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Research Article

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Comparative Analysis of Stable Aqueous Dispersion of Silver Nanoparticle Synthesized from Mangifera Indica and Azadirachta Indica Leaf Extract

Henry L. Barnabas [a, *], Buba A. Aliyu [b], Joshua A. Gidigbi [c], Abdulrasaq B. Abubakar [d], Akinda Markus [e]

[a] Gamma irradiation Facility, Nigeria Atomic Energy Commission, Abuja, Nigeria.
[b] Professor of Industrial Chemistry, Chemistry Department, Modibbo Adama University, Yola, Nigeria.
[c] Department of Chemistry, Modibbo Adama University (MAU), Adamawa State, Nigeria.
[d] Science Laboratory Department, College of Horticulture, Dadinkowa, Gombe State, Nigeria.
[e] Nuclear Power Plant, Nigeria Atomic Energy Commission, Abuja, Nigeria.
*Corresponding author Email: henrylingweb@gmail.com
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Abstract: Mango and neem leaf extract were prepared by soaking the measured leaves into 100ml of distilled water under appropriate conditions. Consequently, biosynthesis of silver nanoparticles was carried out by distinctly adding the mango and neem leaf extract to prepared solution of silver nitrate ($AgNO_3$) to produce aqueous dispersion of silver nanoparticles. The silver nanoparticles produced were investigated using FTIR, UV-Visible and AFM Spectroscopy at 15 minutes, 24 hours and 48 hours respectively. Reduction in OH absorption proves chemical interaction of mango extract with $AgNO_3$. UV/Visible also revealed colour changes from faint yellow to brown to reddish brown within 15 minutes and 24 hours of incubation at room temperature. Atomic Force Microscopy revealed that the sizes of mango-based dispersion are smaller than that of neem-based dispersion.

Keywords: Atomic Force Microscopy, Fourier Transform Infrared Spectroscopy, Nanoparticles, Extract and Extraction.

1. Introduction

The advancement in technology has resulted into possibilities of developing materials at a nanoscale. These nanomaterials are between 1 to 100 nanometres(m^{-9}) in size [1, 2]. Due to this advantageous very small size existence, nanoparticles can exhibit many properties such as optical, physical and chemical, as they are small enough to confine their electrons and produce quantum effects. This has made nanomaterials ubiquitous in its application, as reported that nanomaterials afford the possibilities of application to numerous technological and ecological issues in the field of solar energy conversion, medicine, and wastewater treatment [3, 4]. This is further buttressed by that nanotechnology has extensive applications in several fields such as dye formulations, medical applications like drug delivery, food industry, electronics bio-sensing, textile industry, antimicrobials etc [5, 6].

According to previous studies different kinds of metal nanomaterials have been investigated but silver nanoparticles proved to be most effective because of its unique properties, such as better conductivity, chemical stability, biocompatibility and good antibacterial activities [7-11]. Barnabas et al reported that limitation of silver nanoparticles synthesized via physical and chemical processes such as high cost of synthesis and environmental effects have necessitated further research into biosynthesis of silver-nanoparticles [1, 12]. Furthermore, echoed that bio-synthesis of nanoparticles are more compatible for medical use as compared to chemical and physical methods where toxic material may adsorb on the surface of the nanoparticles that may have adverse effects when used for medicinal purpose. Bio-synthesis process include the uses of fungus, microorganisms' enzymes and plant extracts [4, 9, 13-16].

However, reported that bio-synthesis of silver nanoparticles using plants are more advantageous to using microorganism as the former eliminates the laborious process of cell culture as is commons in the later [9, 14]. Vanlalveni et al reiterated that synthesis of silver nanoparticles using plant extracts is one of the simple and most utilised pathways to bio-synthesis of silver nanoparticles [17]. This is because processes that are environmentally benign which alleviate the involvement of toxic chemicals, forthright, and economical. The recent years has witnessed a lot of research into bio-synthesis process of sliver nano-particles using aqueous extracts of plant parts such as the leaf, seeds, bark, roots, etc [2, 9].

According to, *Mangifera indica L*. is one of the delicious global tropical fruits [6]. Mango belongs to the family of the Anacardiaceous. It is considered as one of the genus Mangifera with high nutritional and medicinal benefits [18]. Studies revealed that *Mangifera indica L* has numerous natural products such as sterols, polyphenols, carotenoids, terpenes and amino acids which act as reducing and capping agent for nano particle synthesis [6, 19]. (?) reiterated that mango fruits contain several vitamins such as Vitamin A; B, D and K. Mango leaf has been reported to contain high yield of mangiferin, as mangiferin is renowned for prevention and treatment of ulcer and neuropathic pain in Traditional Chinese Medicine [20, 21].

