Eco-friendly Green Biosynthesis of Silver nanoparticles (Ag-NPs)

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Abstract

Eco-friendly green biosynthesis of silver nanoparticles (Ag-NPs) at room temperature in aqueous medium by using the extract of naturally occurring Ganoderma mushroom is reported in presnt work. The Ag-NPs are prepared by the reduction of Ag^+ to Ag in aqueous solution of $AgNO_3$. The resultant particles are characterized by using UV-Visible spectroscopy, Fourier transform infrared spectroscopy and transmission electron microscopy (HRTEM). The formation of Ag-NPs is confirmed by recording the UV-Visible absorption spectrum for Surface Plasmon Resonance (SPR) peak around 427 nm and is supported by the prominent changes observed in FTIR spectra. The spherical shaped Ag-NPs are observed in TEM image. The particle size distribution is found to be ~ uniform with average particle size ~ 2 nm.

Keywords: Green biosynthesis, *Ganoderma,* Silver nanoparticles, UV-Visible spectroscopy.

Introduction

Metal nanoparticles have potential applications in catalysis, photonics, optoelectronics, biological tagging and pharmaceutical owing to their unique properties. Further, owing to wide range of applications in catalysis, optics, antimicrobials, biomaterial production etc. the silver nanoparticles (Ag-NPs) are also the main interest of intensive research [1 - 2]. Different approaches chemical, electrochemical, radiation, photochemical methods, Langmuir–Blodgett and biological techniques [3- 9] etc. are reported in literature for the synthesis of Ag-NPs. However, biological synthesis methods are found to be very good to prepare nanostructure materials, because of the reduction in the use/generation of hazardous substances to human health and the environment. By using microorganisms, the preparations of Ag-NPs via. biological synthesis methods of are reported by different researcher in literature [10-12].

Further, the synthesis of Ag-NPs by the using extracts of various plants are also reported [13-16] by different researchers. The biological synthesis of Ag-NPs by using the plant systems is becoming the main subject of exhaustive research in the area of advanced nanotechnology. In view of this, main aim of the present research work was to synthesize the Ag-NPs by using the extract of naturally occurring *Ganoderma* mushroom. The results obtained related to the biological synthesis of Ag-NPs by using extract of *Ganoderma* mushroom are presented in this paper.

Materials and Methods

For the preparation of silver nanopartciles (Ag-NPs), the silver nitrate, $AgNO_3$ (99.98 % pure, Qualigens Fine Chemicals, India) and *Ganoderma* (GD) mushroom were used as precursor materials. The GD mushroom was collected from the forest of Tamhini, District - Pune, Maharashtra, India. Initially, 2.5 mM solution of $AgNO_3$ was prepared in double distilled water (DDW). The GD mushroom was washed with DDW thoroughly and dried under the shade for completely removal of moisture. The GD mushroom was cut into small pieces and finally ground in a mixer. One gram of GD powder was boiled in 100 ml of DDW and filtered by using Whatmann 41 paper. This GD extract was stored at 4 ^{0}C for further use. The Ag-NPs were synthesized by adding 5 ml of GD extract to 95 ml of $AgNO_3$ solution under vigorous stirring for 15 min. The resultant mixture was kept at room temperature (RT) in the dark to avoid any photochemical reactions. The formation of Ag-NPs was confirmed by visual observation for color change from colorless to pale yellow during this chemical reaction. The resultant as-synthesized nanoparticles were characterized by using UV-Visible spectroscopy, Fourier transform infrared (FTIR) spectroscopy and transmission electron microscopy (HRTEM).

Results and Discussion

The reduction reaction between extract of *Ganoderma* (GD) mushroom and $AgNO_3$ is confirmed by observing the change in the color of aqueous mixture of solutions. The color change from colorless to pale yellow as is shown in inset (a) - (b) of Fig. 1. The UV-Visible spectrum of resultant product exhibited well defined surface plasmon resonance (SPR) band. It is reported that the position and broadness of the SPR bands in the UV-visible spectra depend on the shape and size of particles of resultant product, polydispersity, its interaction with the medium, local refractive index and the extent of charge transfer between medium and the particles [17-18]. Based on the position, shape, and width of the absorption bands, it is possible to estimate the predominant presence of spherical silver nanoparticles with relatively small size (< 25 nm) [19]. Fig. 1 gives the UV-Visible spectrum of a product resulted from the reduction reaction between the 2.5 mM aqueous solution of $AgNO_3$ and 5 ml aqueous solution of the GD extract.

The broad band observed and centered at 427 nm clearly indicates the formation of silver nanoparticles (Ag-NPs). The absorption spectra of larger metal colloidal dispersions can exhibit broad bands in the UV-Vis range due to the excitation of plasma resonances or quadrupole or higher multipole plasmon excitation [20]. The broad spectra might be due to the presence of particles with a broad size distribution. For non-spherical metallic nanoparticles (NPs), the surface plasmons are unevenly distributed. This results in the shape dependent SPR absorption spectra [21]. Also according to Mie's theory [20] small spherical or quasi-spherical nanocrystals should exhibit a single SPR band depending on their shape. Hence, in present case, this single SPR band may be due to quasi-spherical nature of as-synthesized

nanoparticles.

