

Green Synthesis of Silver and Gold Nanoparticles Using *Lonicera Japonica* Flower Extract

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A simple green method was developed for rapid synthesis of silver and gold nanoparticles (AgNPs and AuNPs) has been reported using *Lonicera japonica* flower extract as a reducing and a capping agent. AgNPs and AuNPs were carried out at 70 °C. The successful formation of AgNPs and AuNPs have been confirmed by UV-Vis spectro photometer, fourier transform infrared spectroscopy (FTIR), X-ray diffraction (XRD), energy dispersive X-ray Analysis (EDAX), scanning electron microscopy (SEM) and high-resolution transmission electron microscopy (HRTEM). To our knowledge, this is the first report where *Lonicera japonica* flower was found to be a suitable plant source for the green synthesis of AgNPs and AuNPs.

Key Words : *Lonicera japonica*, AgNPs, AuNPs, Green synthesis

Introduction

The development of green synthesis of nanoparticles is evolving into an important branch of nanotechnology.¹ Today huge applications of nanomaterials in the fields of physics (optics, electronics, mechanics), chemistry (catalysis),² biology (drug development, detection and control of micro organism)^{3,4} and medicine (immunoassays).⁵

Chemical methods are the most popular for the production of nanoparticles. However some chemical methods cannot avoid the use of toxic chemicals.⁶ Rapid biological synthesis provides advantage over the chemical and physical method as it is cost effective, environment friendly, and single step method for the large scale synthesis of nanoparticles⁷ and does not require the use of high pressure, energy, temperature and toxic chemicals. The role of plant biochemicals for the synthesis of AgNPs and AuNPs is directly related to the mechanisms of nanobiotechnology and green chemistry.

Recently, AgNPs and AuNPs using several plants, *Carthamus tinctorius* flowers,⁸ *Embllica officinali*,⁹ *magnolia kobus* and *diopyros kaki* leaf,¹⁰ *Saururus chinensis* leaf,¹¹ Aloe vera,¹² *Cinnamomum camphora* leaf,¹³ *Dioscorea* rhizome,¹⁴ papaya fruit,¹⁵ Phyllanthin,¹⁶ fungus *Aspergillus flavus*,¹⁷ *Fusarium oxysporum*,¹⁸ yeast strain MKY3,¹⁹ α -amylase enzyme.²⁰ AgNPs and AuNPs have a diversity of interesting properties between which they emphasize the electrical ones, optical, catalytic and the applications in biomedicine like antimicrobial same that depend on their morphology and size.

Lonicera japonica is also called Japanese Honeysuckle, Suikazura in Japanese and Jinyinhua in Chinese. This plant is native to Asia, mainly in China, Japan and Korea. *Lonicera japonica* flower is still used as a treatment for fever and inflammation. It has been known to have antibacterial, anti-inflammatory and anti viral properties. It is also used as a treatment for many types of skin conditions, such as acne, skin infections, wounds, boils, scars, etc. Experts believe

that the flower can lower blood pressure and lower blood cholesterol levels too. It can provide relief from joint pain, reduce inflammation and bring back joint's normal range of motion with continued use.

Here we report a rapid and expedient method to reductively prepare AgNPs and AuNPs from silver nitrate and chloro auric acid at 70 °C in just 30-60 min using the aqueous extract of *Lonicera japonica* flowers. The formation of AgNPs and AuNPs has been estimated by FT-IR and UV-Vis spectroscopy as well as by SEM, XRD, HRTEM and EDAX.

Material and Measurements

Synthesis of AgNPs and AuNPs Using *Lonicera japonica* Flower Extract. *Lonicera japonica* flowers were purchased from Gyeongju oriental medical market, Gyeongju, South Korea. The flowers were air dried for 10 days, then kept in a hot air oven at 60 °C for 6 hrs. Flowers were ground to fine powder. Plant flower extract was prepared by mixing 10 g of dried flower powder with 100 mL deionized water in 500 mL of Erlenmeyer flask and boiled 20 min. 1 mM silver nitrate and 1 mM chloro auric acid (AgNO₃ and HAuCl₄ purchased from Sigma-Aldrich Chemical Pvt. Ltd) were added to flower extract to make up a final solution 100 ml (5 mL of flower extract + 95 mL of 1 mM chloro auric acid and 1 mM of silver nitrate solution). A change in the color of solution was observed during the heating process.

UV-Vis Spectra Analysis. The reduction of pure Ag⁺ and AuCl₄⁻ ions were monitored by measuring the UV-Vis spectra (Cary 4000 UV-Vis spectrophotometer) of the reaction medium at 5 hrs after diluting a small aliquot of the sample into distilled water.

