<sup>[11]</sup> The rapidity in biosynthesis of AuNPs than other biosynthetic methods is attributed to strong antioxidant capacity of this plant.

### Effect of chloroauric acid and flower extract content

Optimization studies showed that 0.5 mM of chloroauric acid facilitated maximum synthesis of AuNPs as compared



**Figure 1:** A change in the color of reaction mixture after formation of gold nanoparticles

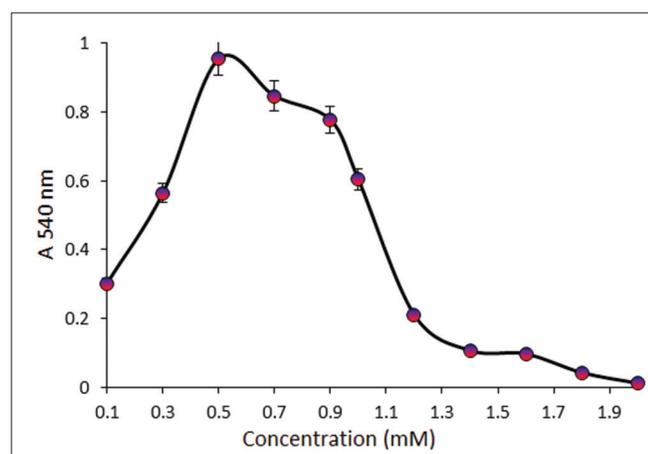
to other concentrations [Figure 2]. The effect of chloroauric acid (0.1-2.0 mM) on the kinetics of the AuNPs synthesis was found to be prominent as although the rate of synthesis increased till 1 mM, there was low or no synthesis at higher concentrations (<1 mM).

A lower amount (5.0 ml) of flower extract is preferred for the generation of small AuNPs as higher content of the biomolecules results into a more intense color and broad peak. When the quantity of the flower extract is increased (25.0 ml), a shift in absorption peak toward longer wavelength was found which is characteristic for an increase in particle size [Figure 3]. A similar effect has been observed with the flower extract of *M. jalapa* and *G. glauca*.<sup>[12]</sup>

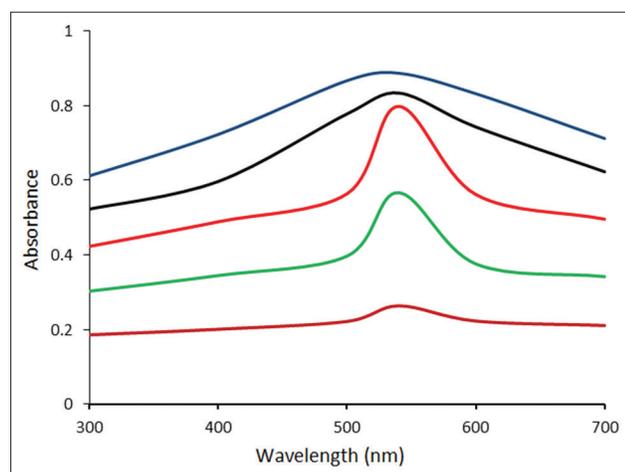
## Characterization of AuNPs

### TEM study

The size, shape, and structure of the bio-reduced AuNPs were elucidated with the TEM. TEM image in Figure 4 confirmed



**Figure 2:** Effect of change of concentration of gold chloride solution on synthesis of gold nanoparticles

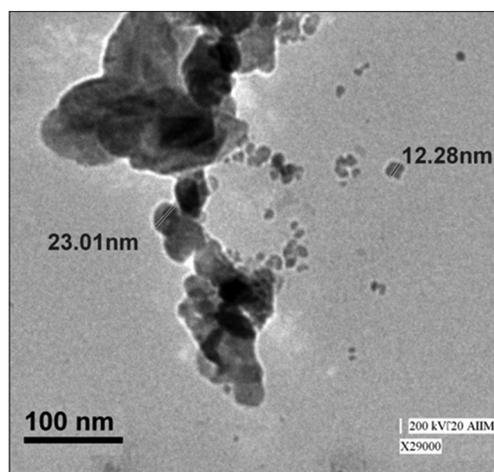


**Figure 3:** A change in the ultraviolet-visible absorption spectra of synthesized gold nanoparticles at different wavelength when the concentration of flower extract has been varied

