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Green Biosynthesis of Silver Nanoparticles Using Musa Acuminata Aqueous Flower Extract and Its Anti-Microbial Activities

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Abstract
Nanomaterials have gained much relevant in the world of science due to their applications in catalysis, wastewater treatment and desulfurization of fossil fuels, biotechnology, pharmaceuticals and medicine. The green approach of nanoparticle synthesis employs the use of non-toxic reagents and is now preferred to the other methods which include thermal decomposition, electrochemical, photochemical, microwave assisted process chemical methods. Silver nanoparticle was biosynthesized using flower extract of *Musa acuminata* as reducing and capping agents. The synthesized silver nanoparticle was confirmed by the colour change after addition of the flower extract of *Musa acuminata* into silver nitrate solution. The silver nanoparticle was characterized by UV–Visible spectrophotometer, scanning electron microscopy (SEM), energy-dispersive x-ray spectroscopy (EDX), and Fourier transform infrared (FTIR) spectrophotometer. The result of SEM reveals the formation of silver nanoparticle which was spherical in shape with varying sizes ranged between 20-30 nm. The biosynthesized silver nanoparticle gave absorption at 375 nm, revealed silver metal as the most abundant element, vibrational bands indicating the presence of quinone, amides and conjugated ketone which served as reducing and capping agent. The bio-synthesized silver nanoparticles revealed potent antibacterial activity and the economical synthesis of silver nanoparticle from aqueous flower extract of *Musa acuminata*which is ecofriendly.
Keywords :Green synthesis; silver nanoparticles; flower extract; capping agents; antibacterial activity; scanning electron microscopy.
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1. Introduction

Nanomaterials can be useful in such areas as catalysis [1, 2], medicine [3], waste water treatment [4-7] and desulfurization [8, 9]. Formation of metal nanoparticles has gained enormous interest in recent times due to their exclusive characters and prospect enforcement in biotechnological stamp, pharmaceuticals, and agriculture [10, 11]. Among the nanoparticles, silver nanoparticles (AgNPs) have attracted much attention because of its attractive properties, such as a high electrical and thermal conductivity, surface-enhanced Raman scattering, chemical stability, high catalytic activity and antimicrobial activities [12-14]. There are many approaches for the synthesis of silver nanoparticles, such as thermal decomposition [15], electrochemical [16], photochemical [17], microwave assisted process [18] and green chemistry methods [19]. These methods of silver nanoparticle synthesis are either expensive or involve the utilization of hazardous chemicals. To overcome these inadequacies, developing an environmental-friendly process for silver nanoparticle synthesis using non- toxic chemicals holds the unique attention of the scientific community. Green synthesis offers a relatively safer, greener and eco-friendlier strategy for silver nanoparticle biosynthesis. Several authors have used bacteria, fungi, algae, spider cobweb and plant extracts for the green synthesis of different types of silver nanoparticles [20-35]. The aim of this research work is to synthesize silver nanoparticles from the aqueous flower extract of *Musa acuminata*.

Musa is one of two or three genera in the family Musaceae; it includes bananas and plantains. Around 70 species of Musa are known, with a broad variety of uses. Though they grow as high as trees, banana and plantain plants are not woody and their apparent "stem" is made up of the bases of the huge leafstalks. Thus, they are technically gigantic herbs. Musa species are used as food plants by the larvae of some Lepidoptera species. The banana fruits and flower are said to be composed of important phytochemicals such as cartenoids especially beta-carotene, lutein, malic acids, ascorbic acid, isopentyl acetate, esters of pentanol, butyric acid, eugenol, O-methyleugenol and elemicin [36]. These phytochemicals are employed in the reduction of silver ion (Ag^+) and also serve as capping agent. In this work, we report the green synthesis of AgNPs using air dried *Musa acuminata* flower and evaluation of its antibacterial activities using some drug-resistant strains of bacteria.

