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Green Synthesize and Characterization of the Plant Mediated Silver Nanoparticles Using Solanumnigrum Leaf Extract

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Abstract: ***Green synthesis of silver nanoparticles using medicine plant extracts has gained keen interest due to their unique attractive physiochemical properties and surface to volume ratio. Hence, in the present study, medicinal plant Solanumnigrum (SN) aqueous leaf extract has been used to produce the silver nanoparticles (Ag NPs). The crystal structure and size of nanoparticle has been studied by using X-ray diffraction and transmission electron microscopy analysis. The calculated particle size is found to be around 20 nm; therefore, this can be used in vivo and in vitro biomedical applications. The silver nanoparticles reveal good antibacterial activities against both gram positive (Staphylococcus aureus) and gram negative (Escherichia coli) microorganisms. UV-Visible spectroscopy exhibited the absorbance peaks in the range of 430 nm. Compounds adsorbed on the surface of the silver nanoparticles were studied by FTIR analysis. Results confirmed that this method is a simple; cost effective, fast, eco-friendly, nontoxi c and an alternative conventional physical/chemical methods.***

Keywords: Green synthesis, Ag NPs, Antibacterial activities, Plant extract

1. Introduction

Recently, the progress of efficient green chemistry approaches for production of metal nanoparticles has become a major attention of scientific community [1-2]. They have intensively studied in order to realize an eco-friendly technique for synthesize of well-characterized nanoparticles. Metal nanoparticles prepared by using organisms are playing a vital role in medicine chemistry [3-4]. Out of all organisms, plants are the potential candidates in the production of large-scale biosynthesis of nanoparticles. Plants mediated nanoparticles are more stable and the rate of synthesis is so rapid due to their significant intrinsic properties such as enzyme activities and biochemical pathways. For instance, heavy metal accumulation and detoxification are the prominent candidates for nanoparticle synthesis. Moreover, the advantages of using plant for biosynthesis of metal nanoparticles have attracted researcher's to explore the possible mechanism of metal nanoparticle formation in plants. The various metallic nanoparticles such as gold, silver, platinum, zinc, copper and nickel were produced from medicine plants have been studied intensively [5-8].

Among these, silver nanoparticles have received keen interest due to their peculiar resistance against wide range of microorganisms and the presence of drug resistance against normally used antibiotics. Further, these nanoparticles are extensively used in catalysis, chemical sensing, biosensing, photonics, electronics, and pharmaceuticals [9-10]. The plant mediated silver nanoparticles have potential applications in medical industry such as tropicalointments to prevent infection against burn and open wounds. It is reported that silver nanoparticles possess antifungal, anti-inflammatory, antiviral, antiangiogenesis, and antiplatelet activity [10].

Various physio-chemical methods such as chemical methods [11], micro emulsion [12], electrochemical method [13], laser ablation [14], autoclave [15], microwave irradiation [16] and photochemical reduction [17] have been used to synthesize bio nanoparticles. Though these methods have been effective used, they have some limitations such as toxic, costly and energy needs. These drawbacks have overcome by an alternative method called green synthesis where nanoparticles were synthesized using microorganisms such as plant extracts [18] and natural polymers [19].It is well documented in the literatures about the syntheses of silver nanoparticles using plant extracts. However, there is a demand for commercially feasible, economic and environment friendly method to find capacity of natural reducing constituent to synthesize silver nanoparticles. Since plant extract of same species were collected from various parts of country, there is a substantial variation in chemical compositions of plant extracts. It may lead to different results in different laboratories. To overcome this problem, biomolecules exist in the plant must be identified which are responsible for mediating the nanoparticles preparation for fast single step protocol. It can offer a new modernization towards green syntheses of silver nanoparticles.

Solanumnigrum (SN) is one of the most important traditional medicinal plants belonging to the family of solanaceae and compositae respectively. These leave's extract possess antiseptic, insecticidal and parasiticidal properties. Therefore, these extracts have been proved to have wound healing property. Hence, in the present work, it is attempted to study the synthesis of silver nanoparticles using medicinal plants as shown in Figure 1 and will be characterized by using UV-visible spectrophotometer, Transmission Electron Microscope (TEM), X-Ray Diffaraction and Fourier transform infrared spectroscopy (FTIR).

Figure 1: The photograph of solanumnigrum

2. Experimental Methods

2.1 Biosynthesis of Silver Nanoparticles

Fresh matured leaves of medicine plant Solanumnigrum, free from diseases were collected from Chidambaram region, Tamilnadu, India. The leaves were washed separately using tap water were washed 2–3 times with de-ionized water. 30 g of fresh leaves was finely sliced and added to 100mL of distilled water and stirred at 50 °C for 2 h. After boiling, the mixture was allowed to cool and filtered with Whatman paper number 1. Filtrate was collected and stored approximately at 5 ˚C in the refrigerator for further use.0.2M of aqueous olution of silver nitrate ($AgNO_3$) was prepared and used for the synthesis of silver nanoparticles. 10mL of leaf extract of Solanumnigrum was added to 90mLof 0.2M $AgNO_3$ solution for bioreduction process at room temperature.

