J. Water Environ. Nanotechnol., 5(1): 81-91 Winter 2020

ORIGINAL RESEARCH PAPER

Green Synthesis and Characterization of Silver Nano Particles

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Received: 2019-10-18 Accepted: 2019-12-20 Published: 2020-02-01

ABSTRACT

Nanotechnology is getting an incredible drive due to the potential of manipulating metals into their nano-size particles. The synthesis and characterization of nanoparticles using green technology have many applications. The wet chemical techniques used presently in the synthesis of nanoparticles are deleterious along with flammable conditions. Silver nanoparticles have the capability of killing microbes effectively. This paper explains the green technology and pollution-free methodology for synthesizing silver particles at the nanoscale using 1mM silver nitrate solution from the extracts of *Carica papaya, Emblica officianalis, Azadirachta indica, and Cocos nucifera*. When the silver nanoparticles are synthesized the solution turns to brownish-yellow color. The tools used in the characterization of silver nanoparticles are Ultra Violet - Visible absorption Spectroscopy and Field emission Scanning Electron Microscopy. The solutions with silver nanoparticles showed the maximum absorption at 450 nm with Ultra Violet - Visible spectroscopy. It is found that *C. Papaya* and *E. oficianalis* showed the maximum absorbance of 0.578 and 0.59 respectively at 450 nm. The average range of the produced silver nanoparticles is analyzed to be 5 – 70 nm with FESEM and the shape is examined to be spherical.

Keywords: *Characterization, Green technology, Metal, Nanotechnology, Silver Nanoparticles, Synthesis*

How to cite this article

Sastry SVAR. Green Synthesis and Characterization of Silver Nano Particles. J. Water Environ. Nanotechnol., 2020; 5(1): 81-91. DOI: 10.22090/jwent.2020.01.007

INTRODUCTION

The field of material science involves the active researches of nanotechnology. The size of nanoparticles, its distribution, and morphology are contemporary and unique. When the metallic particles are reduced to the nanoscale, their characteristic features and properties get enhanced. This unique characteristic of nanoparticles allows its applications in many areas, like diagnosis, antagonistic study, nanoelectronics, and detection of highly sensitive biomolecules [1-2].

The modulation of metals to the nanoscale made the nanotechnology field an important area of research by modern scientists. Unique characteristic nanoparticles can be synthesized by using modern bio nanotechnological methods. The properties and size of the nanomaterials can be engineered, thus enhancing the applications of nanomaterials in diverse fields. Biological sensors, cell labels, biomolecule labels, cancer therapy, etc., include the use of nanoparticles. [3-4].

The atomic-scale engineering of nanomaterials can be used to design contemporary aspects for inhibiting and curing diseases. The research leading to innovations in biological science, biotechnology, and pharmaceutical technology is due to the capability of discovering the biological systems in the nanoscale. In vivo methodology and in vitro methodology of research can be carried out using nanoparticles because the size of nanoparticles is the same as that of biomolecules [5-6].

Nanotechnology is involved in the development of nanoparticles with diverse shapes and sizes, chemical configuration, and promise benefits

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for mankind. It enables the improvement of nanomaterials with unique physicochemical characteristics along with a wide scope of technical and scientific uses. Nanomaterials find their importance in different areas like electronics, imaging, and medical apparatus, fabrics, cosmetics, and water remediation technologies. Due to their novel properties and small size, nanoparticles can interact with most types of cells [7-8].

Metallic silver reduced to nanoscale have the antibacterial capacity and can be economically manufactured. Dissolved silver has been known for decades to be an efficient bactericide, binding to DNA and disrupting cell replication. Silver nanoparticles have become a promising material for their potential use as an alternative bactericide combating antibiotic-resistant strains, a major hazard in hospitals. The filters made with silver nanoparticles are used in purifying water. Silver nanoparticles delay biofilm colonization in the filtration unit and thus increase their service life [9-11] The morphology of silver nanoparticles depends on the conditions used to synthesize, the methodology of preparation, the characteristic feature of reducing agents and stabilizers used. The aspect ratio, size of the crystal, density of crystals, and morphology are the characteristic properties of silver nanoparticles. Biosynthesis of silver nanoparticles is done using fungi, bacteria, plant extracts, and yeast [12-14].

