# GREEN SYNTHESIS OF SILVER NANOPARTICLES USING A MOUNTAIN PLANT EXTRACT

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The present study investigated the synthesis of silver nanoparticles (Ag-NPs) using Artemisia Sieberi Besser leaf extract. To evaluate parameters affecting the synthesis including pH, volume of extract, concentration of silver nitrate solution, temperature and time, Ultraviolet-Visible (UV–Vis) spectroscopy was used. Ag-NPs were characterized by UV–Vis spectroscopy, Scanning electron microscopy (SEM), X-ray diffraction spectroscopy (XRD), Fourier transform infrared spectroscopy (FTIR) and Transmission Electron Microscopy (TEM) techniques. The SEM revealed spherical morphology of the particles with the size around 41–88 nm. The XRD pattern of Ag-NPs confirmed that these nanoparticles were crystalline and had cubic structure with an average size of 20 nm. TEM analysis of synthesized nanoparticles showed spherical and cubic particles with an average size of 20 nm. The results showed that silver nanoparticles could be produced by an eco-friendly biological method with no need to any harmful chemicals using Artemisia Sieberi Besser (a mountain plant) extract.

## INTRODUCTION

Artemisia Sieberi Besser (synonym of Artemisia herba alba) or "desert worm wood", also known as '*Dermaneh*', is an endemic species in Iran. It belongs to the *Asteraceae* family.[1] Artemisia species have practical applications in traditional medicine as drugs and food for coughs, colds, intestinal worms treatment, and wounds healing. Moreover, it is a useful remedy for the diabetes mellitus treatment in Iraq[2]. Some biological activities of A. Sieberi like antifungal activities, antimicrobial, antinociceptive effect, and insecticidal activity were confirmed.[3-14] The Artemisia genus have more than 160 individual components, including santonin, flavonoids, luteolin, apigenin, flavones, davanone, sesquiterpene lactones and bicyclic monoterpene glycosides,[15] and related compounds, cyclic sesquiterpenes[16] and artemisinin.[17] *Dermaneh* is a well-known medicinal plant in Iran. Nowadays, nanotechnology belongs to the large improvement of human life and it has a multidisciplinary research area. Amongst the different fields of nanotechnology, green nanotechnology provides more effective synthesis route with expected products and economical manner for nanoparticles.[18] Nanomaterials, due to their electrical, optical, magnetic and chemical properties compared to the bulk materials, are new, emerging and creating development. Many physical, chemical and biological methods are adopted for nanoparticles synthesizing. Physical and chemical factors including the shape and size of nanoparticles as well as pH and temperature of the reaction mixture were controlled during the nanoparticles synthesis.[19]

In recent years, biological synthesis of metal nanoparticles was achieved using bacteria,[20] algae,[21,22] fungi[23,24] and plants.[25] Green synthesis of metal nanoparticles by extracellular plants and herbal compounds is more eco-friendly, requires low cost and less time, and leads to large-scale

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yields. Plant mediated synthesis route has more advantages compared to the chemical and microbe mediated synthesis method due to the elimination of the culture maintaining process.[26,27] Flavonoids, polyphenols and alkaloids compounds which are found in plants may reduce metal ions to metal nanoparticles and act as stabilizing and capping agents.[28]

As mentioned above, Artemisia plant is full of many compounds, such as flavonoids. So, this study investigated the efficiency of this plant in the synthesis of metal nanoparticles. To this end, silver was selected because of its unique properties. Silver is a transition metal and prehistoric among the noble metals, which has been widely used for thousands of years in human history and acted as a health additive in traditional Indian and Chinese Ayurvedic medicine.[29] Silver nanoparticles have many applications in biomedicine because of their large surface area compared to the bulk materials.[30]

In this work, the optimum conditions for silver nanoparticles synthesis like silver ion concentration, temperature and pH were determined by analyzing the absorbance spectra acquired by an UV-Vis spectrophotometer. To analyze the crystal size, phase composition, morphology and structure, Scanning Electron Microscope (SEM), X-ray diffraction spectroscopy (XRD) Transmission Electron Microscopy (TEM), and Fourier Transform Infrared (FTIR) Spectroscopy were used as silver nanoparticles characterization techniques.

## MATERIALS AND METHODS

Chemicals such as silver nitrate (1 mM), hydrochloric acid (0.1 M), and sodium hydroxide (0.1 M) were purchased from Sigma-Aldrich or Merck and *Dermaneh* leaves (Fig. 1) were collected from Khozestan province, Iran.



