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Plant mediated synthesis of silver nano-particles using *Adhatoda vasica* aqueous leaf extract

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Abstract. The leaves of *Adhatoda vasica* were collected and dried in shade and extracted in aqueous medium using Soxhlet extractor. The extract used for synthesis of silver nanoparticles. The characterization of silver nanoparticles was done. The formation of silver nanoparticles was confirmed by change in the colour of solution from yellow to dark brown. The silver nanoparticles thus formed were subjected to UV-vis spectrophotometric, Scanning Electron Microscop (SEM) and Fourier-Transform Infra-red (FTIR) analysis for characterization of the formed nanoparticles. Thus formation of nanoparticles in the range of 63.25 to 110 nm and average size of particles were 89.93 nm.

Keywords: Adhatoda vasica, Nanoparticles*,* SEM, FTIR

1. Introduction

Biology of plant mediated nanoparticles is an upcoming branch of nanotechnology which is gaining grounds. Nanobiotechnology refers broadly to a field of science whose theme is control of matter a tht atomic and molecular scale [1]. The green method of synthesis of nano-particles have several important applications in the field of biolabelling sensors, drug delivery system, filters and also possess antimicrobial activity; these nanoparticles exhibit new physic-chemical properties, which are not observed in polar or non-polar extracts of plants [2].

Biological routes of synthesis of metal nanoparticles have been proposed by exploiting bacteria [3-6] yeast [7-9] fungi [10-13] actinomycetes [14] and virus [15, 16] involved synthesis, but the processes are not feasible industrially, for their pathogenicity and lab maintenance which require both money and skilled technicians.

In this work we report the synthesis of silver nanoparticles, reducing the silver ions present in the solution of silver nitrate by the aqueous extract of *Adhatoda vasica*, this method yields faster and stable silver nanoparticles compared to other methods. The quantitative formation of nanoparticles were monitored by UV-vis spectroscopy. Also the silver nanoparticles formation were confirmed by reddish brown colour formation.

2. Materials and Methods

Adhatoda vasica Nees (Acanthaceae) commonly known as Vasaka, distributed throughout

*Corresonding author.

India up to an altitude of 1300m. The leaves, flowers, fruit and roots are extensively used for treating cold, cough, whooping cough, chronic bronchitis, asthma and sedative, expectorant and antispasmodic. It was also used by traditional midwives at the time of delivery. The leave, roots and flowers of *Adhatoda vasica* are extensively used in indigenous medicines [17].

2.1 *Preparation of Plant Extract*

Phenol was determined by Folin-Ciocalteau reagent following Ramamorthy and Bono [18]. Tannin was determined as standard published in the quality control methods for medicinal plant materials [19]. Aluminium Chloride colorimetric method was used with some modification to determine flavonoid content following Lin and Tang [20]. Alkaloids were determined by method used by Helrich [21]. Saponin content was determined following Obadoni and Ochuko[22]. The details have been described by Kumar *et al*. [23].

2.2 *Synthesis of Silver Nanoparticles*

For synthesis of nanoparticles, 1 mL of *Adhatoda vasica* leaf extract was added to 99 mL of 1mM $AgNO_3$ (169.8mg) solution. The mixture was allowed to stir for 2h at 90°C (Colour change was observed from light yellow to dark brown, and thereafter no further color change was observed even after 2h). The mixture was allowed to cool down after 2h and was centrifuged at room temperature at 9000 rpm after washing three times with distilled water, a black powder was obtained that was dried overnight in an oven at 80°C [24, 25].

2.3 *Characterization of Nano-Particles*

Characterization of silver nanoparticles was done UV-vis spectrum analysis, SEM analysis, Fourier Transform Infrared Spectroscopy (FTIR) analysis.

2.4 *UV-visible spectrum analysis*

The reduction of pure Ag^+ ions was monitored by measuring the UV-visible spectrum of the reaction medium after 5h after diluting a small aliquot of the sample into Milli-Q water. UV-visible spectral analysis was done by using Parkin Elmer Lambda25 UV-visible spectrophotometer.

2.5 *SEM analysis*

SEM (Scanning Electron Microscope) analysis was done using JEOL JSM-6390 LV (Japan) machine. Thin films of the sample were prepared on a carbon coated copper grid by dropping a small amount of the sample on the grid, extra solution was removed using a blotting paper and then the film on the SEM grid was allowed to dry by putting it under mercury lamp for 5 min and was coated with gold using ion sputter.

