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Biosynthesis of silver nanoparticles using green tea leaf extract and their structural and optical analysis

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Abstract

In the present study, silver nanoparticles (Ag NPs) were synthesized by biosynthesis method using Green tea leaf extract. Biosynthesis is an easy, economical, and environmentally friendly method to prepare NPs. The synthesized NPs were characterized by using an X-ray diffraction spectrum (XRD), UV-Vis spectra, Tauc plot and Dynamic light scattering spectrum analysis. The XRD results of biosynthesized Ag NPs show that the particles are crystalline and face-cantered cubical in shape, with an average size of 14 nm. UV-visible spectra studies and Tauc plot analysis confirm the excellent optical properties of the Ag NPs. Due to these outstanding qualities, we anticipated that the use of green-produced Ag NPs would result in an exponential increase in various applications. Ag NPs exhibit cytotoxicity and anticancer characteristics, antibacterial, antioxidant, and antifungal activity.

Keywords: Silver nanoparticles; Biosynthesis; Light scattering; Optical properties; Tauc plot; Antioxidant

1. Introduction

Nowadays, nanotechnology is one of the most fascinating fields that describe the production and application of Nanomaterials [1]. The field of metal nanoparticle synthesis is vast and constantly growing because of its potential applications in electronics, chemistry, energy and medical research among other fields. Bio synthesis is an easy, economical, and environmentally friendly method to prepare NPs [2]. It can easily scale up for large-scale synthesis. Plant extracts have two functions in the creation of nanoparticles: they mediate the reduction of metal salts and can also serve as stabilizing agents for the NPs that are formed [3]. Plant-mediated synthesis seems to be one of the most advantageous of the bio synthesis techniques since it produces stable nanoparticles more quickly and makes stable synthesis easier. Because they don't contain any harmful compounds and can serve as natural capping agents which are rich in phytochemicals with higher therapeutic qualities, offer a better platform for the production of nanoparticles [4].

Inorganic nanoparticles have the potential capability for the medicinal field. Among the other nanoparticles, silver nanoparticles have strong antioxidant and antibacterial properties [5]. Due to its special qualities, it is widely used for wound dressings, healthcare, the textile, culinary, and cosmetic industries.

In this study, we synthesized Ag NPs by bio synthesized method. The structural. Morphological and optical the synthesized Ag were investigated using X ray Diffraction spectrum, DLS and UV-visible spectra studies.

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2. Experimental details

2.1. Materials required

Silver nitrate ($AgNO_3$) was purchased from Merk India and used without further purification. Green tea powders were obtained from a local market. Double distilled Water was used for this experiment. All the glass used was cleaned and then carefully rinsed with water.

2.2. Synthesis procedure

For the preparation of silver nanoparticles (Ag NPs), 2g of green tea leaves were added to 100 ml of water and heated at 80°C for 1h and stirred. The obtained solution was centrifuged at 3500 rpm and filtered. Hence to obtain tea leaf extract. After that, 0.1mol/L silver nitrate solution was taken in a beaker and 0.1 mol/L green leaf extract was added to the solution. Stirred the above solution for 30 min and heated at 80°C. NaOH solution was taken in a pipette and added drop by drop to attain pH 11.

2.3. Characterization

Bruker D8 Advance X-ray diffraction spectrometer with Cu-Kα (1.54Å), current 30mA, Time/Step 0.3s, voltage 40kV Increment 0.02°source over the range of 10° to 80°was used for X-ray diffraction studies. Particle size analysis of was done by using Dynamic light scattering Analysis (DLS). The Shimadzu UV3600+ spectrophotometer is used for recording the UV – Vis spectra.

3. Results and discussion

Powder XRD spectrum was used to determine the crystalline nature, crystal size and structure of the NPs. The XRD of Ag NPs is shown in Fig.1. The diffraction peaks at 2Θ=38.42°, 44.68°, 64.81° and 77.91° are assigned to the (111), (200), (220) and (311) planes of the face-cantered cubic (FCC) structure of metallic silver with the lattice constant a = 0.4086 nm, analogous to the accessible standards data of Joint Committee on Powder Diffraction Standards (JCPDS card no. 04-0783) [6,7] and earlier published literature [8,9] The extreme peak positions indicate that the black-coloured powder formed exhibits high crystallinity and small particle size. The crystallite size was calculated by using the Scherrer formula[10,11] with Origin software, as described previously, which was found to be ~14 nm. The XRD spectrum displayed only Ag peaks, without any other chemical impurities, further indicating the purity of the sample.

