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ECO FRIENDLY SYNTHESIS OF SILVER OXIDE NANOPARTICLES FROM BORASSUS FLABELLIFER FIBER AND ITS ANTIBACTERIAL ACTIVITY AGAINST REPRESENTATIVE MICRO ORGANISMS

ABSTRACT

The present study reports an easy eco-friendly, cost efficient, and rapid method for the synthesis of silver nanoparticles (Ag NPs) using palm sprouts as reducing cum capping agent. Green synthesis of silver nanoparticles was successfully performed using palm sprouts plant extract via a simple and cheaper eco-friendly method. Palm sprouts extract reduces silver nitrate to silver nanoparticles. The resulting materials were analyzed by Fourier-transform infrared spectroscopy (FTIR), Scanning Electron Microscopy (SEM), and X-ray Diffraction (XRD) analysis. FT-IR spectrum confirms the presence of various functional groups in the active biomolecules, it acts as a capping agent for the nanoparticles. The morphology of this sample was analyzed through SEM and the presence of silver was confirmed accordingly. The green synthesized Ag NPs exhibited an excellent antibacterial activity against *E. coli* and *P. aeruginosa* and *B. subtilis* and *S. aureus* besides imparting efficient antimicrobial activity against pathogenic bacteria as well.

Keywords: *palm sprout; FTIR; XRD; B. subtilis; S. aureus*

INTRODUCTION

Nanotechnology is a new form of technology which has produced a great development in various fields [1, 2]. Due to the unique features and applications of the nanoparticles, they are very useful especially in the field of biotechnology, medical imaging and catalysts [3-5]. Silver nanoparticles of different sizes and shapes have been attracting much attention due to their unusual size and shape-depending optical, electrical, and magnetic properties. Presently, many environmentally friendly approaches have been engaged in the preparation of nanoparticles to address the above said issues by means of nanobiotechnology, which is a promising interdisciplinary

research field [6-8]. Green synthesis of metal and metal oxide nanoparticles has been a very much attractive research area above the last decade [9, 10]. The green synthesis method is a non-toxic, eco-friendly, and cost effective method [11,12]. The plant extract enclose some unique compounds the aid to advance the synthesis efficiency and higher the stability of metal nanoparticles [13-15]. These types of nanoparticles are exploited to analyze antibacterial [16], antifungal [17], antioxidant [18], anticancer [19], material coatings [20], color diminishment [21], wound dressing [22], antimalarial activity [23], Food packaging and antiseptic creams [24, 25].

Merga et al., [26] was prepared silver nanoparticles from ascorbate, poly (ethylene glycol)-block copolymers, sodium citrate, elemental hydrogen, polyol process, and sodium borohydride, it is used to reduce silver ions to metallic silver and then cause its agglomeration into clusters. Agnihotri et al., [27] Ag NPs have been prepared from AgNO_3 as a originator, trisodium citrate and sodium borohydride as stabilizing agents. Trisodium citrate and sodium borohydride are good reducing agents for preparing Ag NPs. Ag NPs have also been synthesized using hydrazine hydrate and polyvinyl alcohol as reducing and stabilizing agents however, the synthesis of silver nano particle using plant extracts is potentially beneficial over different microorganisms still of its simple scale up. Pyatenko et al., [28] prepared silver nanoparticles by irradiating Ag target with a range of 532 nm laser beam in pure water. This method is effectively applied to produce very small nanoparticles with a fine size distribution in pure water not including using any chemical additives with the laser ablation and thermal effusively of nanocomposite.

In past decade we have prepared nanoparticles from organic chemicals but now days nanoparticles prepared from green route. Now days the researchers were focused nanoparticles synthesis from green route. Amal A. et al., [29] expected to prepare zinc oxide nanoparticles (ZnO NPs) via a green method that used *Phlomis* leaf extract as a successful reducing agent. In vitro cytotoxicity was identified in L929 normal fibroblast cells via MTT assay. Das et al. establish that copper sulfate pentahydrate were reduced using 50% ethanol extracts of *Moringa oleifera* leaves at 60°C for 3 h to produce amorphous Cu NPs of size 35.8–49.2 nm as-prepared Cu NPs exhibited antioxidant, antifungal and antibacterial, activities. Yasmina Khane et al., [30] concentrated on the green synthesis of silver nanoparticles (Ag NPs) through the use of aqueous Citrus limon zest extract, optimizing the different experimental factors required for the formation and stability of Ag NPs. The preparation of nanoparticles was confirmed by the observation of the color change of the mixture of silver nitrate, after the addition of the plant extract, from yellow to a reddish-brown colloidal suspension. These bioactive silver nanoparticles can be used in biomedical and pharmacological fields.

