FICUS CARICA BIOMASS-ASSISTED DEVELOPMENT OF SILVER NANOMATERIALS

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ABSTRACT

Drug delivery, medicinal research, catalysis, and other fields may all benefit greatly from silver nanoparticles (AgNPs). Therapeutic AgNPs are in high demand across the world, thus several companies are now synthesising them. These materials may be manufactured at low cost but not without risk due to the use of chemical processes. These processes also pollute the environment, create dangerous byproducts, and have other concerning features. Nanomaterial synthesis that is mediated by plant extracts is gaining popularity as a method to fabricate nanomaterials with consistent size and shape. The suggested study used *F. carica* leaves extract (FCLE) to rapidly fabricate AgNPs, which might provide the groundwork for mass-producing nanomaterials. Silver nanomaterial with a flower-like shape and a mean size of 4000-5000 nm was synthesized using the RESL, which acted as a green-technology. The synthesized silver nanomaterial's optical absorption band peak was shown to be at 440 nm owing to the Surface Plasmon Resonance phenomena. Diffraction grating planes confirmed silver was the primary biofabrication material. The root extract included phytoconstituents, which accounted for the formation of the crystalline peaks. In-depth analyses using ultraviolet-visible spectroscopy, Fourier-transformed infrared spectroscopy, scanning electron microscopy, and X-ray diffraction all corroborated the capping phenomena. The findings of this work have the potential to be used in the industrial scale production of therapeutically active AgNPs as a replacement for the present chemically intensive procedures.

Keywords: *Ficus carica*, Silver, Nanoparticles, Synthesis, Characterization, Extract

1. INTRODUCTION

The need for nanomaterials has increased with the development of nanomedicine, nanobiotechnology, and nanopharmacotherapeutics [1]. These nanoparts are often coupled with various therapeutic biomolecules that are effective against a wide range of illnesses [2]. Drug transport, biological sciences, catalysis, etc. are only a few of the many fields that benefit greatly from silver nanoparticles (AgNPs) [3]. Therapeutic AgNPs are in high demand across the world, thus several companies are now synthesising them. These materials may be manufactured at low cost but not without risk due to the use of chemical processes. These processes also pollute the environment, create dangerous byproducts, and have other concerning features. In addition, the yield of usable nanomaterials is greatly reduced due to thermal deterioration during thermal-based synthesis techniques [4,5].

An increasingly appealing technique for the fabrication of nanoparticles, nanotriangles, nanocubes, and nanorods of controlled size and uniformity is the use of plant material extracts (root, flower, fruit, stem, bark, seed, and leaf) and/or fruits, vegetables, and spices as a mediator [6]. Greener, less polluting, less wasteful, more cost-effective, compliant with regulations, and safe for consumers and producers alike, this method has several advantages [7]. To convert the metallic ionic salt into its elemental form, the biomass is used as both a reductant and a capping component [8].

The fig is the edible fruit of the tiny tree *Ficus carica*, which is native to the Mediterranean and western and southern Asia and is a member of the flowering plant family Moraceae. Its cultivation dates back to antiquity, and now it is one of the most frequently farmed crops in the world. Polyphenols as chlorogenic acid, gallic acid, (+)-catechin, syringic acid, (-)-

epicatechin, rutin, etc. are found in figs (*F. carica*) and are the subject of fundamental study for their possible biological characteristics [9]. Different cultivars of figs may have different hues because to differences in anthocyanin content, with cyanidin-3-*O*-rutinoside being especially abundant. The milky sap of the fig shrub was used to treat calluses, eliminate warts, and ward off parasites in traditional Mediterranean folk medicine. Fresh, dried, or in the form of jam, rolls, biscuits, or any number of different delicacies, figs are a versatile fruit [10].

