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The Proliferation of Refined Optical and Emission Properties of Silver Oxide Nanoparticles using various Leaf Extracts

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Abstract: Plant-mediated synthesis of nanoparticles has emerged as a promising approach, leveraging the unique properties of plant extracts. In this study, extracts from Bidens pilosa, Achyranthes aspera, and Tecoma stans were used to synthesize silver oxide nanoparticles (Ag_2O NPs). The experimental results demonstrated successful synthesis of Ag_2O NPs using a Soxhlet extraction method and subsequent characterization of the nanoparticles. The photoluminescence and optical properties of the synthesized Ag_2O NPs were investigated, revealing distinct emission peaks and strong absorption in the visible region. The antimicrobial activity of the nanoparticles was also assessed, showing potential for their use in controlling and preventing infections. Overall, this study highlights the valuable optical and fluorescence properties of green extracts and their impact on the synthesis and functionality of silver oxide nanoparticles, paving the way for future research in the field of biotechnology and antimicrobial applications.

Keywords: Ag_2O, Bidens pilosa, Achyranthes aspera, Tecoma stans, UV-Vis, PL

1. Introduction

Metal incorporated nanoparticles have attracted the minds of considerable versatile researchers and motivate them to utilize the same for various technological domains particularly in medical and industrial applications. Nobel metals like platinum, gold, silver, and palladium have exceptional optical, electrical, electronic, morphological, catalytic, and antimicrobial properties compared to other groups. Among these noble metal nanoparticles, specifically gold and silver, have substantial properties in photovoltaic, photo-catalytic, and bio-medicinal activities against cancer and tumor cells [1]. They also exhibit diverse morphology structures with a high destructive property towards bacteria and microorganisms, thus being considered the most prominent compared to other specimens [2]. When compared to Gold nanoparticles (Au NP's), the silver nanoparticles (Ag NP's) are economically more feasible and expose atypical properties. Because of their multifaceted properties, silver oxide nanoparticles have a bespoke beneficial interest not only in fundamental research but also at the industry level [3]. This magnificent performance has piqued the interest of numerous academics looking for innovative synthesis techniques. Generally, the silver oxide nanoparticles are produced by a chemical reduction technique using various inorganic and organic reducing agents [4-6]. As a researcher, our prime duty is to synthesize environment benign nanoparticles through varied green routs like microorganisms enzymes and plant extracts as an excellent alternative to chemical methods [7-10]. Among these, green synthesis of nanoparticles especially obtained from plant extracts possesses distinctive qualities to serve as proficient reducing and capping agents. This can be attributed to the abundance of significant phytochemicals within them, including ketones, aldehydes, amides, carboxylic acids, flavonoids, alkaloids, phenolic compounds, terpenoids etc., [11]. Plant-mediated synthesis has gained prominence as a green synthetic approach and is considered highly suitable compared to other biological entities. It provides a clean, safe, and environmentally friendly approach to synthesizing nanoparticles. This method not only proves to be cost-effective but also offers optimal utility and favorable characteristics [12]. The antimicrobial properties of silver nanoparticles have attracted significant interest, as they inhibit the growth of various microorganisms, offering potential for controlling and preventing infections in medical and healthcare applications. Additionally, silver nanoparticles demonstrate anti-inflammatory properties, expanding their potential in biomedical research [13]. In diagnostic applications, their unique optical and surface properties enable the development of precise and accurate assays for detecting specific analytes like biomarkers, pathogens, or chemical substances.

There are three medicinal plants namely Bidens pilosa, Achyranthes aspera, and Tecoma stans chosen to improve the antimicrobial and anti-inflammatory properties of silver oxide nanoparticles. Bidens pilosa commonly known as "Devil's beggarticks" or "Spanish needle," a species of flowering plant in the *Asteraceae* family, Achyranthes aspera commonly known as "*Prickly Chaff Flower*" or "*Apamarga*," a medicinal plant that belongs to the *Amaranthaceae* family, and Tecoma stans commonly known as "Yellow Elder" or "Yellow Bells," a flowering plant belonging to the *Bignoniaceae* family. They have high antibacterial properties and are useful during the treatment towards leprosy, skin diseases, ulcers, and internal haemorrhage. It also has been proficiently used in the wound-healing process and proliferative wound care management.

