UV Light Assisted Biogenic Synthesis of Silver Nanoparticles, their Characterization and Catalytic Activity to Reduce Methylene Blue

V HIMA BINDU, S SATHYA SREE, Y SWETHA,

PROFESSOR [1,] Assistant Professor [1,3]

himabindu1984@gmail.com, satyasreehbs@svitatp.ac.in, swtha.y79@gmail.com

Department of chemistry, Sri Venkateswara Institute of Technology,

N.H 44, Hampapuram, Rapthadu, Anantapuramu, Andhra Pradesh 515722

ABSTRACT

This paper details the biogenic production of Ag nanoparticles utilising a straightforward and quick process that makes use of UV light and a reducing agent derived from the leaves of Bryophyllum pinnatum.Scanning electron microscopy, XRD, EDS, FT-IR, and UV-vis spectroscopy were used to characterise the structure of the AgNPs that were synthesised. Particles with an average size of 20 nm were seen in the SEM analysis. In order to identify the presence of silver, the AgNPs were analysed using energy dispersive spectroscopy (EDS) in the 3-3.1 keV energy range. Using Fourier transform infrared spectroscopy (FTIR), we were able to identify the functional groups of the biomolecules in the Bryophyllum pinnatum aqueous extract and how they interacted with the AgNPs. Within 10 minutes, the catalytic degradation of MB was finished, highlighting the remarkable catalytic capabilities of silver nanoparticles in reducing MB.

Keywords: Bryophyllumpinnatum;AgNPs;UV Light;Biogenic Synthesis; Methylene Blue

INTRODUCTION

Over the last few decades, nanoscience and nanotechnology have attracted a great deal of attention and research from the chemical world. Metal nanoparticles have been the subject of an almost exponential growth in the number of scholarly journals, with results that span disciplines as diverse as engineering, biology, chemistry, physics, and chemistry. According to the principles of green chemistry, there is an increasing need for environmentally friendly techniques of synthesising nanoparticles that outperform chemical and physical approaches.There will be no need to utilise harmful chemicals, high temperatures, or pressurised air with these eco-friendly procedures.7. Living things including bacteria, fungus, and plants, as well as biomass like plant extracts, are used in the biogenic production of AgNPs8–14. To produce nanomaterials with sufficient control over size and form, biological synthetic procedures have arisen as a straightforward and practical substitute for more involved physicochemical methods.15, 16.

The present study aimed to synthesis of Silver Nanoparticles in aqueous medium using leaf extracts of *BryophyllumPinnatum*(BPE).Here we report an ecofriendly, cost effective and green approach for synthesis of Ag-nanoparticles using the aqueous leaf extracts of *Bryophyllum pinnatum* as the reducing and capping agent as well. Specific plants contain specific chemical compounds which can act as active substances in the process of reduction and stabilization of nanoparticles. Biomolecules in plant extracts that can reduce metal ions into nanoparticles include proteins, polysaccharides, alkaloids, flavonoids, terpenoids, and phenolic acids[17,18]. *BryophyllumPinnatum*is rich in alkaloids, triterpenes, glycosides, flavonoids, cardienolides, steroids and lipids. In addition to these leaves contain a group of steroids called bufadienolides**(Fig.1).**whichdisplay a wide range of biological actions[19-20]. Different combinations and concentrations of these organic reducing agents under UV light results in reduction of Ag^{+} to Ag[021, 22].

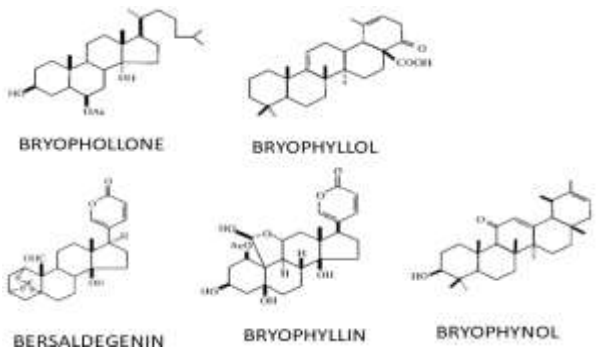

Fig.1: Group of steroids (Bufadienolides)present in leaf extracts of *Bryophyllumpinnatum*

