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Floral Synthesis of Silver Nanoparticles Using *Stenolobium stans* L.

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Green synthesis of nanoparticles has preference due to their non-pollutant nature when compared with other methods of synthesis. In the present investigation, silver nanoparticles were synthesized using green technology as a single step which is cost effective and eco-friendly method. The aqueous floral extract of *Stenolobium stans* belonging to family Bignoniaceae was used in this study. The synthesized silver nanoparticles were characterized for their plasmon resonance using UV-visible spectrophotometer and scanning electron microscope, Energy dispersive X-ray spectroscopy, Laser particle size analyzer and Fourier transform infrared spectroscopy to study other characters. The UV-visible spectrum showed the absorbance peak at 455 nm. The average size range of nanoparticles was recorded as 7.8 to 45.3 nm through SEM and the presence of silver was recorded through EDS. The zeta particle analyzer revealed the average size range of 28.51 nm. Further the presence of phenolics and other organic group was confirmed through FTIR, which reveals that the floral extract of *Stenolobium stans* is involved in synthesis of silver nanoparticles. Thus, the floral extract of *Stenolobium stans* can be used as a potential source for the synthesis of same.

Keywords: Floral synthesis, Green synthesis, *Stenolobium stans,* Silver nanoparticles.

INTRODUCTION

Nanotechnology is rapidly expanding area of research with tremendous implications in society, industry and medicine. The uses of nano sized particles are even more remarkable. Nanoparticles are synthesized by physical, chemical and biological methods. Physical and chemical methods include electric arc deposition, chemical precipitation, hydrothermal method, laser ablation and chemical vapour deposition[1]. The development of green synthesis of nanoparticles is evolving into an important branch of nanotechnology[2]. Numerous microorganisms are used in the synthesis of inorganic nano-structures either intracellularly or extracellularly[3-5]. However, harvesting nanoparticles is difficult in these cases. Thus, green synthesis of nanoparticles using plant materials are studied for their synthesis of Nanoparticles, which includes, *Coriandrum sativum*[6], *Hibiscus rosa-sinensis*[7], *etc*. Recently, flowers are the area of interest to synthesize silver nanoparticles (AgNPs) due to its attractive carotenoid pigments and less complexity of plant metabolites. Only few works have been carried out using flowers (*Lonicera japonica*[8], *Bougainvillea spectabilis*[9], *Datura metel*[10], *Nelumbo nulcifera*[11] and *Ipomoea indica*[12]).

In this study, aqueous extract of the flower of *Stenolobium stans* belonging to Bignoniaceae family was used in synthesis of silver nanoparticles. The plant has sharply toothed and lance shaped green leaves. *S. stans* flower is used as a treatment for stomach pains and digestive problems. Leaves are used for diabetes and urinary disorder control[13,14]. Roots are used as diuretic and vermifuge[15].

EXPERIMENTAL

The flowers of *Stenolobium stans* (Fig. 1) were collected from Avadi, Chennai, Tamil Nadu. To prepare aqueous extract, the collected flowers were washed with running water. 10 g of corolla of flower sample were taken separately and boiled in 100 mL of distilled water (1:10 ratio) for 2-3 min. The solution was filtered with Whatmann filter paper. The extracts were stored at 4 °C for further usage.

Synthesis of silver nanoparticles and characterization: 50 mL of *S. stans* extract was added to 500 mL of 1 mM concentrated silver nitrate solution in a clean conical flask. Conical flasks were shaken well for 5-10 min and kept for 1 h at room temperature and change in colour was observed. After synthesis of silver nanoparticle, the solution was monitored in UV-visible spectrophotometer (Cyberlab, USA) for its plasmon resonance. Part of the prepared solution was diluted to 10 fold and filtered through a 0.22 µm syringe filter unit and the size of the distributed silver nanoparticles were measured using the principle

Fig. 1. *Stenolobium stans* flower

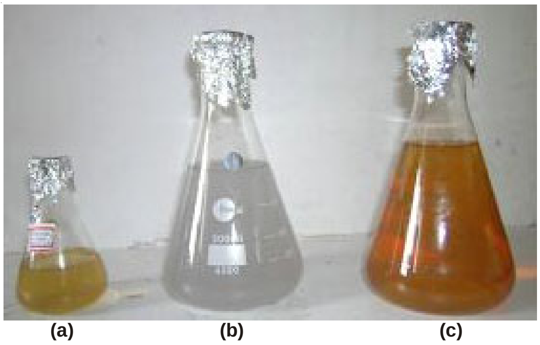

Fig. 2. (a) Aqueous extract (b) silver nitrate solution (c) after adding aqueous extract

