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Synthesis of Silver Nanoparticles via Green Method using leaves of Mangrove *Avicennia marina*

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Abstract:
Background: *Research on nanoparticles is of great interest as it provides a bridge between bulk materials and atomic structures. However, the need of the hour is method of syntheses which are eco – friendly and sustainable. The "Green" method has proven to be reliable and cost – effective for synthesizing various types of nanoparticles. Hence it is regarded as an important tool in order to reduce the negative drawbacks that as re associated with the traditional methods of synthesis.*
Materials and Methods: *For synthesizing silver nanoparticles, leaf extract of mangrove Avicennia marina was used as a precursor along with 1mM $AgNO_3$ solution. The nanoparticles were further characterized using techniques UV – Visible, FTIR, TEM and Nanoparticle Tracking Analysis. The absorption spectrum was obtained using UV – Visible spectrometer. FTIR analysis indicated the presence of functional groups in the synthesis process. TEM images confirmed the morphology of the nanoparticles and size of the formed nanoparticles. The total concentration of the nanoparticle was determined using NTA by tracking their Brownian motion*
Results: *The absorption spectrum was obtained at 416 nm. The nanoparticles formed were spherical in shape and in the size range of 5 to 70 nm with average size of 35 nm.*
Conclusion: *The method applied using naturally available precursor such as mangroves was simple, eco – friendly and sustainable.*
Key Words: *Avicennia marina, silver nanoparticles, UV – Visible, FTIR, NTA, TEM.*

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I. Introduction

The study of structures which have dimensions between 1 to 100 nm is known as Nanotechnology while the particles having size between 1 to 100 nm are called as nanoparticles. These nanoparticles have wide range of applications in various fields such as biomedical, pharmaceutical, biology[1,2,3], environment[4], mechanical industries[5], materials and electronics[6,7,8], etc. due to their unique properties. Novel approaches/ methods have been developed in synthesis of nanoparticles having desired shape, size and functions. These methods are divided into two categories: Top – down approach and Bottom – up approach. Top – down approach involves physical methods of syntheses while the Bottom – up approach involves chemical and biological i.e. green method of syntheses. However, physical and chemical methods have their own set of drawbacks and limitations such as involvement of expensive processes, generation of byproducts, use of harmful chemicals, toxic harm to the environment, etc. In order to counter these limitations, the "Green synthesis" approach has been gaining vast attention in the field of science and technology.

Green synthesis of nanoparticles involves the use of eco – friendly multicellular and unicellular biological entities or precursors such as plants, fungi, bacteria, viruses, yeast and actinomycetes. However, plant – mediated synthesis of nanoparticles are favorable since they are widely available and the phytochemicals present in them have much greater potential to reduce metal ions at a shorter time period as compared to other precursors[9,10]. The aim of this research was to apply this green method in synthesizing silver nanoparticles. Mangroves are salt – tolerant vegetation and found near coastal regions. The results discussed herein reveal the synthesis of silver nanoparticles due to the reduction of silver ions by the aqueous leaf extract of *Avicennia marina*.

II. Material And Methods

***Chemicals and plant materials*:** The leaves of *A. marina* were collected from Mumbai region, Maharashtra, India. The leaves were thoroughly washed with water to remove excess of dirt and impurities present in them. They were further shade dried and then powdered by using an electric blender. The plant extract (P.E) required for synthesis was then prepared by boiling 10g of powdered leaves with 100 ml of distilled water for 10 minutes and later, collecting the filtrate by filtering the solution using Whatman filter paper no. 1. The $AgNO_3$ solution was of 1mM concentration and prepared by dissolving 0.169g $AgNO_3$ (SDFCL manufactured, A. R grade) in 1000 ml distilled water.

***Synthesis of silver nanoparticles*:** Different reaction concentrations of *A. marina* plant extract (P. E) and silver nitrate solution were subjected and suitable results were obtained when 10 ml of P.E was mixed with 100 ml of 1mM $AgNO_3$ solution. The reaction was carried out at room temperature. The reduction of silver ions was completed within 30 minutes. Addition of $AgNO_3$ solution to the P.E resulted in colour change to dull yellow and further to brown. Exposure to sunlight also increased the colour intensity of the solution.