SEM, EDAX and HRTEM Analysis. The biomass after reaction spontaneously precipitated at the bottom of the conical flask in 1 hr. After the precipitation, the suspension above the precipitate was sampled for SEM-EDAX observa-

tions. SEM samples of the aqueous suspension of nanoparticles were fabricated by dropping the suspension onto clean electric glass and allowing water to completely evaporate. Samples were coated by osimum and SEM analyses were performed on a Hitachi S-4800N. HRTEM images and electron diffraction patterns were obtained with a JEM 2011 transmission electron microscope.

XRD Analysis. The AgNPs and AuNPs solutions were purified by repeated centrifugation at 15000 rpm for 15 min followed by redispersion of the pellet of AgNPs and AuNPs into 10 mL of deionized water. After freeze drying of the purified nanoparticles, the structure and composition were analyzed by XRD (Philips-Netherlands). The dried mixture of AgNPs and AuNPs was collected for the determination of the formation of AgNPs and AuNPs by an X'Pert Pro X-ray diffractometer operated at a voltage of 40 kV and a current of 30 mA with Cu K α radiation in a θ -2 θ configuration.

FTIR Analysis. To remove any free biomass residue or compound that is not the capping ligand of the nanoparticles, the residual solution of 100 mL after reaction was centrifuged at 15000 rpm for 15 min and the resulting suspension was redispersed in 10 mL sterile distilled water. The centrifuging and redispersing process was repeated three times. Thereafter, the purified suspension was freeze dried to obtain dried powder. Finally, the dried nanoparticles were analyzed by FTIR (Bruker model, TENSOR 37).

Results and Discussion

UV-Vis, SEM, EDAX and TEM Studies. Bioreduction of aqueous Ag⁺ and AuCl₄⁻ ions can easily be followed by UV-Vis spectrophotometer, and one of the most important features in optical (SPR) absorbance spectra of metal nanoparticles is surface plasmon band, which is due to collective electron oscillation around the surface mode of the particles. The color of silver solution changes from pale yellow to wine red, this reaction takes up 60 min for completion at 70 °C. AgNPs were formed within 5 min, and no spectral changes were observed after 1 h. The color of gold solution changes from pale brown to dark brown with in 30 min, AuNPs were formed within 2 min, and no spectral changes were observed after 30 min, indicating that formation of the AuNPs was completed within 30 min. The sharp band of AgNPs was observed at 445 nm (Figure 1). The intensity of absorption band increases with increasing time period. The different colors of AgNPs and AuNPs solutions are due to its SPR properties. AgNPs λ_{max} values were reported in the visible range of 400-500 nm.²¹ Figure 1(b) shows the characteristic surface plasmon resonance absorption band at 550 nm (AuNPs), same results observed in *Azadirachta indica* leaf.²² This strong broad Plasmon peak has been well documented for various Me-NPs, with sizes ranging all the way from 2 to 100 nm.²³

Figure 2(a)-(f) shows, the SEM images of the synthesized AgNPs and AuNPs. The overall morphology of the AuNPs, were largely triangular, tetrahedral and monodispersed, at higher magnification. The morphology of AgNPs is more

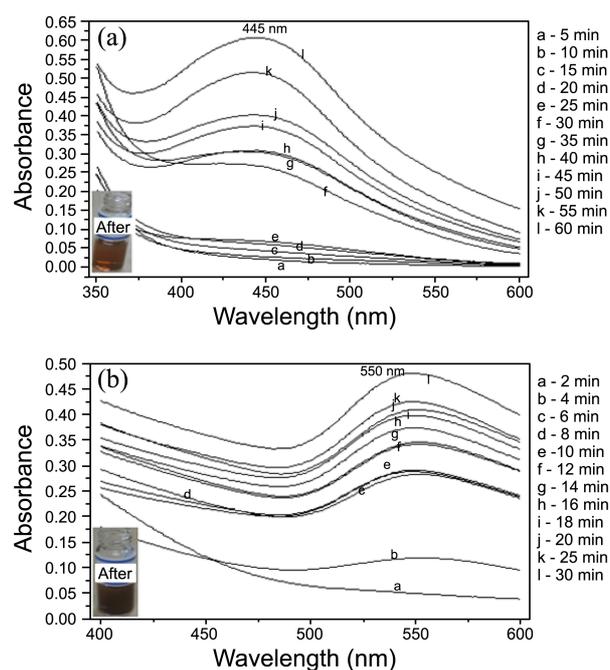


Figure 1. UV-Vis absorption spectra of AgNPs (panel a) and AuNPs (panel b).