2.2 Characterization methods:

UV-Vis spectral analysis has been carried outto calibrate the UV–Vis spectrum of solution between the ranges of 300–600 nm as a function of time at room temperature by using Shimadzu UV-visible spectrophotometer (UV-1800, Japan) with a resolution of 1 nm. FTIR spectroscopy analysis has been performed on silver nanoparticles by using Perkin Elmer 1750 FTIR Spectrophotometer. The crystal structures of the synthesized nanoparticles were confirmed by powder X-ray diffraction using ENRAF NONIUS CAD-4 powder crystal X-ray diffractometer with CuKα radiation. The particle size and surface morphology was studied using Transmission electron microscopy (TEM).

3. Results and Discussion

3.1 Structural analysis

The XRD analysis has been carried out to calculate particles size of these silver nanoparticles. Figures 2 shows the XRD pattern obtained for the silver nanoparticles synthesized using the leaf extract of Solanumnigrum. The sharp peak of silver nanoparticles 13, 14, 17, 20, 27, 29, 38 and 49 in Solanumnigrum identified and are indexed as crystalline in nature. The intense and sharpening of the peaks noticeably designates that the particles are in spherical. The average particle size of the silver nanoparticles is calculated by using Debye Scherrer's formula. The average of particle size of silver nanoparticles prepared by Solanumnigrum is from 20 to 27 nm**.** These results were well agreed with the reported literatures [20-21].

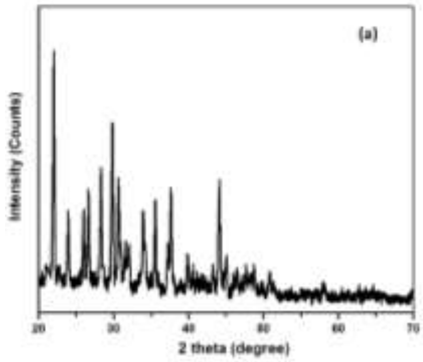

Figure 2: XRD profile of solanumnigrum silver nanoparticle

3.2 UV-vis spectroscopy analysis

The bioreduction of silver nanoparticles using plant leaf extract of Solanumnigrum was confirmed by gradual colour change from light yellow to yellowish brown. It is well documented that the silver nanoparticles displayed significant colours, from light yellow to brown in aqueous solution due to excitation of surface plasmon vibrations [22]. Figure 3 shows the recorded absorption spectra of silver nanoparticle solutions for 12 and 24 hrs reaction time. The strong maximum absorbance peak of Solanumnigrum was found to present at seen at 430 nm. There was an increase in intensity and no found any peak shift in the wavelength when reaction time is increased from 12 to 24 hrs. Hence, it confirms that the reduction of silver ions reaches saturation state and completion of reaction within 24 hrs. These results are good agreement with the reported literatures [23].

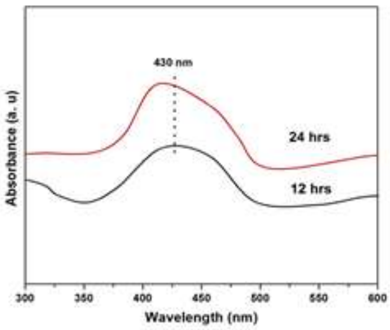

Figure 3: UV-Visible absorbance curve of solanum nigrum silver nanoparticle

3.3Antimicrobial activity

Silver and its compounds show a broad biocidal effect against microorganisms by disturbing their enzymatic activities. Synthesis of plant mediated silver nanoparticles is attracted keen interest by the research community due to their wide range of applications such as wound dressings, topical creams, antiseptic sprays, medicine, textile coatings and eco-friendly applications [25]. A Solanum nigrum leaf extract mediated silver nanoparticle is acted as promising antiseptic agents. Therefore, silver nanoparticles were tested for respective antimicrobial activities towards both gram positive (S. aureus) and gram negative (E. coli) bacterial strains. Based on the zone of inhibition, it is proved that synthesized silver nanoparticles display good antibacterial activity against E. coli and S. aureus. On contrary, no antibacterial activity was found for control and plant extract. The disc diffusion method was used to estimate the antibacterial activities of prepared silver nanoparticles and listed in Table 1. Since the size of nanomaterials is much smaller than that of biological molecules, it has extremely large surface area. Hence, it offers well contact with cell wall of microorganisms. Therefore, resulted silver nanoparticles can be used in both in vivo and in vitro biomedical applications [26].

