EFFECT OF TEMPERATURE AND TIME ON GREEN SYNTHESIS OF SILVER NANOPARTICLES USING EXTRACT OF SOURSOP (ANNONA MURICATA) BARK

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ABSTRACT

In comparison with bulk materials, nanoparticles possess improved characteristics due to their sizes and morphology, thus, making them invaluable for various industrial applications. This study assesses the effect of contact time and temperature on the green synthesis of silver nanoparticles (AgNPs) from the extract of soursop (*Annona Muricata*) bark. The optimization factors were studied at a constant concentration of 0.01 M $AgNO_3$ solution, contact time at 20, 40, 60 and 80 minutes and temperature at 30, 40, 50 and 60^o C. The AgNPs were synthesized using aqueous extract of bark of soursop plant as bio reducing agent. The formation stability of the reduced silver nanoparticles was characterized using ultraviolet-visible spectrophotometer within the wavelength range of 420-700 nm. This study proves that, AgNPs was successfully synthesized and the optimized conditions for this biosynthesis were; contact time, 40 minutes and temperature, 60^o C. This inexpensive and environmentally friendly synthesis can be utilized for the production of silver nanoparticles on a large-scale.

Keywords: *Annona muricata;* silver nanoparticle; optimization; UV-VIS spectrophotometer.

INTRODUCTION

Nanotechnology has drawn attention in the 21st Century; it involves the design and characterization of materials of at least one dimension at the nanometer scale level called nanomaterials or nanoparticles. (Burt, 2005). It is considered as a key technology that has increased the economic importance of nanostructure materials due to their sizes, morphologies, and efficiency, compared to bulk materials. These make it find applications in medicine, energy production, and storage, catalysis, electronics materials, biosensors, etc. (Devaraj, Diviya & Seerangaraj, 2018).

In contrast to chemical reduction which is expensive and requires toxic chemicals and reagents that pose various biological risks, green synthesis of metal nanomaterials has been employed by scientists, as it offers a cleaner, environmentally friendly, and cheaper approach. The green approach uses microbes, enzymes, and plant materials for the synthesis of nanomaterials. However, the use of plant materials has been preferred for the biosynthesis of silver nanoparticles (AgNPs) because microbes may contaminate the nanoparticles when applied for therapeutic use, it is also easily amendable and less time-consuming. (Qadruddin, Nidhi, Ajeet & Surendra, 2017). In the preparation of the AgNPs extract, the major phytochemicals involved are alkaloids, flavonoids, ketones, terpenoids, amides, aldehydes, tannins, and carboxylic acids. Other phytochemicals such as quinines, organic acids, and flavones are responsible for the immediate reduction of AgNPs

because of their solubility in water. (Kaviya, Santhanalakshmi, Viswanathan, Muthumary & Srinivasan, 2011).

A. muricata is a member of the annonaceae family belonging to the genus annona and is commonly called soursop. Populations of various countries in the world have long used soursop plant as herbal remedies such as bark, leaves root, fruit and the seed (Adewole & Ojewole, 2009). The plant showed the ability to inhibit the growth of cariogenic bacteria. Many active chemical compounds especially terpenoids are thought to have potential antibacterial, antidiabetic potential, antihypertensive properties, anti-oxidative and anti-cancer effect (Adefegha, Oyeleye & Oboh, 2015).

In this study, the effect of contact time and temperature on the biosynthesis of silver nanoparticles from the extract of a readily available agricultural waste, *A. muricata* (soursop) bark was investigated, using UV-Visible spectroscopy and Fourier Transform Infrared (FT-IR) Spectroscopy while studying the morphology of the synthesised AgNPs using Scanning Electron Microscopy (SEM).

MATERIALS AND METHODS

Chemicals and Reagents

The silver nitrate ($AgNO_3$) and Ethanol (CH_3COOH) used were purchased from a certified supplier; Nijat Nigeria Limited, Lagos, Nigeria. The reagents were the stored in a cool dark room.