EXPERIMENTAL

Preparation of Bryophyllumpinnatum leaf Extracts (BPE)

Before being cleaned with double distilled water, the leaves of Bryophyllum pinnatum were carefully rinsed under running water to eliminate any debris or dust. The mixture was stirred at 60°C for 30 minutes using a heating mantle after 30 grammes of chopped leaves were added to 100 millilitres of double-distilled water. Once the mixture had boiled, it was chilled for half an hour before being filtered using Whatman filter paper No. 1. The gathered leaf extracts, which have a vibrant green hue, were used in the synthesis of AgNPs as a reducing agent and a capping agent.

Synthesis of Silver Nanoparticles using Bryophyllumpinnatum leaf extracts

3 ml of *Bryophyllumpinnatum* leaves extracts were added to the 40 ml of 5mM $AgNO_3$ solution at ambient temperature and stirred continuously for 15 min using magnetic stirrer. The mixture was irradiated under a UV lamp for 2 hours.

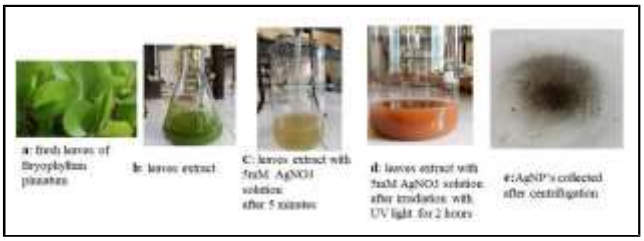

Fig. 2: Changes observed in color of BPE extract of AgNPs

The aqueous leaf extract reduced and stabilized the $AgNO_3$ into AgNPs, which can be seen visually by the change of colorless mixture to dark brown. Slow reduction takes place and kept for 2 hours in UV light to obtain the color change for bio- reduction process. After 2 h bright green color changed to dark brown color this indicates the formation of AgNPs (**Fig.2**).The AgNPs obtained from the solution was purified by repeated centrifugation at 8,000 rpm for 20 min using Remi cooling centrifuge C-24. The amount of leaf extract added to silver nitrate solution varied from 0.5 to 5.0 mL.Each mixture was irradiated under a UV lamp for 2 hours.

The formation of silver nanoparticles through aqueous medium was fairly stable.The nearly monodisperseAgNPs were formed at ambient conditions, without any additive protecting nanoparticles. The green approach using *Bryophyllumpinnatum* would be suitable for developing a biological process for large scale production.

RESULTS AND DISCUSSION

UV-Vis spectroscopy of AgNPs

The bio-reduction of Ag^+ ions in solutions was evaluated by a UV-Vis spectrophotometer (Elico SL-164 PC), at a range between 300 and 700 nm with 1 nm resolution. Aqueous silver nitrate (5 mM) was used as a blank. The formations of Ag

nanoparticles were monitored using the UV-visible spectra as a function of the reaction time and the formation process, which determined that the optimal reaction time for the reduction of Ag^{+} ions was 2 h.

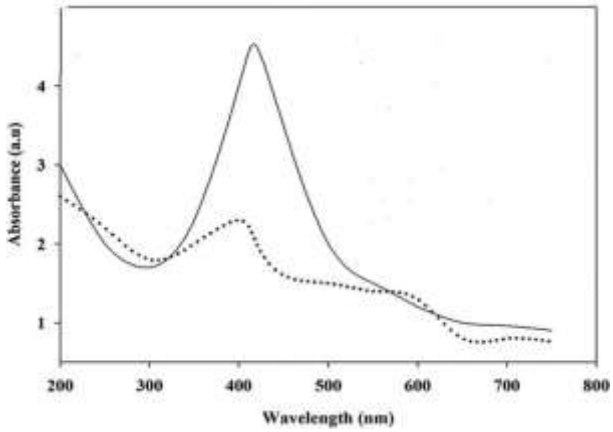

Fig.3: UV visible spectrum of BPE capped with Ag nanoparticles

Nanoparticles (prepared by using 3 mL of BPE) are represented in **Fig. 3.** The strong absorption peak was obtained at 430 nm. The high-quality absorption peak implied that the formation of narrow sized nanoparticles. The surface plasmon response banding at 430 nm indicates the synthesis of AgNPs.

