Federal Polytechnic Ilaro Journal of Pure & Applied Sciences {FEPI- JOPAS}

Volume 3 Issue 1, June, 2021 Edition.

Published by:

The School of Pure and Applied Sciences (SPAS)
The Federal Polytechnic Ilaro, Ogun State, Nigeria.
https://fepi-jopas.federalpolyilaro.edu.ng
E-mail:fepi.jopas@federalpolyilaro.edu.ng

ISSN: 2714-2531

FOREWORD

I warmly welcome all and sundry to the volume 3 issue 1 of Federal Polytechnic – Journal of Pure and Applied Sciences (FEPI-JOPAS) which is a peer reviewed multi-disciplinary accredited Journal of international repute. FEPI-JOPAS publishes full length research work, short communications, critical reviews and other review articles. In this issue, readers will find a diverse group of manuscripts of top-rated relevance in pure and applied science, engineering and built environment. Many of the features that you will see in the Journal are result of highly valuable articles from the authors as well as the collective excellent work of our managing editor, publishing editors, our valuable reviewers and editorial board members.

In this particular issue, you will find that Joseph and Adebanji provided innovative technology on light traffic control system. Ogunkoya and Sholotan engaged standard method for microbiological assessment of shawarma from Igbesa metropolis for possible microbial contamination. Ilelaboye and Kumoye unveiled the effect of inclusion of different nitrogen source on growth performance of mushroom. Ogunyinka et al utilized Fletcher Reeves conjugate gradient method as a robust prediction model for candidates' admission to higher institutions. Omotola and Fatunmbi examined the impact of thermal radiation with convective heating on magnetohydrodynamic (MHD), incompressible and viscous motion of non-Newtonian Casson fluid. Aako and Are meticulously investigated factors affecting mode of delivery using binary dummy dependent models. Abiaziem and Ojelade successfully synthesized biologically active silver nanoparticles using *Terminalia catappa* bark as the eco-friendly source.

In addition, Olowosebioba et al. assessed the rectifying effects of various diodes in power supply units using multisim circuit design software programme. Olujimi et al. successfully accomplished the use of fingerprint based biometric attendance system for eliminating examination malpractices with enhanced notification. Alaba reported the nutritional status assessment of school age children (6-12 years) in private primary school in Ilaro. Muhammed-lawal et. al. assessed the execution and effect of corporate social responsibilities and return to marketing. Awolola and Sanni's research was about achieving quality of engineering education and training in Nigeria using Federal Polytechnic, Ilaro as the case study. Oladejo and Ebisin expatiated on virtual laboratory as an alternative laboratory for science teaching and learning.

Finally, Aneke and Folalu investigated the prospect and problems of the hotels in Ilaro, Ogun State.

I would like to thank and extend my gratitude to my co-editors, editorial board members, reviewers, members of FEPI-JOPAS, especially the Managing Editor, as well as the contributing authors for creating this volume 3 issue 1. The authors are solely responsible for the information, date and authenticity of data provided in their articles submitted for publication in the Federal Polytechnic Ilaro – Journal of Pure and Applied Sciences (FEPI-JOPAS). I am looking forward to receiving your manuscripts for the subsequent publications.

You can visit our website (https://www.fepi-jopas.federalpolyilaro.edu.ng) for more information, or contact us via e-mail us at fepi.jopas@federalpolyilaro.edu.ng.

Thank you and best regards.

E-Signed
Prof. Olayinka O. AJANI

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Green Synthesis of Silver Nanoparticles Using *Terminalia catappa* Bark Extract and Its Antibacterial Activity

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Abstract
In this study, a simple, inexpensive, environmentally friendly and green synthesis was utilised to synthesise silver nanoparticles (AgNPs) using *Terminalia catappa* bark extract (TC-AgNPs). The factors which determine the biosynthesis of these nanoparticles which include, concentration, time and temperature were determined and optimised. However, this study only optimised the effect of time and temperature at a constant concentration of 0.01 M Ag^+ concentration of extract; 10 g/L (1% w/v). The optimum conditions (time and temperature) for the biosynthesis were; time, 80 minutes and temperature, 60°C. The characterisation of the biosynthesised *Terminalia catappa* silver nanoparticles (TC-AgNPs) were carried out using UV-Visible (UV-Vis) spectroscopy at a wavelength range of 300 to 800 nm, fourier transform infra-red spectroscopy (FT-IR) and scanning electron microscopy (SEM). The antibacterial activity was investigated against *Escherichia coli* (*E. coli*) and *Staphylococcus aureus* (*S. aureus*). This study reveals that AgNPs was successfully synthesised from *Terminalia catappa* and the synthesised AgNPs showed inhibition against the *E. coli* and *S. aureus.*