Fig. 1 – Artemisia sieberi Besser (*Dermaneh*) plant.

### Preparation of Leaf Extract

To prepare the leaf extract, 20 g of leaves was washed thoroughly with double distilled water for three times. Then, the leafs were sliced into small pieces and boiled in 200 mL double distilled water at 60 ºC for 30 min. After that, the extract was filtered through Whatman No.1 filter paper; the extract solution was collected and stored at 4 ºC for further nanoparticles' synthesis process.

### Synthesis of Silver Nanoparticles

For typical synthesis process of silver nanoparticles, 5 mL of leaf extract was added to 95 ml of 1 mM silver nitrate aqueous solution and incubated at room temperature. The solution' color changed to brown, indicating synthesis of silver nanoparticles (Fig. 2). To investigate the optimum parameters for silver nanoparticles synthesis, the experiments were carried out at different pH values (2, 4, 6, 8 and 10), volumes of the extract (2, 4, 6 and 8 mL), silver ion concentrations (0.001, 0.003, 0.005 and 0.01 mM), temperature (25, 35, 65, 70 and 80 ºC) and time (10, 25, 45, 65, 100, 1020, 1320 min). In order to investigate the effect of these parameters on silver nanoparticles synthesis, UV-Vis spectrophotometer was used (UV-Vis Agilent – 8541 was setup at wavelengths of 330–800 nm).

### Effect of pH on silver nanoparticle synthesis using *Dermaneh* extract

5 mL *Dermaneh* extract and 0.001 M silver nitrate solution (95 ml) were added to 5 Erlenmeyer flasks. pH of each Erlenmeyer flask was adjusted at 2, 4, 6, 8 and 10 using 0.1 M sodium hydroxide and 0.1 M hydrochloric acid. pH of the reaction mixtures was determined using digital pH meter (EDT GP353 pH meter). Then, the solution was stirred at the stirring rate of 150 rpm for 30 min at room temperature. By adding the metallic salt solution, the color of solution obviously changed from light yellow to dark brown, indicating the formation of silver nanoparticles. After that, UV-Vis spectrum was taken in the range of 330–800 nm and the best pH value for this synthesis was determined and established for further experiments.
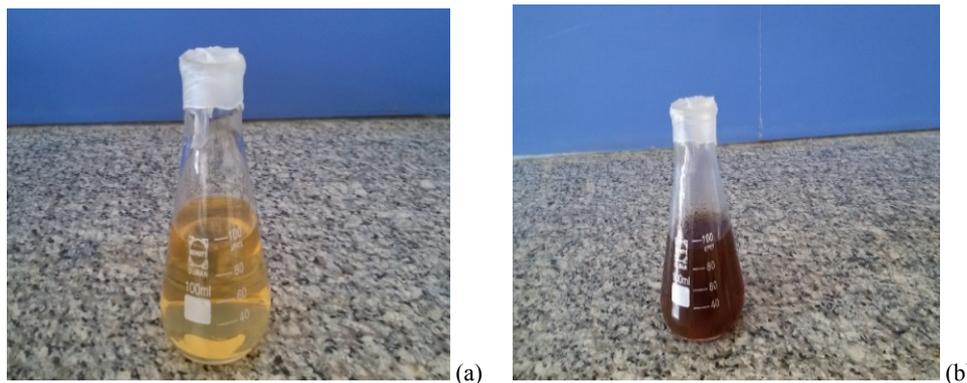
Fig. 2 – a) *Dermaneh* leaf extract solution, b) Colour of the *Dermaneh* extract solution after reaction with AgNO$_3$.

## Effect of *Dermaneh* extract volume on silver nanoparticle synthesis

95 mL of 0.001 M silver nitrate was poured into 4 Erlenmeyer flasks and 2, 4, 6 and 8 mL of *Dermaneh* extract solution were added to them. Then, pH of all Erlenmeyer flasks was adjusted at the optimized pH and the solution was stirred at the stirring rate of 150 rpm for 30 min at room temperature. After that, UV-Vis spectra were recorded like in the previous step. Thus, the best volume of extract has been determined and used for further experiments.