However, to the best of our knowledge and literature survey no one carry the work in *palm sprout* fiber to prepare the silver nanoparticles very effectively. Hence, an effort was made in our present study to the green synthesis and characterization of Ag NPs from *palm sprout* assesses their effect on biological systems.

MATERIALS AND METHODS

Silver nitrate (AgNO_3) and sodium hydroxide were purchased from Sigma Aldrich, India, Muller Hilton Agar and Nutrient agar were obtain from HiMedia, India. *Palm sprout* fiber was collected from the Market, Uthangarai, Krishnagiri (Dt).

Characterization of silver nanoparticles

The resulting nanoparticles were also analyzed using FTIR Agilent Tech-630. X-ray diffraction (XRD) analysis was done RIGAKU (XRD miniflex-600) using monochromatic Cu α radiation.

Synthesis of silver nanoparticles

The *palm sprouts* collected from uthangarai market and then washed carefully 2-3 times with tap water and one time with sterile water. 20 g of fresh leaves was thinly chopped and added to 100 mL of distilled water and stirred at 60° C for 1 h. After heating, the sample was cooled and filtered with proper Whatman paper and collected the filtrate. For the green synthesis of silver nanoparticles, we used palm spout extract prepared in the previous step. For this, 10 mL of leaf extract was added to 90 mL of 1 mM aqueous silver nitrate solution, followed by warmed at 80 °C for 3 h with constant stirring in the magnetic stirrer. The arrangement of the Ag NPs was preliminarily noticed by the change in color from yellow to dark brown. The final green-synthesized silver nanoparticles, which were dried and stored till now further use.

Antimicrobial activity by well diffusion method

The antibacterial activities of the new nanomaterials such as MO_3 and AO_3 were analyzed through well diffusion method. These compounds were different concentrations of 25, 50, 75 and 100 μL correspondingly. The different microorganisms were cultured in Mueller–Hinton broth (MHB) and following 24 h the suspension were used to standard sub culture dilution in Petri dishes including Muller Hinton Agar (MHA) medium. These plates were beginning with freshly synthesized various pathogens. The wells with diameter of 5 mm were prepared with the assist of a sterile steel cork borer. The positive reference standard was drug streptomycin (20 μg) used to determine the sensitivity of each microbial species tested and plates were incubated at 37 °C for 24 h. The clear zone around the disc was measured the diameter.

RESULTS AND DISCUSSION

Nanoparticles, like Ag NPs, show enhance potential to realize this objective through creating safer and minimizing waste, to foster healthy communities, environment, and workplaces. Ag NP fabric treatment is a tremendous way to offer expanded functional properties Ag NPs are going to play an important role in the upcoming decades. Chemical reduction method using inorganic and organic reducing chemicals compounds the most famous method for producing silver nanoparticles Hiba Abbas Widatalla. et al., (2022) [31] were synthesized silver nanoparticles from Green tea extract. Green tea (GT) leaf extract was used as a reducing agent to convert silver ions into free Ag NPs. The use of Ag NPs from Green Tea leaf extracts as an antimicrobial agent to treat chronic infections. The chemical route and green route (plant) to synthesis silver nanoparticles but in our research the silver nanoparticles synthesized from fiber because fiber is good chain entanglement and excellent lattice structure. So it is easy make silver nanoparticles as

well as it act as capping and stabilizing agent and it is used to several application such as coating, solar energy, food packaging and drug delivery application