Plant Collection

The bark of *A. muricata* was collected from Ikosi area, Ilaro, Ogun State, Nigeria. The sample was washed with distilled water to remove dirt, pulverized into pieces and air-dried for two (2) days. The dried sample was stored in an air-tight container for use.

Figure 1: Image of the bark, fruit and leaves of *A. muricata*

Preparation of Plant Extract

About 20g proportion of the air-dried *A. muricata* stem bark was weighed into a 250 mL beaker. 100 mL of distilled water was added into the beaker and was placed in the water bath to heat for 20, 30, 40 and 50 minutes, respectively to subdue the active plant extract. The solution was allowed to cool at room temperature and then filtered using Whatman No 1. paper to separate the clear filtrate (extract) from the residue. The extract was further used for the biosynthesis of the silver nanoparticles

Biosynthesis of Silver Nanoparticles

Approximately 10 mL of the *A. muricata* bark extract was measured into 50 mL 0.01 M $AgNO_3$ while stirring until a colour

change was observed, (light brown to dark brown colour). The resulting solution was centrifuged at 3000 rpm for 20 minutes, the supernatants which contains excess silver ions was discarded. The precipitate (pellet) was re-suspended in distilled water and re-centrifuged. Finally, the *A. muricata* silver nanoparticles (AM-AgNPs) pellet was resuspended in double-distilled water, followed by a subjection to UV-Vis spectrophotometric analysis.

Characterization of the Synthesized AgNPs

The characterization of the AgNPs was carried out using UV-Visible spectrophotometry, Fourier Transform Infrared Spectroscopy (FT-IR), and Scanning Electron Spectroscopy (SEM).

UV-Visible Spectroscopy

The reduction of the silver ions which resulted to the formation of silver nanoparticles was confirmed using UV-Visible spectrophotometry (UV-Vis Jenway 6305) at wavelength ranges of 300 to 800 nm.

Fourier Transform Infrared Spectroscopy (FT-IR)

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

Scanning Electron spectroscopy (SEM)

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

Optimization of Silver Nanoparticles Preparation

The optimum condition for the preparation of AgNPs using *A. muricata* was carried out by investigating the effect of the factors that affect the synthesis of silver nanoparticles, such as contact time and temperature.

Effect of Time

The extract was prepared as illustrated above and the nanoparticles synthesis was carried out by adding 10 mL of *A. muricata* extract to 50 mL of $AgNO_3$ solution and stirred. After certain time points 20, 40, 60 and 80 minutes, the nanoparticles were centrifuged, re-suspended in double-distilled water shaken vigorously, and taken for UV-Vis spectrophotometry analysis.

Effect of Temperature

The AgNPs were synthesized as stated above, however, varying the temperature at 30, 40, 50 and 60, followed by UV-Vis spectrophotometry c analysis.

RESULTS AND DISCUSSION

Biosynthesis of AgNPs using *A. muricata*

Figure 3 shows the formation of silver nanoparticles (AgNPs) with $AgNO_3$ solution using an aqueous extract of *A. muricata*. The reduction from Ag^+ to Ag^0 was observed with a colour change from light-brown to dark-brown which denotes the formation of AgNPs. (Henry, Harry & Audy, 2019)

UV-Visible Spectrophotometry (Effect of Time)

One of the factors that affect the biosynthesis of AgNPs is contact time. The observed increase in the colour intensity as the time increases from 30 to 80 minutes is evident that an increase in contact time increases the formation of AgNPs. This was further confirmed following the UV-Visible analysis spectra peak between the wavelength 0f 350 – 450 nm as an increase in the reaction time from 30 – 80 minutes spurred a gradual increase in the absorption spectrum, consequently, increasing the surface plasmon resonance (SPR) peak at 420 nm. Thus, this study reveals that the optimum time for the formation of AgNPs using *A. muricata* was 80 minutes. This result is similar to that reported by Bagyalakshmi and Haritha (2017).