2. Materials and experimental methods

Musa acuminate flowers were collected from a residence in Ajilosun area of Ekiti State, Nigeria. The flowers were peeled and air dried. The dried flowers were crushed using mortar and pestle, and thereafter pulverized using an electric blender.

Figure 1: *Musa acuminata* with flowers

2.1 Preparation of the aqueous Musa acuminata flower extract
About 20 g of the powdered flower of *Musa acuminata* was weighed into 100 mL of distilled water in a 500 mL beaker and boiled on hot plate for 30 mins. The beakers were allowed to cool and filtered using a mesh net. The extracts were centrifuged using a centrifuge (800D, China) at 4000 rpm for 20 min. The supernatant was collected and used for the synthesis of the Ag nanoparticles.

2.2 Biogenic synthesis of AgNPs
The aqueous extract of the *Musa acuminata* flower was used to synthesize AgNPs. 10 mL of the extract was added to the reaction vessel containing 90 mL of 1mM silver nitrate ($AgNO_3$) solution for the reduction of silver ion (Ag^{+1} to Ag^0) according to this reaction :
$Ag^+ + e^- \rightarrow Ag^0$
The reaction was carried out in static condition at room temperature (30 ± 2 °C) for 2 h [27].

2.3 Characterization of the biosynthesized AgNPs
The AgNPs was characterized using UV-Vis spectrophotometer, Fourier transform Infrared spectrophotometer (FTIR), Scanning Electron Microscope (SEM), Energy Dispersive X-ray (EDX)
2.3.1 UV-Vis spectrophotometer
The formation of AgNPs was monitored through visual observation of the change of colour and measurement of the maximum absorbance using UV–visible spectrophotometer model 6715 (Jenway Ltd. Essex, UK)
2.3.2 Fourier Transform Infrared Spectrophotometer
To give qualitative and preliminary analysis of the main functional groups that might be involved in nanoparticle synthesis, FT-IR analysis was performed on the AgNPs and concentrated *Musa acuminata* aqueous extract using Fourier Transform Infrared Spectrometer (Perkin Elmer Spectrum 100 series spectrometer, USA). This was conducted at the University of Ibadan, Department of Geology, Nigeria. Five milligramme (5 mg) of AgNPs and *Musa acuminata* aqueous extract were homogenously mixed separately with dry potassium bromide in a disc by applying pressure. The spectra of the AgNPs were measured within the range of 4000–400 cm^{-1}wave number.
2.3.3 Scanning Electron Microscope (SEM) and Energy Dispersive X-Ray Analysis (EDX)
The morphology of the AgNPs was examined. Sample was first gold coated using sputter coater, Edwards S150, which provides conductivity to the samples and then the SEMs spectra was taken. This technique allows SEM to examine the internal ultrastructure of thin AgNPs. The quantitative and qualitative elemental composition of the AgNPs was carried out in the Department of Geology, University of Ibadan, Nigeria using a Horiba Energy Dispersive X-ray Spectrometer coupled with x-ray microanalysis, transmitted electrons can be used for acquisition of elemental information and distribution