FTIR spectrum of silver nanoparticles

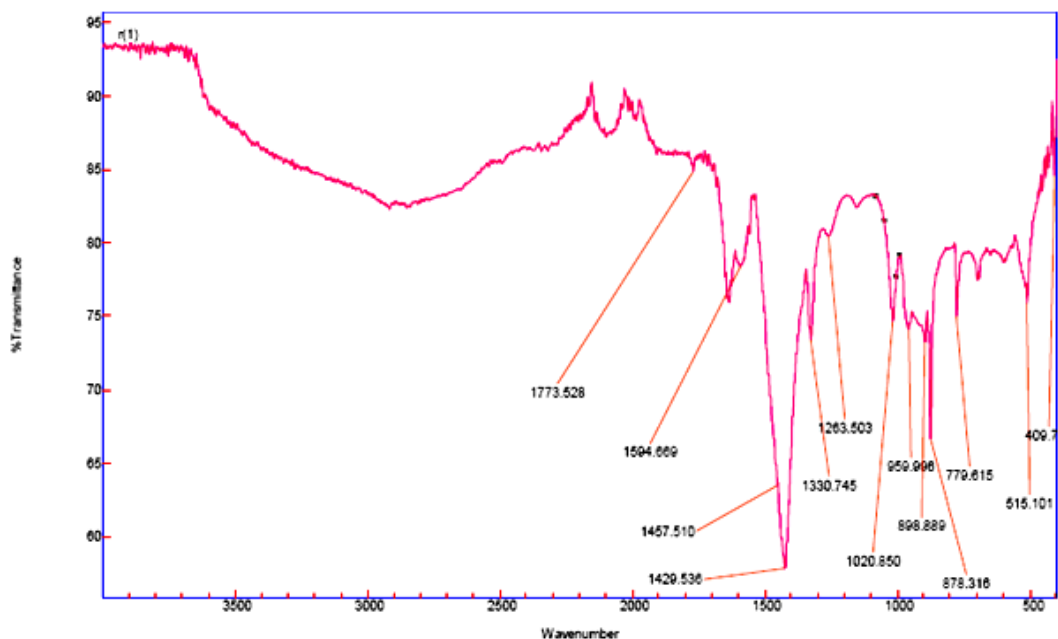


Fig. 1. FTIR Spectrum of silver nanoparticles from palm sprout

Fig. 1 illustrates the surface functional groups and their interaction with the Ag NPs by the FT-IR spectroscopy. The spectrum indicates absorption peaks at 515, 1020, 1330 cm^{-1} , 1457 cm^{-1} , 1504 cm^{-1} and 3050 cm^{-1} , which clearly confirm that the plant molecules act as capping agents that were bound on Ag NPs. The absorption peak at region 3050 cm^{-1} was the reason for -OH stretching vibration. The absorption peak at 2720 cm^{-1} characterized the CH stretching vibration. Also, the absorption band 1504 cm^{-1} appended by Ag NPs with the nitro compounds [32]. The peak at 779 analogous to the CH stretching of the aliphatic group and 515 cm^{-1} signify the corresponding OH group.

XRD Spectrum of silver nanoparticles

XRD used to confirm the nanoparticles as silver and identifies their structural information. Fig. 2 shows for Ag NPs prepared from natural plants extraction. The green Ag NPs showed the plane 2θ angles at the different range of 32.4°, 38.28°, 45.1°, 67.11° and 78.4° corresponding to the 122, 111, 200, 220 and 311 (JCPDS NO: 04-0783). These peaks are due to the presence of organic compounds in the extract and accountable for Ag ions reduced and stabilized to resulting nanoparticles

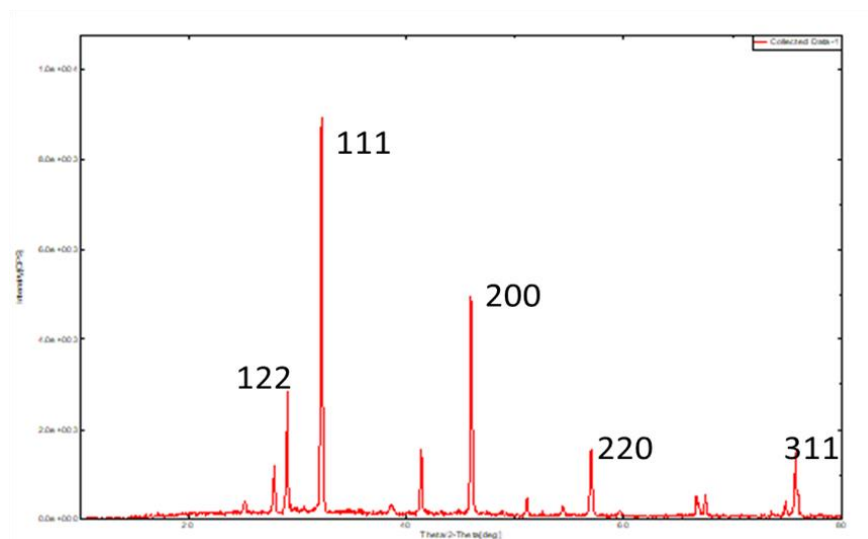


Fig. 2. XRD Spectrum of silver nanoparticles from palm sprouts

SEM Analysis of silver nanoparticles

SEM resolves the morphology of the biosynthesized Ag NPs to be more or less spherical. The morphology and size of the Ag NPs were analyzed by Scanning Electron Microscope (SEM). The images had shown the presence of Ag NPs as well as number of aggregates (Fig. 3). SEM clearly demonstrates the particles are mostly spherical in shape and aggregate into extra superior particles with not well known morphology.