The present study aims to synthesize silver oxide nanoparticles via green synthesis route using medicinal plants and analyze the impact of extracts on the optical properties.

2. Experimental details

2.1 Preparation of leaf extract

Medicinal plants like Bidens pilosa, Achyranthes aspera, and Tecoma stans were identified and leaves collected from Coimbatore area. The fresh leaves were washed several times with tap water to remove dust observed from the atmosphere and dried in closed room environment. The 10g of washed and dried leaves were cut into tiny pieces, crushed using mortar and pestle and dissolved in 100 ml distilled water. The prepared extracts were boiled at 80°C for 10 minutes and allowed to cool at room temperature and then filtered with whatman filter paper. The filtrate was centrifuged at 8000 rpm for 30 minutes, and the obtained light green and dark green filtrates (Figure. 1) were used as stabilizing and capping agents.

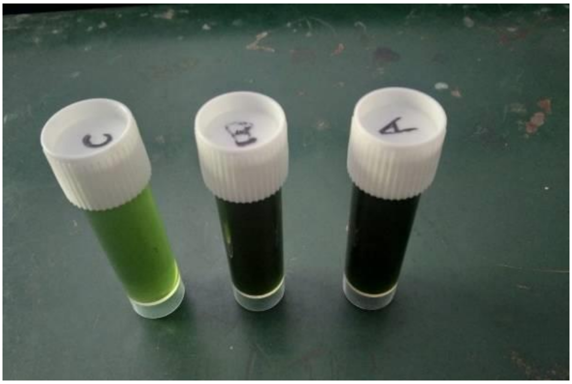

Figure 1. Illustration of leaf extracts from (a) Bidens pilosa, (b) Achyranthes aspera, (c) Tecoma stans

2.2 Synthesis of Ag_2O nanoparticles

In this experimental procedure, a homogeneous solution was prepared by dissolving 0.2 M of silver nitrate in 50 ml of deionized water using a beaker and continuous magnetic stirring for 30 minutes. 10 ml of Bidens pilosa extract was drop by drop to the above solution accompanied by continuous stirring, resulted in the formation of dark green coloured slurry. To eliminate any excess impurities, the slurry underwent several washes with water and ethanol. The obtained slurry was dried and annealed at 450°C for 5 hours to get fine and smooth particles.

The same method was applied to the other two extracts namely Achyranthes aspera, and Tecoma stans. The resulting slurry exhibited a pale and dark brown colour. The synthesized powders were labelled as Ag_2O with Bidens pilosa, Ag_2O with Achyranthes aspera, and Ag_2O with Yellow elder. These powders are comprehensively characterized by various techniques to evaluate their properties, with a specific focus given to their antibacterial activity.

3. Result and Discussion

3.1 Emission properties

PL spectra of Ag_2O nanoparticles prepared from Bidens Pilosa exhibit four intense and sharp emission peaks at 326, 392, 424, and 473 nm corresponding to near band edge at UV region, violet and blue emissions in the visible region respectively.

Similarly, the samples prepared from Yellow Elder show six intense and sharp peaks in their PL spectra at 342, 406.5, 438, 481, 504.5, and 544 nm. These peaks ascribed to the deep level emission encountered at violet, blue, green, and cyan in the visible region.

Ag_2O nanoparticles derived from Achyranthes aspera extract display four intense and sharp peaks in their PL spectra at 353, 450.5, 496, and 549 nm as indexed in Fig. 2. These peaks are attributed to blue and green emissions in the visible region.

The emission peak at 326 and 342 nm can be related to the hopping of electrons from higher energy Ag4d state to the lower energy O2p valence band. High intense green emission is also observed at 473, 481 and 496 nm, possibly due to low density of oxygen vacancies incorporated in the samples. The peak observed at 420-450 nm, which is attributed to the excitation of silver ions on the surface of oxygen [14]. This peak corresponds to the surface plasmon resonance (SPR) frequency and is in agreement with the results obtained from ultraviolet (UV) measurements.