On the other hand, *Azadirachta indica* belong to the family of Meliaceae [9]*. It is commonly known as* Neem plant. According to neem plant is first seen in India and is abundant in nearby Indian subcontinents [22, 23]. reported that Neem leaf is a source of bio-active secondary metabolites such as terpenoids, nimbidin gedunin azadirachtin etc [24]. which also act as reducing and stabilising agents in stabilizing the nanoparticles. Neem leaf is known for its wide medicinal applications, especially in traditional medicine such as prevention and treatment of malaria, typhoid, fever etc., [23]. These two leaves are abundant in Nigeria, especially the northern part of the nation. The leaves usually litter the environment, thereby constitute part of land pollution, as many people concentrate more on the utilisation of the fruits than the leaves. have been the target of usage in the plantation. When silver salt ($AgNO_3$) is treated with the extract of these leaves, the silver salt is reduced to Silver nanoparticles (AgNPs). The choice of these leaves is based on their abundance in the study area.

In line with the UN directive of finding alternative renewable and environmental raw materials, this study seeks to develop alternative methods for the development of environmentally benign nanoparticles that do not use toxic chemicals.

2. Materials and Methods

2.1. Materials

2.1.1.Collection and Preparation of Leaves for Extraction

Fresh leaves of Mango *Mangifera indica* and *Azadirachta indica* were identified and collected from the Modibbo Adama University campus, Yola, Adamawa State. The leaves were prepared by removing dirt and washed thoroughly with distilled water [25]. The leaves were stored in an air-free container till subsequent extraction process.

2.1.2. Extraction of the Sample Leaves

The extraction of the sample leaves was carried out using the method described by [26, 27]. 25 g of the leaves were thoroughly washed in distilled water for 5 min, chopped into fine pieces and placed into a 250 ml beaker containing 100 ml distilled water. The mixture was maintained at 60°C in the water bath for 10 minutes. The mixture was then filtered with Whatman Filter Paper No.1. The filtrate (leaf extract) was used for the preparation of dispersion.

2.1.3. Preparation of Dispersed Silver Nanoparticles

The dispersion was prepared according to the method described by [1, 26]. 0.5 M silver nitrate ($AgNO_3$) was prepared by weighing 0.212 g silver nitrate in 250 mls volumetric flask and adding distilled water to the mark. 15 ml of the leaf extracts was added to 45 ml of the prepared solution of $AgNO_3$ at room temperature while stirring. Colour changes to brown or reddish brown usually marks the end point of the synthesis. The mixture was taken for characterization after 15 minutes, 24 hours and 48 hours of mixing using magnetic stirrer.

2.1.4. Characterization of Silver Nanoparticles

2.1.4.1 Fourier Transform Infrared Spectroscopy

Fourier Transform Infrared Spectroscopy (FTIR) analysis was carried out according to the method described by to monitor the chemical interaction between the plant extract and Silver Nitrate. Buck Scientific M530 FTIR was used to monitor the progress of the Silver nanoparticles (AgNPs) formation [16, 28]. The mixture was initially centrifuged at high speed of 15,000 rpm for 15 minutes to isolate AgNPs from other organic compounds which may interfere in the analysis of protein–AgNPs interaction. The pellet thus obtained was dispersed in distilled water. The centrifugation and re-dispersion of pellet in distilled water was repeated thrice. Finally, KBr pellet method was carried out, where approximately 100 mg of KBr was mixed with 1 mg of the sample to prepare the sample discs. The FTIR analysis was carried out when the reaction was 5mins, 10 mins and 24-hour.

2.1.4.2 UV – visible spectroscopy

The UV-Visible assessment was carried out according to the method described by to monitor the absorption spectrum of the Silver nanoparticles (AgNPs) [1, 4]. The Jenway UV/Visible spectrophotometer with model 6850 was used to assess the optical parameter of the AgNPs. After addition of extract to Silver Nitrate ($AgNO_3$), the absorbance was taken after the complete reaction of 24 hours. The wavelength range was taken as 350 nm – 750 nm.

2.1.4.3 Atomic Force Microscopy (AFM)

Atomic Force Microscopy is one of the notable scanning techniques used for micro/nano-structured high-resolution imaging [1, 29]. It utilises atomic force between the probe and the sample. AFM has been previously used in several nanomaterials' analysis [17]. The AFM imagining was carried out according to the method described by [1, 8].

3. Results and Discussion

3.1. FTIR Analysis of The Leaves Extracts and Agnps At Specified Time Interval

According to Kaniappan and Latha, Fourier Transform Infrared (FTIR) spectroscopy is one of the unique tools specialise in identifying and investigating the presence of functional groups in a chemical bond which usually has a specific energy absorption band [30]. reported that FTIR spectroscopy has been widely used by many researchers to study the formation of blends [31]. FTIR spectroscopy was carried out in this study to identify possible interactions between silver ions and the biomolecules in the extract forming silver. Figure 1 revealed the organic compound component of the mango leaf extract. The broad band with strong intensity obtained in the region 3330 – 3340 cm^{-1} may be attributed to the presence of O – H group due to phenol [32]. The weak absorption intensity peak at 1637 – 1638 cm^{-1} may be due to C=C stretching of aromatic ring which is present in terpenoids. These terpenoids play a major role in the reduction of metal ions as reported by [32]. The peak can also be obtained due to C=O which is present in flavonoids which has also been reported by to reduce silver ions [33].