UV-Visible Spectrophotometry (Effect of Temperature)

Temperature is another significant factor affecting the synthesis of silver nanoparticles. Fig. 4 revealed the absorption spectra of silver nanoparticles at different temperatures, 30, 40, 50 and 60^0 C. As the temperature increases, the reduction of silver nanoparticles also increased rapidly, this was indicated by the color change of the solution. The peak absorption wavelength shifted from 450 to 540 nm as the temperature varies from 30 to 60^0 C, this is due to the localization of the surface plasmon resonance of the AgNPs. At higher temperatures, the kinetic energy of molecules increased and the silver ions are taken up faster, thus leaving probability for the particle size growth. (Verma, & Mehata, 2015).

Fourier Transform Infrared Spectroscopy

Figure 5 represents the FTIR spectrum of AM-AgNP; the broad absorption peak at 3460 cm^{-1} indicates the presence of O – H stretch hydroxyl associated with H_2O. The peaks at 1383 cm^{-1} and 2925 cm^{-1} are attributed to the presence of C – H stretching of alkane, the peaks at 1740 cm^{-1} and 2355 cm^{-1} reveal the presence of C = O carbonyl stretching and C = O = of aliphatic esters, and an intense peak at 1640 cm^{-1} reveals the presence of C = C alkene stretch. These functional groups are evidence of the presence of phytochemicals such as terpenoids, alkaloids, phenols and other compounds.

Scanning Electron Microscopy

The biosynthesized AgNPs morphology studied at a magnification of 12000 is shown in Figure 6. The TM-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. The observed result is analogous to that stated by Santhosh, Yuvarajan, & Natarajan (2015); Narayanaswamy, Athimoolam, & Ayyavoo (2015).

a. 

b. 

Figure 2. (a)Extract of *A. muricata* bark (b) Colour change of *A. muricata* bark extract and silver nitrate solution

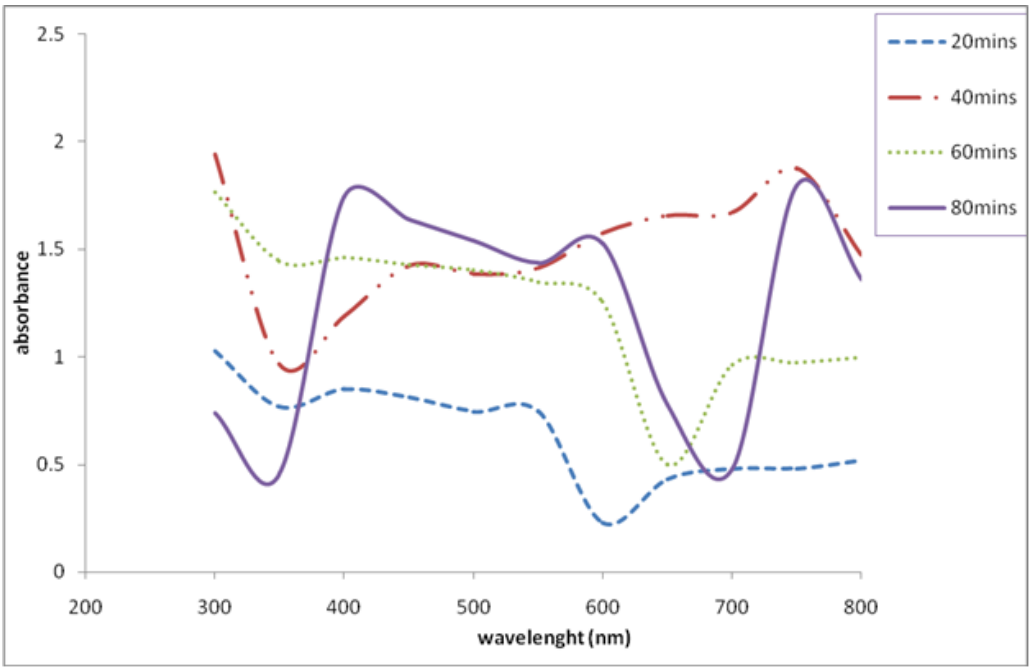

Figure 3: The UV-Visible spectrum of synthesised AM-AgNPs at different time intervals