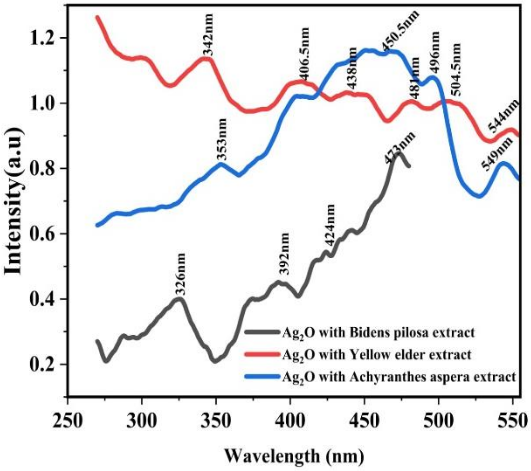

Figure 2. PL spectra of the extract mediated Ag2O nanoparticles

Overall, the PL spectra of the mentioned samples exhibit multiple intense and sharp peaks at various wavelengths, indicating different energy transitions and emissions in the visible region. These observations provide valuable insights into the excitation and emission properties of the materials. Ag_2O nanoparticles prepared from Yellow elder extract significantly ameliorate the emission intensities of broad and sharp peaks compared with the other two extracts.

3.2 Optical properties

Optical properties of the prepared samples were investigated using UV-Vis spectrophotometer. The analysis of the absorbance spectra revealed the presence of strong and sharp absorption peaks at specific wavelengths. The sample derived from Bidens Pilosa, an absorption peak was observed at 234 nm, while for the sample prepared from Yellow Elder, the peak occurred at 243 nm and Achyranthes Aspera leaf extract the absorption peak was found at 238 nm, as depicted in Figure 3.

Moreover, the samples prepared with extracts exhibited robust and distinct absorption peaks in the range of 234-243 nm and an additional peak at 345 nm, resulting in a violet-blue shift within the visible region.

Regarding the band gap energy, the calculated values for the nanoparticles prepared from various extracts ranged from 2.75 eV to 3.36 eV. The minimum band gap energy 2.75 eV was obtained for the sample derived from Bidens Pilosa, while the maximum band gap energy (Fig. 4) 3.36 eV was observed for the nanoparticles synthesized from Achyranthes aspera. This significant increase in band gap energy can be attributed to the presence of phytochemicals in the extracts and the quantum confinement effect [15, 16], which renders these nanoparticles favorable for optoelectronic and photovoltaic applications.

Additionally, the transmittance spectra of the silver oxide nanoparticles prepared with different leaf extracts were examined. It was found that the nanoparticles derived from Yellow Elder exhibited the highest transmittance, while those obtained from Bidens Pilosa exhibited the lowest transmittance. These findings highlight the exceptional optical absorbance, band gap energy, and transmittance characteristics of the silver oxide nanoparticles synthesized from Yellow Elder extract, which can be attributed to the specific phytochemicals present, such as glycosides and phytosterols.