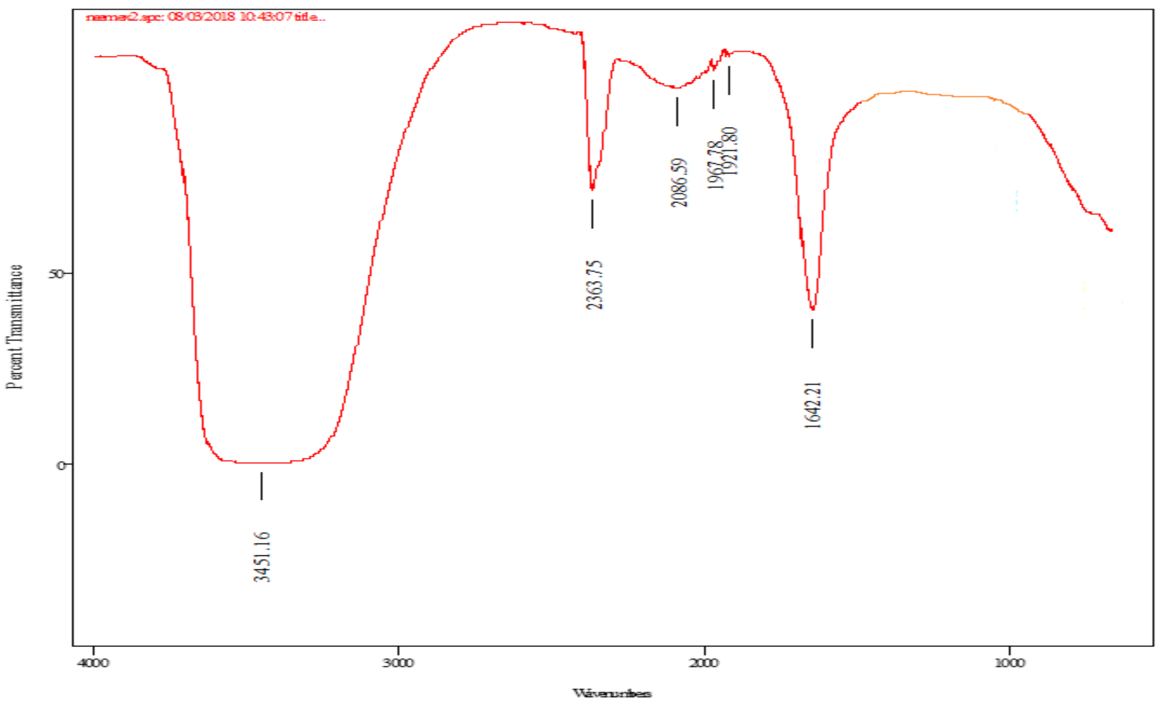


Figure 1. FTIR of Mango leaf extract

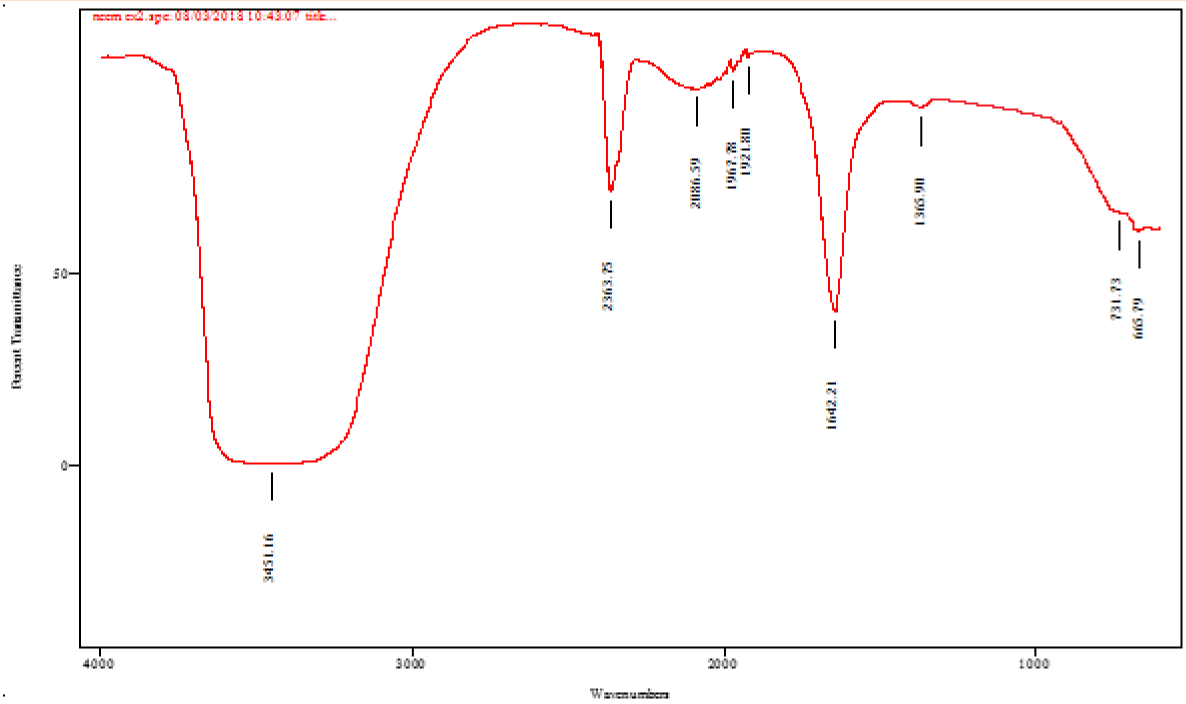


Figure 2. FTIR of Neem leaf extract

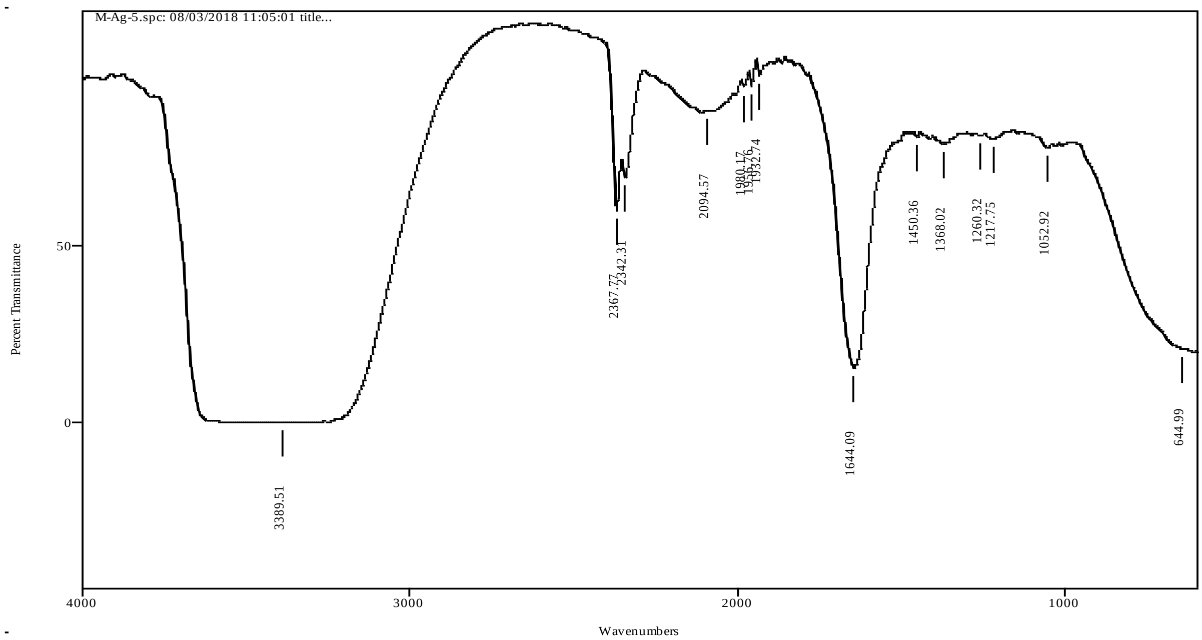


Figure 3. FTIR Spectra of Mango AgNPs after 15 mins

Figure 2 also revealed the bio component of neems leaf extract. Absorption at 1642.21 cm^{-1} also suggested the presence of –C=C-. while 3451.16 cm^{-1} peak denotes the broad absorption of O-H which may subjective of polyphenols compound. Multiple absorption at 1365.90 cm^{-1}; 1219.98 cm^{-1} suggested the vibration for aromatic ring [34]. Presence of flavonoids was confirmed from both plants extracts this was responsible for the reduction of silver nitrate to silver ions.

Figure 3 revealed the progress of chemical interaction between the mango leaf extract and silver nitrate at exactly 15 mins after the commencement of the formulation of AgNPs. Broad absorption at 3389.51 cm^{-1} suggests O-H polyphenol compound, while dual absorption at 2367.11 cm^{-1} and 232.31 cm^{-1} indicates the presence of –C≡C- and –C≡N- which may characterise reduction of nitrate [34].

