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RESEARCH ARTICLE

Green synthesis of *Mangifera indica* silver nanoparticles and its analysis using Fourier transform infrared and scanning electron microscopy

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ABSTRACT

Background: Cost effective and environmentally favorable green synthesis of metallic nanoparticles is a fast growing research in nanotechnology. **Aims and Objectives:** The present study reports the synthesis of silver nanoparticle (AgNP) using *Mangifera indica* leaves extract, and its constituents and particle size was analyzed by Fourier transform infrared (FTIR) spectroscopy and scanning electron microscopy (SEM). **Materials and Methods:** Preliminary phytochemical analysis of *M. indica* leaves extract was performed, and AgNPs were prepared by *M. indica* leaves extract when treated with silver nitrate. Finally, various functional groups in the plant extracts and size of the AgNPs were identified by FTIR and SEM analysis. **Results:** Qualitative phytochemical analysis revealed the presence of alkaloids, tannins, flavonoid, quinines, steroids, coumarins, and phenolic compounds in *M. indica* leaves extract. Presence of AgNPs in the green extract was confirmed by color changes from pale yellow to dark brown color and by an intense peak in the ultraviolet-spectrophotometer at 420 nm. FTIR analysis showed the presence of various functional groups between the frequency range of 400 and 4000/cm and SEM analysis showed the nanometer size of silver particles that formed. **Conclusion:** This novel green approach may be used for large scale production of metallic nanoparticle and can be used in pharmacological aspects based on the medicinal uses of *M. indica*.

KEY WORDS: Fourier Transform Infrared; *Mangifera indica*; Scanning Electron Microscopy; Silver Nanoparticles; Ultraviolet-visible Spectroscopy

INTRODUCTION

Nanotechnology is the process of synthesizing nanoparticles of variable sizes (1-100 nm), shapes, and chemical compositions with controlled dispersity for human benefits. This technology offers nanocomposites or nanostructures in new products by technological processes. In addition, it is significant on account of its preeminence in the medical field for its extensive applications.[1] Even in other fields such as pharmacy and food production or packaging, researchers on nanoparticles are increased as they are effectively a bride between bulk materials and atomic or molecular structures.[2] Chemical and physical methods of nanoparticle synthesis are expensive and highly dangerous to the sustaining environment. An alternative to those above-mentioned methods are of using biological organisms such as microorganism, plant extract or plant biomass that are eco-friendly and cost effective.[3]

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Plant extracts for metallic nanoparticles preparation are the most common method utilized to enhance its application in medicine. Green nanoparticle production contains phytochemicals such as phenolic acid, flavonoids, alkaloids,

and terpenoids and the presence of these compounds are involved in the reduction of metallic compounds to synthesize nano-sized metallic particles.[4]

Among various metals used for nanoparticles production, silver nanoparticles (AgNPs) are considered to be of great importance in the medical field as they can be synthesized by a chemical method or by biological method. Indeed, silver has highly specific surface area for its maximum contact with environment and has strong antimicrobial property.[5] When comparing the noble metals, silver is also the widely used metal due to its unique properties as wound healer agent its use in the biomedical field.

Many previous reports demonstrated that AgNP synthesis from plant extracts with perfect structural properties.[6] When comparing the noble metals, silver is also the widely used metal due to its unique properties as wound healer agent in the biomedical field. When comparing the various methods such as physical, chemical, enzymatic, and biological methods that are involved in the synthesis of AgNPs, biological methods using the plant extracts have been gained considerable interest because of use of environmentally benign materials.[7] In this study, *Mangifera indica* leaves extract was used for AgNP synthesis as mango possesses antidiabetic, antioxidant, antiviral, anti-inflammatory, anticancer, antipyretic, hypolipidemic, hepatoprotective, and gastro protective activities.[8] The bioreductive potential of the *M. indica* is responsible for AgNPs production. Indeed, previous studies reported the phytochemicals present in the plant extracts act as reductants in preparing the AgNPs when treated with metal salts.[9] Due to the rapid development in nanostructured noble metals and its usage in medicine, the present study deals with the preparation of AgNPs using *M. indica* leaves extract which has multiple medicinal activities. Presence of phytochemicals in the *M. indica* leaves extract was qualitatively analyzed. The prepared AgNPs using *M. indica* leaves extract were further characterized for functional groups that are responsible for nanoparticles production by Fourier transform infrared spectroscopy (FTIR) analysis. Scanning electron microscopy (SEM) analysis was performed to know the detailed structure of AgNPs.