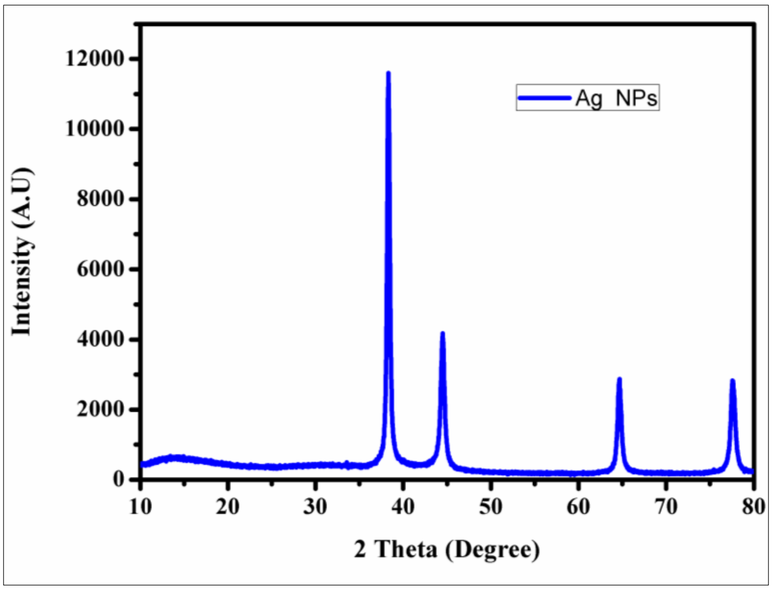

Figure 1 XRD pattern of Silver nanoparticles

The DLS histogram (Fig.2) of the synthesized Ag NPs depicts the Nanocrystalline size which supports the XRD results.

The UV-vis absorption spectrum of Ag NPs is shown in Fig 3. The UV-vis absorbance spectrum was plotted at 200-800nm. The maximum absorption peak for Ag NP_s was observed to be found at around 320 nm confirms the formation of Ag NP_s. This absorption peak can be ascribed to the Surface Plasmon Resonance (SPR) of Ag NP_s. The formation of the silver nanoparticle was considered successful by change in colour of the solution. The change in SPR band may shift based on the individual particle properties such as size, shape, etc.

The UV-Vis reflectance spectrum is displaced in Fig 5. This spectrum exhibits band at should be attributed to the quantum size effect because of the so small particle size of the as-prepared Silver nanoparticles. The peaks obtained at 230nm represents the Ag NP_s from this reflection spectrum. The reflectance value obtained from this spectrum of the prepared silver nanoparticle is used to make suitable materials for antireflection coating.

The band gap energy was estimated by tauc plot[12,13] (plotting $(\alpha h\upsilon)^2$ of the Ag NPs against the photon energy ($h\upsilon$)), as shown in the Fig.5 . The good relationship between $(\alpha h\upsilon)^2$ and $h\upsilon$ implies the direct transition nature of Ag NPs. From this Tauc plot, the band gap energy is observed to be 2.5 eV.