Table 1: Zone of inhibition (mm) estimated by disc diffusion method

Components	Zone of inhibition (mm)	
	E. Coli	*S. aureus*
Control	NZ	NZ
Plant extract (SN)	NZ	NZ
Silver nanoparticles (SN)	9	9

3.4 FTIR analysis

FTIR analysis was performed to detect the biomolecules which responsible for the capping and stabilization of the synthesized silver nanoparticles using plant extracts. In order to carry out this experiment, synthesized silver nanoparticles solution was centrifuged at 8000 rpm for 45 minutes. The pellet was cleaned thoroughly with 10mL of distilled water to remove the proteins or enzymes that are not capping thesilver nanoparticles. Furher, the pellet was dried by using drier. Figures 4 exhibits the FTIR spectra of synthesized Ag NPs by using the leaf extract Solanum nigrum and their vibrational frequencies are listed in Table 2.

Table 2: Vibrational assignments of plant mediated silver nanoparticles

SN mediated Ag NPs	Assignment
748, 660	C-H alkenes stretch
1195	C-N amines stretch
1401	C-H alkenes stretch
1618	C-C aromatic stretch
2889	C-H stretch
3312	O-H stretch

Vibrational assignments of Solanumnigrumwere observed at 3340 cm−1 assigned to O–H stretching, 2825cm^{-1} attributed to C–H stretching, 1626cm^{-1} corresponded toC=C aromatic stretching, 1447cm^{-1} assigned to C–Halkenes stretching, 1150cm^{-1} associated to C–N aminesstretching, 876 cm^{-1}and 654cm^{-1}1 indicates C–H alkenes stretching. The existence of organic compounds such as flavonoids and terpenoids are responsible for the preparation of silver nanoparticles. Therefore, the observed fucntional peaks are mainly due to these organic compounds present in plants extract.

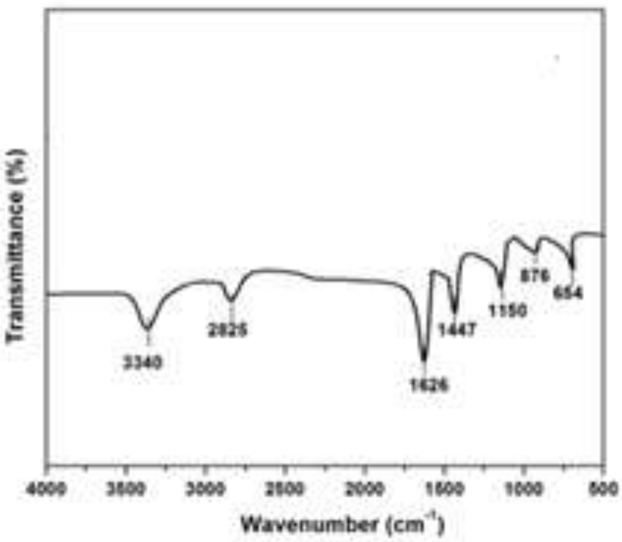

Figure 4: FTIR spectra of synthesized Ag NPs by using the leaf extract Solanumnigrum

3.5 TEM Image

Figure 5shows the TEM images of synthesized Ag NPs by using the leaf extract Solanum nigrum. It was found that majority of nanoparticles were in the spherical shape and varying shapes from 10 to 30 nm with a variety of morphology. The particle size of the silver nanoparticles was further confirmed by XRD analysis. The XRD studies proved that silver nanoparticles are polydispersed and ranged in size from 10 to 50 nm with an average size of 27 nm.

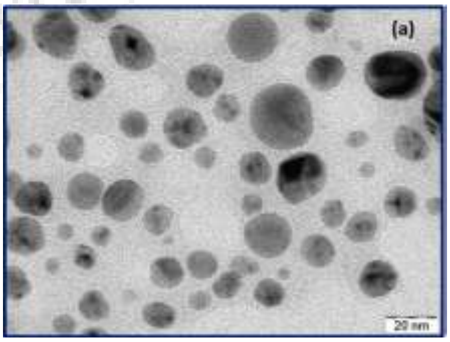

Figure 5: TEM images of silver nanoparticles synthesized by using the leaf extract

4. Conclusions

A green eco-friendly approach has been adopted to synthesize silver nanoparticles. In the present work, it is demonstrated that the synthesized Ag NPs have excellent antimicrobial activities against both E. coli and S. aureus. The plant extract act as a stabilizing, reducing and capping agent to control the shape and size. The existence of some functional groups was confirmed by FTIR analysis. The Ag NPs have an average particle size of 20-30 nm with a spherical shape, confirmed by the XRD studies and d TEM analysis.

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