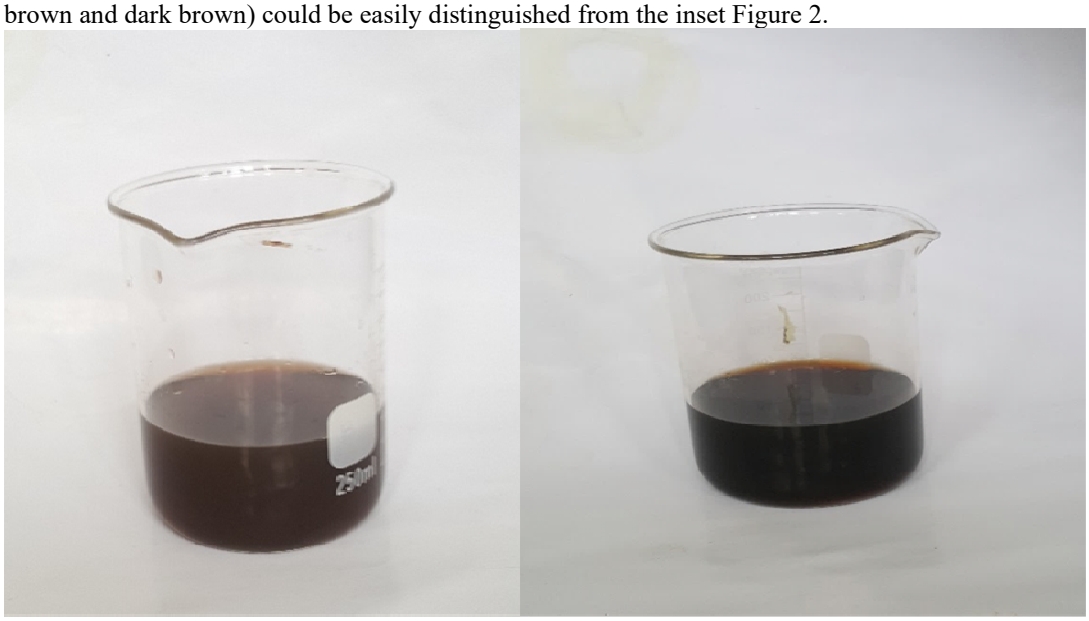
2.4 Antimicrobial activities of synthesized AgNPs
Silver nanoparticles exhibit promising applications in several biomedical fields such as biomedicine, drug delivery and antiangiogenics [37].The AgNPs was tested against two gram positive (*S. aureus and B. subtilis*)

shown in Plates 1 below and two gram negative microbes (*E. aerogenes and E. coli*) shown in Plates 2 below to evaluate their antimicrobial activities.

3. Results and discussion

3.1 Ultraviolet–Visible (UV–Vis) spectroscopic analysis

The visual observation of the *Musa acuminata* extracts, silver nanoparticles (Figure 2) synthesized revealed colour change from light brown to dark brown for the Ag nanoparticles. The UV–Vis spectrum of the Ag nanoparticle shown in Figure 3 is the spectra of the stabilized AgNPs. The appearance of the color was due to the excitation of the surface plasmon vibrations. The maximum absorbance of the AgNPs obtained was 375 nm (figure 3) which falls within the range 320nm – 550nm reported by [38]. The colour of the two solutions (light brown and dark brown) could be easily distinguished from the inset Figure 2.



(a) (b)

Figure 2.*Musa acuminata*flower extract (a) and Ag nanoparticles (b)