FTIR Analysis

FT-IR analysis was performed with a mixture containing powdered potassium bromide (KBr) and lyophilized leaf extract. To record the molecular functional vibration of chemical groups present in the sample, Perkin-Elmer FT-IR spectrum spectrophotometer (Shimadzu 8400) was used and operated at a resolution of 2 cm^{-1}ranging from 4000 to 500 cm^{-1}.FTIR characterization was conducted to investigate the interaction between functional groups of BPE**(4a)** and in the BPE capped AgNPs**(4b)**. FTIR spectra show the wavenumber shift of BPE functional groups before and after AgNPs formation as shown in **Fig 4.** The vibrations of the -OH group shifted from 3371 to 3435 cm−1 and those of the C=C aromatic group shifted from 1609 to 1693 cm−1. These small shifts are due to the interaction of functional groups (-OH and C=C) in BPE extract on AgNPs surface. This indicates that AgNPs are capped by the chemical constituents in BPE.

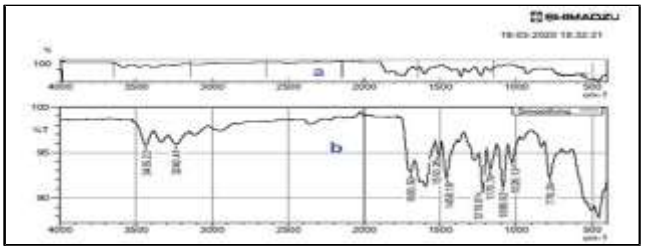

Fig. 4: IR spectrum of synthesized Ag nanoparticles

XRD Analysis

XRD characterization was conducted to determine the crystallinity of AgNPs.X-ray diffraction data (XRD) was recorded in the 2θrange of 30-80 using XRD 6000, (Shimadzu) of Cu-Ka radiation, the energy of which was 8.04 keV and wavelength was 1.54
A. The applied voltage was 40 kV and current was 25 mA. The crystallite size was estimated using the Scherer equation. From the results, there are some peaks of 2θ values: 16.06, 22.31, 27.84,32.27,38.17,46.17,54.88,57.3964.448,67.37,74.34,76.83,81.27,85.81,92.45^{0} **(Fig 5.)**

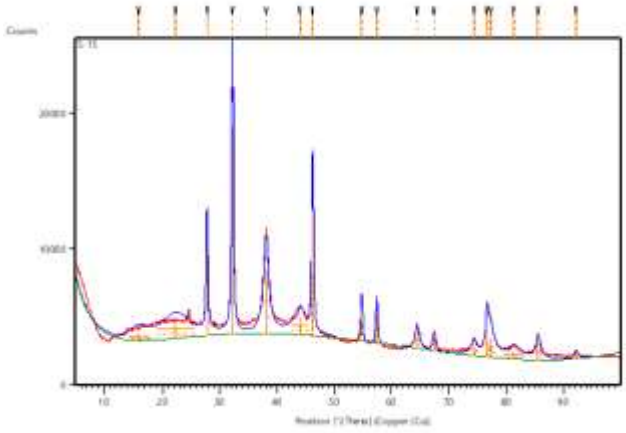

Fig. 5:XRD spectra of BPE capped AgNPs.

SEM and EDX Profile

The AgNPs shape and size was determined by scanning electron microscopy-energy dispersive spectra (SEM-EDS-JEOL JSM 6390 model). SEM analysis showed the formation of particles with average sizes of 20 nm. Elemental silver in the prepared nanoparticles was recognized by EDX study. A major peak within the energy range of 3–3.1 keV was observed in EDX profile of silver nanoparticles confirming the presence of elemental silver in the prepared nanoparticles **(Fig. 6).**