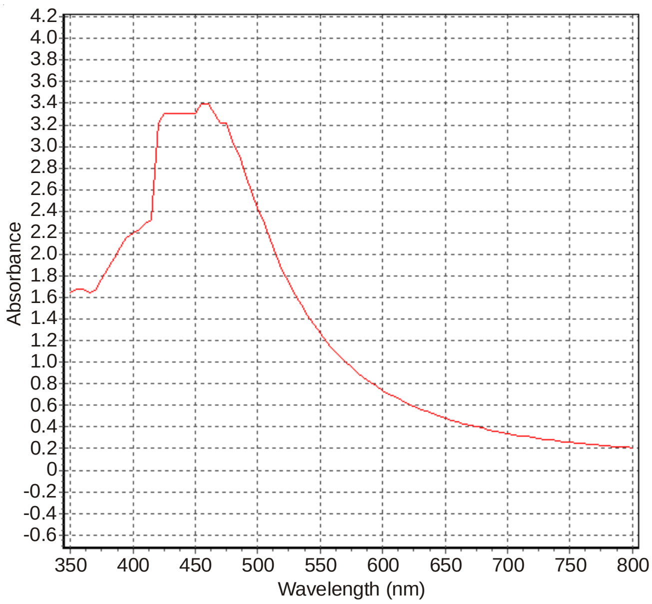

Fig. 3. UV-spectra of synthesized nanoparticles from *S. stans* flower extract

of dynamic light scattering (DLS) technique made in a Malvern Zetasizer Nano series compact scattering spectrometer.

Few of the prepared solution were centrifuged for 3 to 4 times at 3000 rpm for 10 min to remove the constituents of floral extract. The filtrate was washed thrice in methanol to remove floral constituents and dried in hot air oven at 120 °C for 3 h and the dried silver particles were used for the SEM-EDS. Field emission-scanning electron microscopy (FEI Quanta FEG 200) and the elemental particle of silver nanoparticles was performed using Bruker 20 mm dry EDS, energy dispersive spectroscopy. A strong absorption peak was viewed at 3 keV. The functional biogroups bound on the silver nanoparticles was identified using FTIR analysis.The spectrum was measured from 4000 to 400 cm^{-1}. The sample was measured by ALPHA-T (Bruker Corp), Fourier-transform infrared spectroscopy (FTIR).

RESULTS AND DISCUSSION

A biological route is used for synthesizing silver nanoparticles by using the aqueous floral extract of *Stenolobium stans*. The silver nitrate solution has turned to reddish brown colour by adding the floral extracts. Addition of floral extract to 0.1 mM silver nitrate solution resulted in formation of golden brown colour to the solution (Fig. 2a-c).The reduction of silver ions to silver nanoparticles was confirmed through the change of colour observed in silver nitrate solution[16]. The instantaneous change in colour of the solutions from a clear liquid to a darker colour in the reaction suggested the formation of silver nanoparticles[17]. This colour change is due to reduction of silver ions, which confirmed the formation of silver nanoparticles. The plasmon resonance studied for the synthesized nanoparticles confirmed the peak at 455 nm (Fig. 3) and increased in its intensity as reaction time proceeds. Noble metal nanoparticles exhibit specific surface plasmon resonance which shows peak characteristic for each metal[1]. Similar results were observed in silver nanoparticles synthesized using *Datura metel* flower[10].

The SEM image shows the exact size of silver nanoparticles at various magnification ranges (Fig. 4). These synthesized nanoparticles were spherical and cuboid in shape. The size range of silver nanoparticles varied from 7.8 to 45.3 nm. The EDS revealed a peak denoting the presence of elemental silver (Fig. 5). The average size of the synthesized silver nanoparticles was analyzed using laser particle size analyzer, which revealed the average size as 28.51 nm. The size distribution of the particles was between 5-100 nm (Fig. 6).

The FTIR spectra showed the absorption bands at 3940-3633, 3472-3404, 3589-3509, 3324 cm^{-1} and 3262, 1632, 1407, 1359, 1109 cm^{-1}. These absorbance bands are known to be associated with O-H stretch, N-H stretch, O-H stretch of phenol or alcohol group, a primary amine, C-C=C symmetric stretch of alkene group, N=O bend of nitro group, -NO of aliphatic group, C-O stretch of ester and ether group. These functional groups recorded may serve as a reducing agent resulting in formation of silver nanoparticles from silver nitrate. The phytochemical composition of the flower was already reported which showed the presence of phytoconstituents like flavonoids and saponins[18] which may also serve as a reducing agent helping in reduction of silver nitrate and formation of silver nanoparticles. The study amply demonstrates the floral synthesis of silver nanoparticles at a satisfactory level.