Chemically synthesized nanoparticles are not suitable for medical use because of the binding of the toxic chemicals on their exterior. Additionally, the by-products formed in chemical methods are noxious for the environment. Notably, the bio-synthesized nanoparticles are free of toxic substances on their exterior. They also can be encrusted with organic materials making them appropriate for the medical applications. These give distinct advantages to the biosynthesis of nanoparticles over the traditional methods [22, 23].

The advancements made in the eco-friendly process of nanoparticle synthesis forms an essential division of nanotechnology. Nowadays, the synthesis of nanoparticles from plants is achieving more priority because of its easy method of synthesis and eco-friendliness. Fungi and bacteria are reported to produce nanoparticles both internally and externally [16-17]. Although many methods are used in the development of nanoparticles, the green methods are best and have driven attention from researchers because of its quality and pollution-free nature. Nanoparticles synthesized by chemical methods lead to adverse effects, due to the presence of noxious and toxic chemicals [18]. The plants like *Alfalfa*, *Aloe vera*, *Diopyros kaki, Hibiscus rosasinensis,* and *Capsicum annuum* are some of the plants which succeeded in the synthesis of nanoparticles [15].

The extracts of plants are economical, pollution-free and nanoparticles can be synthesized in large amounts. The extracts of plants act as capping and reducing agents for the synthesis of nanoparticles is more beneficial over the other biological methods, because they remove the complex process of culturing and preserving the cells. Apart from this, these can also be sized up for bulk-scale synthesis of nanoparticles. Furthermore, plant-mediated synthesis of nanoparticles is favored since it is environmentally friendly, cost-effective and a single step process for therapeutic use.

In the latest studies, researchers used Allium saralicum [20-22] for the bio-synthesis of Silver nanoparticles and studied their anti-microbial properties. Nanoparticles are being used as a new contrivance for use in cancer treatment. Medicinal plants are a good source of pharmaceutically active substances. Researchers have used *Falcaria vulgaris* to synthesize copper nanoparticles and tested for its effective cytotoxicity, anti-fungal, anti-oxidant, anti-bacterial, and wound-healing behavior [23].

The current work intends to make silver nanoparticles using a green organic pathway with the extracts derived from *Carica papaya, Emblica officianalis, Azadirachta indica, Cocos nucifera*, and characterization of the nanoparticles using UV-visible spectroscopy and Field Emission Scanning Electron Microscope (FESEM).

MATERIALS AND METHODS

Collection of raw materials

Fresh plant leaves of *Carica papaya, Emblica officianalis,* and *Azadirachta indica* and *Cocos nucifera* are procured from the campus of MVGR College of Engineering (A), Vizianagaram, A.P, India.

Preparation of plant extracts

The leaves of *C. papaya, E. officianalis* weighing 25 g each were taken after thoroughly washing with distilled water. The leaves were crushed separately using distilled water and filtration is done to separate the extract from solid particles. The extracts from 25g of *A. indica* leaves and pulp

of *C. nucifera* were prepared and filtered. The water content present in C. *nucifera* is filtered and made ready to carry out the experiments [24,25].

Synthesis of Silver Nano Particles

To reduce silver particles to nanoscale by using the above extracts, 1mM silver nitrate solution is prepared. The synthesis is done with varying concentrations of $AgNO_3$ solution added to each of the extracts prepared using *Carica papaya, Emblica officianalis, Azadirachta indica* leaf extract and to milk and water of *Cocos nucifera*. The $AgNO_3$ solution of 90 ml is mixed with extract such that the mixture becomes 100 ml and then it is kept undisturbed for 6 hrs. The above process is followed for 80 ml, 70 ml, 60 ml and 50 ml of aqueous 1mM silver nitrate solution added to 20 ml, 30 ml, 40 ml and 50 ml of each plant extracts separately and the mixture is kept undisturbed for 6 hrs [19, 26, 27]. All the stages of the experimentation were executed in three replicates.