ScienceDirect, PubMed, Google Scholar, and other pharmaceutical databases were searched to confirm that *F. carica* leaf extract has not yet been used in the manufacture of AgNPs. Though much has been written about using other fig components for nanomaterials production, this is the first account of its use. The suggested study used an efficient synthesis method for AgNPs by using *F. carica* leaves extract (FCLE), which might provide the groundwork for mass-producing AgNPs.

2. MATERIALS AND METHODS

2.1. Chemicals

The local supplier stocked up on silver nitrate from the German firm Sigma-Aldrich. All of the other compounds used in this analysis were from HiMedia (India) and were of analytical quality. We used BoroSil® equipment to distil water twice to conduct the experiment.

2.2. Plant Extract

2.2.1. Collection

This particular specimen was gathered at the college's Medicinal Plant Garden in the Besa neighbourhood of Nagpur, Maharashtra, India. The plant's legitimacy was also confirmed by the Department of Botany at RTM Nagpur University in Nagpur, Maharashtra, India.

2.2.2. Extraction

After collecting and cleaning the *F. carica* leaves, their size was steadily decreased. After dividing the dried, powdered material into 32 cycles, soxhelation was done in a hydroalcoholic solution (50:50 ratio) at 65-70°C. The extract was concentrated further by removing the solvent in a rotating vacuum evaporator operating at low pressure [11].

2.2.3. Phytochemical evaluation

The phytochemical screening was performed for the presence of alkaloids, sugars, tannins, glycosides, steroids, flavonoids, terpenes, and proteins as per the given standard test procedures [12].

2.3. Preparation of Silver Nitrate Solution

Preparing a 1 mM silver nitrate ($AgNO_3$) solution included dissolving 0.01698 g of solute in 100 ml of double-distilled water. This solution was used in the preparation of AgNPs.

2.4. Synthesis of Silver Nanoparticles

Leaf extract was added to 6 mM $AgNO_3$ at 1:4 ratio, while being stirred for the formation of AgNPs. The browning of the solution indicated the reduction of Ag+ and the formation of AgNP. After that, it was autoclaved for 5 minutes at 121°F and 15 pounds per square inch pressure. Then, it was diluted with pure water, centrifuged for purity, dried at 80 degrees Celsius, and kept at room temperature until needed [13].

2.5. Characterization of Silver Nanoparticles

2.5.1. UV-Vis Spectroscopic Analysis

Using a UV-Vis Spectrophotometer (double beam Shimadzu® UV-1800, Kyoto, Japan), the development of ionic silver's transformation into its corresponding element type was studied between the wavelengths of 200 and 800 nm. Double-distilled water was used to make small aliquots of the colloids, and their behaviour over the course of 5 minutes was monitored at time intervals of 40 seconds, 2 minutes, 3 minutes, and 5 minutes. The use of the distilled water served as a standard. To verify the AgNPs' production, we measured their absorption peak [14].

2.5.2. Fourier-transformed Infrared Spectroscopic Analysis

Using a potassium bromide dispersion method, the IR absorption spectra of the produced AgNPs were recorded between 4000-400 cm^{-1} using Fourier transform infrared spectrophotometer (Perkin Elmer® GX-FT-IR, USA). The compounds were scanned at 20 scans per second with a resolution of 0.15 cm^{-1} [15].

2.5.3. X-ray Diffraction Analysis

The researchers set out to verify the presence of AgNPs, investigate the impact of different bioreductants, and delve further into the structures' mysteries. Powder X-ray diffraction analysis

(P-XRD) was performed on the AgNPs using an X-ray diffractometer (ULTIMA-III, RIGAKU, Japan) by placing a sample of the material in an aluminium crucible. The procedure was performed at 40 kV using monochromatic CuK-radiation with a scanning speed of 4/min and an angle range of 10-90°. Careful notation and analysis of the diffractogram were performed [16].

2.5.4. Scanning Electron Microscopy Analysis

The scanning electron microscope (JOEL-JSM 6390 SEM equipment) was used to capture the micrograph at an acceleration voltage of 20 kV. SEM analysis was performed by scattering sample material over a double-sided tape wedge affixed to an aluminium stub. The shape of the AgNPs was shown by randomly scanning the sample [17].