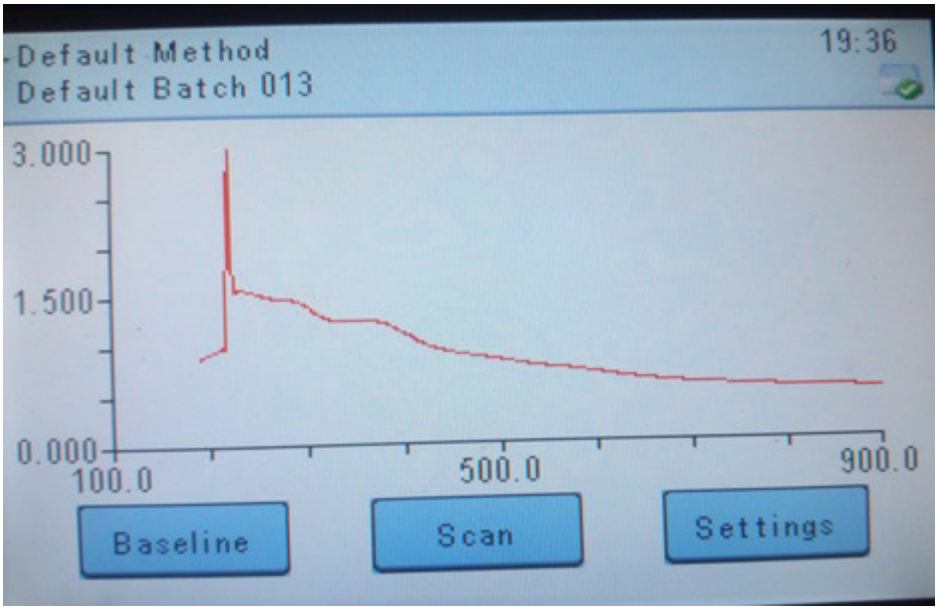


Figure 3. UV spectra of the AgNPs

3.2 Fourier Transform Infrared Spectra (FTIR)

The FTIR spectral in Figure 4 (H1) for the flower extract of *Musa acuminata* has band 3413 cm^{-1} assigned to –OH stretching vibration bonded with Hydrogen, 1624cm^{-1} is indicative of N-H vibration of primary amine,1383cm^{-1} is associated with –OH bending vibration of phenol or tertiary alcohol / N-O stretching

vibration and 1036 cm^{-1} shows the presence of C-N stretching vibration of aromatic primary amine or C-O stretching vibration of primary alcohol.

Figure 4 (He1) revealed bands at 3420cm^{-1} assigned to –OH stretching vibration bonded with Hydrogen, 2936cm^{-1} which shows the presence of C-H stretching vibration of methylene group, 1651cm^{-1} C=O of quinone, amide or conjugated ketone, 1384cm^{-1} indicative of –OH bending vibrations, 1084cm^{-1} suggested the presence of C-N stretching for primary amine,467cm^{-1} was assigned to Ag.

The vibrational bands observed in the FTIR spectral in figure 4(H1) implied that the *Musa acuminata*extract is composed of amide, phenolic compounds which served as the reductant and stabilizing agents during the bionanosynthesis [39, 40]. In figure 4(He1) the bands confirmed that the quinone, amide, phenolic compounds were present in the AgNP although had their bands reduced due to the stabilizing effect by chelation or electrostatic attraction [8].

