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BIOMIMETIC SYNTHESIS OF SILVER NANOPARTICLES USING AQUEOUS EXTRACT OF *AMARANTHUS POLYGONOIDES*

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ABSTRACT

Green nanotechnology involves the application of green chemistry principles to design nanoscale particles, developing facile method of synthesis and its application. This approach aims to synthesize silver nanoparticles using the aqueous extract of *Amaranthus polygonoides*. The formation of silver nanoparticles was confirmed by UV Visible spectroscopy, X-ray diffraction, use of Scherrer's equation Scanning Electron Microscopy and Fourier transform infrared spectroscopy. The size of synthesized silver nanoparticle was found to be less than 50nm.

KEY WORDS: *Amaranthus polygonoides*, Nanoparticles, SEM, FTIR, XRD



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INTRODUCTION

Nanotechnology deals with the development of experimental processes for the synthesis of nanoparticles of different sizes, shape and controlled dispersity. Nanoscale materials and structures are usually ranging from 1-100 nm and is an emerging area of nanoscience and nanotechnology. Synthesis of noble nanoparticles for the applications such as catalysis, electronics, environmental and biotechnology is an area of constant interest¹. Recently, green nanoparticle synthesis has become an important branch of nanotechnology owing to its potential application in biomedical, magnetics, energy science and aerospace industries. Large amounts of nanoparticles can be easily synthesized from plants and the majority of these are nontoxic². The biosynthesis of silver nanoparticles has been reported using bacteria³, fungi⁴, plants, and plant extract⁵⁻⁸. For several years, scientists have constantly explored different synthetic methods to synthesize nanoparticles. Chemical synthesis involves toxic solvents, high pressure, energy and high temperature conversion. Also microbe involved synthesis is not feasible due to its lab maintenance⁹. Green methods of synthesis of nanoparticles are easy, efficient, and eco-friendly in comparison to chemical-mediated or microbe-mediated synthesis. An eco-biological approach to the synthesis of silver nanoparticles is an eco-friendly and cost-effective method as compared to the other chemical and physical methods. Several antibiotics use silver compounds such as metallic silver, silver nitrate, silver sulfadiazine for treatment of burns, wounds and several bacterial infections¹⁰. The silver nanoparticles and Ag⁺ carriers can be beneficial in delayed diabetic wound healing as diabetic wounds are affected by many secondary infections. These nanoparticles can help the diabetic patients in early wound healing with minimal scars. Silver nitrate is still a common antimicrobial used in the treatment of chronic wounds¹¹. This has promoted research in the well known activity of silver ions and silver-based compounds, including silver nanoparticles. Amaranth "the crop of the future", has been proposed as an inexpensive native crop that could be cultivated

by indigenous people in rural areas for several reasons. It is easily harvested, highly tolerant of arid environments, which are typical of most subtropical and tropical regions and seeds are a good source of protein, rich in essential amino acids. *Amaranthus polygonoides* is a species of flowering plant. It goes by the common name of Tropical Amaranth. In the synthesis of nanoparticles chemical methods of synthesis are more common. This may not be economical and eco-friendly. Use of Amaranth makes the process highly economical. In the present work, we report a low cost, non-toxic and easy synthesis of silver nanoparticles by the reduction of silver ions using the aqueous extract of *Amaranthus polygonoides* under various experimental conditions.

MATERIALS AND METHODS

(i) Preparation of the extract

The fresh leaves of *Amaranthus polygonoides* (20g) were washed thrice thoroughly with double distilled water. Leaves were finely cut and boiled for 5mins with 100 ml of distilled water in a 500 ml Erlenmeyer flask. The prepared extract was filtered through Whatman filter paper and stored at -4° C for further experiments.