3. RESULTS AND DISCUSSION

3.1. Phytochemical evaluation

Phytochemical screening of the extract revealed the presence of tannins, carbohydrates, alkaloids, flavonoids, phenol, sterols, and glycosides.

Table 1. Phytochemical profile of of *B. ceiba* thorns.

Chemical constituent	Test performed	Observations	Inference
Alkaloid	Hager's test	Yellow precipitate	Alkaloid present
Flavonoid	Shinoda's test	Pinkish-red appeared	Flavonoid present
Tannin	Gelatin test	Green color appeared	Tannin present
Glycoside	Borntrager's test	Faint pink color observed	Anthraquinone glycoside present
Glycoside	Legal's test	No red color observed	Cardiac glycoside absent
Saponin	Froth formation test	A small height froth formed for 5 min	Saponin absent
Carbohydrate	Fehling's test	Red precipitate	Carbohydrate present
Phenol	$FeCl_3$ test	Bluish-black color observed	Phenol present
Protein	Xanthoprotic test	No yellow color observed	Protein absent
Sterol	Libermann-Burchard's test	Brown-ring formation	Sterol present
Diterpene	Copper acetate test	No emerald green color observed	Diterpene absent
Triterpene	Salkowski's test	No yellow color observed	Triterpene absent

3.2. Formation of nanoparticles

The creation of AgNPs was indicated by a rapid shift in colour within a few seconds. Within 30 minutes, the colour had completely changed due to the response (**Figure 1**). The existence of bioactive components may account for the depletion of the elemental form.

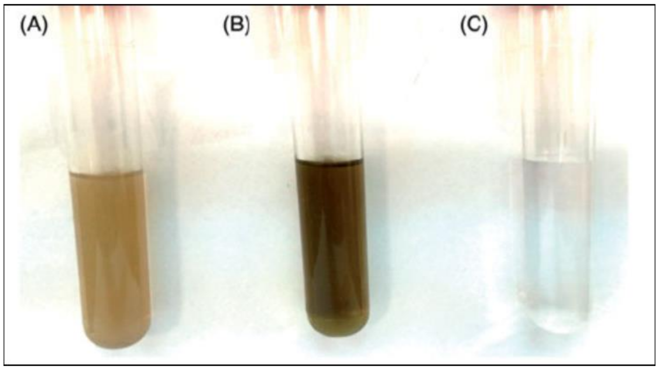

Figure 1. (A) Aqueous leaf extract of *Ficus carica*, (B) Changing color from yellowish to reddish brown after adding 6 mM $AgNO_3$ and exposing to stirring, and (C) 6 mM $AgNO_3$.

3.3. Characterization of nanoparticles

3.3.1. UV-Vis Spectroscopic Study

As a result of the Surface Plasmon Resonance (SPR) phenomenon, it was discovered that the optical absorption band peak of the synthesised AgNPs occurred at 440 nm. In a study using UV-Visible spectroscopy to examine the effect of reaction time on AgNPs production, it was shown that a longer reaction time results in a narrower absorbance peak. This time-dependent rise in brightness may be attributed to the gradual production of nanoparticles brought about by the gradual conversion of silver ions into the elemental form. After 1 hour, the nanoparticle reduction process was evident from the disturbance in the absorbance region of 200-300 nm, indicating that the capping phenomena had taken place. Alternatively, the interaction of silver ions with the organic molecules in the solution, which may cause the transformation of ionic silver into the elemental component, was identified as "the probable mechanism" by the appearance of an absorption peak at 200 nm. Excitation of surface plasmon vibration occurs in the 400-450 nm range (**Figure 2**) [18].