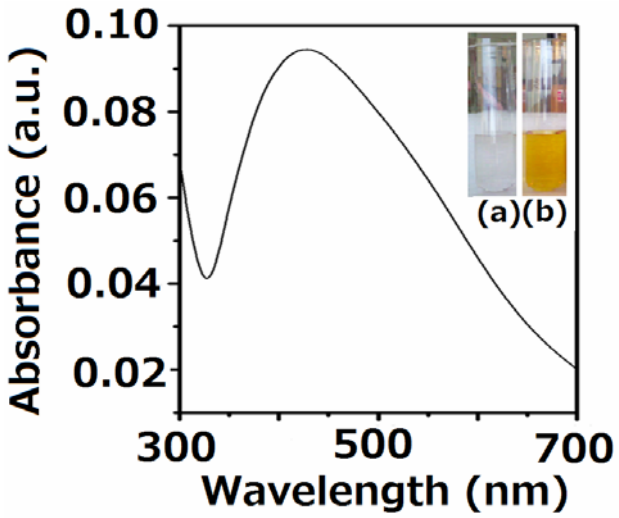


Fig. 1 UV-Visible spectrum of as-synthesized Ag-NPs

Fig. 2 gives the Fourier transform infrared (FTIR) spectra for the (a) $AgNO_3$, (b) GD and (c) as-synthesized Ag-NPs. The FTIR spectrum of GD shows the intense absorption band at 1636 cm^{-1} [fig 2(b)]. The absorption bands between 1200 - 1400 cm^{-1} are the characteristics of $AgNO_3$ [22]. The absorption band at 1376 cm^{-1} in $AgNO_3$ spectrum is characteristic of the ion pair Ag^+ NO_3^- [22]. The band intensity of the ion pair Ag^+ NO_3^- is found to be decreased and shifted to a higher wavenumber value of 1390 cm^{-1} (shown by arrow). This peak, centered at 1390 cm^{-1} is characteristic of the NO_3^- ion in free form [22] and the absorption band displacement is caused by a change in the electronic environment of the anion, as a result of the separation of its counterpart Ag^+ [23].

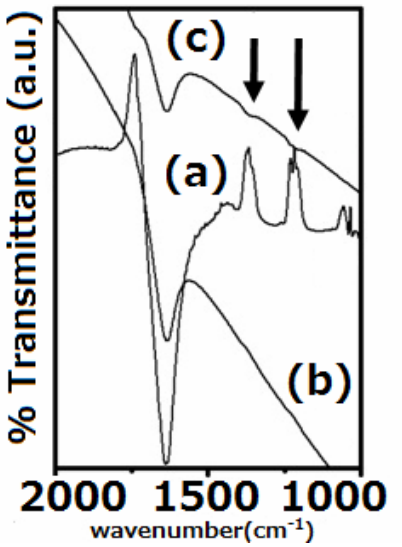
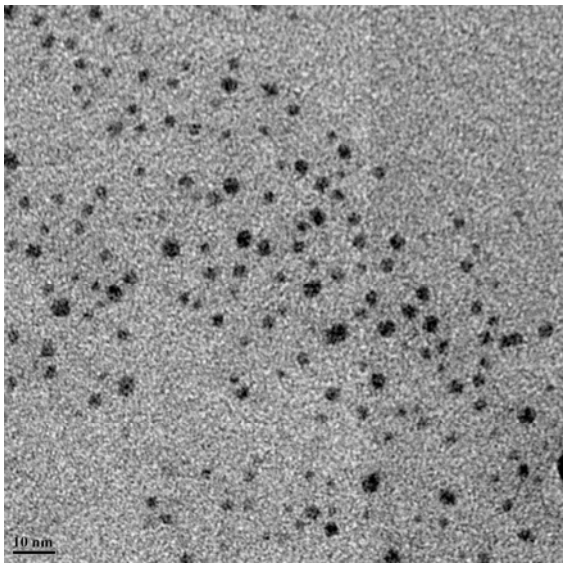


Fig. 2 FTIR spectra for (a) $AgNO_3$, (b) GD and (c) Ag-NPs

Further, the diminished intensity of the absorption band from residual NO_3^-, may indicate the reduction of Ag+ to Ag^0 to the large extent [24]. This clearly confirms the formation of Ag-NPs during reaction between aqueous solution of $AgNO_3$ and water soluble extract of GD. To understand the morphology of resultant as-synthesized nanoparticles, the transmission electron microscopy (TEM) study was undertaken. Fig. 3 gives the TEM image of resultant as-synthesized nanoparticles. The following observations are noted from TEM image.



TEM image for as-synthesized Ag-NPs

The spherical morphology of resultant particles is clearly seen in all parts of TEM image. The bigger particles are soft agglomerates. Each agglomerate particle contains few number primary spherical particles.

The shape of primary particles is spherical. The particle size distribution was determined by measuring the diameters of more than 100 particles on the TEM image. The particle size distribution is found to be ~ uniform. The spherical particles are not mono-dispersed. The average particle size is found to be ~ 2 nm. All these TEM observations support the result obtained during the UV-Visible spectroscopy studies.

Conclusions

The biosynthesis is simple, cheaper and eco-friendly approach for the prepration metal nanoparticles. The simple reduction rection between aqueous soltuion of $AgNO_3$ and water soluable extract of naturally occurring *Ganoderma* mushroom gives the spherical silver nanoparticles (Ag-NPs) with average partcile size ~ 2 nm. The partcile size distribtuion is found to be ~ uniform.

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