(ii) Synthesis of silver nanoparticles

The aqueous extract of *Amaranthus polygonoides* was treated with aqueous solution of 3mM silver nitrate under various experimental conditions.

a) Conventional method

The plant extract (1ml) was mixed with different concentrations (6ml, 7ml, 8ml, 9ml and 10ml) of silver nitrate solutions and kept at room temperature.

b) Higher temperature method

Different concentrations (6ml, 7ml, 8ml, 9ml and 10ml) of silver nitrate solutions and aqueous

extract (1ml) were maintained at a temperature (75°C) using steam bath, till the formation of silver nanoparticles.

c) Sonication method

Different concentrations (6ml, 7ml, 8ml, 9ml and 10ml) of aqueous silver nitrate and plant extract were sonicated using ultrasonic bath (PCI Ultrasonics 1.5 L (H) till the formation of silver nanoparticles.

(iii) Separation of silver nanoparticles

The reddish brown silver solution was centrifuged (Spectrofuge 7M) at 13000 rpm for 15 minutes and again redispersed the particles and centrifugation. The supernatant solutions were analyzed for further experiments.

(iv) Characterization of silver nanoparticles

a. UV-visible spectra analysis

The bioreduction of silver ions in aqueous solution was monitored by UV-visible spectra of the supernatant solution as a function of time at room temperature using Double beam spectrophotometer 2202 (Systronics).

b. XRD analysis

X-ray diffraction (XRD) analysis of drop-coated films of silver nanoparticles in a glass substrate was prepared for the determination of the formation of Ag nanoparticle by an Lab X XRD-6000 (Shimadzu) operated at a voltage of 40 kV and a current of 30 mA with Cu K α radiation.

c. Determination of crystalline size of AgNPs

XRD patterns were analyzed to determine peak intensity, position and width. Fullwidth at half maximum (FWHM) data, was used with the Scherrer's formula to determine mean particle size. The Scherrer's equation is given by $D = 0.94\lambda/\beta\cos\theta$ where d is the mean diameter of the nanoparticles, λ is wavelength of X-ray radiation source, β is the angular FWHM of the XRD peak at the diffraction angle θ in radians¹²⁻¹³.

d. SEM observation of silver nanoparticles

SEM samples of the aqueous suspension of silver nanoparticles were fabricated by dropping the suspension onto glass substrate and allowing water to completely evaporate. SEM observations were carried out on a TESCAN Electron microscope (Vega TC software).

e. FTIR analysis of silver nanoparticles

The aqueous solution of synthesized silver nanoparticles after centrifugation was analyzed by FTIR spectrum (Bruker FTIR Tensor-27).

RESULTS AND DISCUSSIONS

Green synthesis of silver nanoparticles using 3mM AgNO₃ and different volume fractions of aqueous extract of *Amaranthus polygonoides* are shown in (Fig 1). (Fig 2) shows the characteristic surface plasmon resonance (SPR) absorption band at 425nm for reddish brown silver nanoparticles as 1ml of plant extract solution is used. Silver NPs have unique optical properties because they support surface plasmons. At specific wavelengths of light the surface plasmons are driven into resonance and the AgNPs have a distinct color that is a function of their size, shape and environment¹⁴⁻¹⁵. A concentration variation study of AgNO₃ using aqueous extract was carried out under various conditions. (Fig 2) shows that increasing intensity of 425nm SPR band with increasing concentration of AgNO₃, another band at 465nm is appeared. Increasing intensity of the 425nm SPR band indicates increasing concentration of particle. It is observed that the surface plasmon resonance band occurs at 425 nm and steadily increases in intensity as a function of concentration. To optimize the reaction time, a time variation study was carried out using the optimized concentration of aqueous extract (1ml) and silver nitrate shown in (fig 3). From this figure, it is quite evident that the rapid biosynthesis of silver nanoparticles can be achieved at higher temperatures compared to conventional and sonication methods.

