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Synthesizing Silver Nanoparticles Biogenetically Using Easily Accessible Weeds

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ABSTRACT

Greener approach for fabrication of metal nanoparticles (NPs) with catalytic properties and their small size has smoothened the way to get better and shield the ecosystem by lessening the use of hazardous chemicals. Weeds are the beneficial resource for synthesizing silver nanoparticles. Weeds provide simple, effortless way with a faster rate of synthesis and are eco-companions. In this study, four weeds, namely, *Solanum nigrum*, *Cannabis sativa*, *Parthenium hysterophorus* and *Calotropis gigantean* were taken for the synthesis of silver nanoparticles (AgNPs). The silver ions are reduced by the aqueous leaves extract. Visual colour change shows the formation of silver nanoparticles, but it is confirmed by the UV-visible spectra. The UV-Visible spectral analysis revealed distinct bands centered at 417 nm for *S. nigrum*, at 405 nm for *C. sativa,* 417 nm for *P. hysterophorus* and 427 nm for *C. gigantean*. The size of the green synthesized AgNPs and their morphology were determined by transmission electron microscopy (TEM) analysis. TEM analysis showed the average particle size from 16-20 nm for synthesized AgNPs. The morphology of AgNPs was predominantly spherical. This paper reports a simplistic and faster biosynthetic route for AgNPs from potential weeds like *S. nigrum, C. sativa, P. hysterophorus* and *C. gigantean.* Results revealed that plants were the efficient source for AgNPs fabrication, which had many applications in diverse fields.

Key words : Green synthesis, silver nanoparticles, weeds, *Solanum nigrum, Parthenium hysterophorus, Cannabis sativa, Calotropis gigantean,* TEM

INTRODUCTION

Advancement of environmental tuned and greener processes for creation of noble metal nanoparticle are growing into a main branch of nanotechnology. Metal nanoparticles (NPs) are having exclusive properties (physical and chemical) like large surface/volume ratio (Guo *et al.*, 2013; Saha *et al.*, 2017) optical and electronic properties associated with the quantum size effect. NPs can be synthesized using different methods e. g. chemical methods, physical methods and biological methods (Huang *et al.*, 2011). Biological systems for nanoparticle synthesis include fungi, yeasts, bacteria and the most vital plant extracts (Arya, 2010). Biological methods are the economical and eco-friendly choice and superior substitute for chemical and physical methods. As a result, materials with their size in nano range have been synthesized by plant extracts as well as microorganisms. Instead, plants are the better choice for the synthesis of NPs as they are even profitable over microorganisms because microorganism requires proper maintenance of cell cultures and also there is a risk of biohazards (Njagi *et al.*, 2010; Zargar *et al.*, 2011).

Greener ways of synthesizing metal nanoparticles have established as clean and safe method against chemical and physical ones. Accepting the greener approach could be a easy way of metal nanoparticle synthesis on a larger scale, without the need of any toxic or harmful chemical, high energy and temperatures and pressure (Gul *et al.,* 2016; Ismail *et al.,* 2016). It is an economical and simplistic route to metal nanoparticles production through environmentally benign approach. This facilitates the possibilities to come closer to the natural products which are cheap and widely available and lessen the use of industry based products, on the other hand, also provides an active coating of biological residues on the nanoparticle surface (Dar *et al.,* 2013; Dwivedi *et al.,* 2015). AgNPs are antimicrobial, anti-inflammatory, anti-fungal, anti-viral, antiplatelet activity and antiangiogenesis (Priyadarshini *et al.,* 2013). AgNPs have also been used as biosensors and in wastewater purification, etc. (Park, 2014; Banerjee *et al.*, 2014).

