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Research Article

Biosynthesis and Characterization of silver nanoparticles from *Acacia auriculiformis* flower extract

N. Prabhu[1]*, T. Gajendran[2], V. Shiney[1], S. Keerthana[1], J. Naveena Bhashini[1]

[1]Department of Biotechnology, Vivekanandha College of Engineering for Women, Elayampalayam, Tiruchengode-637 205, Tamilnadu, India.
[2]Department of Biotechnology, Bharathidasan Institute of Technology, Anna University, Tiruchirappalli-620 024, Tamilnadu, India.

*Corresponding author's e-mail: prabhu.aut.26@gmail.com

Abstract

Development of reliable and eco-friendly process for synthesis of nanoparticles is an important step in the field of nanotechnology. The present study reports an environmentally friendly method for silver nanoparticles synthesis using ethanolic extract of *Acacia auriculiformis* flower that acts as reducing agent. UV-visible spectroscopy was used for quantification of silver nanoparticle synthesis. The synthesized silver nanoparticles were characterized with UV-Vis Spectroscopy (UV-Vis), Fourier transform Infrared Spectroscopy (FTIR), X-ray Diffraction (XRD), Scanning electron microscopy (SEM), Zeta Potential. The green synthesis approach seems to be cost efficient, eco-friendly and easy alternative to conventional methods of silver nanoparticles synthesis.

Keywords: Silver nanoparticles; *Acacia auriculiformis;* Biosynthesis; Characterization.

Introduction

The field of nanobiotechnology is an active research area in modern materials science. Nanoparticles show completely new properties based on specific characteristics such as dimension, distribution and morphology. New solicitations of nanoparticles are emerging rapidly. Nano crystalline silver particles have found numerous applications in the field of high sensitivity bimolecular detection and diagnostics, antimicrobials and therapeutics, Catalysis and microelectronics [1].

However, there is still need for affordable, commercially viable as well as environmentally safe synthesis route to synthesize silver nanoparticles [2]. A number of approaches are available for the synthesis of silver nanoparticles including, reduction in solutions, sonochemical, micro wave assisted process etc., recently green synthesis route is employed.

Research is going on for discovering unique properties of materials which are used in day today life at the sub micrometer scale [3]. Nanoparticles are classified accordingly on the basis of diameter, with a range between 100 and 2500 nanometers and on the other hand, ultrafine particles are sized between 1 to 100 nanometers [4].

The properties of noble metal particles like electrical, magnetic, and chemical etc. Attracts the scientists around the world to focus on these properties [5]. These unique properties are because that they are small and they have large surface area. Now nanoparticles of noble metals are used, and being evaluated in many fields.

The chemical methods are expensive and also involve the use of toxic chemicals that possess various risks for human health. But, synthesis of nanoparticles using plant extracts is the most accepted method as green, clean, environment-friendly production of nanoparticles has an advantage that the plants are distributed widely , readily available, which is a valuable source of several metabolites [6]. Also, most of the secondary metabolites that micro-organism produces, in other words say antibiotics seem to be less sensitive towards many micro-organisms. Hence, scientists around the world are determined to find new potential antimicrobial agent [7]. So in this regard, silver compounds are reported to

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have a strong bacteriocidal and fungicidal activity [8]. Nanoparticles that have surface area to volume ratio which is higher have the higher antimicrobial activity [9].

Materials and methods

Collection of plant materials

The flowers of *Acacia auriculiformis* were collected in and around Anna University, BIT Campus, Trichy, Tamilnadu, India. The flowers were rinsed with tap water thrice followed by distilled water to remove the fine dust materials and then, the flowers were shade-dried for 1 week to completely remove the moisture [10].

Preparation of flower extract

The dried flowers were crushed well with mortar and pestle to make a powder. The flower extract is prepared by pouring powder sample of flower in soxhlet apparatus and 150 ml of ethanol is added to get the desired extract. The excess solvent is removed using rotary vacuum evaporator [11].