***Characterization of silver nanoparticles*:** The *A. marina* plant extract, 1mM $AgNO_3$ and silver nanoparticle solutions were analyzed in UV – Visible spectrophotometer. The FTIR analysis was carried out by preparing KBr pellets of all three solutions and analyzing them in the instrument, scanned over the range of 500 to 4000 cm^{-1}. For NTA, the silver nanoparticles solution was inserted into the sample cell by sterile injection. The NTA image analysis software was used for tracking the Brownian motion of the particles and to record the size and total concentration of the silver nanoparticles. The TEM study was carried out by first bringing the silver nanoparticles solution in dispersed phase using a sonicator. This solution was then loaded on carbon coated copper grids and allowed to dry for 45 minutes. The disc was then inserted into the sample holder and then interacted with electrons which resulted in formation of image. The images were observed at different magnifications.

III. Results

1) UV – Visible spectroscopic analysis: The formation of silver nanoparticles was due to the bioreduction of silver ions by the aqueous leaf extract of *A. marina*. The absorption peak was obtained at 416 nm. The colour change and change in intensity of the colour was due to the increase in vibrations induced by surface plasmon[11].

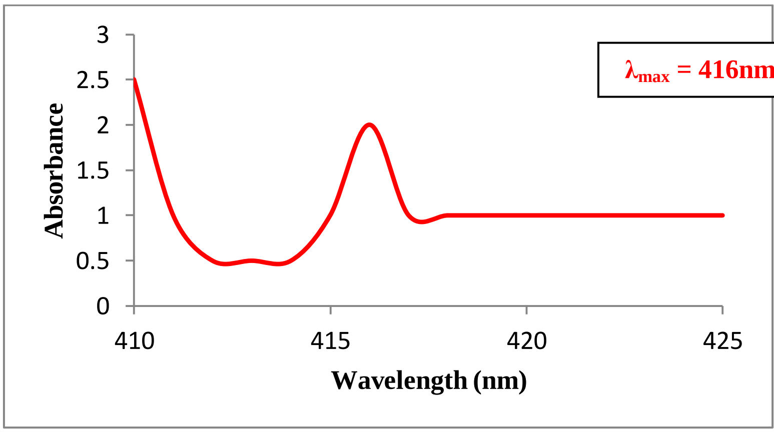

Figure – 1: UV – Visible absorption spectrum of silver nanoparticles synthesized from aqueous leaf extract of *A. marina*

2) FTIR spectroscopic analysis: The FTIR analysis of *A. marina* plant extract, 1mM $AgNO_3$ solution and silver nanoparticles was carried out in order to determine the functional groups which may be responsible for the reduction and stabilization of silver nanoparticles (Fig. 2 – 4). In Fig. 4, functional group bands observed at 3426 cm^{-1}, 3339 cm^{-1}, 3210 cm^{-1} and 3057cm^{-1} have been assigned to O – H stretching of alcohol, stretching vibrations of amines, O – H stretching of carboxylic acid and C – H stretching of alkenes respectively. Peaks at 1673cm^{-1} and 1631 cm^{-1} are assigned to the stretching vibrations of carbonyl and C=C of alkenes respectively, while peaks at 1325cm^{-1}, 1296cm^{-1} and 1241cm^{-1} correspond to the bending vibrations of phenols and stretching vibrations of C – O of acids and C – N of amines respectively. The peaks observed are related to major functional groups belonging to different chemical classes such as flavonoids, saponins, triterpenoids, polyphenols, etc. which have been previously proved to be potential reducing agents [12, 13]. This confirmed the presence of functional groups of different phytochemicals.