Characterization with UV-Visible Spectroscopy

The reduction of silver particles to the nanoscale is monitored using the UV-Visible Spectroscopy. From the extracts mixed with metallic silver solution after 6hrs, a small amount is withdrawn, diluted with water and the readings are observed and recorded.

Characterization with FESEM

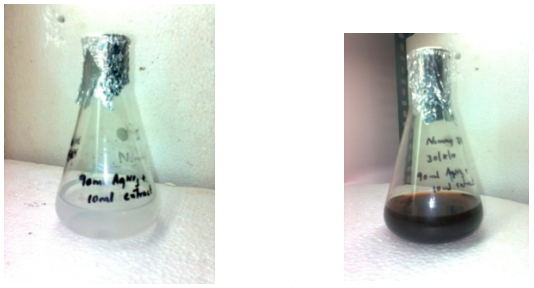
Characterization is done using Field Emission Scanning Electron Microscopy (FESEM) to find the structure, shape, and size of nanoparticles. The images of silver nanoparticles are taken using FESEM (*Hitachi, S 4160*). The size distribution of biosynthesized silver nanoparticles was found using the Dynamic Light Scattering Analysis (DLS).

RESULTS AND DISCUSSION

Because of vast applications of nanoparticles in fields like Electronics, Catalysis, Energy, Medicine, and Chemistry, the demand for nanoparticles has increased. The method described in this paper is an economical and pollution-free green technique. The biological route for the synthesis of nanoparticles doesn't involve very high energy, pressure, heat, and noxious substances.

Synthesis of silver nanoparticles from C. papaya and E. officianalis extract

The extract of *C. papaya* is blended with 1mM silver nitrate and after 6 hours of incubation, mixture color changes to brownish-yellow color. Due to the action of plasmon resonance reverberations on the surface of silver nanoparticles, the change in color happens. It is observed in all the samples prepared as seen in Fig. 1 and Fig. 2. Ultra Violet – Visible Spectroscopy is used in the analysis of the nanoparticles. The Ultra Violet - Visible Spectra showed maximum absorption values at 450 nm for



a) Before Incubation b) After Incubation

Fig. 1. 90 ml Silver Nitrate with 10 ml *C. papaya* extrac

a) Before Incubation b) After Incubation

Fig. 2. *C. Papaya* extract after addition of Silver Nitrate at different concentrations

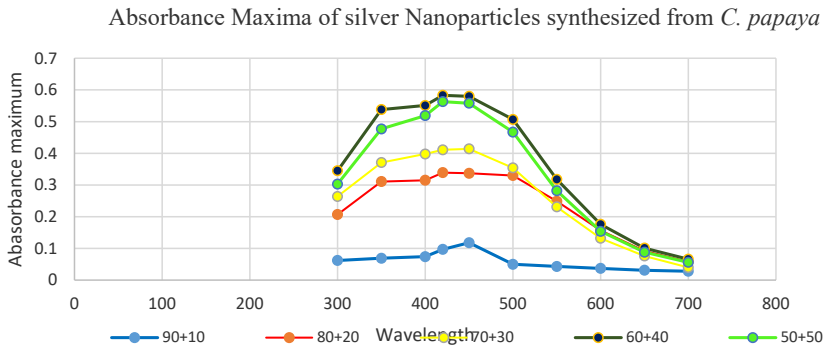
the different concentrations of *C. papaya* extract [22,23]. The absorbance maxima at 450 nm are detected in the 60+40 concentrations as described in Fig. 3 and Table 1.

Similarly, for *E. officianalis,* brownish-yellow color in all the 5 samples is observed after 6 hours of incubation showing the formation of silver nanoparticles as shown in Fig. 4.