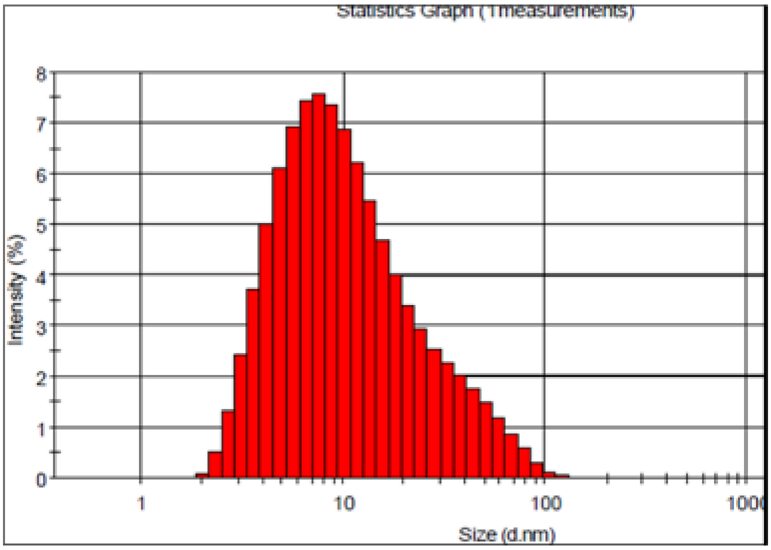

Figure 2 DLS histogram of silver nanoparticles

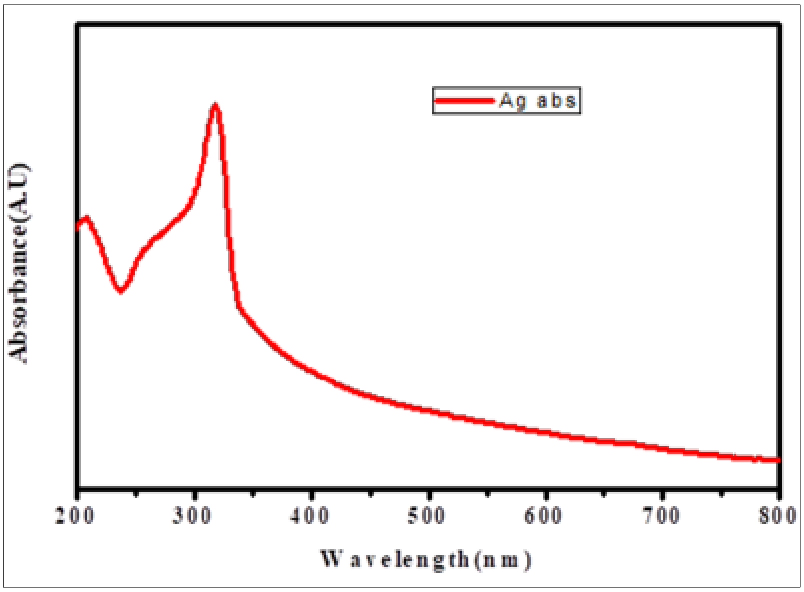

Figure 3 UV-vis absorption spectrum of Silver nanoparticle

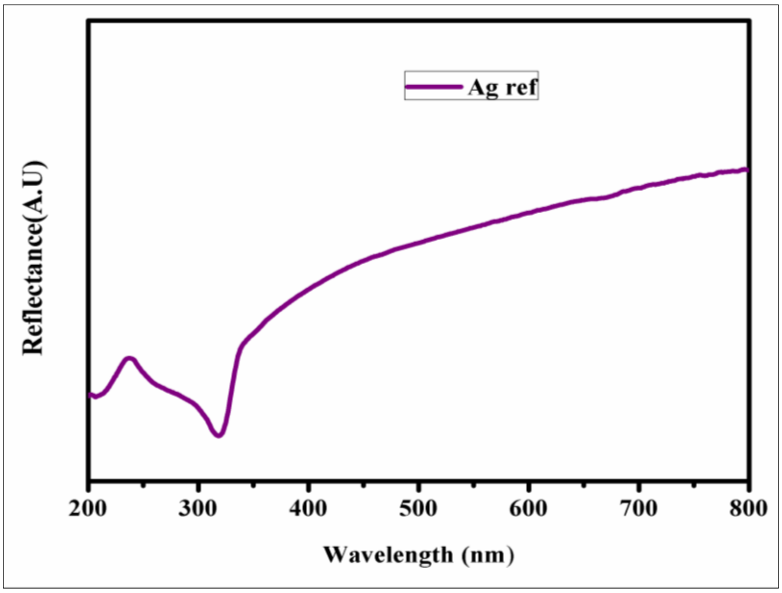

Figure 4 UV-vis reflectance spectrum of Silver Nano particle

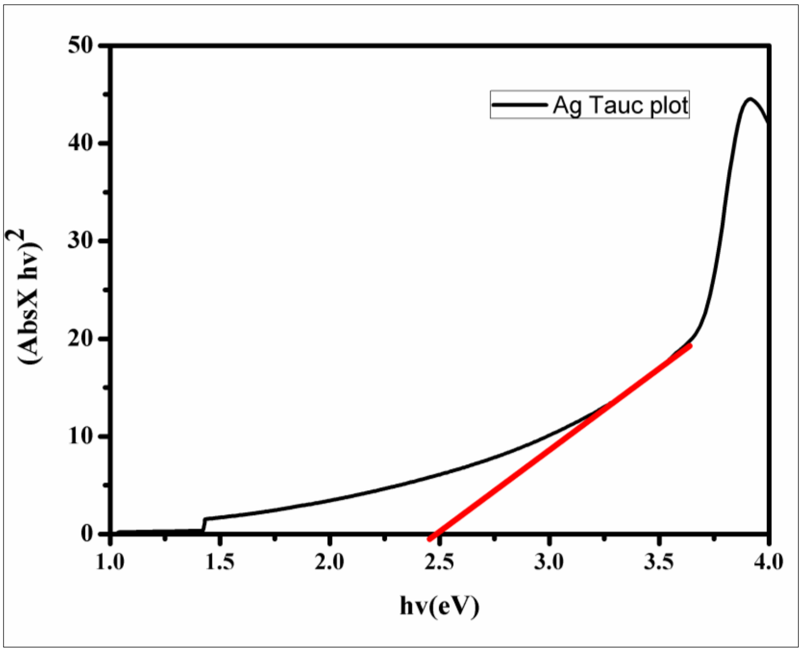

Figure 5 Tauc plot of Silver Nano particle

4. Conclusion

In conclusion, silver Nanoparticles were synthesized by bio synthesis method by using green tea leaf extract as a reducing and stabilizing agent. This biosynthesis method has many advantages such as high yields, easy to process which can be scaled up, no toxic reagents, economic and environmental friendly. The formation of Nano-sized particles was evident from XRD and DLS analysis. Synthesized Ag NP_s are highly crystalline, cubical in shape with an average size 14 nm. The formation of particles was supported from the UV-visible spectroscopy. The absorption peak around 320 nm was confirming the formation of stable Ag NP_s in the reaction mixture. The UV-vis spectra reveal that the number and position of SPR peaks, the effective spectra range, and the band position are strongly dependent on the particle shape, size, symmetry and the morphology.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

Authors declare no conflict of interest.

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