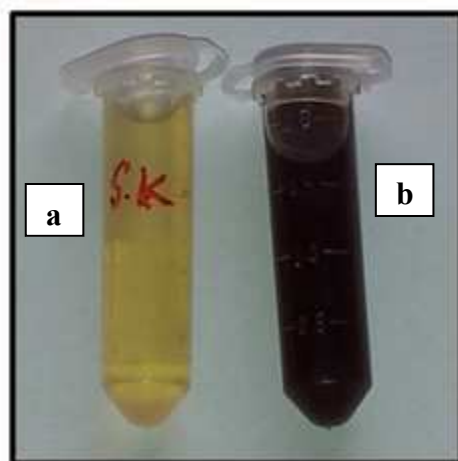


Figure 1
Amaranthus polygonoides- Colour change of extract containing Ag before (a) and after synthesis of Ag nanoparticles (b)

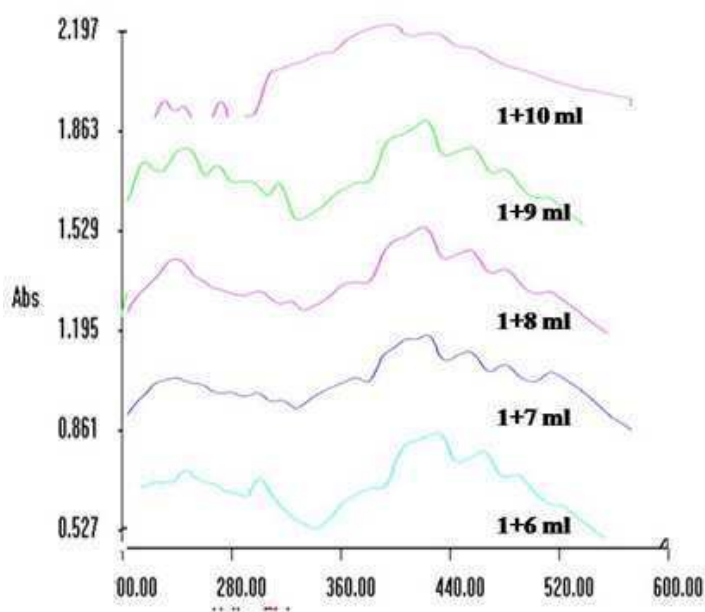


Figure 2
UV-Visible spectra absorption spectra of silver nanoparticles from extract of Amaranthus polygonoides and silver nitrate solution at different concentrations

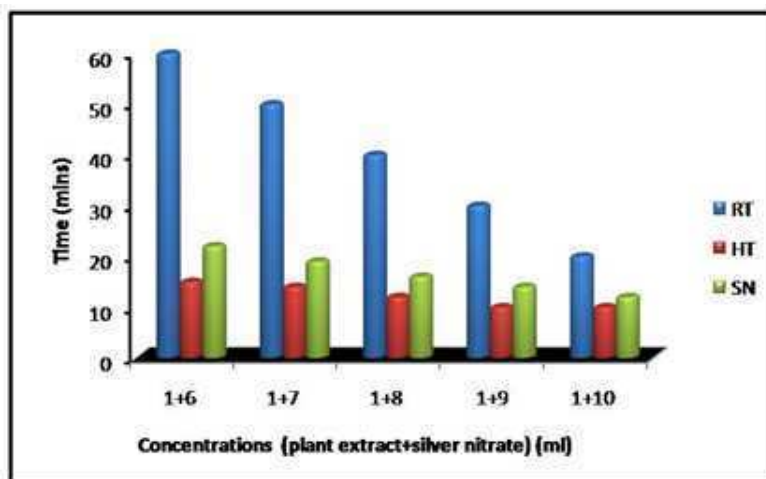


Figure 3
Comparative studies of different methods as a function of time

(Fig 4) shows that the XRD patterns of drop coated silver nanoparticles synthesized using aqueous extract of *Amaranthus polygonoides*. The XRD pattern showed three intense peaks of Bragg reflections with 2θ values of 27.38° , 31.95° and 38.40° set of lattice planes are observed which may be indexed to the (220), (101) and (111) based on face centered cubic

structure of silver respectively (JCPDS no. 04-0783)¹⁶⁻¹⁷. XRD pattern thus clearly illustrates that the silver nanoparticles formed in this present synthesis are crystalline in nature. The average size of the silver nanoparticles was estimated from the FWHM of the (111) peak using the Scherrer's formula is 16.03nm is given in table.1.

