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Casuarina equisetifolia Leaf Extract Mediated Biosynthesis of Silver Nanoparticles

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ABSTRACT

In the present work, biosynthesis of silver nanoparticles (Ag NPs) was synthesized from silver ion using the reducing agents of *Casuarina equisetifolia L.*, leaf extract. Initially, the reaction mixture color change has visually identified the product of Ag NPs. The UV-Vis absorbance of the surface plasmon resonance band at 425 nm was confirmed the formation of Ag NPs. FTIR spectroscopy has to identify the presence phytochemical functional group in the extract and capping the NPs. The powdered X-ray diffraction (XRD) analysis of four peaks was identified the fcc crystal nature of synthesized Ag NPs. The surface morphology of the Ag NPs was viewed by High resolution transmission electron microscopic (HRTEM) with selected area electron diffraction (SAED) technique, the spherical shapes of NPs with sizes from 14 to 50 nm.

1. Introduction

Nanotechnology is the newest and one of the most promising areas of research in modern science and technology. Syntheses of metal nanoparticles (MNPs) are being different physicochemical composition. The MNPs has environmentally nontoxic, energy efficient and low cost synthesis method as compared to the chemical method. MNPs show to enormous potential application in medicine, biology, material science, physics, chemistry, photography, catalysis, biological labeling, and photonics, optoelectronics [1-5]. Recently, *Ocimum sanctum* leaf extract used biosynthesis of stable Ag NPs with size range 4-30 nm and used in antimicrobial activity [6]. *Cacumen platycladi* leaves extract was used in the green synthesis of Ag-Pd alloy nanoparticles and its excellent catalyst for the hydrogenation of 1,3-butadiene [7]. Mostly the plant extract contains the major phytochemicals such as tannins, saponins, flavonoids, amino acids, and carbohydrates are present. These compounds are good reducing and stabilizing agents of the green/bio-synthesis of MNPs.

Casuarina equisetifolia L., belongs to Casuarinaceae family and its commonly known as coastal she oak tree. The leaf of *C. equisetifolia* are used as folk medicine for the treatment of nervous disorders, dysentery, diarrhea, stomach-ache, cough, ulcers, toothache, lotion for swelling, diabetes, and powder bark for treating pimples on the face [8-10]. The isolated major/minor phytochemical compounds such as kaempferol, quercetin, alicyclic acids (shikimic acid and quinic acid), amino acids, lupenone, lupeol, gallic acid, catechin and gallocatechin [11, 12]. The present work reports, green synthesis of Ag NPs was synthesized from reducing agents of the medicinally valuable plant *C. equisetifolia* leaves extract.

2. Experimental Methods

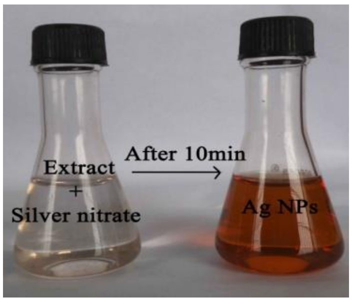
2.1 Preparation of Plant Extract and Green Synthesis of Silver NPs

The healthy leaf of *Casuarina equisetifolia* L., (12 g) was collected from Manonmaniam Sundaranar University main campus, Tirunelveli, Tamil Nadu, India during the month of January 2014. The *C. equisetifolia* leaf was washed with running tap water followed by triple distilled water in order to remove the dust particles. The washed leafs were taken in a 250 mL Erlenmeyer flask; add 100 mL distilled water and boiled at 80 °C for 10 min. After, the leaf extract was filtered through Whattman No.1 filter paper and stored at 4 °C for further uses in the green synthesis of Ag NPs. In the typical process, green synthesis of Ag NPs was synthesized from 8 mL of 1 mM silver nitrate using 0.1 mL of the reducing agents of *C. equisetifolia* leaf extract at room temperature. The obtained Ag NPs were periodically characterized by various spectral techniques.