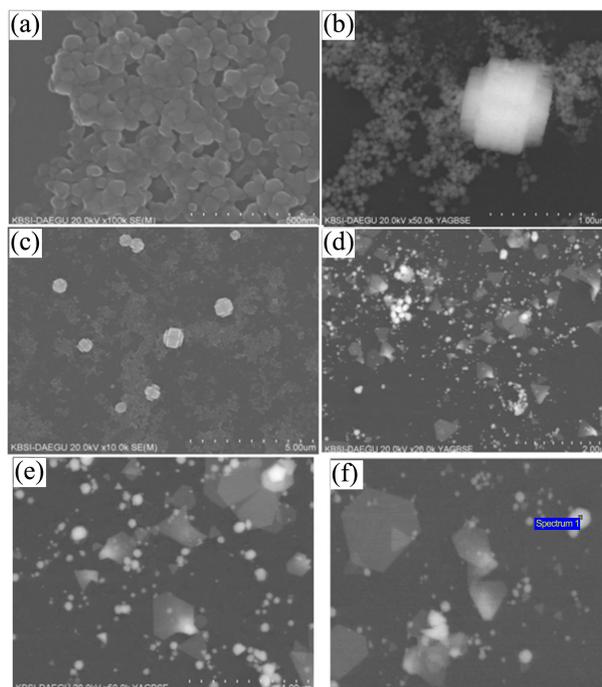


Figure 2. SEM images of AgNPs (panel a, b, and c) and AuNPs (d, e and f).

clearly seen, the particles shapes are circular and poly-dispersed at 70 °C.

Figure 3(a) and (b) shows the EDAX spectra of AgNPs and AuNPs synthesized at 70 °C. Strong signals from the silver and gold atoms in the nanoparticles were observed. The presence of the elemental silver and gold can be observed in the graph obtained from EDAX analysis, which also supports the XRD results. This indicates the reduction

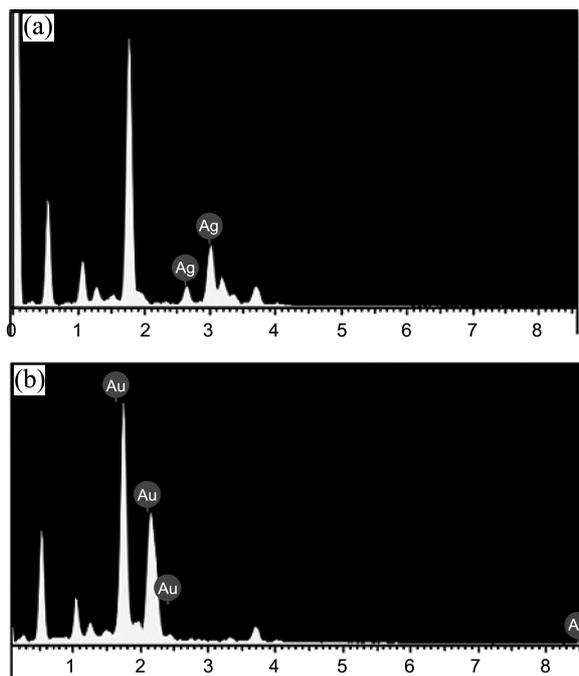


Figure 3. EDAX spectra of AgNPs (panel a) and AuNPs (panel b).

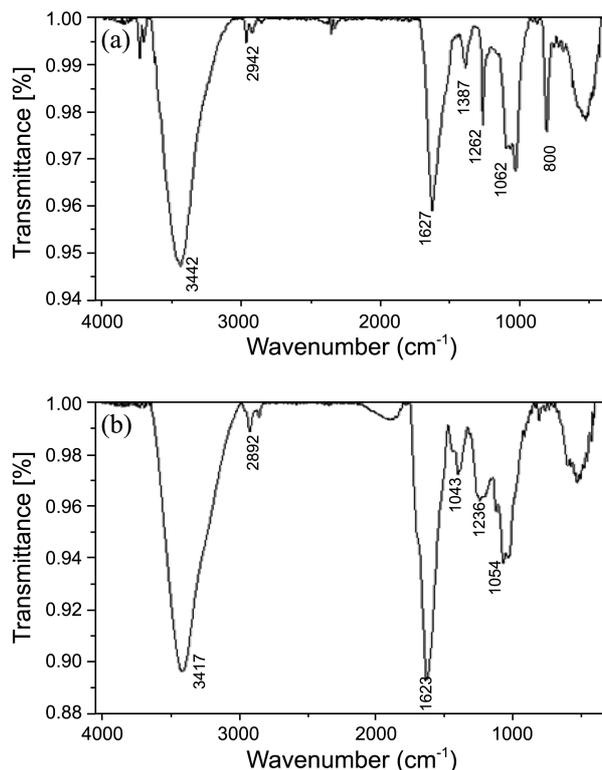


Figure 5. FTIR spectra of AgNPs (panel a) and AuNPs (panel b).