MATERIALS AND METHODS

Preparation of Plant Material

Fresh leaves of *M. indica* were collected and washed thoroughly in distilled water for 3-4 times, and about 20 g of leaves were homogenized using a mortar and pestle. The homogenate was filtered and transferred to a sterile container. Simultaneously, the extract was evaporated to obtain dry powder using Soxhlet apparatus. Both the extract and powder were used for the study and were stored in a freezer at −20°C till subsequent use.

Phytochemical Analysis

Preliminary phytochemical analysis such as saponins, phenols, tannins, terpenoids, and flavonoids test was performed for screening the bioactive chemical compounds present in *M. indica* using the standard procedure.[10]

Preparation of Silver Nanoparticles

From the commercially purchased silver nitrate, 0.1 M silver nitrate aqueous solution (90 ml) was prepared, and to this, 10 ml of *M. indica* leaves extract was added which was then exposed to the sunlight for the synthesis of AgNPs with constant stirring. Change in a color from green to brown occurred. The particles were then subjected to centrifugation for removal of any supernatant. About 1 ml of acetone was then added to the clear suspension to exclude any extra moisture content.[11]

Ultraviolet-visible (UV-VIS) Spectra Analysis

Maximum production of AgNPs in solution was monitored by measuring the UV-VIS spectrum in the range of 300-540 nm. The duration and progress of the reaction between metal ions and the leaf extract were observed. The reduction of silver ions and formation of AgNPs were occurred within an hour. Control was maintained using $AgNO_3$, and deionized water was used as a blank.[12]

FTIR Analysis

FTIR spectroscopy in the frequency range of 400-4000 cm^{-1} was used for the analysis of various functional groups present in the solution which was absorbed at their own characteristic frequencies. The peak values of FTIR were recorded where the readings were repeated twice for the spectrum confirmation.[13]

SEM Analysis

Details of AgNPs such as morphology and size were analyzed using SEM. The suspension above the precipitate of plant extract biomass was taken as SEM samples and was dropped on sterile electric stubs to remove excess water before introduced into SEM. The particles cluster was focused by SEM and image was observed.[14]

RESULTS

The leaves extract of *M. indica* has been analyzed for their phytochemical constituents. The phytochemical analysis of *M. indica* leaves extract confirmed the presence of phytochemicals such as alkaloids, tannins, flavonoid, quinines, steroids, coumarins, and phenolic compound except sugar.

AgNPs were then prepared using *M. indica* leaves extract, and the present study demonstrated the formation of AgNPs by the reduction of aqueous silver metal ions by plant extract prepared using *M. indica* leaves. Finally, yellowish brown color was formed as a result of AgNPs formation. Reduction of silver nitrate solution by *M. indica* leaves extract, and the formation of AgNPs was shown in Figure 1.

Reduction of silver metal ions to AgNPs was preliminarily analyzed using UV-VIS spectrophotometer. This analysis on *M. indica* AgNPs showed maximum absorbance peak at 420 nm that proved the presence of AgNPs.

FTIR Analysis

FTIR spectrum of *M. indica* AgNPs leaves extract was shown in Figure 2 where different functional groups of different compounds were found. The spectrum was recorded in the wavelength region between 600 and 4000/cm.

The FTIR spectrum showed the highest peak at 3470.40/cm which indicates the presence of O-H stretching and H-bonded of alcohols and phenols. The peaks at 2832.16/cm indicate the presence of C-H stretching of alkanes. The peak observed at 2719.36/cm represents the CHO stretch of aldehydes. The N-H bend of primary amines and C-H bend of alkanes occurred at 1630.36/cm and 1362.33/cm, respectively. This N-H bend is responsible for AgNPs stability as reported in the previous studies.[15] The C-H bend occured as a weak band at 699/cm, corresponded to alkynes.

SEM Analysis

The SEM image showing the high intensity of AgNPs synthesized by *M. indica* extract further confirmed the development of silver nanostructures. When applied into SEM, they showed the minute particle size of about 100 nm as well the crystal structure of the nanoparticles. Figure 3 represents the SEM analysis of AgNPs formed from *M. indica* leaves extract.