***Keywords*:** Antibacterial activity, green synthesis, silver nanoparticles, *Terminalia catappa*

INTRODUCTION
In recent times, Green synthesis had drawn attention by introducing and developing new chemical methods employed for the synthesis of metal-nanoparticles from plant leaves, root, stem, bark, fruit peel, fruit, and seed. Unlike the conventional techniques such as; ion sputtering and chemical reduction which involves the use of toxic chemical reagents. Green synthesis is simple, cost-effective, eco-friendly, reproducible, and usually results in more stable materials.

Terminalia catappa (*T. catappa*) belongs to the lead-wood tree family of combretacae which grows mainly in Africa, Asia and Australia. A normal *T. catappa* tree grows up to 30 m with branches which are arranged in tiers, horizontally. (Praveena, 2014). It is commonly known as ‘fruit’ in Nigeria. Studies have shown that, *T. catappa* bark extract has been widely used in West Africa for the treatment of various health challenges which include diarrhoea, dysentery, sores, gastric ailments, gonorrhoea, fungal diseases, and sexual dysfunction (Praveena, 2014).

Silver nanoparticles, among other metal-nanoparticles have gained remarkable attention and focus because of their antimicrobial, anticancer and cytotoxic activities. (Yahya& Esther. 2019). Study revealed that, Silver nanoparticles show potential effects against both Gram-positive and Gram-negative such as; *Escherichia coli*, *Vibrocholerae*, *Bacillus subtilis*, *Syphilis typhus*, *Staphylococcus aureus* etc. (Cho, Park, Osaka & Park, 2005 and Klaus-Joerger, Joerger, Olsson & Granqvist, 2001). Silver nanoparticles are formed when Ag^+ dissociates from a silver compound (when dissolved) and gains an electron in a redox reaction with a reducing agent. The reduction of Ag^+ to a pure form of AgNPs and their stabilization is favoured by the presence of proteins and enzymes in the plant extract. (Ahmed, Gupta, kumar & Nimesh, 2017). The synthesis of silver nanoparticles depends on some important factors, irrespective of the method of synthesis. These factors are; effect of time and temperature. This study therefore, studied the optimum conditions required for the synthesis of AgNPs from *T. catappa* bark extract and its antibacterial activity.

MATERIALS AND METHODS
Materials
The procurement of all the reagents used was from a certified supplier, Nijat Nigeria Limited; they were bought and stored in a cool dark room. The reagents were ethanol (C_2H_5OH), and silver nitrate ($AgNO_3$).

Plant collection
T. cattapa bark was collected from a Tropical almond tree within the campus premises of The Federal Polytechnic Ilaro, Ogun state, Nigeria. It was washed to remove dirt materials, pulverized into pieces and air-dried in the laboratory for 3 days.

Figure 1: Image of *T. catappa* bark tree

Extract preparation

About 20 g of pulverized *T. catapppa* bark was weighed out into a beaker, 100 ml of distilled water was added and the solution was heated for 20 minutes. Using Whatman filter paper No. 1, the extract was filtered and allowed to cool and stored for further studies.

Biosynthesis of Silver Nanoparticles

10 ml of the *T. catapppa* bark extract was added in drops into 50 ml of 0.01 M Ag^+ concentration of extract; 10 g/L (1% w/v) until a colour change was observed, yellowish-brown to dark brown, the solution was centrifuged at 3000 rpm for 30 minutes. Then the supernatant which contains excess silver ions was removed. The resulting precipitate (pellets) was re-suspended and centrifuged. Finally, 0.01 M of *T. catappa* silver nanoparticles (TC-AgNPs) pellet was incubated in a dark cupboard to reduce photo-activation of silver nitrate at room temperature. Its formation was confirmed using UV-Visible spectroscopy.