2.6 *Fourier transform infrared spectroscopy (FT-IR) analysis*

FT-IR analysis was carried out on IPResting-21 (Shimadzu) in the diffuse reflectance mode operated at a resolution of 4 cm^{-1} in the range of 400 – 4000 cm^{-1} to evaluate the functional groups that might be involved in nanoparticles formation.

3. Results and Discussion

3.1 *UV-vis spectrophotometer analysis*

The aqueous solution changed from light yellow colour to dark brown, which is a well know confirmation of nanoparticle formation [26]. As the *Adhatoda vasica* fruit extract was mixed in the aqueous solution of the silver ion complex, it started to change the colour from yellow to brown due to reduction of silver ion (Fig. 1). Which indicated the formation of silver nanoparticles. The

colour change is due to the Surface Plasmon Resonance (SPR) phenomenon [27].

Figure 1. figure showing change in colour of aqueous solution from yellow to deep brown

From different literatures it was found that the silver nanoparticles show SPR peak at from 415-490 nm. In this study the *Adhatoda vasica* silver nanoparticles showed SPR peak at 458 nm. Dhnalakshmi [28] reported SPR peak for silver nanoparticles synthesized using *Tridax procumbens*. Several workers have reported absorbance peak from 450-500 nm for silver nanoparticles synthesizes using *Argemone Mexican* [29], Papaya fruit extract [30] , *Trianthema decandra* [31].

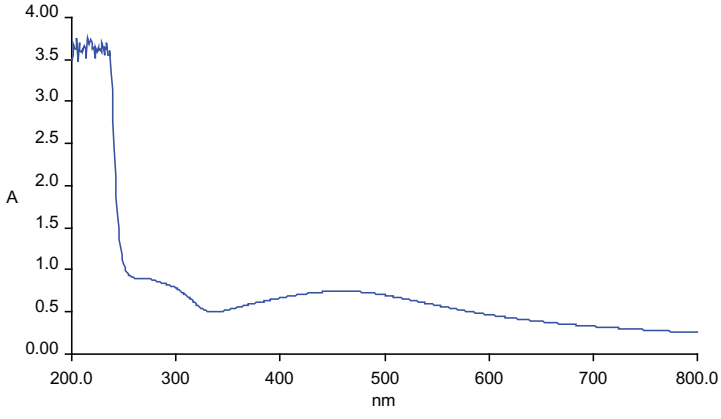

Figure 2. Result of UV-vis spectrophotometric analysis, showing peak at 458 nm SEM analysis

The size and structure of silver nanoparticles synthesized with help of *Adhatoda vasica* leaf extract was further subjected to SEM analysis to examine the morphology of the nanoparticles. The *Adhatoda vasica* leaf extract mediated synthesized silver nanoparticles were spherical and cubical in shape and had diameter of nanoparticles ranged from 63.25 – 110 nm and average size of particles were 86.93 nm. Kumar [32] reported size of alion mediated synthesized nanoparticles to be in range of 287-293 nm and average size was 70 nm. Firdhouse [33] reported the size of nanoparticles ranging from 20 – 150 nm in diameter.