The UV-Vis Spectra analysis of *E. officianalis* exhibited the absorption maxima peak at 450 nm for the 50+50 concentrations as seen in Table 2. At 550 nm the silver nanoparticles synthesized from *E. officianalis* showed the highest absorption of 0.59 compared to other concentrations of *E. officianalis* with silver nitrate.

Fig. 5 denotes the Ultra Violet spectra readings of silver nanoparticles developed from *E. officianalis.*

Synthesis of Silver Nanoparticles from A. indica, C. nucifera milk, C. nucifera water



(90+10 denotes 90ml silver nitrate+10ml extract, 80+20 denotes 80ml silver nitrate+20ml extract, 70+30 denotes 70ml silver nitrate+30ml extract, 60+40 denotes 60ml silver nitrate+40ml extract, 50+50 denotes 50ml silver nitrate+50ml extract)

Fig. 3. Absorbance Maxima of silver nanoparticles synthesized from *C. papaya*

Table 1. UV-Vis spectra reading of *C. papaya* with Silver Nitrate at different concentrations

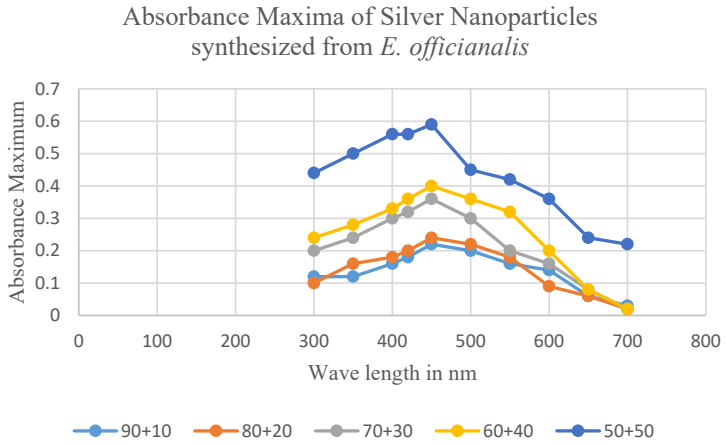
Absorption	Varying concentrations of *C. papaya* extract with 1mM silver nitrate				
Nm	90+10	80+20	70+30	60+40	50+50
300	0.062	0.207	0.264	0.345	0.303
350	0.069	0.311	0.371	0.538	0.477
400	0.074	0.315	0.398	0.551	0.519
420	0.097	0.339	0.411	0.583	0.563
450	0.118	0.337	0.414	0.585	0.558
500	0.050	0.330	0.354	0.507	0.467
550	0.043	0.249	0.231	0.318	0.282
600	0.037	0.157	0.132	0.176	0.154
650	0.031	0.092	0.076	0.101	0.088
700	0.028	0.058	0.040	0.066	0.056

a) Before Incubation b) After Incubation

Fig. 4. *E. officianalis* extract after adding silver nitrate at different concentrations

Table 2. UV-Vis spectra reading of *E. officianalis* with Silver Nitrate at different concentrations

Absorption	Varying concentrations of *E. officianalis* extract with 1mM silver nitrate				
Nm	90+10	80+20	70+30	60+40	50+50
300	0.12	0.10	0.20	0.24	0.44
350	0.12	0.16	0.24	0.28	0.50
400	0.16	0.18	0.30	0.33	0.56
420	0.18	0.20	0.32	0.36	0.56
450	0.22	0.24	0.36	0.40	0.59
500	0.20	0.22	0.30	0.36	0.45
550	0.16	0.18	0.20	0.32	0.42
600	0.14	0.09	0.16	0.20	0.36
650	0.06	0.06	0.08	0.08	0.24
700	0.03	0.02	0.02	0.02	0.22



(90+10 denotes 90ml silver nitrate+10ml extract, 80+20 denotes 80ml silver nitrate+20ml extract, 70+30 denotes 70ml silver nitrate+30ml extract, 60+40 denotes 60ml silver nitrate+40ml extract, 50+50 denotes 50ml silver nitrate+50ml extract)