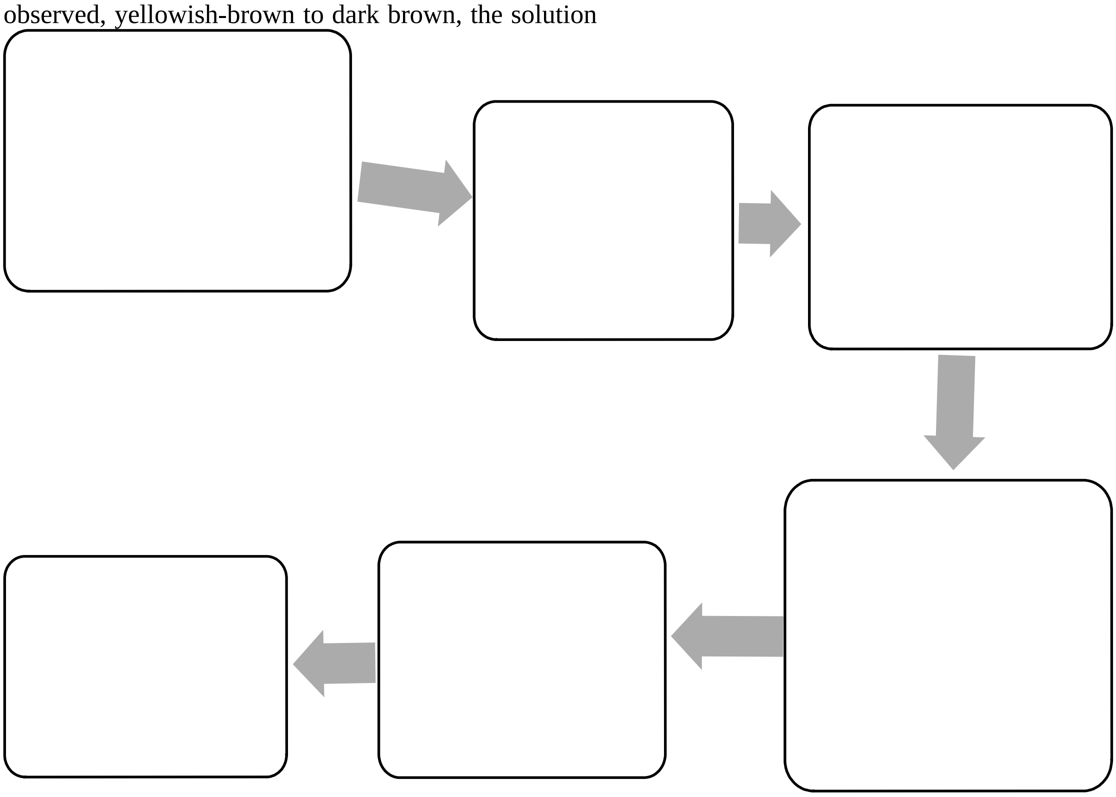


Figure 2: A flow chart of synthesis of silver nanoparticles

AgNPs Characterisation

Ultraviolet Visible Spectroscopy

The visual observation of a colour change from yellowish-brown to dark brown was a confirmation of the presence of silver nanoparticles which shows the reduction of Ag^+. This was further confirmed using a UV-Visible spectrophotometer (UV-Vis Jenway 6305) at wavelength ranges of 300 to 800 nm.

Fourier Transformed Infrared Spectroscopy

FTIR (Perkin Elmer Spectrum, Japan)in the range of 4500 cm^{-1} to 650 $cm^{-1}$was used to determine the presence of certain functional groups presence in the synthesised TC-AgNPs. The result was recorded on KBr pellet on an FT-IR spectroscope at room temperature.

Scanning Electron Microscopy

The study of the surface morphology of the AgNPs was carried out using scanning electron microscope (JOEL-JSM 7600F).

Optimization of Silver Nanoparticles preparation

a. Effect of time

T. catappa extract was prepared as mentioned above. Using the above method, AgNPs were however synthesised at particular time intervals of 20, 40, 60 and 80 minutes, followed by AgNPs confirmation using UV-Vis spectroscopic analysis.

b. Effect of temperature

The AgNPs were synthesised as mentioned above, however, at certain temperature of 30, 40, 50 and 60^o C, followed by AgNPs confirmation using UV-Vis spectroscopic analysis.