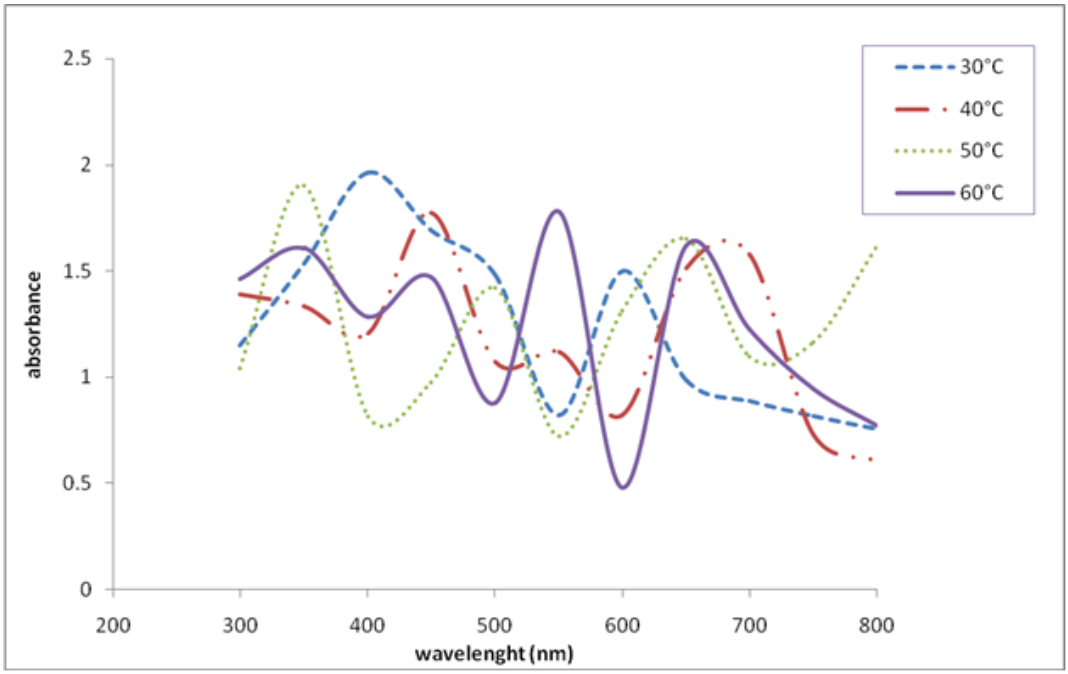

Figure 4: The UV-Visible spectrum of synthesised AM-AgNPs at different temperature intervals