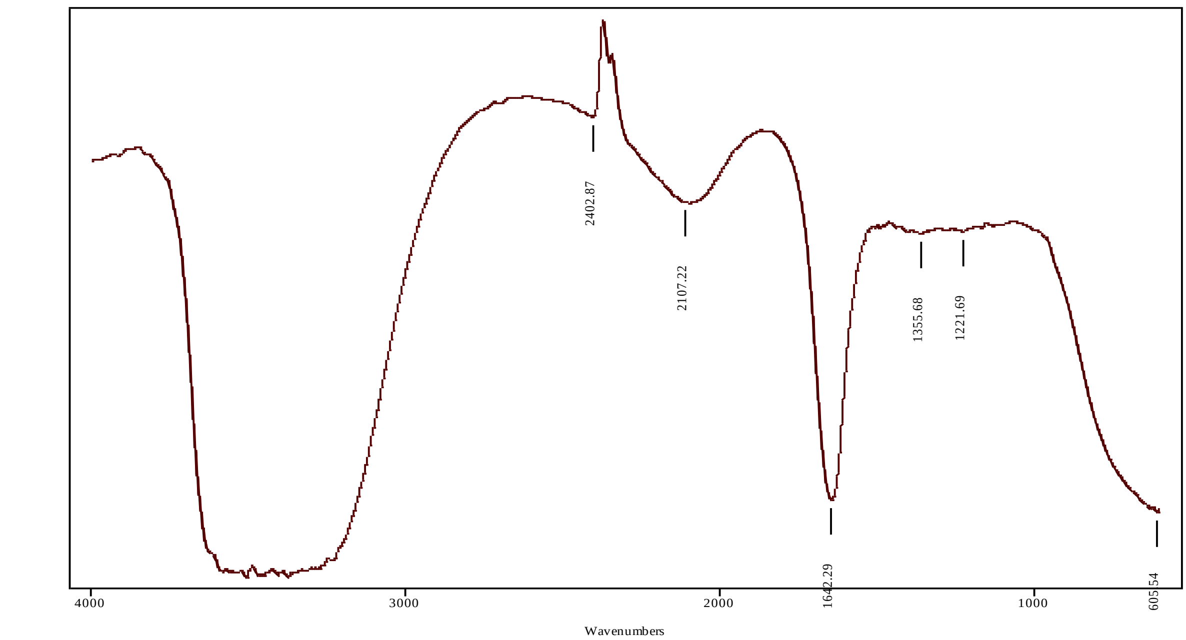


Figure 4. FTIR Spectra of Neem AgNPs after 15 min

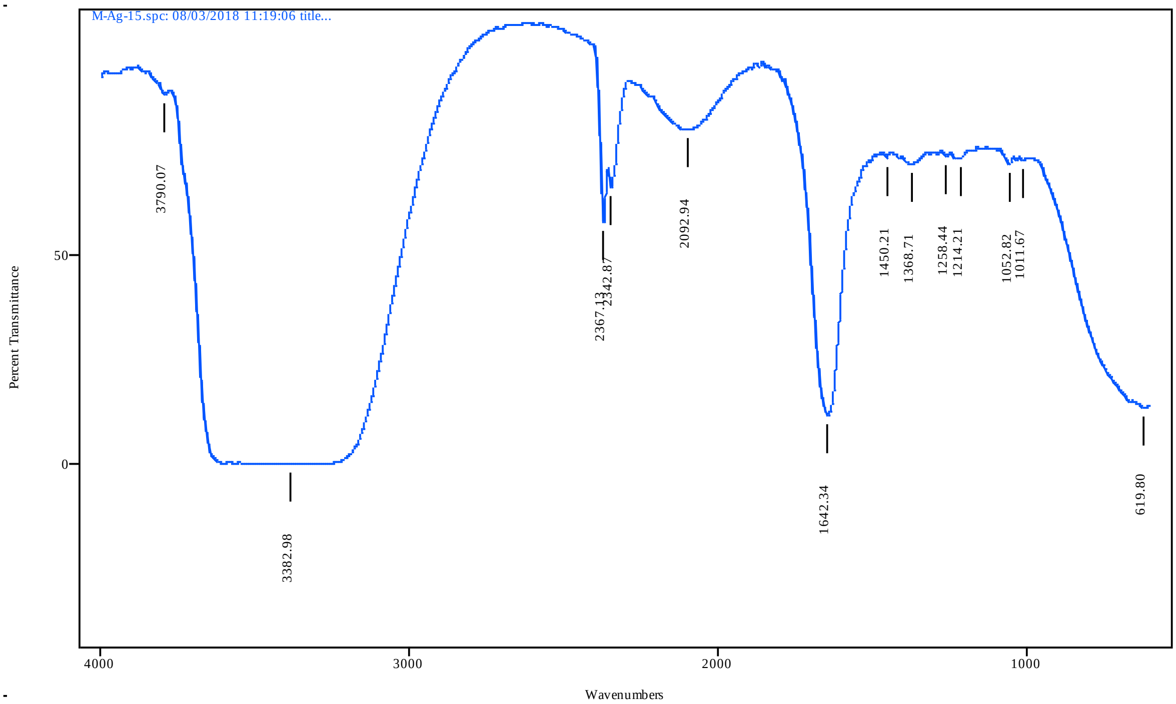


Figure 5. FTIR Spectra of Mango extract AgNPs after 24 hours

Disappearance of a peak at the 1642.21 cm^{-1} earlier noticed in mango leaf extract maybe indicative of further chemical reaction.

Figure 4 expresses the progress of reaction between the Silver nitrate and neem leaf extract 15 minutes after the initiation. Double absorption at 2402.87 cm^{-1} and 2107.22 cm^{-1} are suggestive of –C ≡≡C- and –C ≡≡N-, and fingerprint region absorption at 1355.18 cm^{-1} and 1221.19 cm^{-1} are indicative of –C-N- bond formation [34]. This is to show chemical interaction between the silver nitrate and the neems leaf extract.