Synthesis of silver nanoparticles using flower extracts

Silver nanoparticles were prepared by adding 0.2 µl of ethanolic extract of *Acacia auriculiformis* to 5 ml aqueous solution of 1 mM silver nitrate($AgNO_3$) [12]. The reaction is carried out at room temperature. The effect of pH was studied varied using 1 N NaOH. Fig. 1 shows the colour change after the reduction of Ag+ to Ag with and without flower.

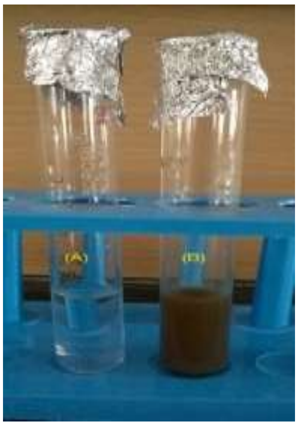

Fig. 1. The colour change after the reduction of Ag+ to Ag (A) 1 mM $AgNO_3$ without flower extract (B) Silver Nanoparticles (1 mM $AgNO_3$ with flower extract after 12 h of incubation

UV-Vis Spectra analysis

The reduction of pure Ag+ ions was monitored by measuring the UV-Vis spectrum of the reaction medium after diluting a small aliquot of the sample into distilled water. UV-Vis spectral analysis was done by using UV-Vis spectrophotometer UV-2460 [13].

FTIR analysis

FTIR measurements were employed to identify the possible biomolecules responsible for the reduction of the metal precursors [14]. The measurement was taken between 4000 cm^{-1} and 400 cm^{-1} which is characteristic of silver nanoparticles.

Particle size analysis

The prepared Nanoparticles were analysed for their particle size and size distribution in terms of the average volume diameters and polydispersity index by photon correlation spectroscopy using a particle size analyser (Malvern Instruments Ltd., Malvern, United Kingdom) at 25°C. The nanoparticles suspension was diluted with distilled water before analysis [15].

Zeta Potential

The zeta (ζ) potential of the nanoparticles was determined by Zeta PALS (Zetasizer Nano ZS, Malvern Instruments Ltd) using a zeta potential capillary cell equipped with integral gold electrodes. The Zeta potential of a nanoparticle is commonly used to characterize the surface charge property of nanoparticles [16]. It reflects the electrical potential of particles and is influenced by the composition of the particle and the medium in which it is dispersed. Nanoparticles with zeta potential above (+/-) 30mV have been shown to be stable in suspension, as the surface charge prevents aggregation of the particles [17].

X-Ray Diffraction analysis

The silver nanoparticle solution thus obtained was purified by repeated centrifugation at 10000 rpm for 15 min followed by re-dispersion of the pellet of silver nanoparticles into 10 ml of deionized water [18]. The reaction mixture was kept for drying in hot air oven for 3 days and was combusted to form powder to be characterized by X-Ray Diffraction (XRD) for the presence of silver nanoparticles. The XRD Analysis was done using X-ray diffractometer operated at 40 kV and 30mA current with Cu Kα radiation in a θ-2θ configuration [19]. The crystallite domain size was calculated from the width of the XRD peaks, assuming that they are free from non-uniform strains, using the Scherrer formula in Eq. (1).

$$D = \frac{0.9\lambda}{\beta \cos\theta} \quad (1)$$

Where D is the average crystallite domain size perpendicular to the reflecting planes, λ is the X-ray wavelength (1.5418A°), β is the full width at half maximum (FWHM), and θ is the diffraction angle [20]. The XRD analysis was performed in the Department of Physics, Alagappa University, Karaikudi.

SEM analysis

SEM analysis was done using Hitachi S-3500SEM machine [21]. Thin films of the sample were prepared on a carbon coated copper grid by just dropping a very small amount of the sample on the grid, extra solution was removed using a blotting paper and then the film on the SEM grid were allowed to dry by putting it under a mercury lamp for 5 min [22].