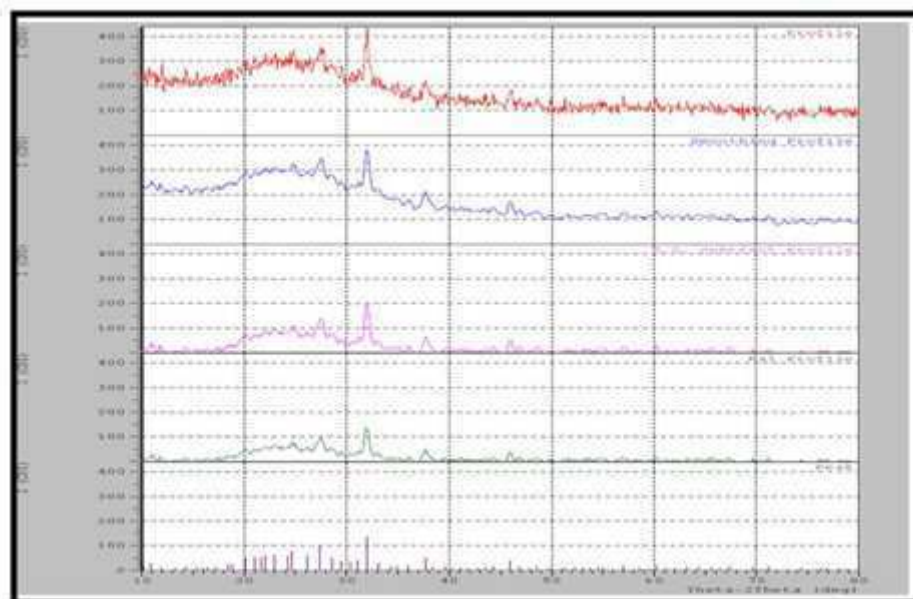


Figure 4
XRD pattern of drop coated silver nanoparticles synthesized using aqueous extract of *Amaranthus polygonoides*.

Table 1
Determination of crystalline size of AgNP's by using Debye-Scherrer's equation

S.No	2 θ	FWHM	$\beta = \pi * \text{FWHM} / 180$	$D = k \lambda / \beta \cdot \text{Cos}\theta$
1.	31.9594	0.6188	0.01079	13.37
2.	27.3500	1.2250	0.02136	6.68
3.	38.4000	0.3000	0.00523	28.05

Average size of the nanoparticle = $13.37 + 6.68 + 28.05 / 3 = 16.03\text{nm}$

SEM micrograph recorded from a drop coated films of silver nanoparticles synthesized using aqueous extract of *Amaranthus polygonoides* after reaction with silver nitrate solution shows

that the sample composed of large number of silver nanoparticles (fig 5). The diameter of the silver nanoparticles was in the range from 40-50 nm, possessing spherical shape.