Antibacterial Activity

The antibacterial activity of the synthesized silver nanoparticles was investigated against *Escherichia coli* and *Staphylococcus aureus* using Agar-diffusion method. The agar used was Mc Corkey and Nutrient agar. After agar plates were prepared, sterilized and allowed to solidify, each bacterial strain was streaked evenly on them with an inoculating wire/loop. A well of approximately 6 mm in size was made in each plate and 0.5 ml of the TC-AgNPs was placed into the well. The inhibition zone was determined in millimetres after 24 hours of incubation at normal body temperature 37^{o}C.

RESULTS AND DISCUSSION

Synthesis of AgNPs Using *Terminalia catappa*

The colour change from yellowish-brown to dark brown observed on the addition of the *T. catappa* bark extract to the aqueous solution of $AgNO_3$ indicates the reduction of Ag^+ to Ag^0, consequent of the heat applied and Ag^+ complex. The colour change indicates the formation of silver nanoparticles (Henry, Harry & Audy, 2019).

UV-Visible Spectroscopy (Effect of time)

As the time increases from 20 – 80 minutes, the intensity of the color increased, changes from light yellow to clear brown and finally to dark brown was observed. The optimum time was observed at 80 minutes. This indicates the formation of silver nanoparticles which was further confirmed using the UV-Visible spectrophotometer. Figure 4 shows peak around 400 – 600 nm, which falls within the visible region. The sharp peak around 450 nm is a characteristic feature of the formation of metal-nanoparticles. This result is in accordance to that reported by Vanaja, Gnanajobitha and Paulkumar (2013).

UV-Visible Spectroscopy (Effect of Temperature)

The absorption spectrum of the synthesized AgNPs at temperature between 30 – 60^{o}C is illustrated in Figure 5. Increase in temperature resulted in an increase in the synthesis of AgNPs which was visible in the intensity of the color as the temperature increases. This was further confirmed by the absorption peak between 400-550 nm. In this study, 60^{o}C was chosen as the optimum temperature as all other absorption peaks were minimal compared to it. Particle size growth is less possible at higher temperature because the kinetic energy of molecules increases as the temperature increases and the Ag^+ get consumed faster (Verma & Mehata, 2015).

Fourier Transform Infra-red Spectroscopy

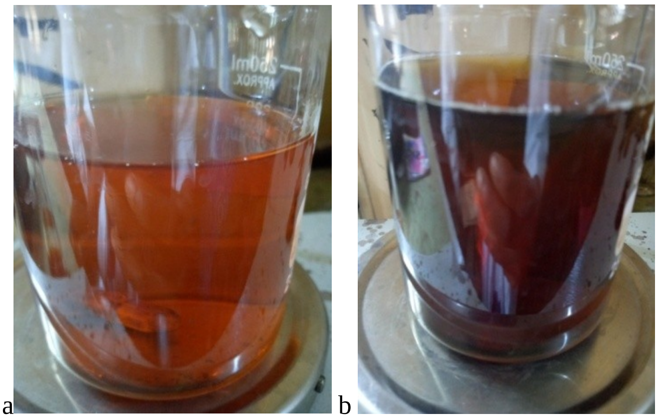
Figure 6 represents the FTIR spectrum of AgNPs. FTIR was carried out to examine bio-reducing and capping agents which may be present in the extract. A broad absorption peak was observed at 3440 cm^{-1} indicating the presence of (O – H stretch) hydroxyl group associated with H_2O. The absorption peaks at 2927 cm^{-1}, 2355 cm^{-1}, 1735 cm^{-1}, 1633 cm^{-1} and 1032 cm^{-1} are attributed to the presence of C – H alkane stretch, O = C = O (CO_2 stretch), N – H bend, and C – N stretch, respectively. The detected absorption peaks are primarily ascribed to flavanoids and terpenoids excessively present in plants extract (Shakeel, Saifullah, Babu & Saiqa, 2016)

Scanning Electron Microscopy

The morphology of TC-AgNPs at magnification of 12000 as shown in Figure 7. The TC-AgNPs revealed a spherical shape; this presents a coarse and aggregated surface, showing a width diameter of 10.5 mm. This showed an aberration of the fibular structure into a nano scale indicating a large surface area for the inhibition of bacteria.