AgNPs have been synthesized through a green approach using different weeds, namely, *Solanum nigrum, Cannabis sativa, Parthenium hysterophorus* and *Calotropis gigantean.* AgNPs formed are synthesized through the process of reduction of Ag^{+} using leaf extract of different weeds used. *P. hysterophorus* is a harmful weed species of Asteraceae family. *P. hysterophorus* contains compounds like ambrosin, hysterin, flavonoids, such as 6-hydroxyl kaempferol 3-0 arabinoglucoside, quercelagetin 3, 7-dimethyl ether, fumaric acid and alcohols (Lata *et al.*, 2008). Plants of the genus *Cannabis* are found in the Northern Hemisphere. The *Cannabis,* a potential weed, has approximately 400 known secondary metabolites out of which more than 60 of which are cannabinoid compounds (Pearce *et al.,* 2014; Singh *et al.,* 2018). Genus *C. gigantean* belongs to family Asclepiadaceae. These species are generally salt tolerant, drought resistant and can grow up to 900 meters (msl) all over the nation. Leaves of this weeds have compounds generally the amyrin acetate, amyrin, ß-sitosterol, calotropin, urosolic acid, cardenolide, calotropagenin (Balaji *et al.*, 2015). *S. nigrum* is commonly called as black night shade and in Hindi as Makoi. It is medicinal plant of family *Solanaceae.* Since history it has been used for the treatment of many illnesses such as gastrointestinal diseases and inflammation fever. It also cures STDs (sexually transmitted diseases). This weed is accomplished with anti-oxidant, anti-tumorigenic, diuretic, anti-inflammatory and anti-bacterial behaviour. *S. nigrum* has the property to bioreduce the metal ions as this contains various biomolecules e.g. glycoproteins, glycoalkaloids, polysaccharides, polyphenolic compounds, etc. Therefore, the aim of the study conducted is fast fabrication of green synthesize AgNPs by means of leaves extract of *S. nigrum, C. sativa, P. hysterophorus* and *C. gigantean.* This green process of bioreduction of Ag^{+} ions results in high density stable AgNPs.

MATERIALS AND METHODS

Weeds, namely, *S. nigrum*, *C. sativa*, *P. hysterophorus* and *C. gigantean* were collected from the Maharishi Dayanand University, Rohtak, Haryana (India). Silver nitrate ($AgNO_3$) pure, was procured from Central Drug House (P) Ltd, New Delhi. Analytical grade chemicals were used without any extra purification. For the preparation of aqueous solutions double distilled water was utilized throughout the experiment. All glass wares were rinsed with nitric acid.

The collected weed samples were washed thoroughly under running tap water and again with distilled water and then oven-dried at 70^{o} C. The dried plant samples were pulverized to a fine powder using mortar and pestle. To prepare aqueous leaf extract, 2.0 g powder of dried leaf was taken to dissolve in 100 ml of double distilled water and further boiled for 10 min at 60^{o}C. Filtrate was thus acquired after filtration of boiled leaf extract through Whatman No. 1 filter paper. Filtrate was refrigerated at 4°C. The extract thus made was used within seven days of preparation, because the extracts retained their integrity only up to seven days since there is no variation in the extent of synthesized AgNPs (Ganaie *et al.*, 2016). 1 mM metal ion solution was prepared by dissolving 0.169 g of silver nitrate in 1000 ml distilled water. The weed extract of the plants was added to silver nitrate in the ratio of 1 : 5.

UV-visible spectroscopy technique is generally used for metal NPs characterization. Noble metal NPs exhibit specific Surface Plasmon Resonance (SPR) which show peak specific characteristic for each metal. The characteristic SPR of colloidal AgNPs ranges between 390 nm to around 420 nm due to Mie scattering (Kleemann, 1993). UV-visible spectra were recorded as a function of reaction time at wavelength 300 to 700 nm with a dual beam UV Vis spectrophotometer (Lab India analytical UV 3000^{+}; Sr. No.-22-1885-01-0044). Double distilled water has been used as a reference for background correction of readings. The radiation source used was a Tungsten Lamp. The reduction of Ag^{+} metal ions was monitored using UV-Visible spectrum of reaction suspensions.

Transmission electron microscopy (TEM) measurements were achieved using model no-TECHNA G^{2}-20 S-Twin-HRTEM from fEI company, Holland to confirm the particle size and morphology, operated at an accelerated voltage of 200kV. This facility of TEM was availed from All India Institute of Medical Sciences (AIIMS), New Delhi.

RESULTS AND DISCUSSION

In aqueous solutions, AgNPs reflect yellowish colour. Transparent $AgNO_3$ was transformed to a yellowish colour minutes after adding the different leaf extracts of weeds (*S. nigrum, C. sativa, P. hysterophorus* and *C. gigantean*). The reason for this colour change in aqueous solution is because of the occurrence of phenomenon called "surface plasmon resonance (SPR)," an optical characteristic of AgNPs. This phenomenon is associated with characteristic surface plasmon spectra of every metal nanoparticle (Rajasekharreddy *et al.,* 2010). The shape and size of the particle, degree of charge transfer between the particle and the medium and also interaction with the medium contributes in the formation of SPR (Bhakya *et al.*, 2015). Carrillo-López *et al.* (2014) observed that after adding the leaf extract to the transparent 10 mM $AgNO_3$ ion solution, colour attained was yellowish brown though the colour becomes more intense as we add the leaf extract with time.