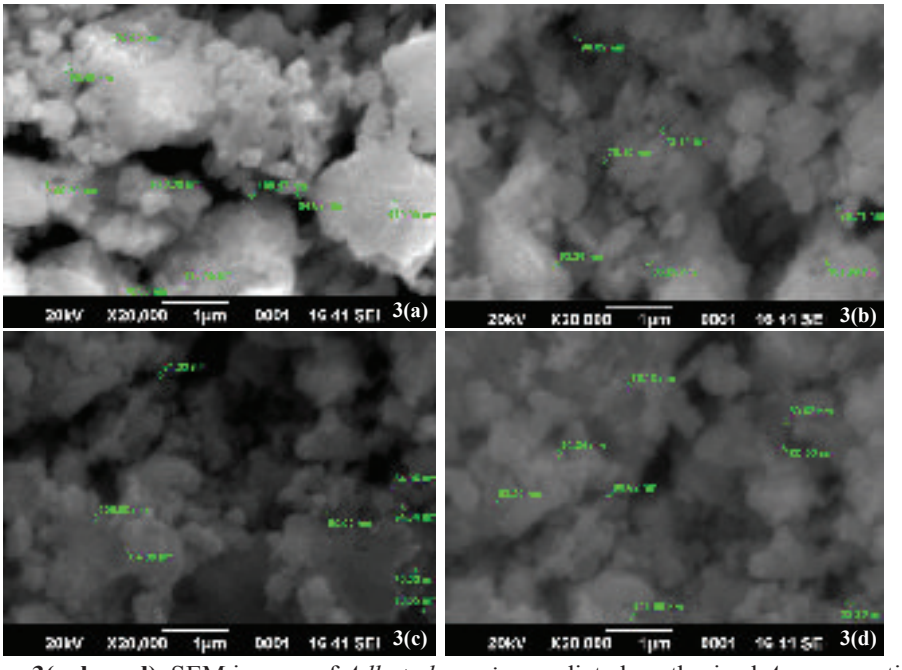

Figure 3(a, b, c, d). SEM images of *Adhatoda vasica* mediated synthesized *Ag* nanoparticles

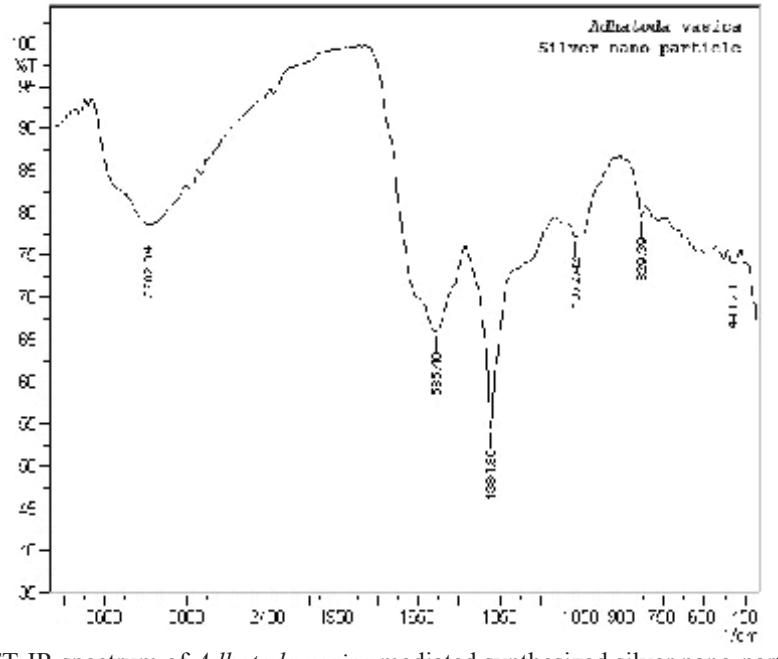

Figure 4. FT-IR spectrum of *Adhatoda vasica* mediated synthesized silver nano-particles

3.2 *Fourier transform infrared spectroscopy (FT-IR) analysis*

FT-IR analysis was carried out to analyze the role of plant extract as capping agent and highly bioreductant agent[34] and functional groups [35, 36]. FT-IR absorption spectra of green Ag nanoparticles is presented as Fig. 4.

The spectra observed by FT-IR analysis was compared with reference value previously published by Coates [37]**.** The spectra showed broad transmission peak at 3282 Cm^{-1}, which corresponds to hydrogen bonded hydroxyl group (O-H and H stretch) of alcohols and Phenols. 1585 Cm^{-1} corresponds to C=C stretch, which represents alkenes; 1384 Cm^{-1} corresponds to N=O bend as aliphatic nitro compounds; 1072 Cm^{-1} corresponds to C=N stretch that represents aliphatic amines; 829 Cm^{-1} corresponds to aliphatic phosphate symmetric P-O-C and 493^{-1} corresponds to S-S stretch correspondings to Polysulfides.

The study included the synthesis of silver nanoparticles from the aqueous leaf extracts of *Adhatoda vasica* and their characterization. On the basis of observations of present study it is concluded that the aqueous silver ions exposed to the aqueous extract of *Adhatoda vasica* were reduced and nanoparticles were synthesized. The change in the colour of the solution containing the $AgNo_3$ solution and aqueous leaf extract of *Adhatoda vasica* confirmed the formation of the silver nanoparticle. The formation of silver nanoparticles were further confirmed by UV-Vis spectrophotometric and SEM analysis.

4. Acknowledgements

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