Antibacterial Activity

As shown in Figure 8 a and b, AgNPs is efficacious in the inhibition of bacteria growth in contrast with other salts; such as gold and platinum salts due to its huge surface area which allows better contact with micro-organisms.TC-AgNPs exhibits significant antibacterial properties against both *S. aureus* (Gram-positive bacteria) *E. coli* (Gram-negative bacteria). However, the highest inhibition was recorded in *E. coli* which measured 30 mm followed by *S. aureus* which measured 24 mm.



a b

Figure 3: Image showing the reduction of $AgNO_3$. (a) *T. catappa* bark extract. (b) Synthesised TC-AgNPs

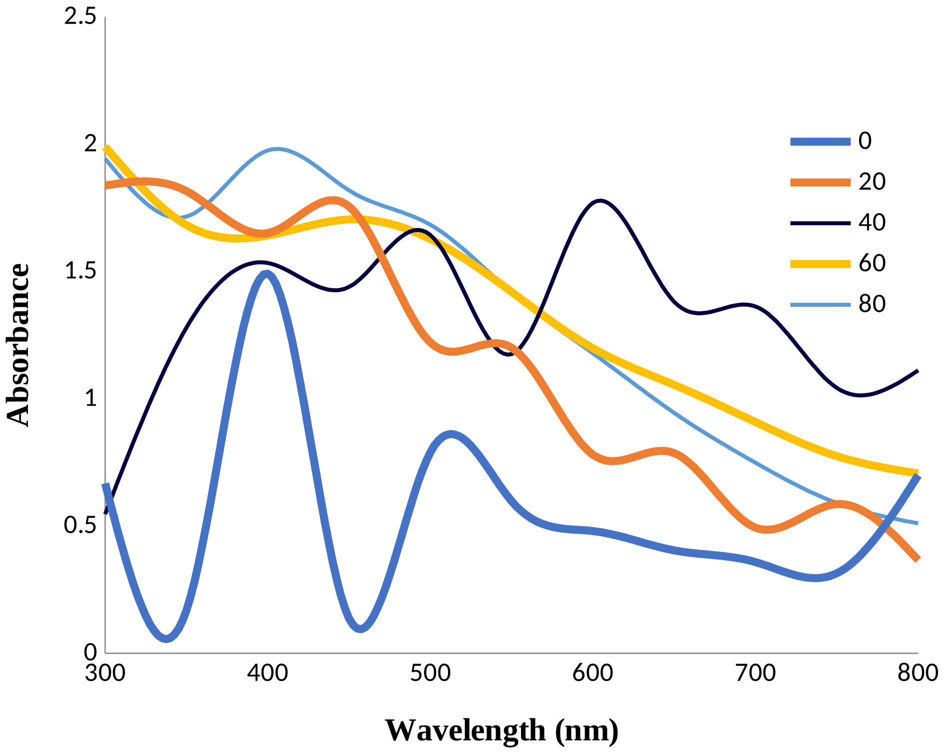


Figure 4: The UV-Visible spectrum of synthesised TC-AgNPs at different time intervals