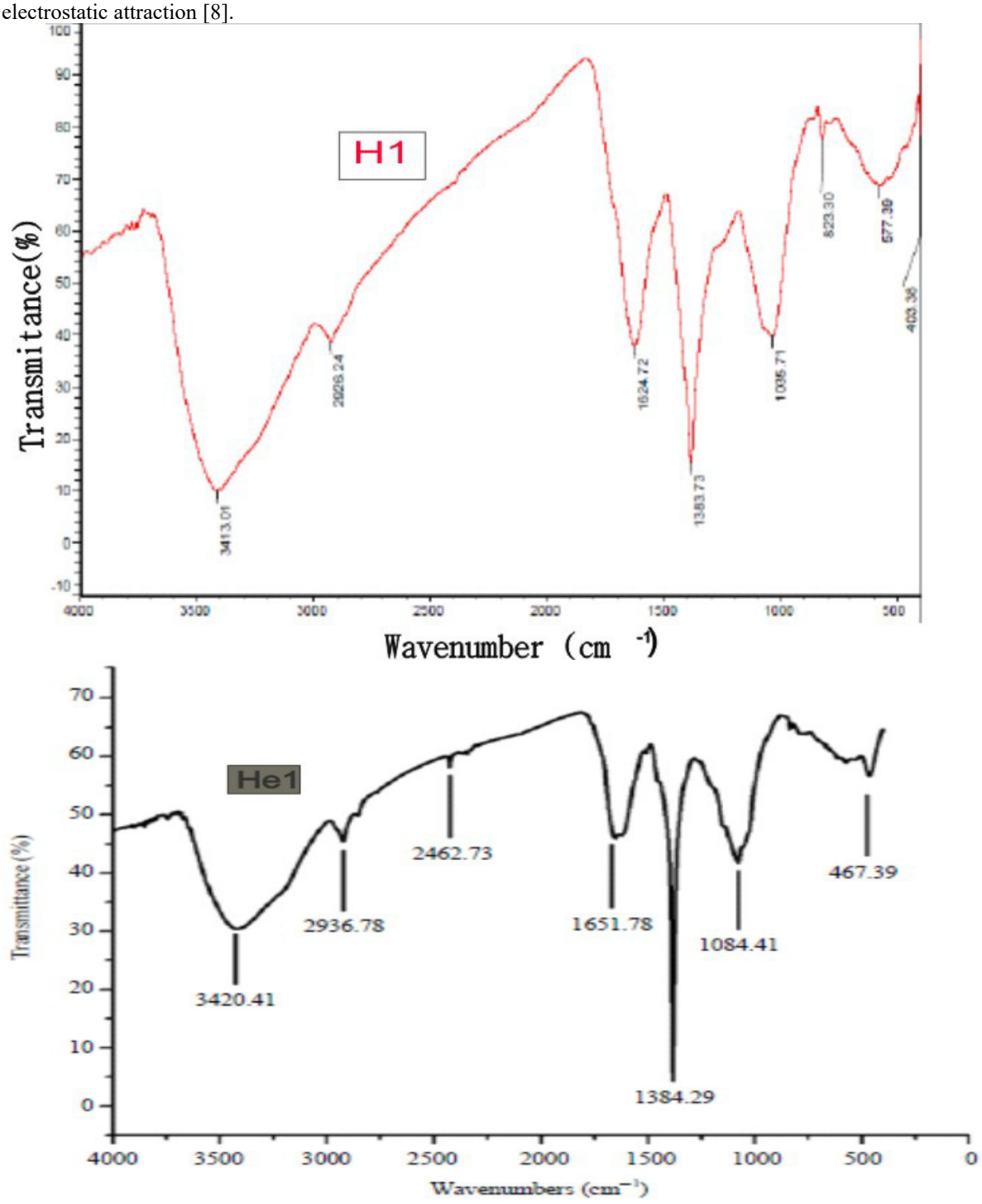
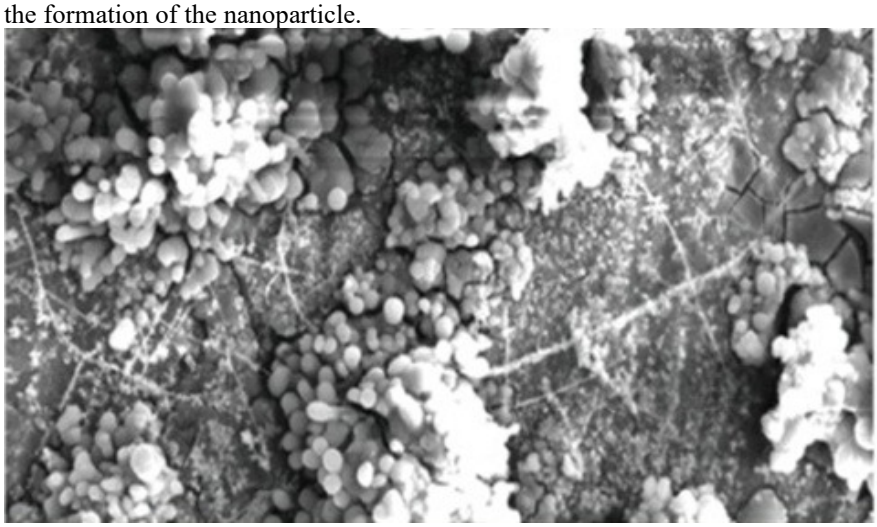


Figure 4. FTIR spectra for flower extract (H1) and the AgNPs (He1)

3.3 SEM and EDX Analysis

The morphology of the silver nanoparticle (figure 5b) is completely different from the aqueous flower extract (figure 5a). The qualitative, as well as quantitative elemental profile was ascertained using EDX microanalysis. EDX spectral analysis demonstrated higher counts at 3 keV due to silver confirming the development of silver nanoparticles, thus revealed the elemental composition of other elements present in the AgNP (Figure 6).