DISCUSSION

Numerous plant herbs and their extracts were previously reported for their medicinal actions. The *M. indica* extract showing phytochemical constituents also have pharmacological properties such as antioxidant and antimicrobial properties that can be attributed by the phytochemicals such as flavones, iso flavones, flavonoids, anthocyanin, coumarin, lignans, catechins, and iso catechins.[16] The results are in line with the previous findings reported by Shah et al.[8]

AgNPs were produced by aqueous silver metal ions reduction within 20 min of incubation period. Silver nitrate is a reducing agent with silver has its own specific properties of good

Figure 1: *Mangifera indica* leaves extract (a) before and (b) after the formation of silver nanoparticles

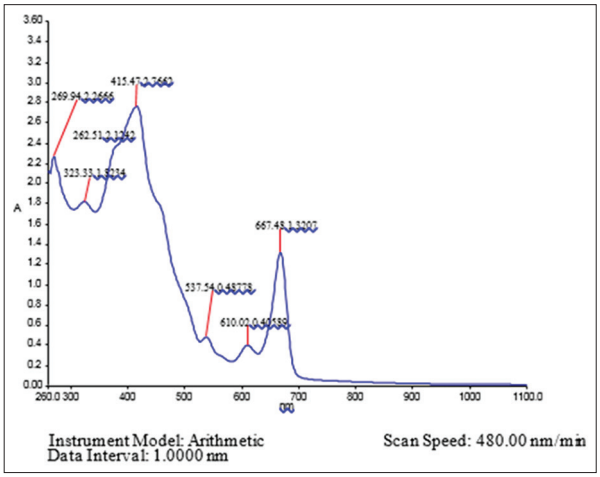

Figure 2: Fourier transform infrared analysis of *Mangifera indica* silver nanoparticles leaves extract

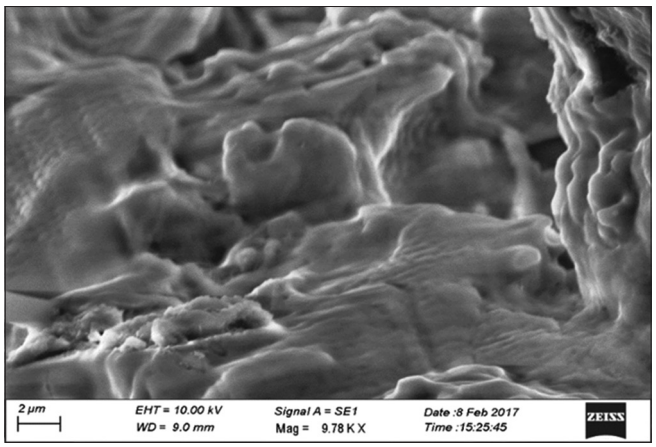

Figure 3: Scanning electron microscopy analysis of *Mangifera indica* silver nanoparticles leaves extract

conductivity, catalytic, and chemical stability. Therefore, the aqueous silver ions when treated with herbal plant extracts were reduced in solution to form silver hydrosol.[17] UV-VIS spectroscopy is an important technique to determine the formation and stability of metal and can determine the

reduction process. Results are in accordance with Sundeep et al., except the absorbance at 392 nm confirmed the presence of AgNPs.[1]

FTIR spectroscopy is one of the reliable and sensitive methods for detection of biomolecular fractions of various plant extract.[18] In this study, different functional groups such as alcohols, phenols, alkanes, aldehydes, primary amines, and alkynes were identified using FTIR.

Development of *M. indica* AgNPs leaves extract was determined by SEM where the AgNPs were observed as cubical and spherical in shape. The hydrogen bond and electrostatic bonds were responsible for AgNPs formation.[19] The results exhibit the same phenomenon as described by Ponarulselvam et al.[20]

CONCLUSION

Nanotechnology finds extensive applications in nanomedicine, an emerging new field. The present study is an eco-friendly procedure for synthesizing AgNPs using *M. indica* leaves extract. This technique gives us a simple and efficient way for the synthesis of nanoparticles with tunable optical properties governed by particle size. The phytosynthesis of AgNPs was demonstrated by visual inspection and by performing some spectral techniques using UV-VIS absorption, FTIR spectroscopy and SEM analysis. This green AgNPs can be extensively used in future nanomedicine.

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