Fig. 5. Absorbance Maxima of silver nanoparticles synthesized from *E. officianalis*.

a) Before Incubation b) After Incubation

Fig. 6. *A. indica* extract after adding silver nitrate at different concentrations

The change of color to brownish-yellow in all 5 samples denoted the formation of silver nanoparticles due to the reduction of silver ions. Due to the action of plasmon resonance reverberations on the surface of silver nanoparticles, the change in color happens. Absorption showed a maximum peak at 450 nm for 50+50 concentrations. Similarly, in the case of *C. nucifera* milk and *C. nucifera* water, observance of brownish-yellow color after 6 hours of undisturbed condition, indicates the development of silver nanoparticles. Absorption showed a maximum peak at 450 nm for 50+50

concentrations. Observance of brownish-yellow color in the 5 samples of *C. nucifera* milk and *C. nucifera* water showed the formation of silver nanoparticles. Maximum optical density is found at 450 nm for 50+50 concentration of plant extract with silver nitrate solution.

The color change in *A. indica* blended with silver nitrate solution as brownish yellow color is shown in Fig. 6.

The absorption maxima of silver nanoparticles produced by *A. indica* are observed and tabulated in Table 3. The maximum absorption in silver nanoparticles synthesized by *A. indica* is found to be 0.56 at 450 nm.

The absorbance maximum of silver nanoparticles synthesized from *A. indica* is shown in Fig. 7. The highest peak range is obtained for silver nanoparticles synthesized at 50 + 50 ml concentrated mixture of silver nitrate and *A. indica*.

The *C. nucifera* milk prepared from the pulp of *C. nucifera* is tested for the formation of silver nanoparticles. The milk of *C. nucifera* at concentrations of 10 ml, 20 ml, 30 ml, 40 ml, and 50 ml is prepared and blended with silver nitrate solution of 1 mM, such that the solution becomes 100 ml. Fig. 8 denotes the color change of pure white *C. nucifera* milk to brownish-yellow solutions due to the formation of silver nanoparticles.

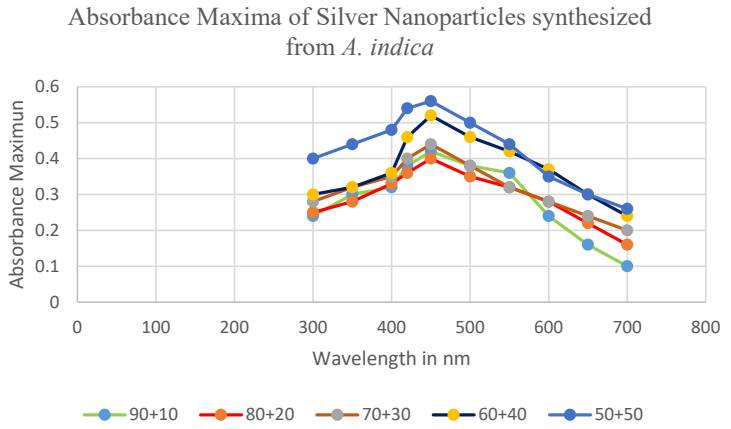
The UV Vis spectra reading of the different concentrations of *C. nucifera* is analyzed and the maximum absorption is found at 450 nm as 0.42 for 50 + 50 ml concentration as shown in Table 4.

The filtered water content of *C. nucifera* mixed with the $AgNO_3$ solution turned to brownish yellow color after 6 hrs of incubation.

The UV Vis spectra reading of the different concentrations of *C. nucifera* is analyzed and the maximum absorption is found at 450 nm as shown in Table 5 and Fig. 11 [22,23].