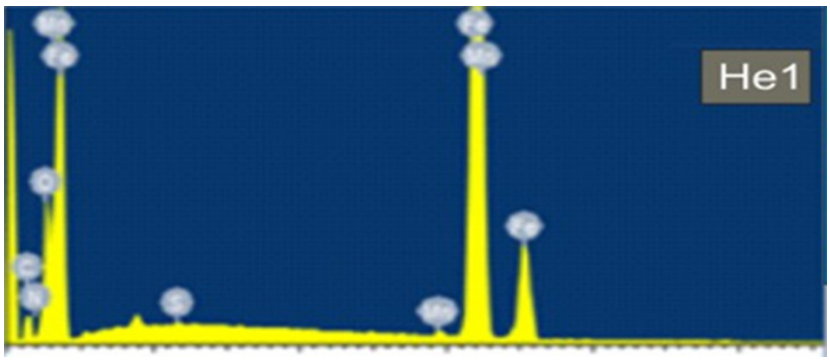
SEM image denote that the synthesized AgNPs were spherical in shape with varying sizes ranged between 20-30 nm. The EDX spectra revealed that Ag metal is the most abundant element in the AgNP which confirmed the formation of the nanoparticle.



(a)

(b)

Figure 5. SEM micrographs of flower extract (a) and AgNP (b)



Element	Wt %
Ag	70.42
Si	1.44
C	30.68
K	0.90
O	9.12

Figure 6. EDX spectra of AgNP (He1)

3.4 Antibacterial activities of biosynthesized AgNPs

The AgNPs was tested against two gram positive (*S. aureus* and *B. subtilis*) shown in Plates 1-2 below and two

gram negative microbes (*E. aerogenes* and *E. coli*) shown in Plates 3-4 below to evaluate their antimicrobial activities.

The flower extracts AgNP inhibited *E. aerogenes* by 7.5mm. This implied that the AgNP possess antimicrobial activity after the nanosynthesis .*E.coli* was inhibited with the flower extract AgNP by 11mm, *S. aureus* showed inhibition to AgNPs by 3mm. *B. subtilis* showed a greater inhibition with AgNPs by 7.5mm. Table 1 below showed the size of inhibition of the AgNPs on each microorganisms used. Thus, it can be inferred that the AgNPs prepared have good antibacterial activity and employed as potent therapeutic agents at much smaller concentration. It has been reported that the changes observed in the membrane structure of bacterial cell wall due to the action of AgNPs was caused by the interaction of embedded silver nanoparticles resulting in increased membrane permeability and consequently, death of the bacteria [42]. *Musa acuminata* flower extract is capable for the green and eco-friendly synthesis of Ag nanoparticles which can be used as a potential entrant species having antibacterial applications.

Table 1: Antimicrobial activity of AgNPs against microorganisms

Microorganism	AgNPs
E. aerogenes	7.5 mm
E. coli	11.0 mm
S. aureus	3.0 mm
B. substilis	7.5 mm