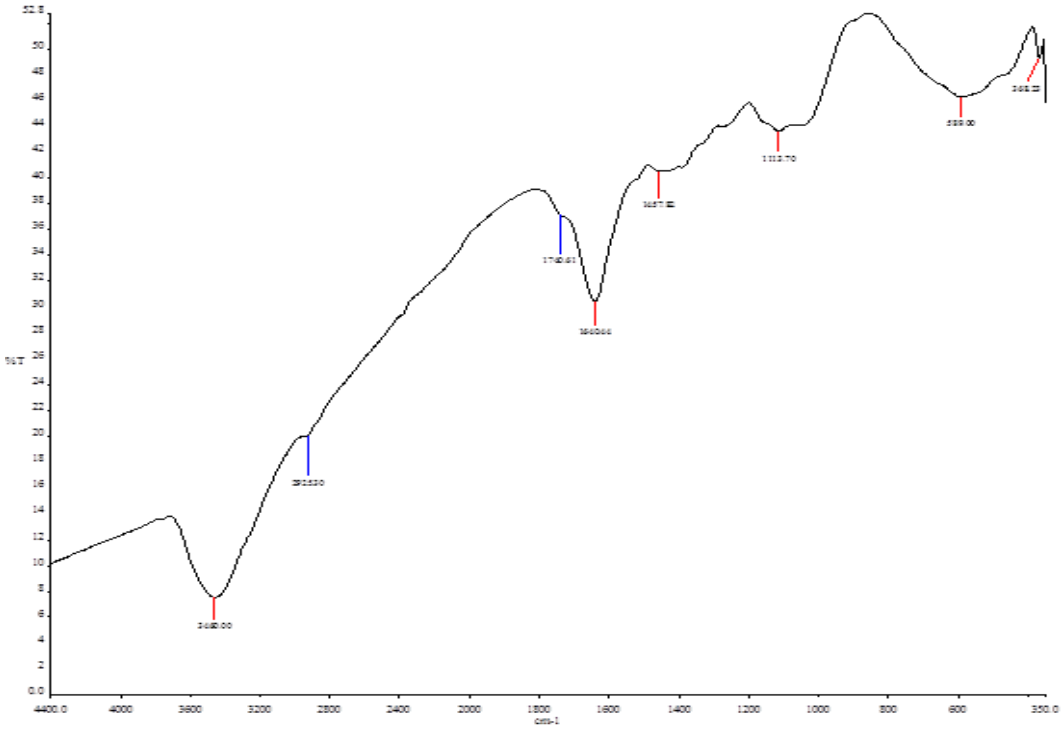

Figure 5: The FT-IR spectrum of synthesised AM-AgNPs

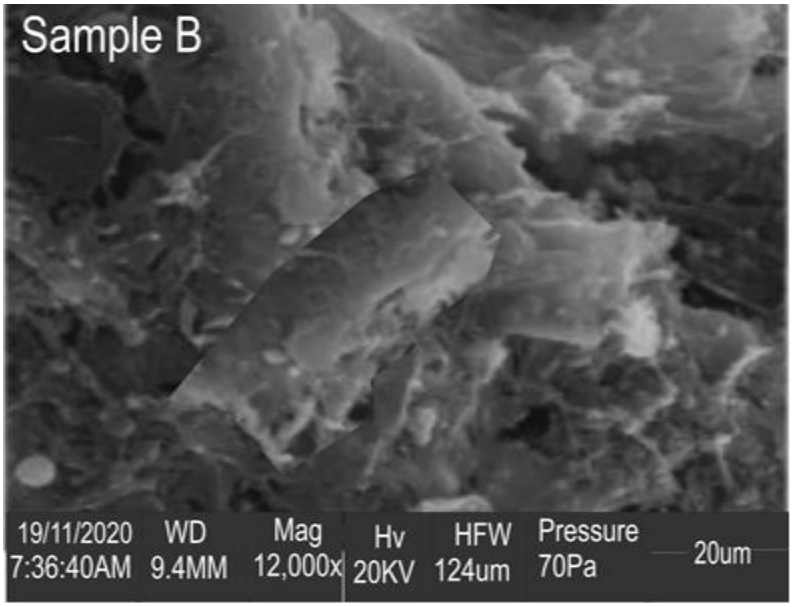

Figure 6: Scanning Electron Microscopy Image of AM-AgNPs

CONCLUSION

In conclusion, this study successfully synthesized silver nanoparticles (AgNPs) using *A. muricata* (Soursop) tree bark by employing an eco-friendly, easier and cost-effective method, compared to the usual chemical methods. The reduction of Ag^{+} ions to Ag^{0} which led to the formation of the silver nanoparticles with relative to factors affecting the synthesis, (contact time and temperature) were monitored at 20, 40, 60 and 80 minutes, and 30, 40, 50 and 60^{o} C, respectively, using UV-Visible spectrophotometry. The optimum conditions for the green synthesis of the silver nanoparticles from the plant extract of interest was 80 minutes at 60^{o} C, as revealed by the result. The functional groups present in the synthesized AgNPs as studied using FTIR were terpenoids, alkaloids, phenols and other compounds and the SEM micrograph revealed spherical nanoparticles.

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