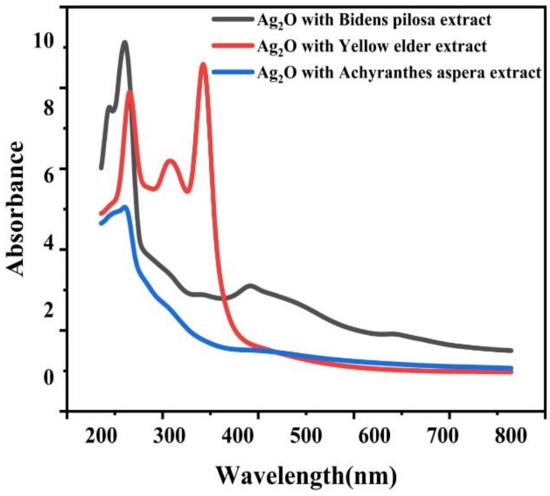

Figure 3. Absorbance spectra of the extract mediated Ag2O nanoparticles

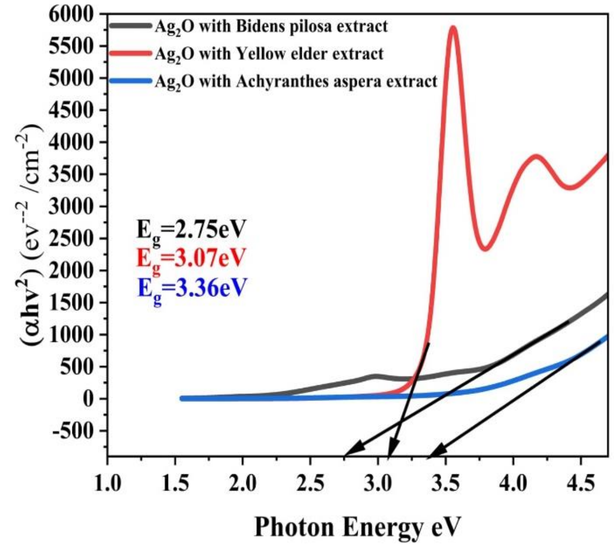

Figure 4. Tauc's plot of the extract mediated Ag2O nanoparticles

3.3 Antireflection properties

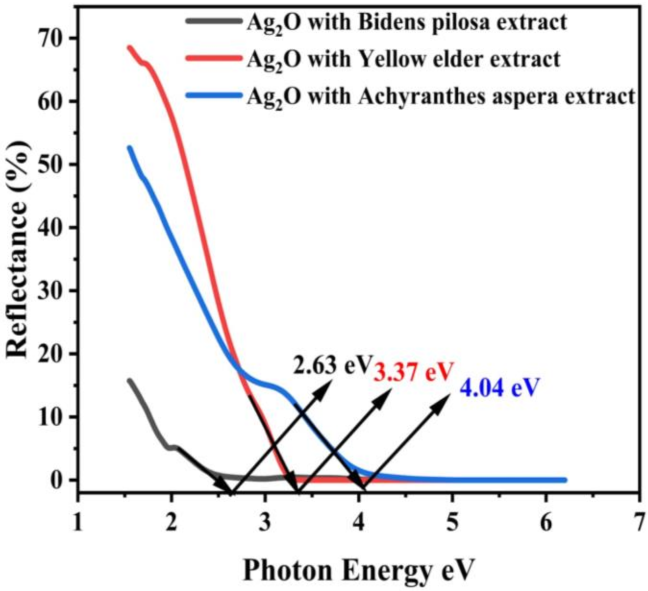

Figure 5. DRS analysis of extract mediated Ag2O nanoparticles

The Bidens pilosa assisted silver oxide nanoparticles showed sharp absorption band appeared at 2.63 eV as shown in Fig. 5. For further the band was and broadening of yellow elder and Achyranthes Aspera extracts assisted silver oxide nanoparticles were observed at 3.37 eV and 4.04 eV respectively. Achyranthes Aspera extracted silver oxide nanoparticles having highest band gap energy than the other two extracts. Ag_2O nanoparticles derived from Yellow elder extract have the strongest intensity peaks compared with the other two extracts authenticates that the samples have high antireflection behaviour which can be used as sunscreen materials.

4. Conclusion

The silver oxide nanoparticles were successfully prepared using Bidens pilosa, Yellow elder, Achyranthes aspera leaf extract by simple, cost effective precipitation technique. The prepared samples were analyzed by various characterization techniques to assess the impact of leaf extract on various properties. The following observations were identified;

- ✓ The absorbance spectra explore the presence of strong and sharp absorption peak encountered at 234, 243 and 238 nm for bidens pilosa, yellow elder and achyranthes aspera leaf extract respectively.
- ✓ The minimum value of band gap energy was obtained as 2.75 eV for the samples prepared from bidens pilosa and maximum value as 3.36 eV for achyranthes aspera extracted samples due to phytochemicals present in the extracts and quantum confinement effect.
- ✓ The highest transmittance was obtained for the samples prepared from yellow elder and lowest transmittance was obtained for bidens pilosa extracted nanoparticles.
- ✓ The emission spectra of all the samples have strong and sharp emission peaks at violet, blue, green and cyan in the visible region thus favourable for LED applications.
- ✓ Finally, the exceptional optical absorbance, band gap, reflectance, transmittance and emission properties were obtained for yellow elder extracted silver oxide nanoparticles compared with the other two extracts due the impact of specific pytochemicals like glycosides and phytosterols.

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