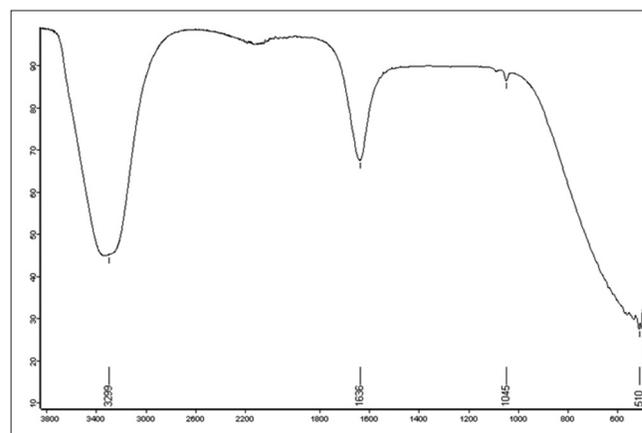
the formation of nanoparticles. AuNPs synthesized were stable, small, spherical-shaped nanoparticles of size range 12-24 nm as reported in case of other flower extracts as well.<sup>[13]</sup> It is evident from the TEM study that AuNPs coalesced as nanoclusters, spherical shaped, and had crystalline structure.

### FTIR analysis

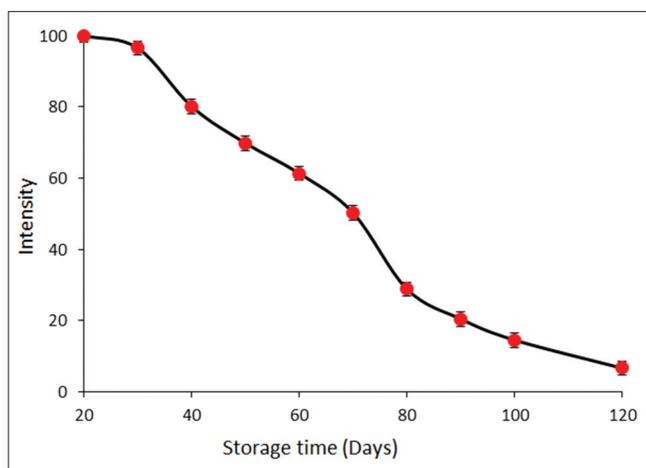
FTIR absorption spectra of the control (without gold chloride) with a number of peaks reflect the complex nature of biological material by showing the presence of characteristic bands for Ar-C=C-H stretching between 1607 and 1509  $\text{cm}^{-1}$ , bending  $-\text{CH}_2$  and  $-\text{CH}_3$  asymmetrical and symmetrical between 1462 and 1363  $\text{cm}^{-1}$  and  $-\text{C}-\text{C}-\text{O}-\text{C}$ -stretching at 1247, 1183  $\text{cm}^{-1}$ . The band intensities in different regions of the spectrum for the test samples were analyzed and shown in Figure 5. The vibration shift around 1647-1557  $\text{cm}^{-1}$  was suggestive of the involvement of aliphatic and aromatic (C-H) plane deformation and vibrations of methyl, methylene, and methoxy groups in the reductive process as compared with *S. aromaticum* flower extract.<sup>[14]</sup> The peak



**Figure 4:** Transmission electron microscopic image of gold nanoparticles showing size range of individual nanoparticles



**Figure 5:** Fourier transform infrared spectroscopy of gold nanoparticles synthesized by flower extract



**Figure 6:** Effect of storage time (days) on stability of green synthesized gold nanoparticles

located at  $3299\text{ cm}^{-1}$  was attributed to the N–H stretching or the C–O stretching vibrations. Reduced vibrations of functional groups and absence of strong bands, especially between  $800$  and  $1000\text{ cm}^{-1}$ , confirmed the synthesis of stable AuNPs by the flower extract.<sup>[15]</sup>

### Stability studies

Storage stability of synthesized AuNPs has been evaluated by decrease in absorption intensity and absorption maxima of the reaction mixture after an interval of 20 days [Figure 6]. A precipitation rate of the reaction mixture was also noticed which indicates higher stability as even after completion of 4 months a negligible amount of precipitation occurs. Thus, stable and biocompatible AuNPs have been synthesized using flower extract.