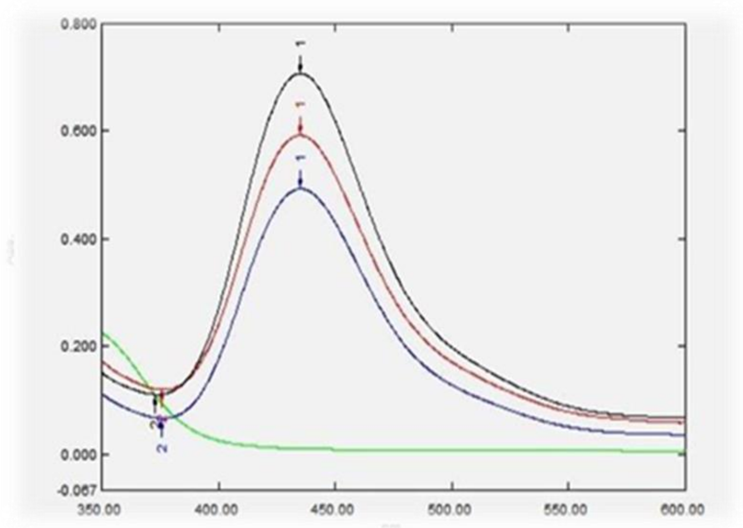

Figure 2. UV-Vis Spectra (at 440 nm) Recorded at Different Time Intervals from Aqueous Solution of Silver Nitrate with Extract: (a) Green: 40 sec; (b) Blue: 2 min; (c) Red: 3 min; and (d) Black: 5 min.

3.3.2. Fourier-transformed Infrared Spectroscopic Study

The spectrum presented the formation of AgNPs where prominent peaks represent the process of reduction of silver ions into their elemental form through bioreduction by phytoconstituents (also known as bioreductant). The peaks (stretching and bending) showed the presence of hydroxyl, amino, nitro, azide, sulfonyl, sulphydryl, hydroxyl, ether, carbonyl, cyano, azomethine, nitrile, and also halide (chlorine and bromine).

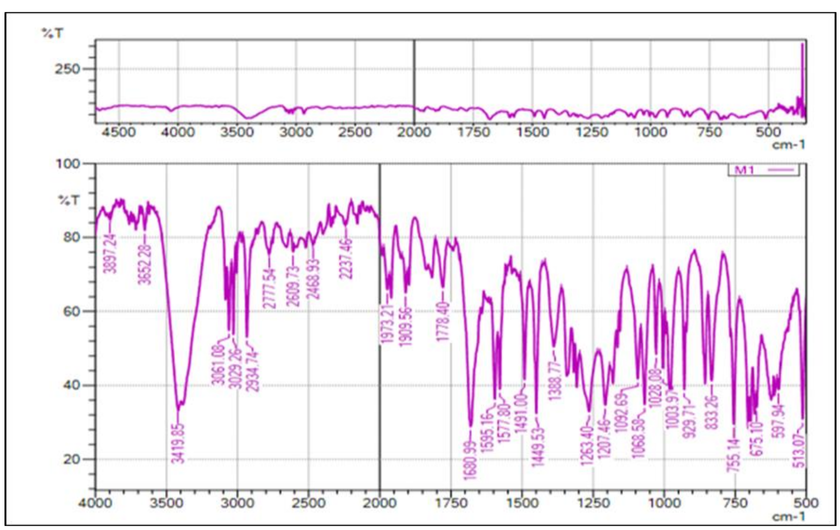

Figure 3. FTIR spectra of AgNPs prepared from leaf extract of *F. carica*.

3.3.3. X-ray Diffraction Study

Several phytoconstituents, which have been crucial in the biosynthesis of AgNPs, were found by powder XRD analysis to be present. The (111), (200), (220), (311), and (222) planes all have prominent peaks at 2 of 35, 44, 7, 76, and 82 in the diffractogram (**Figure 4**). The presence of the phytoconstituents in the root extract caused the formation of crystalline peaks. The first two peaks, which reflect capping phenomena, were caused by bioorganic molecules present on the surface of the AgNPs. The silver used in the biofabrication process was reflected in the flat surfaces [19]. The macromolecular nature of the phytochemicals may help explain the high intensity (count) shown in the diffractogram. The computed lattice constant was found to be consistent with previous estimates. Smaller than expected, the cell volumes were observed in the synthesized AgNPs.