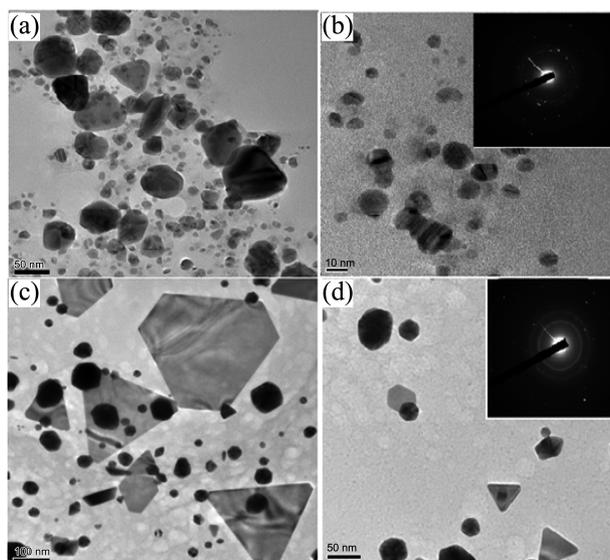


Figure 4. HRTEM images of AgNPs (panel a and b) and AuNPs (panel c and d).

of silver and gold ions into elements of silver and gold.

The HRTEM images of AgNPs and AuNPs are shown in Figure 4(a)-(d) respectively. From the images it is evident that the morphology of AgNPs and AuNPs is nearly spherical, triangle and hexagonal. The selected area electron diffraction pattern (SAED) with bright circular spots reveals that the particles are crystalline in nature.

FTIR and XRD Studies. FTIR results reveal that absorption bands at 3442, 2942, 1627, 1387, 1262, 1062 and 800 (AgNPs at 70 °C) and 3417, 2892, 1623, 1403, 1236, and 1054 (AuNPs at 70 °C) respectively (Figure 5). The vibrational bands corresponding to the bonds such as amino

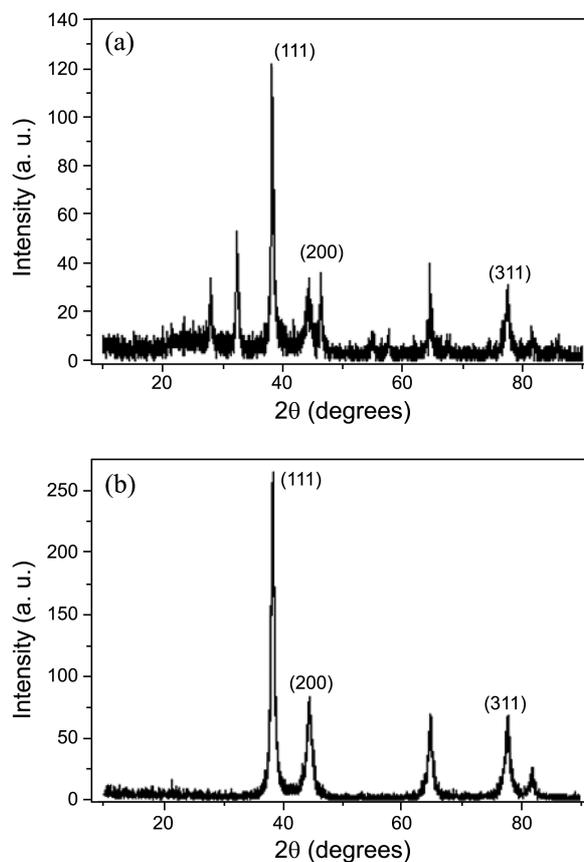


Figure 6. XRD spectra of AgNPs (panel a) and AuNPs (panel b).

(=N-H), >C=C (alkenes), -O-H (alcohol), flavonoids and -NH₂ (amine) which was in the region range of 800-3442

cm⁻¹. The most wide spectra absorption was observed at 3417 and 3442 cm⁻¹ and it can be attributed to the stretching vibrations of amino (N-H).²⁴

The XRD pattern of the AgNPs and AuNPs is shown in the Figure 6(a) and (b) various Bragg reflections clearly indicated the presence of (111), (200) and (311) sets of lattice planes and further on this basis of they can be indexed as face-centered-cubic (FCC) structure of silver and gold. Hence from the XRD pattern this is clear that AgNPs and AuNPs formed using *Lonicera japonica* flowers broth were essentially crystalline in nature. In addition to the Bragg peaks representative of FCC AgNPs and AuNPs, additional as yet unassigned peaks are also observed suggesting that the crystallization of bio-organic phase occurs on the surface of the nanoparticles. AgNPs the estimate mean size of AgNPs and AuNPs were 7.8 and 8.02 nm respectively.

Conclusion

The rapid biological synthesis of AgNPs and AuNPs using flower broth of *Lonicera japonica* provides an environmental friendly, simple and efficient route for synthesis of benign nanoparticles. The spectroscopic characterizations from UV-Vis, FTIR, SEM and HRTEM support the formation and stability of the green synthesized AgNPs and AuNPs. The estimated mean size of AgNPs and AuNPs particles were 7.8 and 8.02 nm.

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