UV-Vis spectroscopy was done to confirm the formation of AgNPs through the process of bioreduction of silver metal ions through exposure to the different weed extract. Fig. 1 (a-d) shows the peaks of UV-Vis spectra recorded of the reaction for silver nitrate and extract of different weeds. It was observed that the maximum absorbance of AgNPs occurred at 417 nm for *S. nigrum* (Fig. 1a), at 445 nm for *C. sativa* (Fig. 1b) and 417 nm for *P. hysterophorus* (Fig. 1c) and at 427 nm for *C. gigantean* (Fig. 1d). Awwad *et al.* (2013) recorded the absorbance peak at 420 nm, it confirms the bioreduction of silver metal ions into AgNPs. The silver ions were reduced to AgNPs as the reaction started and reaction was completed within 2 min at room temperature, indicating fast biosynthesis of AgNPs.

The synthesized AgNPs were subjected to transmission electron microscopy for the analysis of size and shape of the prepared AgNPs. The TEM images of the AgNPs are shown in Fig. 2 (a-d). AgNPs of spherical shapes were obtained with diverse number and nature of biomolecules present in the leaf extract which play role of reducing and capping agents. TEM images show the prepared metal nanoparticles having an average size ranging from 10-22 nm. Dwivedi and Gopal (2010) represented TEM micrographs of leaf extract of different plants and metal ion concentration. At 1 mM concentration of silver nitrate, the spherical and some triangular NPs were formed with 10-30 nm in size. The solvents used and also the reducing agents can affect the morphological

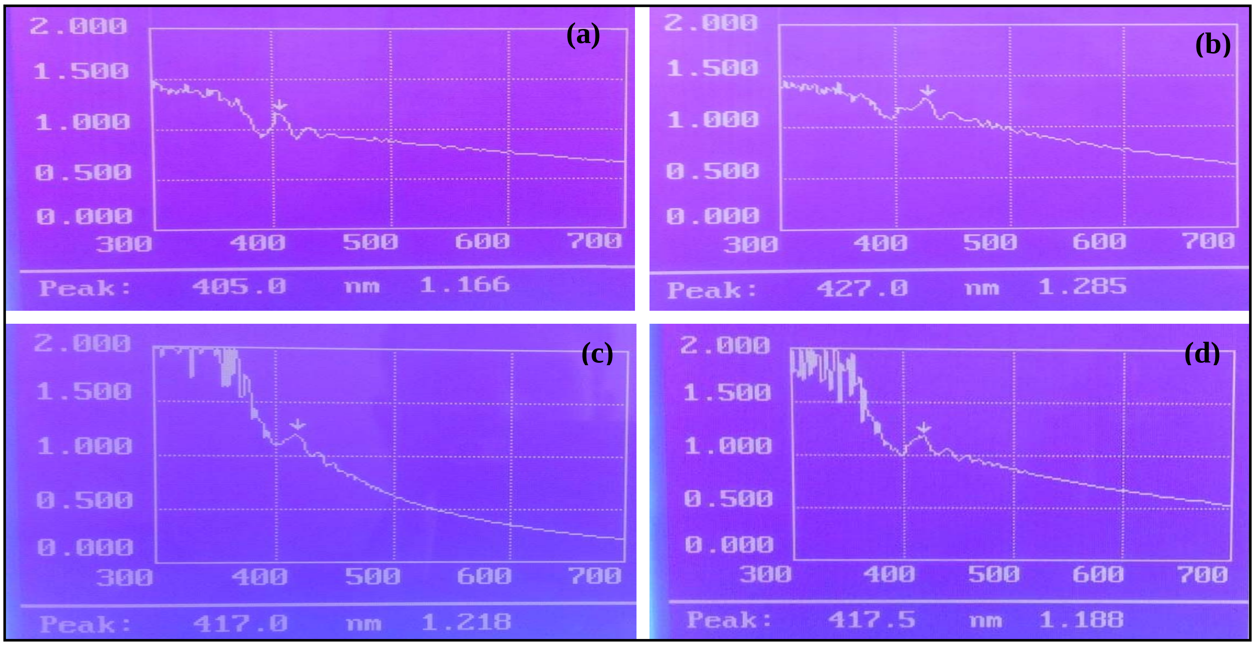

Fig. 1. UV-vis spectral analysis of silver nanoparticles synthesized using (a) *Cannabis sativa,* (b) *Calotropis gigantean,* (c) *Solanum nigrum* and (d) *Parthenium hysterophorus.*