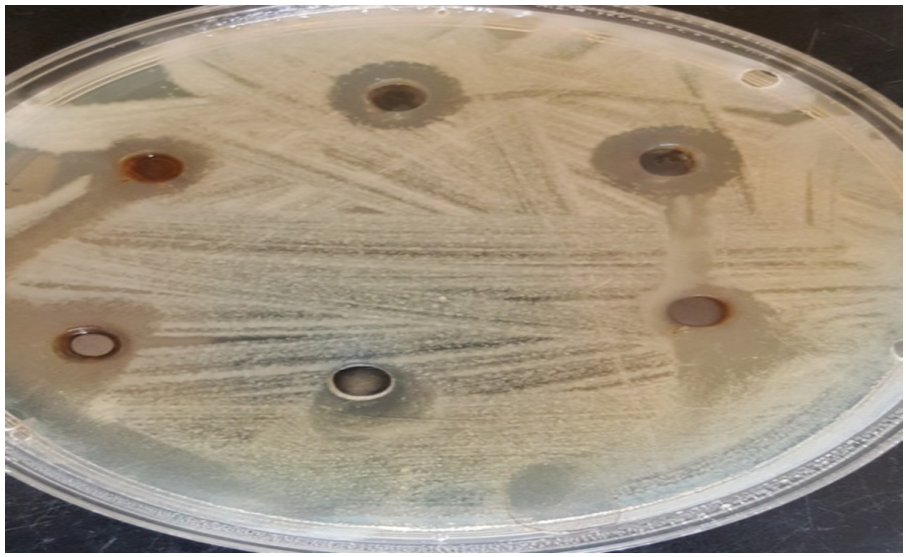


Plate 1: Inhibition of AgNPs on *B. subtilis*

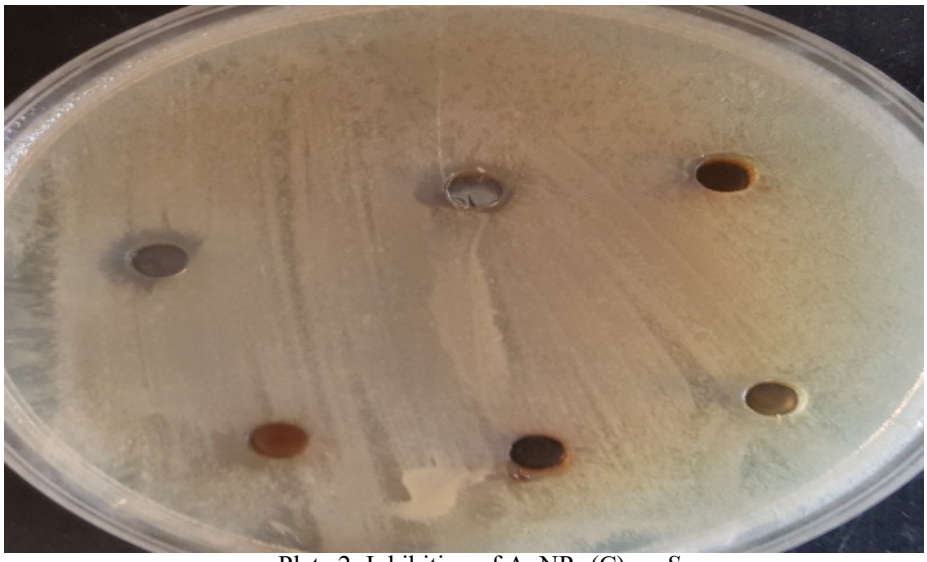


Plate 2: Inhibition of AgNPs (C) on *S. aureus.*

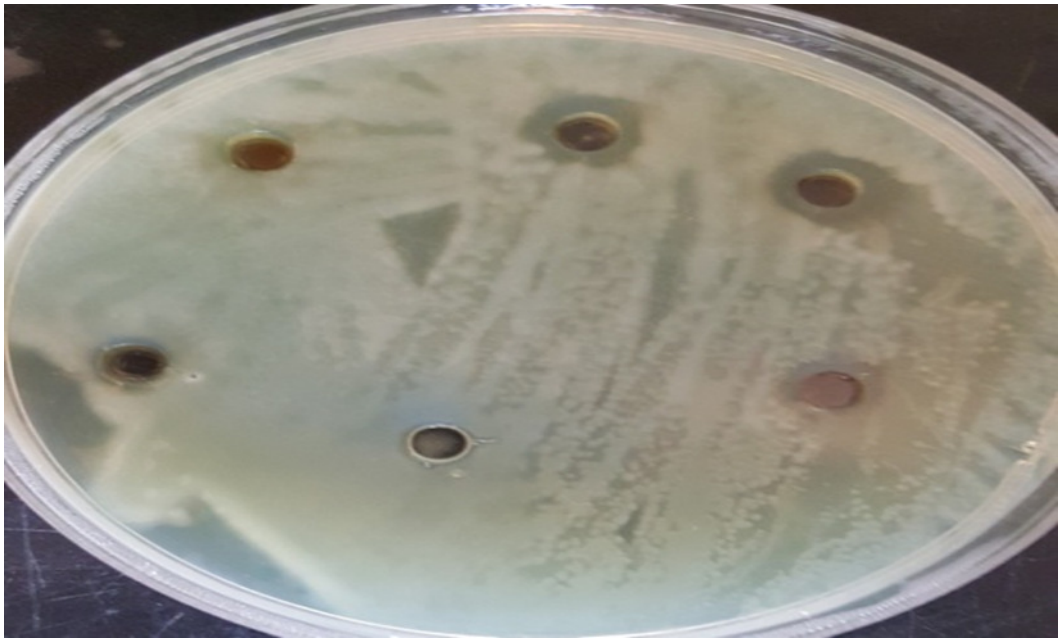


Plate 3: Inhibition of AgNPs on *E. coli*

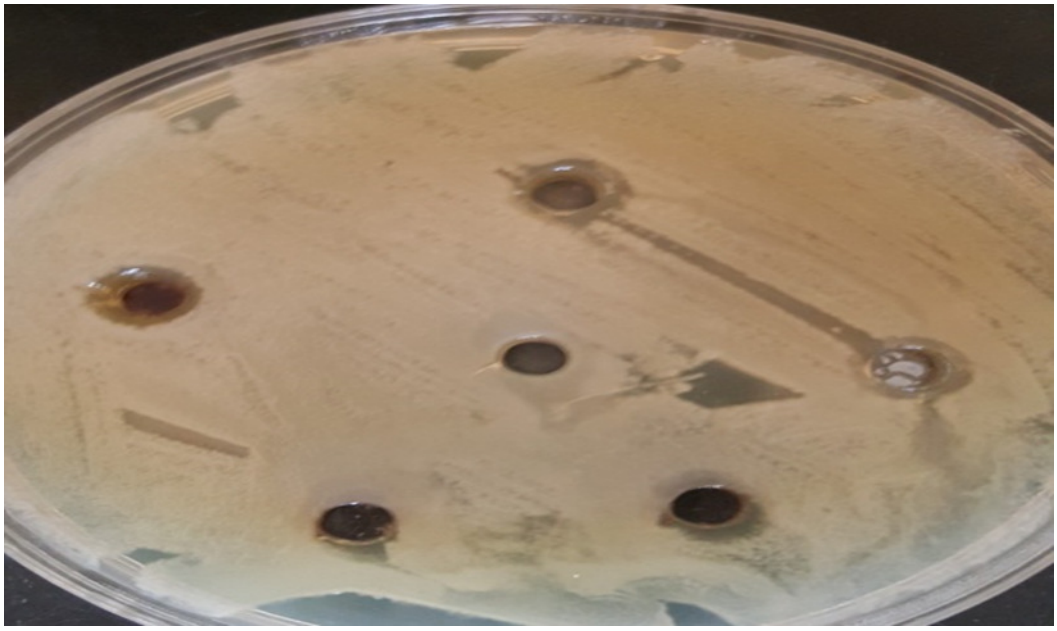


Plate 4: Inhibition of AgNPs on *E. aerogenes*

4. Conclusions

In this study, *Musa acuminata* mediated Ag nanoparticles were synthesized using flower extract. The synthesized AgNPs was analyzed using UVspectrophotometer, FTIR, SEM and EDX. The biosynthesized silver nanoparticles were proved to have excellent antibacterial performance against selected microbes. Therefore, *Musa acuminata* mediated Ag nanoparticles may be potentially utilized for the economic production of AgNPs for many pharmaceutical applications.

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Disclosure statement

No potential conflict of interest was reported by the author.

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