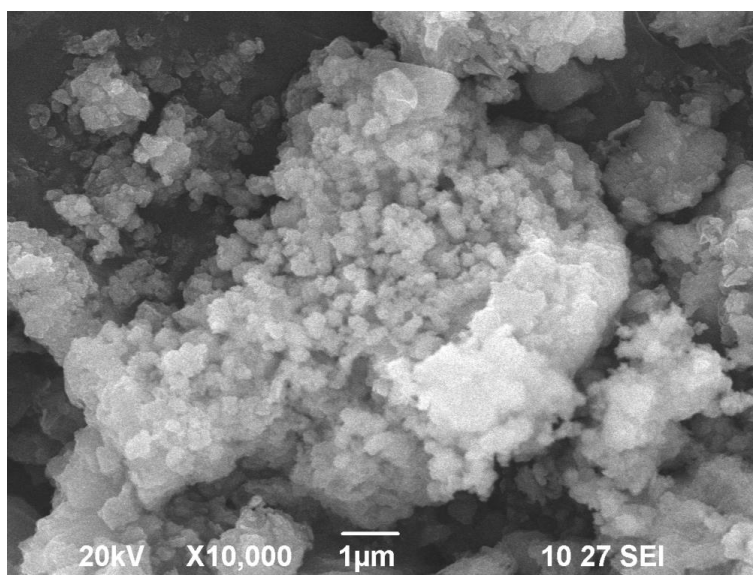


Fig. 3. SEM Images of silver nanoparticles from palm sprout

This aggregation might be due to the occurrence of inferior metabolites in the leaf extracts. Analogous results with regard to silver nanoparticles size were accounted by using Aloe Vera extract [33]. Accordingly, SEM images propose that the biosynthesized Ag NPs are almost spherical in structure.

Antimicrobial activity of silver nanoparticles

The antimicrobial activity of silver nanoparticles synthesized by natural *palm sprout* fiber was investigated against various bacteria pathogenic organisms such as *B. subtilis*, *S.aureus*, *P. aeruginosa*, and *E.coli* using well diffusion method (Fig. 4). Combination of Ag NPs and anti-microbial Streptomycin exposed a synergistic effect to demonstrate the enhanced antimicrobial activity against.