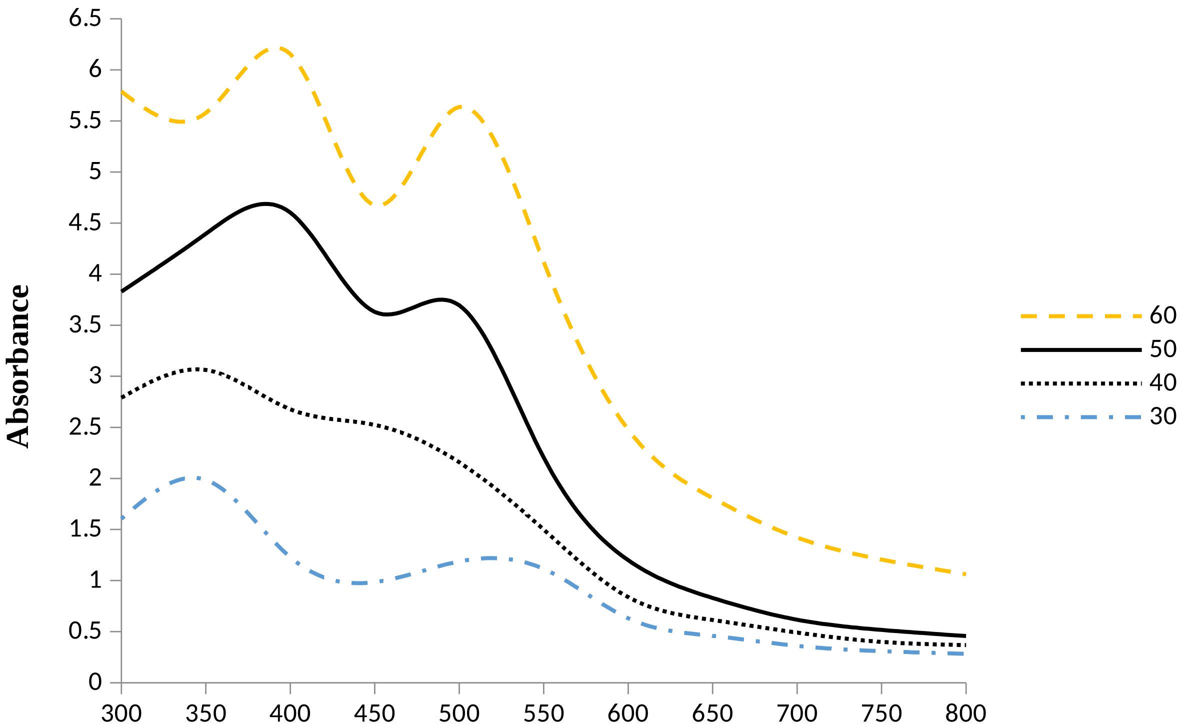


Figure 5: The UV-Visible spectrum of synthesised TC-AgNPs at different temperature intervals