Results and discussion

UV-Vis analysis

UV–vis spectroscopy is an important technique to ascertain the formation and stability of metal nanoparticles in aqueous solution. Fig. 2 shows the UV–vis spectra of the silver [23]. In the UV-Vis Spectroscopy absorption maxima appeared at 420 nm which is a characteristic of Ag NPs. The formation and growth of the particles was slow in the beginning but get accelerated as the time goes on. After about 12 h of AgNPs formation brown precipitate was seen [24].

FTIR analysis

FTIR measurement was carried out to identify the possible biomolecules in *Acacia auriculiformis* flower responsible for leading to efficient stabilization of the silver nanoparticles. Prominent IR bands are observed at 3415, 1728, 1173, 1054, 881, 584 cm^{-1}. Most of the IR bands are characteristic of flavonoids and terpenoids present in the flower (Fig. 3). The bands at 1173 and 1054 cm^{-1} arise from C–N stretching modes due to aliphatic amines and alkyl halides [25].

The band at 1728 cm^{-1} is assigned to the stretching vibrations of C=O which may be aldehydes; The absorption band located at 3415 cm^{-1} may be attributed to –H and O–H stretching modes that may be due to alcoholic and phenolic groups. The medium intense band at 881 cm^{-1} arises from the =C–H stretching mode of the alkene group. The band at 584 cm^{-1} arises from C-Cl stretch which is a characteristic of alkyl halides. The vibrational bands corresponding to bonds such as =C-H, C-Cl, –C=O and –C–N are derived from the water soluble compounds such as flavonoids, terpenoids and saponins present in *Acacia auriculiformis* flower. Hence, it may be assumed that these biomolecules are responsible for efficient stabilization. The presence of reducing sugars in the extract could be responsible for the reduction of silver ions and formation of the nanoparticles. This rapid and environmentally benign method is a faster synthesis comparable to chemical reduction methods.

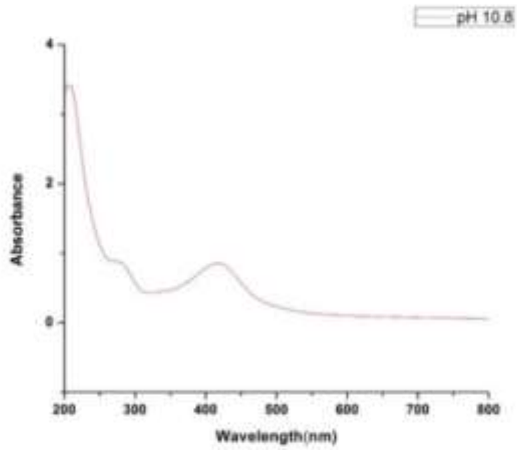

Fig. 2. UV-Vis spectra of silver nanoparticles

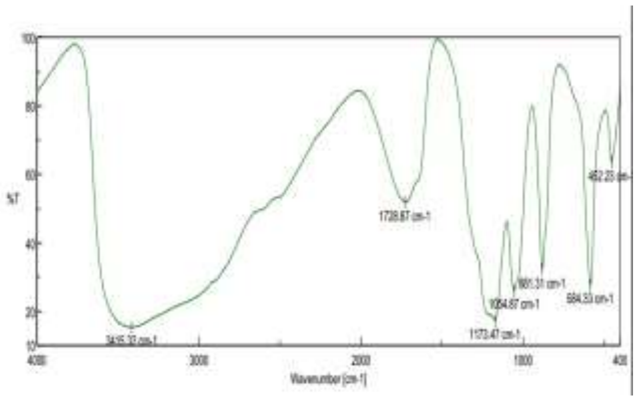

Fig. 3. FTIR Spectra of silver nanoparticles

Particle size analysis

The average particle size of the silver nanoparticles from Zeta Sizer was estimated as

47.33nm. There is a uniform distribution of size in the prepared formulation as shown in the Fig. 4.