2.2 Characterization of Silver Nanoparticles

The green synthesized Ag NPs was characterized by UV-vis spectrophotometer on a Perkin–Elmer (model Lambda 25) instrument and the absorbance was measured in the wavelength region at 200–800 nm with a resolution at 1 nm. The performed Ag NPs were centrifuged at 10,000 rpm speed at 10 min to obtain the NPs residues. The obtained residual part of Ag NPs was thoroughly washed with triple distilled water to remove the untreated biomasses and dried in hot air oven at 60 °C for 24 h. FTIR spectra were recorded by JASCO FTIR spectroscopy using a KBr pellet disc technique in the range of 4000-400 cm^{-1} with resolution at 4 cm^{-1}. XRD analysis was recorded by PAN analytical X'PERT-PRO Powder X-ray diffractometer. The sample scanning speed at 0.02 min per degree at the anode materials CuKα radiation (1.5406 Å) recorded a 2θ range in 20-80° of the spectrum. Further, the surface morphology and the sizes of the Ag NPs were viewed by HRTEM spectroscopy in TECNAI T30 G^2 S-TWINFEI (Netherland) instrument with a selected area electron diffraction (SAED) pattern. The colloidal Ag NPs solution was loaded with carbon-coated copper grid and allowed to dry in a vacuum.

3. Results and Discussion



(a) (b)

Fig. 1 Formation of Ag NPs in the visible observation: a) silver ions with *Casuarina equisetifolia* leaf extract at initial time; b) after 10min of reaction mixture

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Green synthesis of Ag NPs was synthesized from the aqueous silver ions (10^{-3} concentration) using the biomass reducing and capping agents of *C. equisetifolia* leaf extract. After 10 min, the colourless (Fig. 1a) reaction mixture was changed to yellowish brown (Fig. 1b) indicates the formation of Ag NPs respectively [13, 14]. The stability of the NPs solution was monitored by UV-vis spectroscopy at the different time intervals (Fig. 2). This UV-vis SPR value at 425 nm was confirm the product of Ag NPs [15]. After 7 h, there is no changes the absorbance intensity to identified the maximum amount of silver ions was reduced to metallic silver in the present reducing agents of leaf extract.

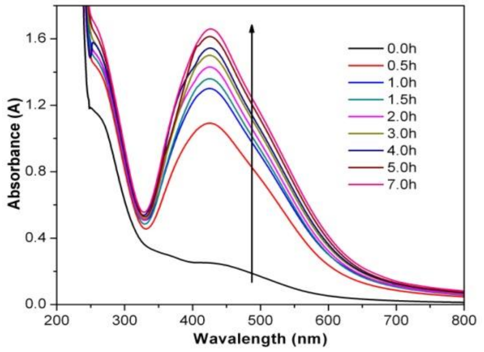

Fig. 2 UV-Vis absorption spectra of the synthesis of Ag NPs at different time intervals

FTIR spectra indicated the possible functional groups intensity were increased and decreased the Ag NPs and *C. equisetifolia* leaf extract. Fig. 3 showed prominent transmission peaks of leaf extract at 3413, 2884, 1701, 1636, 1521, 1365, 1214, and 1073 cm^{-1}. Similarly, Ag NPs obtained peaks at 3440, 3113, 2887, 1705, 1636, 1515, 1375, 1188, and 1088 cm^{-1}. The O-H stretching of the hydroxyl group of the broad peak at 3413 cm^{-1} was indicated leaf extract to shifted at 3440 cm^{-1} and decreases the intensity of the formation of NPs. A small peak at 2884 and 2887 cm^{-1} is due to the symmetric stretching of a C-H group of leaf extract and NPs respectively. The characteristic band at 1521, and 1520 cm^{-1} indicates the bending vibrations of the N-H group. The sharp bands at 1705 and 1701 cm^{-1} are due to carbonyl stretching groups of extract and NPs respectively. The two bands at 1639 and 1636 cm^{-1} were represented by an amide group. The value at 1375cm^{-1} may be interpreted to C-O stretching mode [16]. The FTIR spectra results were formerly reported the leaf extract phytochemicals such as polyphenols, tannin, flavonoids (kaempferol, quercetin), and amino acid might be reducing and capping agent in the synthesis of Ag NPs [14, 16, 17].