Table 3. UV-Vis spectra reading of *A. indica* with Silver Nitrate at different concentrations

Absorption	Varying concentrations of *A. indica* extract with 1mM silver nitrate				
Nm	90+10	80+20	70+30	60+40	50+50
300	0.24	0.25	0.28	0.30	0.40
350	0.30	0.28	0.32	0.32	0.44
400	0.32	0.33	0.35	0.36	0.48
420	0.38	0.36	0.40	0.46	0.54
450	0.42	0.40	0.44	0.52	0.56
500	0.38	0.35	0.38	0.46	0.50
550	0.36	0.32	0.32	0.42	0.44
600	0.24	0.28	0.28	0.37	0.35
650	0.16	0.22	0.24	0.30	0.30
700	0.10	0.16	0.20	0.24	0.26



(90+10 denotes 90ml silver nitrate+10ml extract, 80+20 denotes 80ml silver nitrate+20ml extract, 70+30 denotes 70ml silver nitrate+30ml extract, 60+40 denotes 60ml silver nitrate+40ml extract, 50+50 denotes 50ml silver nitrate+50ml extract)

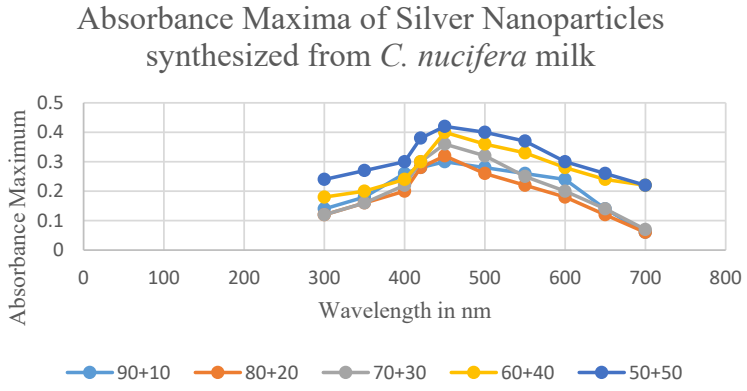
Fig. 7. Absorbance Maxima of silver nanoparticles synthesized from *A. indica*

a) Before Incubation b) After Incubation

Fig. 8. *C. nucifera* milk extract after adding silver nitrate at different concentrations

Table 4. UV-Vis spectra reading of *C. nucifera* milk with Silver Nitrate at different concentrations

Absorption	Varying concentrations of *C. nucifera* milk with 1mM silver nitrate				
Nm	90+10	80+20	70+30	60+40	50+50
300	0.14	0.12	0.12	0.18	0.24
350	0.18	0.16	0.16	0.20	0.27
400	0.26	0.20	0.22	0.24	0.30
420	0.28	0.28	0.30	0.30	0.38
450	0.30	0.32	0.36	0.40	0.42
500	0.28	0.26	0.32	0.36	0.40
550	0.26	0.22	0.25	0.33	0.37
600	0.24	0.18	0.20	0.28	0.30
650	0.14	0.12	0.14	0.24	0.26
700	0.06	0.06	0.07	0.22	0.22



(90+10 denotes 90ml silver nitrate+10ml extract, 80+20 denotes 80ml silver nitrate+20ml extract, 70+30 denotes 70ml silver nitrate+30ml extract, 60+40 denotes 60ml silver nitrate+40ml extract, 50+50 denotes 50ml silver nitrate+50ml extract)

Fig. 9. Absorbance Maxima of silver nanoparticles synthesized from *C. nucifera* milk extract