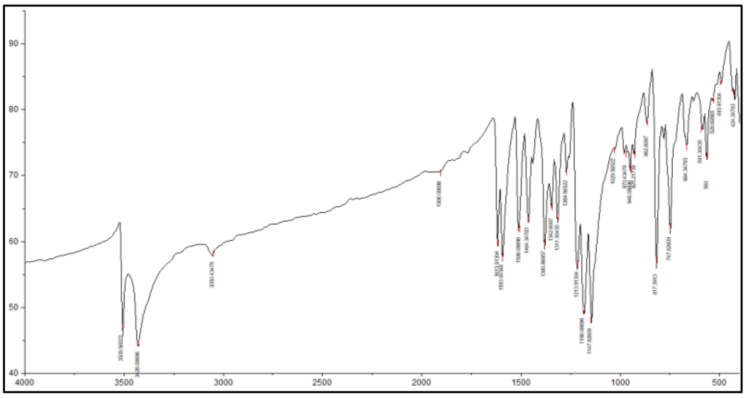

Figure – 2: FTIR spectra of aqueous leaf extract of *A. marina*

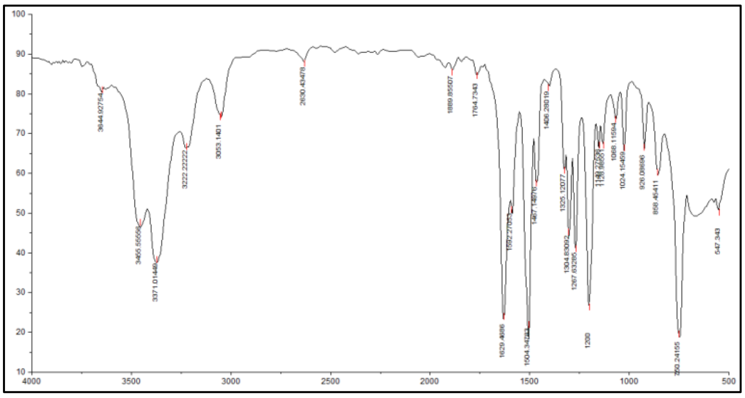

Figure – 3: FTIR spectra of 1mM $AgNO_3$ solution

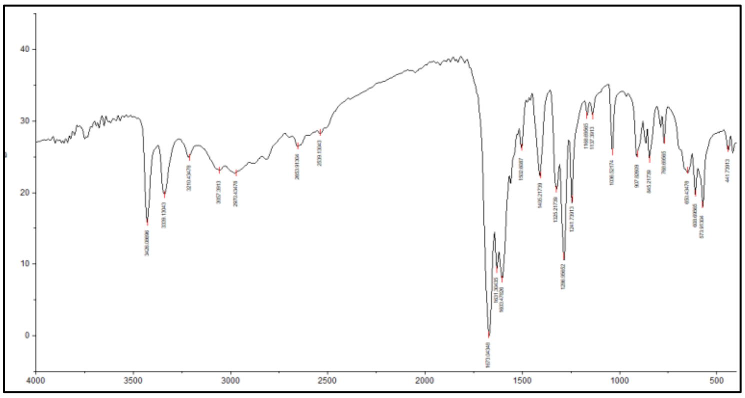

Figure – 4: FTIR spectra of silver nanoparticles synthesized from *A. marina*

3) Nanoparticle Tracking Analysis (NTA): The NTA was used to characterize the nanoparticle size distributions in liquids. It is based on Rayleigh scattering from small particles performing Brownian motion in the liquid[14]. The total concentration of the silver nanoparticles was found to be 138.73 particles/ frame, 6.24particles/ml. Further, the mean and mode of the nanoparticles was found to be 35 nm and 25 nm respectively. From NTA, the nanoparticles were found within the size range of 5 to 70 nm.

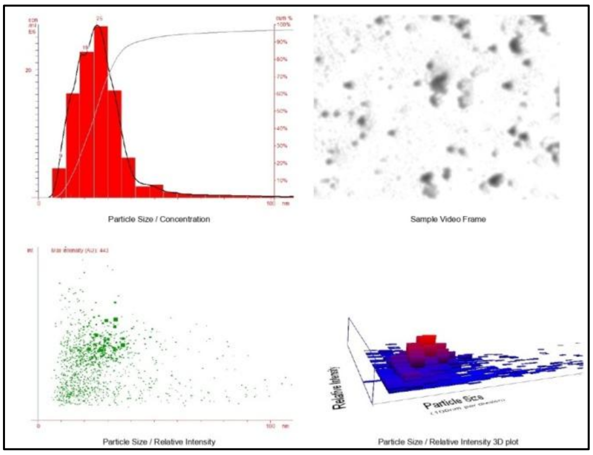

Figure – 5: NTA of silver nanoparticles synthesized from *A. marina*

4) TEM analysis: Fig. 6 shows the TEM images of the synthesized silver nanoparticles. The morphology of the nanoparticles affects the properties of the nanoparticles. The silver nanoparticles were predominantly spherical in shape and were obtained in the size range of 5 to 70 nm. The average size was found to be 35nm.