Conclusion

A single step, green synthesis of silver nanoparticles was carried using the floral extracts of *Stenolobium stans.* The study revealed the particles were synthesized with the size range of 7.8 to 45.3 nm with an average of 28.51 nm. The study revealed the presence of functional groups like flavonoids and saponins in the floral extract of *Stenolobium stans* might served as a reducing agent thus, reducing silver nitrate to silver nanoparticles. The study amply demonstrates the floral synthesis of

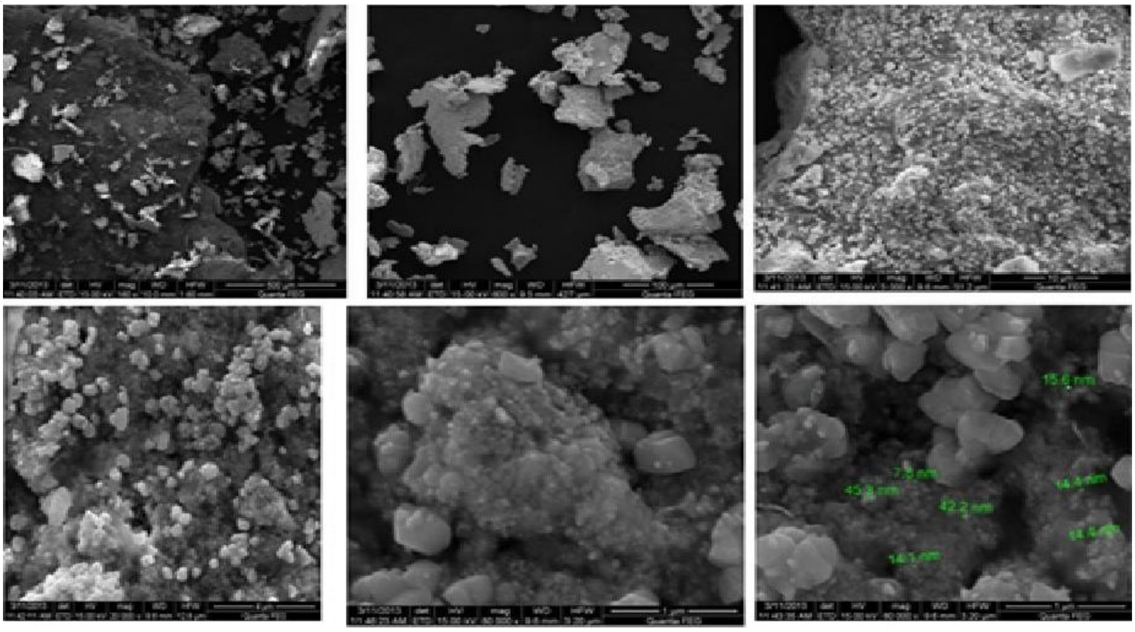

Fig. 4. SEM analysis of silver nanoparticles synthesized using *S. stans* flower extract

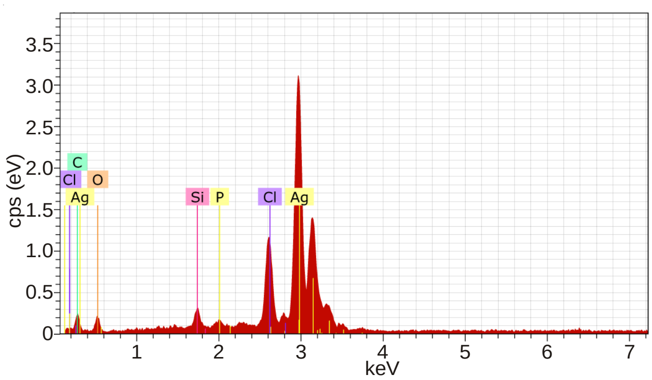

Fig. 5. EDS analysis of silver nanoparticles

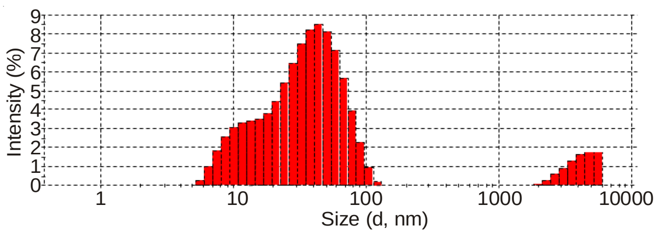

Fig. 6. Laser particle size of synthesized silver nanoparticles

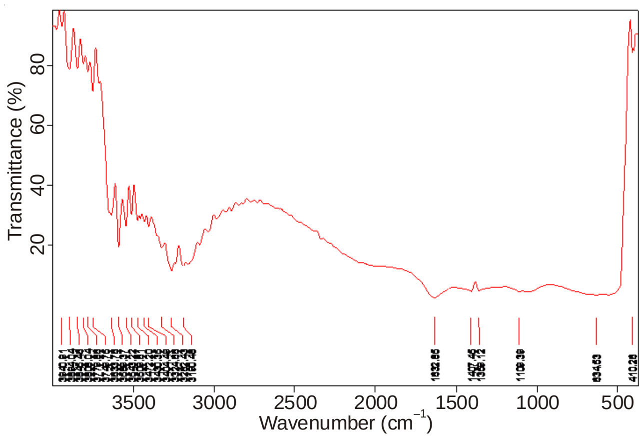

Fig. 7. FTIR spectra of synthesized nanoparticles from *S. stans* flower extract

silver nanoparticles at a satisfactory level. The synthesized route is simple, rapid, cost effective and safety for environment without any hazardous chemicals. Thus, the floral synthesis of silver nanoparticles using *Stenolobium stans* can be utilized successfully in industries.

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