Comparative studies

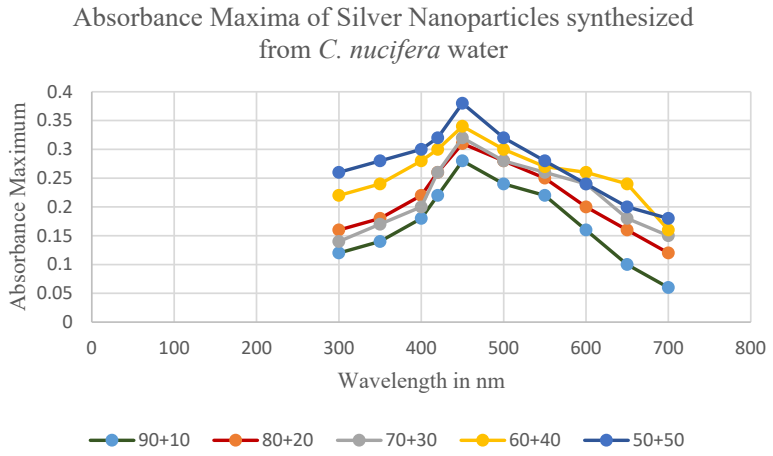
Comparison of absorption spectra reading at 450 nm of *C. papaya, E. officianalis, A. indica, C. nucifera* milk, *C. nucifera* water shows that the *C. papaya* extract at 60+40 concentration has the maximum peak. Next to *C. papaya*, *E. officianalis extract* shows the maximum absorption value at 50+50 concentration. From Fig. 12 it is found that *C. Papaya* and *E. oficianalis* showed the maximum absorbance of 0.578 and 0.59 respectively at 450 nm. From this value, it is analyzed that when the silver nitrate and extract are in equal amounts, there can be rapid development of silver nanoparticles [22,23].

a) Before Incubation b) After Incubation

Fig. 10. *C. nucifera* water extract after adding silver nitrate at different concentrations

Table 5. UV-Vis spectra reading of *C. nucifera* water with Silver Nitrate at different concentrations

Absorption	Varying concentrations of *C. nucifera* water with 1mM silver nitrate				
Nm	90+10	80+20	70+30	60+40	50+50
300	0.12	0.16	0.14	0.22	0.26
350	0.14	0.18	0.17	0.24	0.28
400	0.18	0.22	0.20	0.28	0.30
420	0.22	0.26	0.26	0.30	0.32
450	0.28	0.31	0.32	0.34	0.38
500	0.24	0.28	0.28	0.30	0.32
550	0.22	0.25	0.26	0.27	0.28
600	0.16	0.20	0.24	0.26	0.24
650	0.10	0.16	0.18	0.24	0.20
700	0.06	0.12	0.15	0.16	0.18

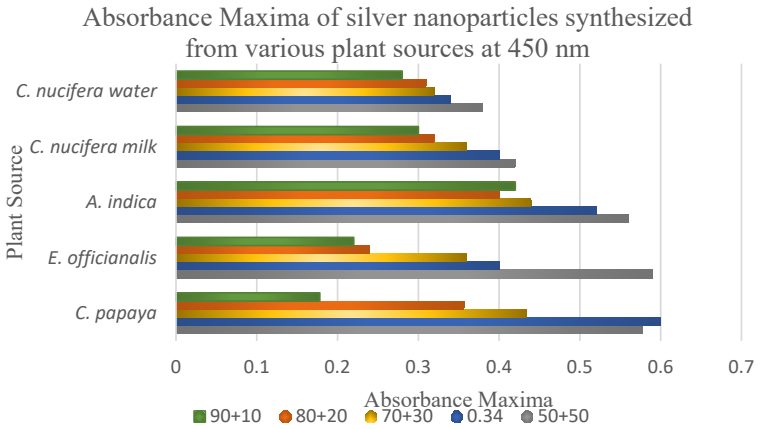


(90+10 denotes 90ml silver nitrate+10ml extract, 80+20 denotes 80ml silver nitrate+20ml extract, 70+30 denotes 70ml silver nitrate+30ml extract, 60+40 denotes 60ml silver nitrate+40ml extract, 50+50 denotes 50ml silver nitrate+50ml extract)

Fig. 11. Absorbance Maxima of silver nanoparticles synthesized from *C. nucifera* water.

To carry out the characterization of silver nanoparticles at the structural level, UV - visible spectroscopy is used. The crest observed at 450 nm denotes that the silver particles at the nanoscale are present.