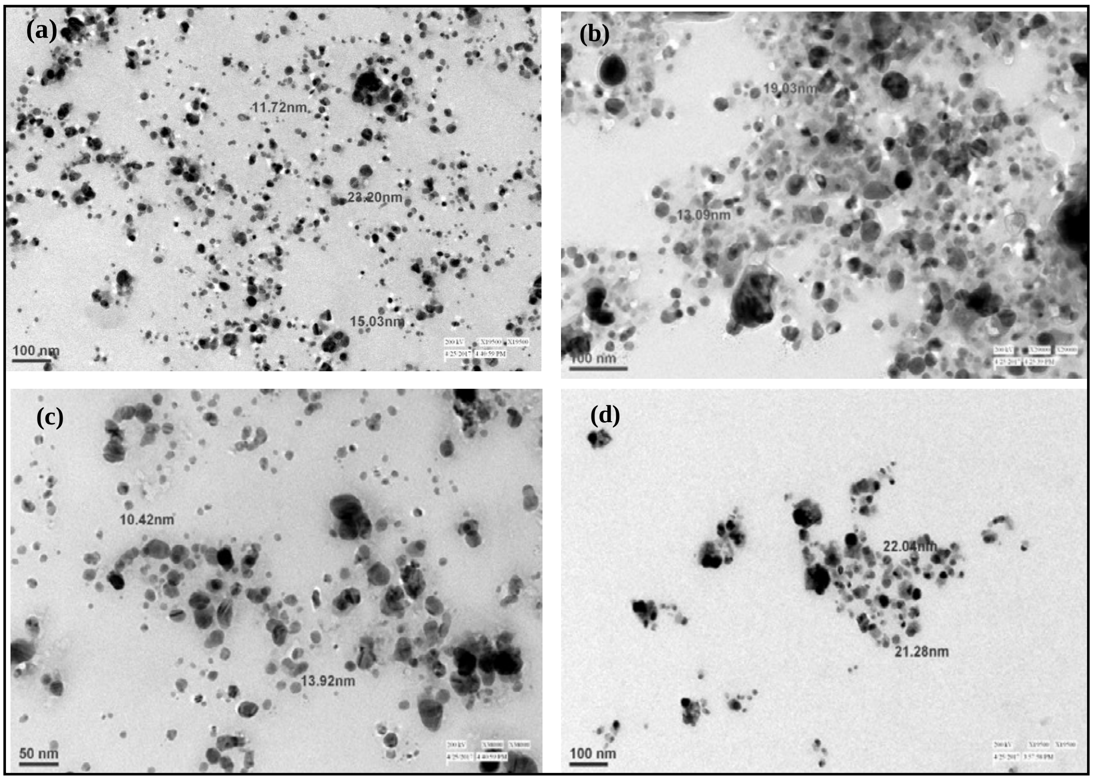

Fig. 2. TEM micrograph of silver nanoparticles synthesized from (a) C*annabis sativa,* (b) *Calotropis gigantean,* (c) *Solanum nigrum* and (d) *Parthenium hysterophorus.*

as well as physical features of AgNPs. The morphology of AgNPs is determined by reducing precursor. The variation in size, shape and morphology influenced the applications of the NPs (Khatoon and Sardar, 2017).

CONCLUSION

In to-day's era, there is a vast progress in the field of nanotechnology. In this paper, the process of fabrication of metal nanoparticles has been well described through the process of bioreduction of Ag^+ ions by addition of different weed extracts. Since there are various routes available for the synthesis of metal NPs, the emphasis should be towards greener mechanism for a healthier ecosystem. The synthesis was accomplished in a single step, without the use of any surfactants or protecting agents. Presence of bioreducing agents in the leaf extract is the reason for Ag^+ ions reduction. Capping agents provide the better stability to the green synthesized AgNPs and hence prevent their aggregation. Metallic NPs reveal better performance in environmental remediation and treatment of hazardous waste than other conventional techniques. Among various green synthesized metal nanoparticles, silver nanoparticles are of high purity, have promising applications for many environmental applications. This study concluded that weeds could be a superior source of reduction for metal NPs fabrication.

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