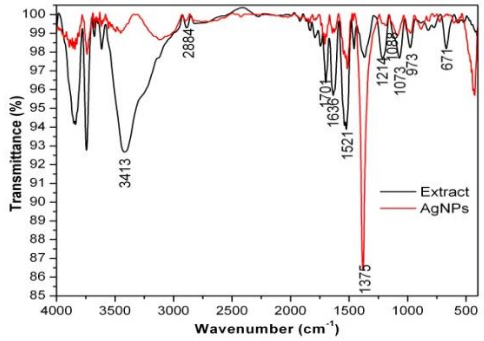

Fig. 3 FTIR Spectrum of Ag NPs and *C. equisetifolia* leaf extract

In the green synthesized Ag NPs solution was centrifuged at 10,000 rpm for 10 min to obtained crystalline residues. Fig. 4 shows a number of XRD peaks at 38.09, 44.29, 64.52 and 77.47 was identify the corresponding to the lattice planes (111), (200), (220), and (311) of face centered cubic crystal structure of Ag NPs. The XRD pattern results are corroborated with the data base of the Joint Committee on Powder Diffraction Standards (JCPDS, file no. 04-0783). The Ag NPs size was theoretically calculated the width of the XRD values using the Debye-Scherrer formula (1) [18-20],

$$D = K\lambda/\beta\cos\theta \qquad (1)$$

where D is the average crystalline domain size perpendicular to the reflecting planes, K is a shape factor, λ is the X-ray wavelength, β is the full width at half maximum (FWHM) and θ is the diffraction angle. The calculated average particle size of the metallic silver was found to be 26 nm.

The surface morphology of Ag NPs was viewed by HRTEM, the lower magnification image (Fig. 5a) represent to the morphology of the particles has spherical shapes. At higher magnification image (Fig. 5b and 5c) shows the Ag NPs sizes from 14 to 50 nm. The selected area electron diffraction (SAED) ring pattern of the metallic Ag suggests single crystalline (Fig. 5d) NPs were oriented with (111) planes respectively, reported [21].

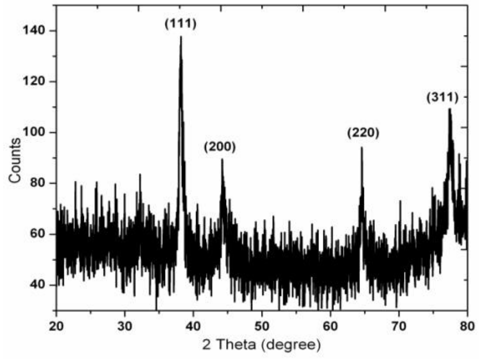

Fig. 4 XRD analysis of the green synthesized Ag NPs

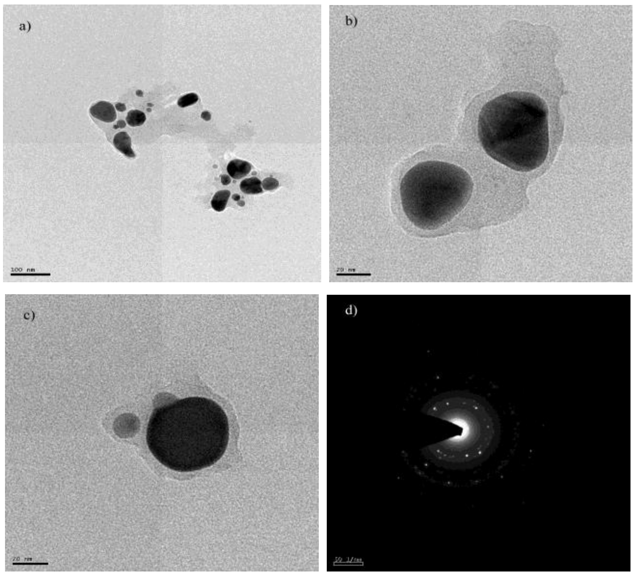

Fig. 5 HRTEM images of Ag NPs: a) lower magnification; b) & c) Higher magnification images of particles; d) SAED pattern

4. Conclusion

Green synthesis of Ag NPs is an economical, eco-friendly, nontoxic, and simple one step synthesis. The synthesized Ag NPs were confirmed by the change of colour, UV-Vis absorption of the SPR value at 425 nm, FTIR spectra, and XRD analyses. From the HRTEM images, the Ag NPs are spherical shapes with sizes 14-50 nm. The *C. equisetifolia* leaf extract phytochemicals such as polyphenolic groups of tannin, kaempferol, quercetin, catechin and gallocatechin seem to play an important role in reducing and stabilizing agents in the synthesized Ag NPs.

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