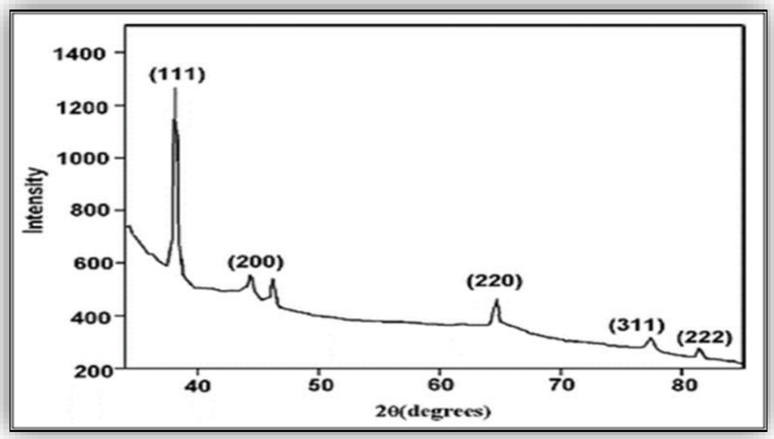

Figure 4. X-Ray diffractogram of fabricated silver nanoparticles.

3.3.4. Scanning Electron Microscopic Study

The average diameter of the Ag nanomaterials has been measured to be between 4000 and 5000 nm, and they have an intriguing floral form. The nanoparticles were measured to have sizes between 1000 and 1500 nm. However, the typical morphologies for plant-mediated AgNP production, such as oval, round, elliptical, etc., were not found. The SEM analysis has shown that the nanoparticles are consistently spherical and small. The capping of the AgNPs by the bioreductants has been shown to make the middle of the particles brighter than the edges [20]. These bioreductants include chlorogenic acid, gallic acid, (+)-catechin, syringic acid, (-)-

epicatechin, rutin, etc. According to **Figure 5**, all of the particles fall between 1000 and 5000 nm in size.

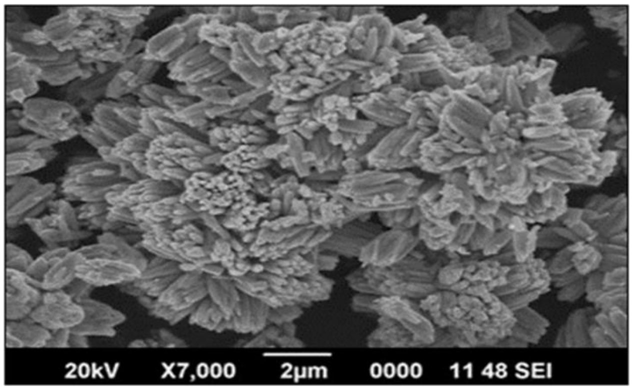

Figure 5. SEM Photomicrograph of Fabricated Silver Nanoparticles.

CONCLUSION

This study explored a novel approach to synthesizing AgNPs that is less harmful to the natural world. Green technology in the form of *F. carica* leaf extract was used to create a silver nanomaterial with a flower-like shape and an average size of 4000-5000 nm. The SPR phenomenon causes the synthesized silver nanomaterial to have an optical absorption band peak at 440 nm. Diffraction grating planes confirmed silver was the primary biofabrication material. The root extract included phytoconstituents, which accounted for the formation of the crystalline peaks. Extensive analysis using UV, FTIR, SEM, and XRD techniques also validated the capping phenomena. Future research might see this methodology used in large-scale commercial synthesis of therapeutically active AgNPs, opening up the possibility of a greener alternative to the traditional chemical synthesis now in use.

CONFLICT OF INTEREST

No conflict of interest is declared.

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