Figure 5 denotes the spectra of AgNPs formulated from mango leaf extract after 24 hours of formation. Absorption at 3790.07 and 3382.98 suggest the O-H stretching of polyphenol group. 1642.34 is an indication of –C=C- absorption of aromatic group. Multiple absorptions at 1450.21 cm^{-1}, 1368.71 cm^{-1}, 1258.44 cm^{-1}, 1214.21 cm^{-1}, 1052.82 cm^{-1}, 1052.82 cm^{-1}, 1011.67 cm^{-1}, 6198.0 cm^{-1} witnessed at finger print region suggest –C-O- and –C-N- bond formation [34].

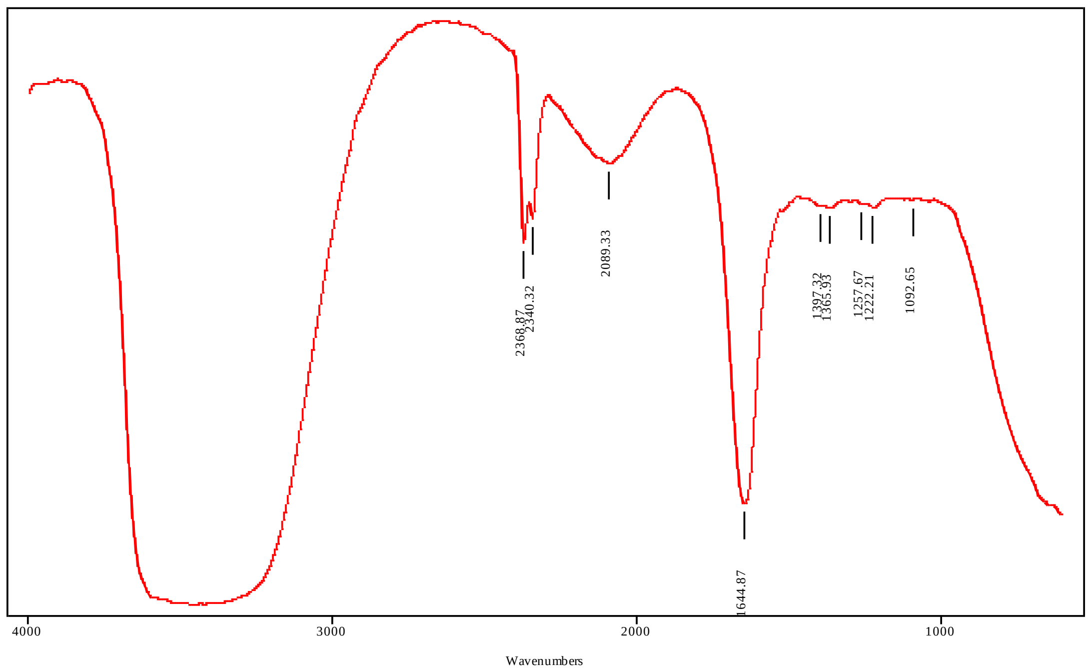
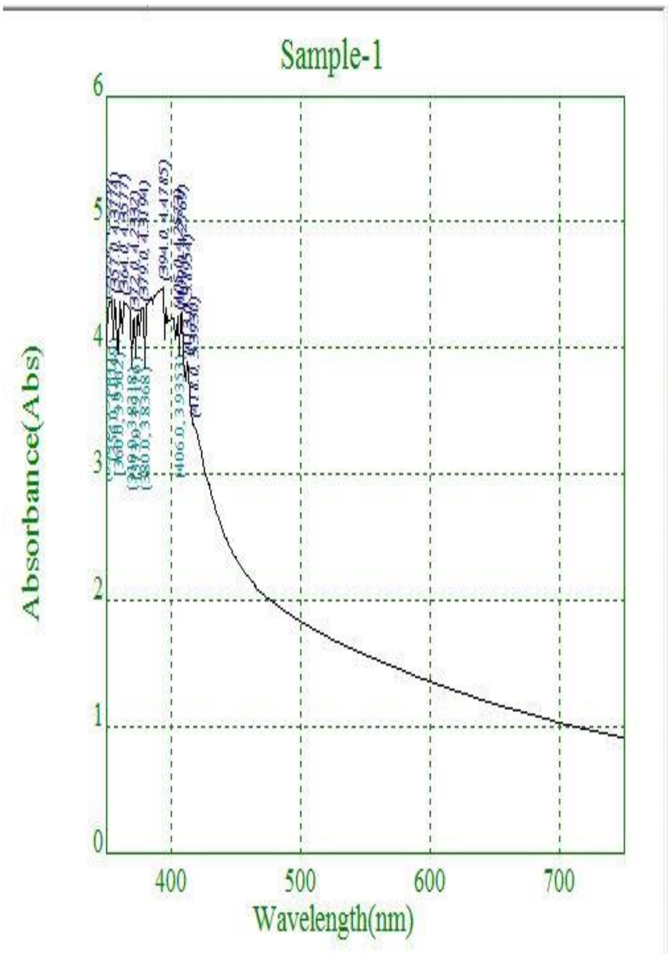