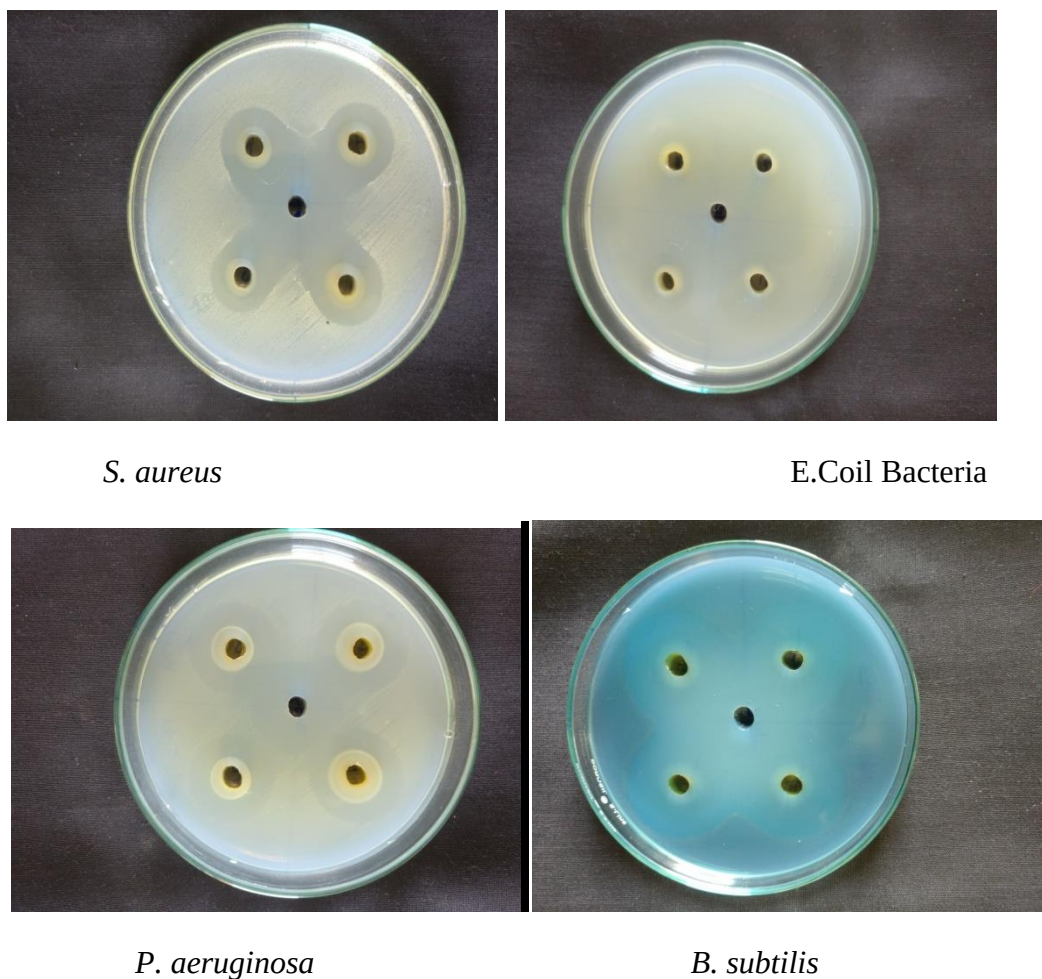


Fig. 4. Zone of inhibition of silver nanoparticles against various pathogenic microorganisms

The diameter of inhibition zones around each well with silver nanoparticles solution is represented in Table 1. The silver nanoparticles synthesized by *palm sprout* extracts were found to have highest antimicrobial activity against *P. aeruginosa* and *S. aureus* respectively. The silver nanoparticles showed efficient antimicrobial property compared to other salts due to their extremely large surface area, which provides better contact with microorganisms. It is additionally caught on that this green approach shows up to be a low cost, non-toxic, and an ecofriendly elective to the predictable physical, microbiological, and chemical strategies and would be appropriate for creating an organic prepare for large-scale generation.

Table 1. Zone of inhibition of silver nanoparticles

Sample code	Zone of inhibition (mm) and MIC $\mu\text{g/mL}$															
	Bacillus subtilis				Staphylococcus aureus				Pseudomonas aeruginosa				Escherichia coli			
	25 μL	50 μL	75 μg	100 μL	25 μL	50 μL	75 μg	100 μL	25 μL	50 μL	75 μg	100 μL	25 μL	50 μL	75 μg	100 μL
MO ₃	20	22	24	26	23	25	26	27	27	29	31	32	20	20	22	22
AO ₃	17	19	20	20	20	22	23	23	15	27	28	30	15	16	17	20
Streptomycin (20 μg)	26				23				24				19			

A few fundamental instruments underlie the bioactivity properties of Ag NPs against microorganisms. To begin with, Ag NPs connect to the negative charged cell surface; alter properties such as physical and chemical properties of the cell membrane & the walls and significant capacities like permeability and respiration. Following, Ag NPs cause advance harm to bacterial cells by cell mixture, where they associated with DNA, proteins and other phosphorus and sulfur containing cell constituents [21-23]. Third, Ag NPs discharge silver particles, creating a made strides biocidal effect, which is measure and dose measurements [14]. The more bactericidal movement of Ag NPs may be due to their enormously huge surface zone, which offers enhanced contact with microorganisms. Besides, Ag NPs act as reservoirs for the bactericidal agent [24-26].

CONCLUSIONS

In conclusion, a significant need in the field of nanotechnology is the progress of a reliable and eco-friendly process for synthesis of metallic nanoparticles. Green synthesis of silver nanoparticles has a vast potential for their use in biomedical applications. Silver nanoparticles play a profound role in the field of biology and medicine due to their attractive physiochemical properties. In the present study, we have demonstrated that use of a natural, low cost biological reducing agent. This study clearly provides an economic, environmental friendly and straight forward reproducible approach in Ag NPs synthesis employing *palm sprout* extract. The biosynthesized Ag NPs were characterized thoroughly by XRD, FTIR and SEM technique. The XRD pattern of Ag⁺ ions exposed to these plant extracts proves the reduction of silver ions to silver nanoparticles. FTIR spectrum showed the presence of different variety of functional groups in the biosynthesis molecules, so it acts as a capping agent for the nanoparticles. SEM image ascertained the reduction of silver nitrate to silver nanoparticles and mentioned that the bio synthesized Ag NPs are nearly spherical in structure. The zones of inhibition were formed in the antimicrobial screening test indicated, that the Ag NPs synthesized in this process has the efficient antimicrobial activity against pathogenic bacteria. The biologically synthesized silver nanoparticles could be of immense use in medical field for their efficient antimicrobial function.

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