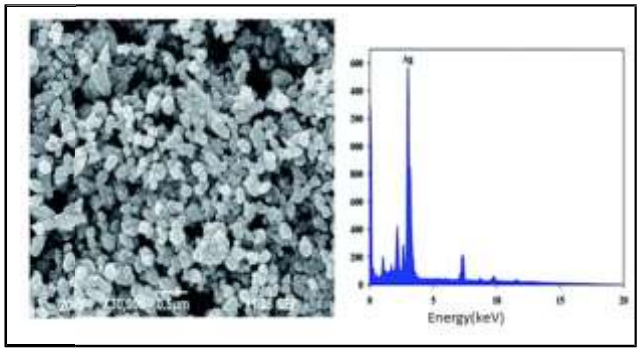

Fig 6: SEM analysis of synthesized nanoparticles

The catalytic ability of synthesized AgNPs

Researchers examined the catalytic activity of synthesised AgNPs by simulating the reduction process of MB by NaBH4.The thiazine dye family includes the heterocyclic aromatic dye methylene blue (tetramethylthionine chloride). The substance has several applications in various sectors, such as medicine, biology, and chemistry, and it is soluble in water and chloroform but very poorly soluble in alcohol. It is found as dark blue crystals.ages 23–25. MB becomes colourless leucomethylene blue when it is reduced. When catalyst 'AgNPs' is not present, the UV-Vis absorption spectra of MB reduction by NaBH4 show a slower rate of reduction.Figure 7a shows that only 30–40% of the reduction was finished within 30 minutes when AgNPs were not included in the reaction mixture.The reduction was finished in under 10 minutes when 3.0 mL of AgNPs were present (Fig. 7b).The π-π^* and n-π^* transitions cause MB to normally exhibit an absorption maximum band at around 664 nm in aqueous solutions 26. The reduction in absorption band maxima at 663 nm and the simultaneous development of a new band with maxima at 430 nm, which grows in intensity with time, make it easy to trace the progress of the catalytic degradation. According to these results, adding the right amount of AgNPs improved the efficiency of the MB reduction process. In addition, it was shown that the synthesised AgNPs served as an efficient "green catalyst" and electron transfer mediator during the reduction of MB by NaBH4.

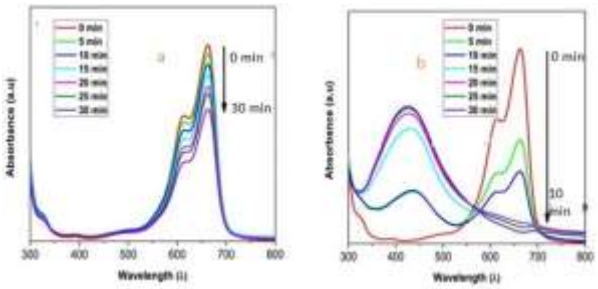

Fig.7:UV-Vis absorbance spectra at 5 min intervals showing reduction of MB by $NaBH_4$ (a) reaction mixture without AgNPs(b) reaction mixture with 3.0 mL of AgNPs

When it comes to chemical reactions, the bond dissociation energy (BDE) is a key factor in either breaking bonds or forming new ones. When NaBH4 is used as a donor and MBdye as an acceptor in a process, an electron transfer takes place 27. One possible intermediary between MB dye and BH4-ions was the inclusion of AgNPs to the reaction mixture. At first, it reduced the BDE and improved the efficiency of electron transmission between them. Therefore, in the presence of AgNPs, the rate of MB reduction by NaBH4 was enhanced. In under 10 minutes, the MB dye had entirely broken down, proving that the synthetic AgNPs might be put to good use in the chemical industries' effluent treatment (dye degradation) processes.

CONCLUSIONS

In this research, the aqueous extract of Bryophyllumpinnatum is used to create environmentally friendly, non-toxic, and commercially feasible AgNPs.The synthesis of AgNPs is accomplished efficiently and effectively using UV-assisted reduction. Biosynthesized AgNPs measure 20 nm in diameter and have a spherical, single-crystalline form.The process didn't call for any hazardous chemicals or organic solvents, and it was quick, cheap, and straightforward to do. In addition, the researchers found that the produced AgNPs had high catalytic activity when it came to reducing MBdye at room temperature. The synthesis of AuNPs using this environmentally friendly process has the potential to make significant contributions to several sectors, including medication delivery, antimicrobial, adsorbent, detector, and green separation technology and science.

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