## CONCLUSIONS

Flower extract of *A. maurorum* could be used as an efficient green material for the rapid and consistent synthesis of AuNPs. The reducing capability of *A. maurorum* seems to be a promising approach for utilizing weed as a source for nanobiotechnology. A variation in reaction conditions brought about the synthesis of small-sized (12–24 nm), spherical-shaped nanoparticles, displaying vivid colors, and typical UV-VIS spectra. These biocompatible, stable, eco-friendly, non-toxic synthesized AuNPs could be used as an antimicrobial agent in drug delivery system and in pharmaceutical and medical industry for the human welfare.

## ACKNOWLEDGMENT

The author would like to thank Department of Botany and Biochemistry for providing excellent facilities for the above

work. We are also grateful to the Sophisticated Advanced Instrumentation Facility (SAIF), All India Institute of Medical Sciences, New Delhi, India, for the support and providing the SAIF facilities.

## REFERENCES

- Soloviev M. Nanobiotechnology today: Focus on nanoparticles. *J Nanobiotechnology* 2007;5:11.
- Iravani S. Green synthesis of metal nanoparticles using plants. *Green Chem* 2011;13:2638-50.
- Raveendran P, Fu J, Wallen SL. Completely “green” synthesis and stabilization of metal nanoparticles. *J Am Chem Soc* 2003;125:13940-1.
- Chatterjee S, Bandyopadhyay A, Sarkar K. Effect of iron oxide and gold nanoparticles on bacterial growth leading towards biological application. *J Nanobiotechnol* 2011;9:34.
- Andeani JK, Kazemi H, Mohsenzadeh S, Safavi A. Biosynthesis of gold nanoparticles using dried flowers extract of *Achillea wilhelmsii* plant. *Dig J Nanomater Biostruct* 2011;6:1011-7.
- Philip D. Rapid green synthesis of spherical gold nanoparticles using *Mangifera indica* leaf. *Spectrochim Acta A Mol Biomol Spectrosc* 2010;77:807-10.
- Noruzi M, Zare D, Khoshnevisan K, Davoodi D. Rapid green synthesis of gold nanoparticles using *Rosa hybrida* petal extract at room temperature. *Spectrochim Acta A Mol Biomol Spectrosc* 2011;79:1461-5.
- Nasir E, Ali SI. The Flora of West Pakistan. Karachi, Pakistan: Department of Botany, University of Karachi; 1973. p. 319.
- Laghari AH, Memon S, Nelofar A, Khan KM, Yasmin A, Syed MN, et al. A new flavanone with urease-inhibition activity isolated from roots of manna plant camelthorn (*Alhagi maurorum*). *J Mol Struct* 2010;965:65-7.
- Smitha SL, Philip D, Gopchandran KG. Green synthesis of gold nanoparticles using *Cinnamomum zeylanicum* leaf broth. *Spectrochim Acta A Mol Biomol Spectrosc* 2009;74:735-9.
- Vankar PS, Bajpai D. Preparation of gold nanoparticles from *Mirabilis jalapa* flowers. *Indian J Biochem Biophys* 2010;47:157-60.
- Ghosh S, Patil S, Ahire M, Kitture R, Gurav DD, Jabgunde AM, et al. *Gnidia glauca* flower extract mediated synthesis of gold nanoparticles and evaluation of its chemocatalytic potential. *J Nanobiotechnology* 2012;10:17.
- Das RK, Gogoi N, Bora U. Green synthesis of gold nanoparticles using *Nyctanthes arbortristis* flower extract. *Bioprocess Biosyst Eng* 2011;34:615-9.
- Raghunandan D, Bedre MD, Basavaraja S, Sawle B, Manjunath SY, Venkataraman A. Rapid biosynthesis of irregular shaped gold nanoparticles from macerated aqueous extracellular dried clove buds (*Syzygium*

*aromaticum*) solution. *Colloids Surf B Biointerfaces* 2010;79:235-40.

15. Singh AK, Talat M, Singh DP, Srivastava ON. Biosynthesis of gold and silver nanoparticles by natural

precursor clove and their functionalization with amine group. *J Nanopart Res* 2010;12:1667-75.

**Source of Support:** Nil. **Conflict of Interest:** None declared.