FESEM is used to analyze the size and shape



(90+10 denotes 90ml silver nitrate+10ml extract, 80+20 denotes 80ml silver nitrate+20ml extract, 70+30 denotes 70ml silver nitrate+30ml extract, 60+40 denotes 60ml silver nitrate+40ml extract, 50+50 denotes 50ml silver nitrate+50ml extract)

Fig. 12. Absorbance Maxima of Silver Nanoparticles synthesized at 450 nm.

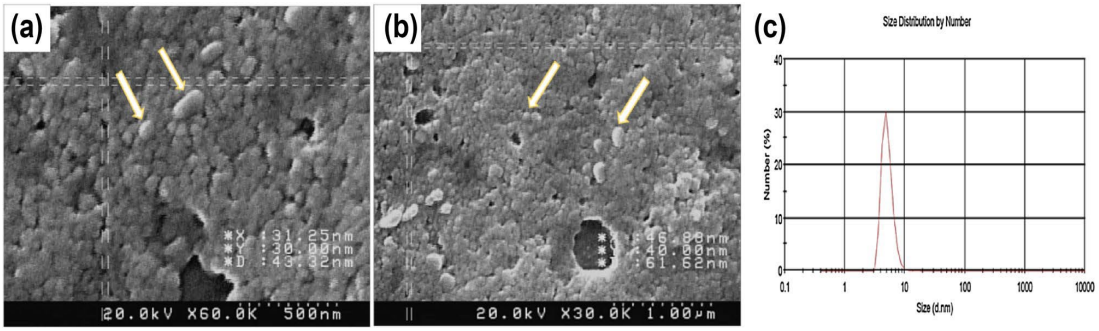


Fig. 13. FESEM image of silver nanoparticles
(a) 500 nm and (b) 1 µm c) DLS analysis of silver nano particles

of nanoparticles. The silver nanoparticles can be seen individually and also in agglomerated form, as shown in Fig. 13.

Silver nanoparticles are stretched comprehensively in solution. As per the FESEM images, the size of nanoparticles was in the range of 5–70 nm. The average diameter of synthesized silver nanoparticles was calculated using the Dynamic light scattering (DLS) analysis. The bulk of the silver nanoparticles were about 7 nm in diameter (Fig. 13 c). The results are in concurrence with the findings of Oves et al. [28].

The silver nanoparticles attach to the surface of bacteria, based on the availability of surface area. When the silver particles get reduced to the nanoscale, the surface area of silver nanoparticles gets increased leading to the attachment of more silver nanoparticles on the cell membrane of bacteria. The bactericidal quality of silver nanoparticles increases with an increase in surface area of nanoparticles. The tendency of silver nanoparticles to interact with sulfur and phosphorus containing compounds is high. By interacting with these compounds the damage to the bacterial cell can be carried out [2].

The methodology used here to develop silver nanoparticles is easy, economical, and reproducible. The nanoparticles thus produced are stable and eco-friendly. Thus, the biological route for synthesizing silver nanoparticles is safe compared to other methods.

CONCLUSION

The plant extracts of *Carica papaya, Emblica officianalis, Azadirachta indica, and Cocos nucifera* were successfully used for the synthesis of silver nanoparticles. The presence of brownish-yellow color in varying concentrations of extract proved the existence of silver nanoparticles. Characterization study is carried out by Ultra Violet – Visible spectra

analysis. At 450 nm, silver nanoparticles showed the absorbance maxima. Among the raw materials, *C.papaya* and *E.officianalis* showed the maximum absorption spectra reading in 60+40 concentration and 50+50 concentrations respectively. FESEM showed that the synthesized silver nanoparticles are crystalline and spherical. The synthesized silver nanoparticles showed good bactericidal activity. This method of synthesizing silver nanoparticles appears to be non-toxic, cost-effective, and eco-friendly alternative to the traditional physical, chemical and microbiological methods, and can be used for developing an organic route for bulk scale manufacture. Apart from these, the silver nanoparticles can also be used in the effluent management plants for decreasing the microbial load.

CONFLICT OF INTEREST

There are no conflicts to declare.

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