Figure 6. FTIR Spectra of Neem leaf extract of AgNPs after 24 hours



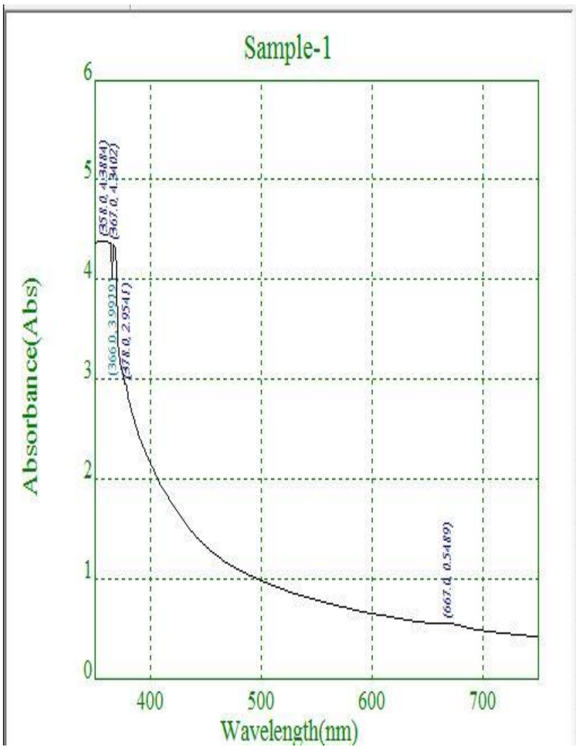
Wavelen...	Abs	FW...
300.0nm	4.1643	
301.0nm	4.4874	3.0
304.0nm	3.8854	
305.0nm	4.4684	6.0
311.0nm	3.5816	
312.0nm	4.4275	3.0
315.0nm	3.7673	
316.0nm	4.4030	1.0
317.0nm	4.0695	
318.0nm	4.3919	5.0
323.0nm	4.0077	
324.0nm	4.3521	3.0
327.0nm	3.8915	
349.0nm	4.3396	22.0
350.0nm	3.9081	
356.0nm	4.0749	
357.0nm	4.3774	3.0
360.0nm	3.9562	
364.0nm	4.3577	9.0
370.0nm	3.8318	
372.0nm	4.2332	2.0
373.0nm	3.9176	
379.0nm	4.3194	6.0

Figure 7. UV Spectrum of mango leaf extract of AgNPs after 24 hours

Figure 6 denotes the FTIR spectra of AgNPs formulated via neem leaf extract after 24 hours of reaction. Multiple absorption at 2368.87 cm^{-1}, 2340.33 cm^{-1} and 2089.33 cm^{-1} suggests O=C=O stretching. The Multiple absorptions 1397.32 cm^{-1},1365.93 cm^{-1}, 1257.67 cm^{-1}, 1222.21 cm^{-1}, 1092.65 cm^{-1} connote presence of C-H bending of aldehyde, C-O stretching of aromatic ester, C-O stretching of vinyl ether and C-O stretching of aliphatic ether [35]. These absorptions may be attributed to the binding of the molecule to the surface of AgNPs through COOH carboxylate group. This agrees with what was observed by [33].

3.2. UV – Visible Spectrophotometer Analysis

The maximum absorbance of the dispersion of silver particle prepared by mixing $AgNO_3$ with mango leaf extract was 429 nm (Fig 7), while that of $AgNO_3$ with neem leaf extract at 438 nm (Fig 8). This value was constant, even after 48 hours of incubation. This result is consistent with those of (2015) [25, 36]. The absorbance obtained may be a result of actual absorption of radiation along with scattering of incident beam. No other peaks were observed in the spectrum, thus ruling out the possibility of other products from the reaction.



Wavelen...	Abs	FW...
200.0nm	1.8818	
202.0nm	1.9813	3.0
204.0nm	1.8781	
206.0nm	2.0722	3.0
208.0nm	2.0294	
213.0nm	2.2753	
229.0nm	4.4337	16.0
230.0nm	4.3172	
231.0nm	4.4589	1.0
232.0nm	4.3030	
233.0nm	4.4094	1.0
234.0nm	4.2098	
245.0nm	4.5490	35.0
270.0nm	4.3119	
271.0nm	4.5991	68.0
339.0nm	4.2324	
358.0nm	4.3884	26.0
366.0nm	3.9979	
367.0nm	4.3402	11.0
378.0nm	2.9541	70.0
667.0nm	0.5489	472.0
851.0nm	0.3275	183.0