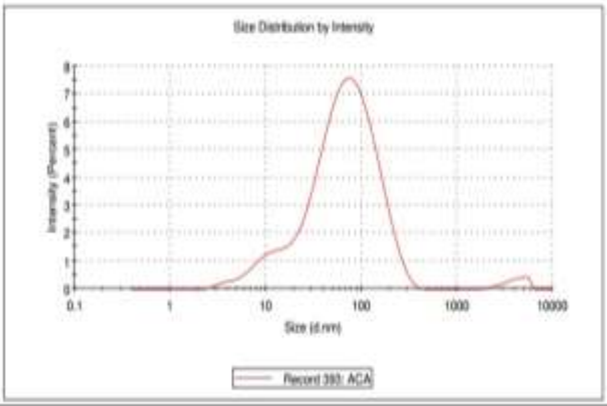

Fig. 4. Particle size distribution of nanoparticles

Zeta potential measurements

Zeta potential is the potential difference between the dispersion medium and the stationary layer of fluid attached to the dispersed particle [26]. The zeta potential of a system is a measure of charge stability and controls all particle-particle interactions within a suspension. Zeta Potential is an important physicochemical parameter, which can influence factors like stability of nanoparticles. The Zeta potential of nanoparticles prepared with an aqueous solution was +0.0212 mV for silver nanoparticles as shown in Fig. 5. The Zeta Potential value will be normally positive or negative. In this case, the zeta potential value is neutral as it is often not the scenario. But the zeta potential for nanoparticles is reported to between -40mV and +40mV. Since the zeta potential is neutral, we can assume that the precipitate formation is easily possible [27].

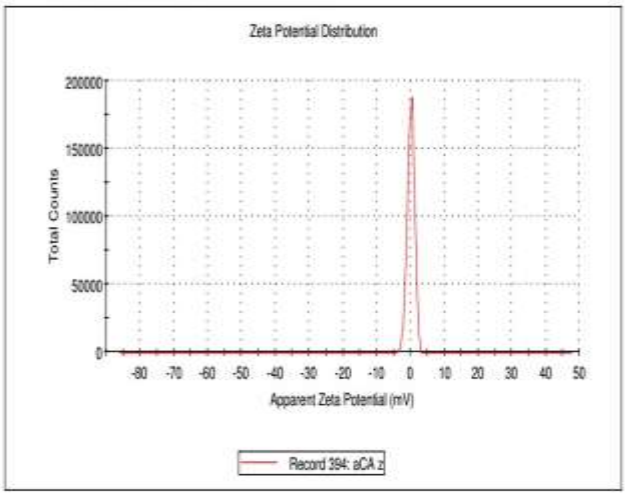

Fig. 5. Zeta potential measurements for silver nanoparticles

X-Ray Diffraction analysis

To study the crystalline nature of the silver nanoparticles, the XRD analysis was performed. XRD pattern of derived AgNPs (Fig. 6) shows ten intense peaks in the whole spectrum of 2θ values ranging from[32.47°, 35.48°, 38.68°, 48.73°, 53.42°, 58.24°, 61.50°, 66.08°, 67.95°, 72.29°, 75.01°] for *Acacia auriculiformis* flower extract. A few intense additional and yet unassigned peaks were also noticed in vicinity of the characteristic peaks of silver [28]. These sharp Bragg peaks might have resulted from some bioorganic compounds/protein(s) present in the *Acacia auriculiformis* flower extract. The XRD pattern revealed five peaks corresponding to 5 diffraction facets of silver [29].

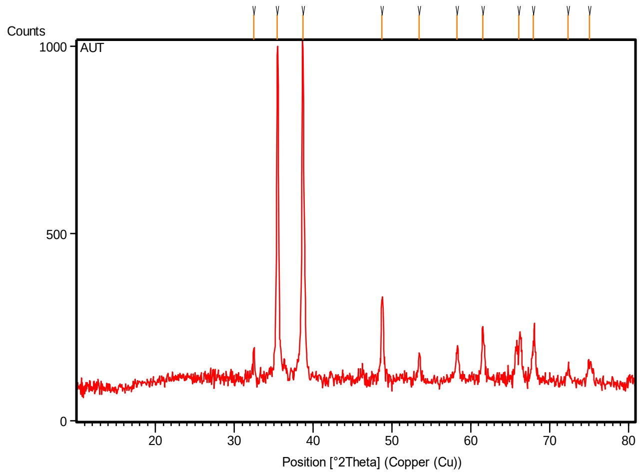

Fig. 6. XRD pattern of Silver nanoparticles

SEM Analysis

Fig. 7 shows typical results of the studies of silver nanoparticles. Part (a) of the figure represents the view of the sample at 50.00 KX. Around the area one can find presence of objects of size 2-3 µm. Part (b) of the figure represents the view of the sample at 160- 200 KX. Around this area one can find presence of objects of size 200-300 nm [30].