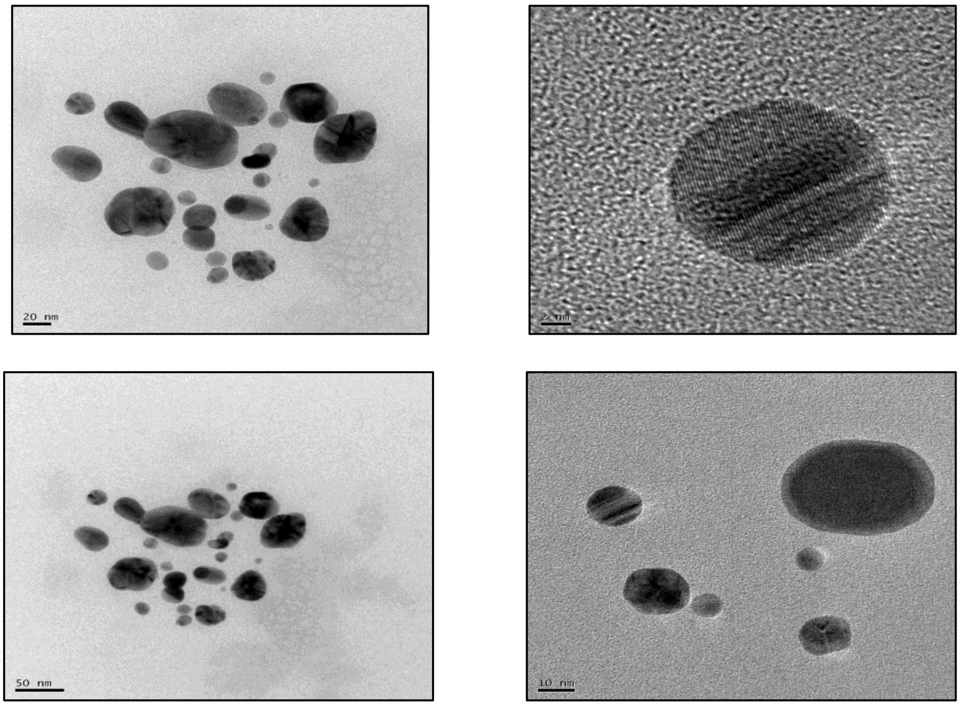

Figure – 6: TEM images of silver nanoparticles synthesized from *A. marina*

IV. Discussion

The synthesis of nanoparticles can be achieved by applying both physical and chemical methods. However, these methods are expensive, time consuming and can be potentially toxic to the environment. With the increasing demand of eco – friendly methods in the current times, biological methods i.e. green synthesis of nanoparticles has proven to be a better alternative. Use of naturally available precursors such as plants, fungi, bacteria, etc, has its own benefits by eliminating the use of toxic reagents and development of better results[15]. Using plants over other biological precursors is advantageous as they eliminate the requirement of elaborate process for maintaining cell culture. Also, the phytochemicals present in plants play a dual role of reduction and stabilization of nanoparticles. Due to their unique size and shape dependent properties, silver nanoparticles have garnered massive attention[16, 17]. Moreover, synthesizing silver nanoparticles using various parts like roots, flowers, stem, etc. of the plants have also been reported[18, 19, 20]. Further, research has been dedicated to explore the various applications of silver nanoparticles in different fields of science[21].

V. Conclusion

The bioreduction of silver ions was carried out using the leaf extract of mangrove *Avicennia marina*. The synthesized silver nanoparticles were characterized using UV – Visible spectra which showed the absorbance at 416 nm. The FTIR analysis confirmed the presence and role of phytochemicals in the synthesis of nanoparticles. The TEM images confirmed the morphology of the silver nanoparticles to be spherical and, along with NTA results, the average size of the nanoparticles was 35 nm. In conclusion, the green synthesis method applied was reliable, inexpensive, non – toxic and eco – friendly.

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