Figure 8. UV Spectrum of neem leaf extract of AgNPs after 24 hours

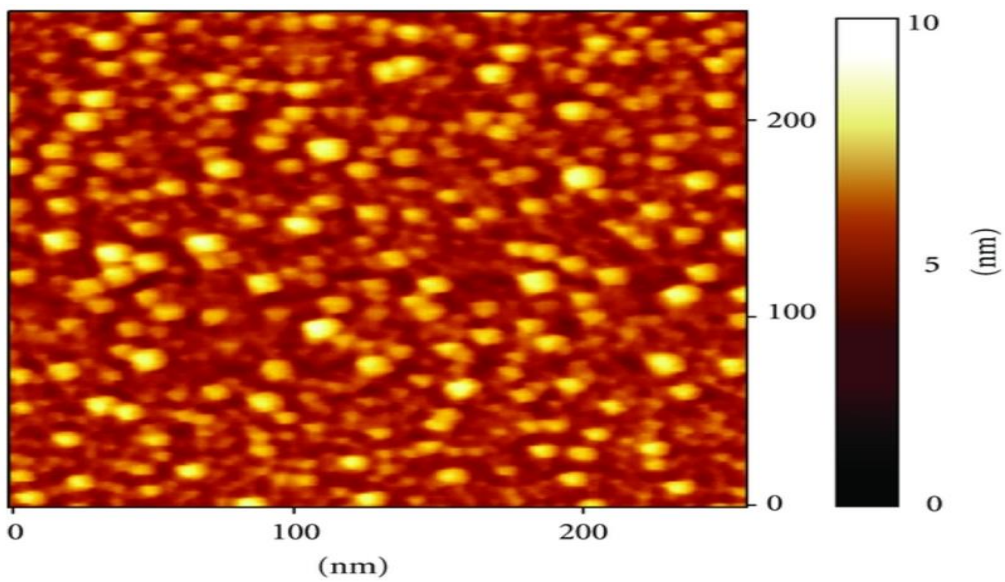


Figure 9. AFM images of the silver nanoparticles prepared by $AgNO_3$ and mango leaf extracts

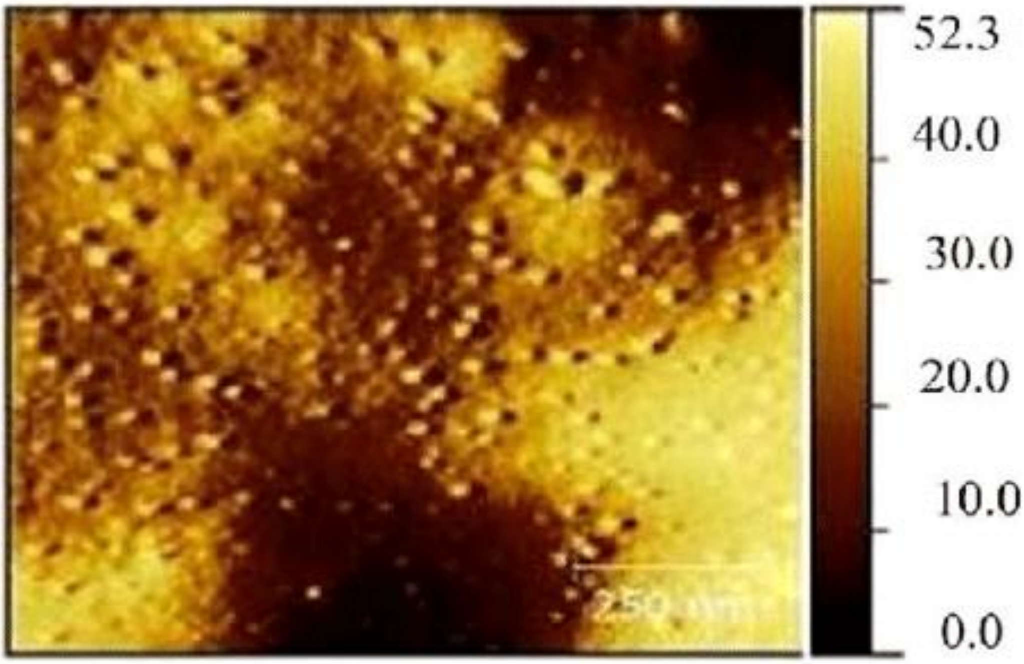


Figure 10. AFM images of the silver nanoparticles prepared by $AgNO_3$ and A. indica (neem) leaf extracts

3.3. The Atomic Force Microscopic Image Analysis

The atomic force microscopic results showed that the AgNPs formed by neem leaf extract were larger than those of mango leaf extract. The result for mango leaf extract based AgNPs particles was in the range 10nm-53nm (Fig 9) while that obtained from neem leaf extract was in the range of 50nm-100nm (Fig 10). Digital photograph showed that the nanoparticles formed from both leaves extracts were of rod shaped with thickness of 5-6 nm only, hence they are said to be nano particles.

4. Conclusion

Neem and mango leaves extracts have been found from this study to possess high capping and reducing properties, which are exhibited in the formation of aqueous silver nanoparticles dispersion, though with little variations. Both formed at 15 minutes of mixing with $AgNO_3$. A simple rapid production of aqueous dispersion of silver nanoparticles can be achieved by using neem leaf and mango leaf extracts. The sizes of mango-based dispersion are smaller than that of neem-based dispersion, and this is a green production route since it is done at room temperature using water and leaves, which are biological materials. Therefore, both neem and mango leaf extracts were good for the biosynthesis of Silver nanoparticles.

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Yes

Conflict of interest

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