Conclusions

The present study reveals that the reduction of particle size is done by characterization techniques. The addition of silver and the reaction resulted in synthesis of silver nanoparticles. The silver nanoparticles were seen through the UV visible spectroscopy. The FTIR analysis of plant gives that the IR bands which are characteristics flavonoids and terpenoids. Zeta potential of the nanoparticles is neutral it confirms that precipitate formation is easy. The XRD studies reveal that, the silver nanoparticles of the plant have diffraction facets. Further the particle is characterized with SEM analysis shows that the presence of objects.

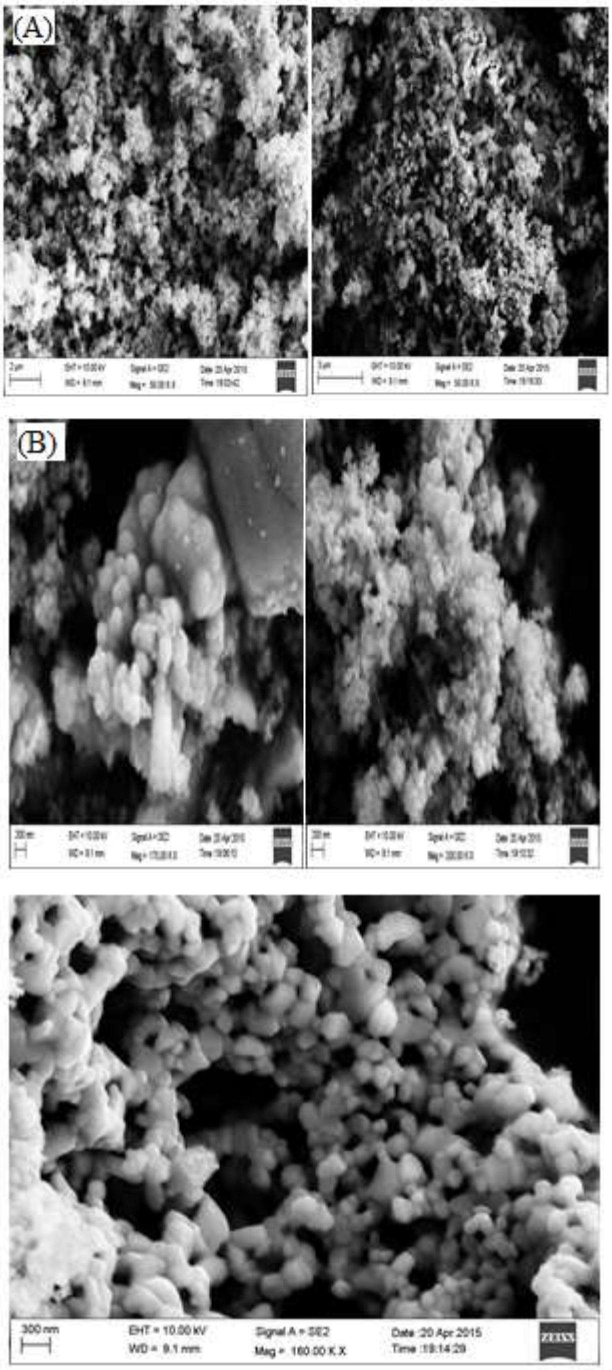

Fig. 7. SEM analysis of silver nanoparticle (A) Magnification at 50 KX (B) Magnification at 160-200 KX

Conflicts of interest

The authors declare no conflict of interest.

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