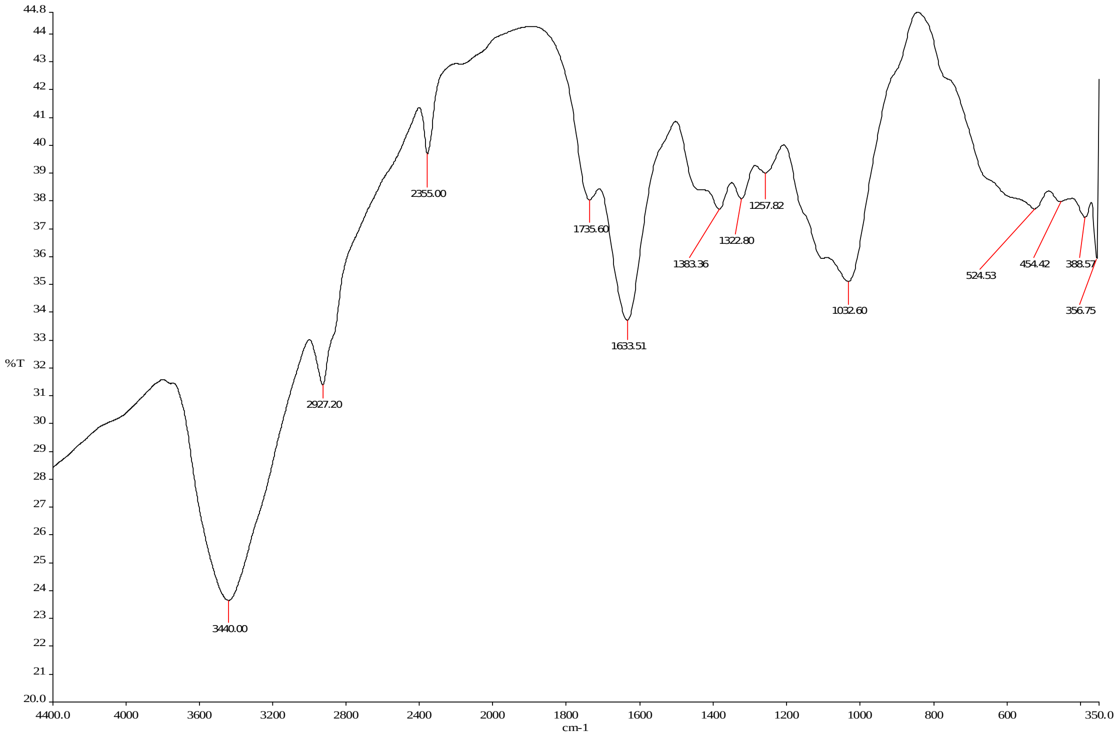


Figure 6: The FTIR spectrum of synthesised TC-AgNPs

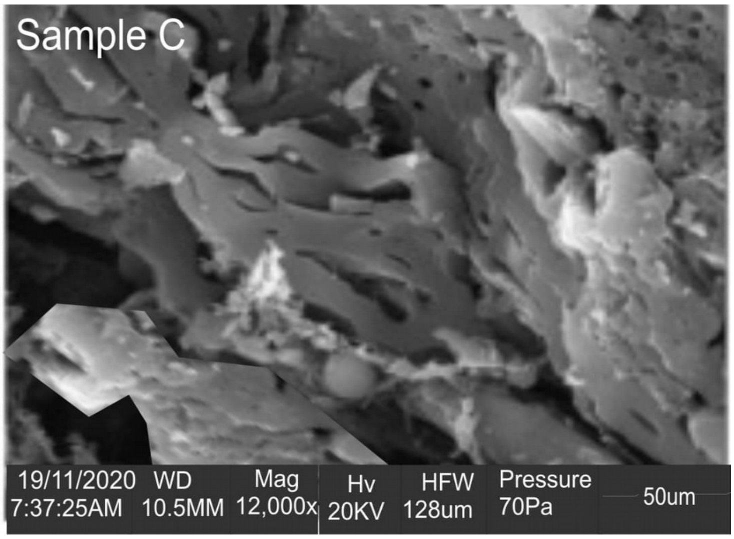
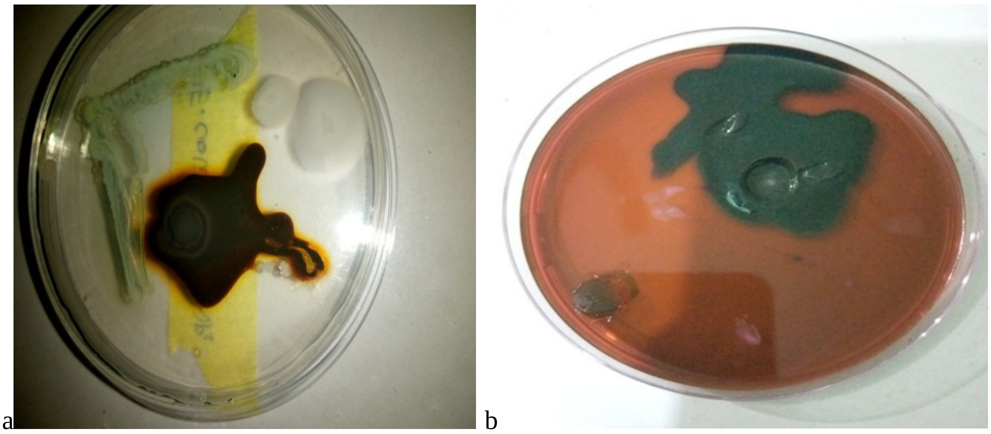


Figure 7: Scanning Electron Microscopy image of TC-AgNPs



a b

Figure 8: Antibacterial activity of TC-AgNPs against; (a) *E. coli,* (b) *S. aureus*

CONCLUSION

The present study employed an environmentally friendly, robust, inexpensive technique to synthesise silver nanoparticles using the bark extract of *T. catappa* tree. Using a concentration of 0.01 M Ag+ concentration of extract; 10 g/L (1% w/v), the optimum temperature and time are 60^{o}C and 80 minutes, respectively. The phytochemicals present in the extracts include alkaloids, terpenoids, flavonoids, which act as strong reducing and capping agents for the formation of AgNPs. The FT-IR study revealed the presence of some functional groups, the bio-reduction of Ag^{+} and the stability of the AgNPs. *T. catappa* AgNPs, hence, showed a strong inhibition against the growth of *E. coli* and *S. aureus.*

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