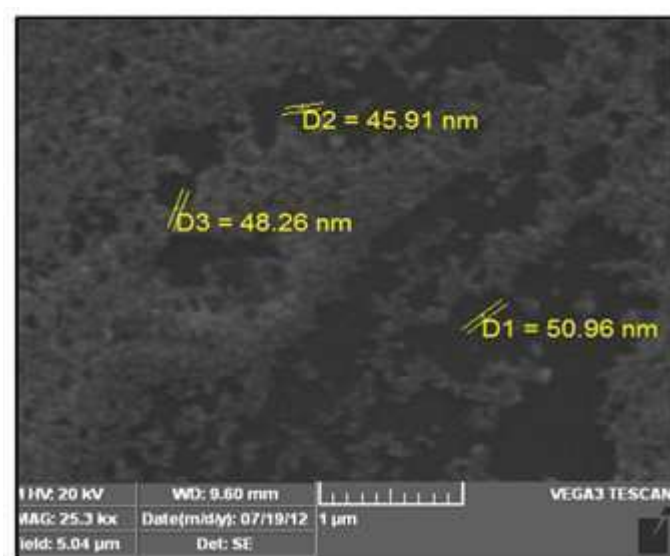


Figure 5
SEM micrograph of drop coated silver nanoparticles synthesized using Aqueous extract of *Amaranthus polygonoides*.

The FTIR spectra of the synthesized silver nanoparticles from aqueous extract of *A. polygonoides* in (fig 6) shows the presence of various functional groups. The peaks located at 1595 and 1484 cm^{-1} are associated with the stretching vibrations of $-\text{C}-\text{C}-$ in aromatic ring. The vibration frequencies at 1667 cm^{-1} , 2422

cm^{-1} and 2507 cm^{-1} are assigned as absorption peaks of CN double and triple bonds respectively. Thus the presence of above functional groups revealed that the amide groups in protein linkage of the extract may be responsible for the reduction of silver ions.

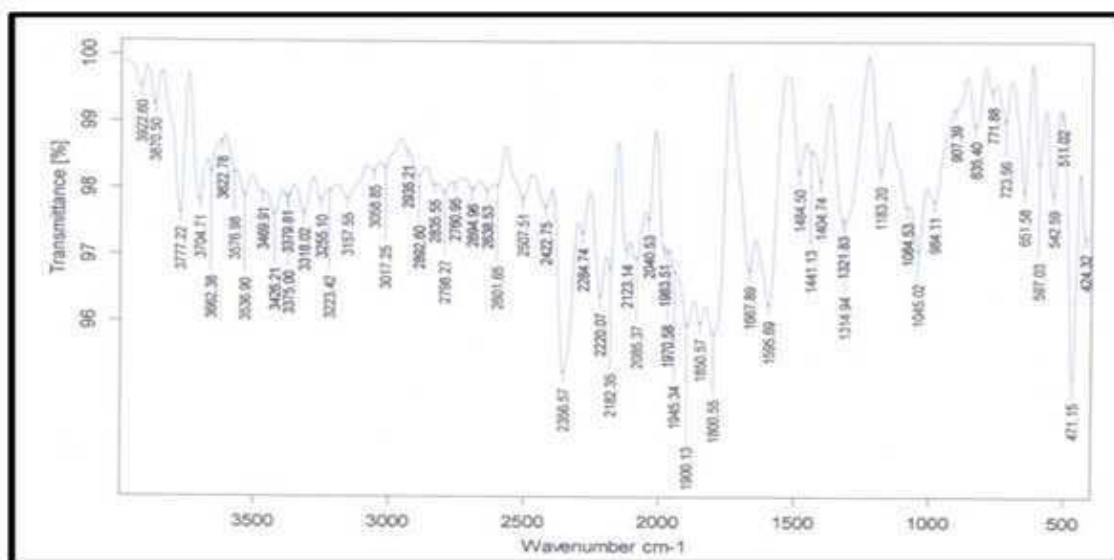


Figure 6
FTIR spectra of the synthesized silver nanoparticles from aqueous extract of *A. polygonoides*

CONCLUSION

A facile method of synthesizing silver nanoparticles from the aqueous extract of *A. polygonoides* under various experimental conditions is reported. The concentration of silver nitrate and the aqueous extract of *A. polygonoides* play an important role in size and shape of the synthesized silver nanoparticles.

Comparative study of various methods revealed that high temperature method results in rapid synthesis of silver nanoparticles. The size of the nanoparticle was found to be less than 50 nm possessing spherical shape which was confirmed by XRD and SEM analysis.

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