## Effect of metal salt concentration on silver nanoparticle synthesis by *Dermaneh* extract

In order to optimize the concentration of the metal salt solution, 8 mL of *Dermaneh* extract was poured into 4 Erlenmeyer flasks, then 5 mL of 0.001, 0.003, 0.005 and 0.01 M silver nitrate was added to them. The pH of all Erlenmeyer flasks was adjusted to the optimized pH, and after a while, these solutions were stirred at the stirring rate of 150 rpm for 30 min at room temperature. Then, UV-Vis spectrum was taken from them in the range of 330–800 nm and the best concentration was determined and used for next experiments.

## Effect of temperature on silver nanoparticle synthesis by *Dermaneh* extract

Like in the previous steps, the optimal temperature was measured. 8 mL of *Dermaneh* extract and 95 mL silver nitrate (0.01 M) were poured into 7 Erlenmeyer flasks and pH was set at 10. Then all Erlenmeyer flasks were placed in the oven at temperatures of 25, 35, 70 and 80 °C for 1 hour. After that, all samples were centrifuged and UV-Vis spectra were recorded with the same conditions as before. So the optimal temperature was obtained.

## Effect of time on silver nanoparticle synthesis by *Dermaneh* extract

Determining the appropriate time for silver nanoparticles synthesis is an important step because metal ions are increased and released at specific time. Then the surface plasmon resonance would be decreased. 8 mL of the *Dermaneh* extract and 95 mL silver nitrate (0.01 M) were poured into 7 Erlenmeyer flasks and pH was set at 10. The experiments were performed at 80 °C. Then, the UV-Vis spectrum was taken after 10, 25, 45, 65, 100, 1020 and 1320 min, respectively. According to the results, the best time for nanoparticles synthesis was determined.

## Characterization of the green synthesized silver nanoparticles

It has been reported that the nanoparticles size and shape mainly depend on different factors like concentration of leaf extract, salt solution, pH and temperature.[31,32] In order to characterize silver nanoparticles by SEM, XRD, TEM and FTIR devices, according to obtained results from the UV-Vis spectra for the studied optimal parameters (Figures 3–7), silver nanoparticles were re-synthesized at the following conditions: pH=10, *Dermaneh* extract volume = 8 ml, salt solution concentration = 0.01 M, temperature = 80 ˚C, time = 1020 min. After a suitable time, to separate the metallic nanoparticles sediment from solution, the sample was centrifuged. Then, metallic nanoparticles were characterized by above-mentioned methods after washing and drying.

## RESULTS AND DISCUSSION

The UV-Vis spectra show the effect of different optimal parameters on silver nanoparticles synthesis by *Dermaneh* extract. Metal-based nanoparticles have many free electrons leading to the surface plasmon resonance (SPR) effect when excited with light of specific wavelengths. The yielded spectrum records vibrations of the free electrons of nanoparticles. In this work, the high peak which is appeared in the visible area also confirms the formation of silver nanoparticles and SPR absorption band was observed at 420 nm wavelength region due to the presence of brown-colored synthesized silver nanoparticles (Figures 3–7). Similar results were reported by Muhammad Amin *et al.*[33]

### Effect of pH on silver nanoparticle synthesis

pH is another major factor affecting the reduction of silver ions, that is shown in Fig. 3. According to obtained results from the UV-Vis spectra, at pH=2 and pH=4, no absorption peaks were observed in the range of 400–600 nm for the samples after 30 min of the reaction. An absorption band appeared at about 440 nm when pH increased from 4 to 8, indicating the formation of Ag-NPs. Upon a further increase in pH (up to 10), a red-shift appeared from 406 nm to 550 nm and then a decrease occurred. This behavior may be due to the ionization of phenolic compounds and tannins in the extract of *Dermaneh*.[34] It was observed that the absorption peak intensity increased gradually with an increase in pH, suggesting that the reduction rate of silver ions increases with the increase in pH. According to the Fig. 3, the formation of Ag-NPs was repressed by acidic conditions and raised by basic conditions. At lower pH (pH=5), larger silver nanoparticles were formed, whereas, smaller and highly dispersed silver nanoparticles were formed at higher pH[33]. Thus, pH=10 was selected as an optimum pH.

### Effect of *Dermaneh* extract volume

From Fig. 4, it can be seen that by increasing the extract volume of *Dermaneh*, the SPR bands became sharper and for all samples the band appeared at 420 nm.[35] This occurred by increasing the extract volume of *Dermaneh*, leading to an increase in the concentration of tannins, phenolics, alkaloids and sugars, *etc.* which is responsible for the forming and stabilizing of silver nanoparticle.

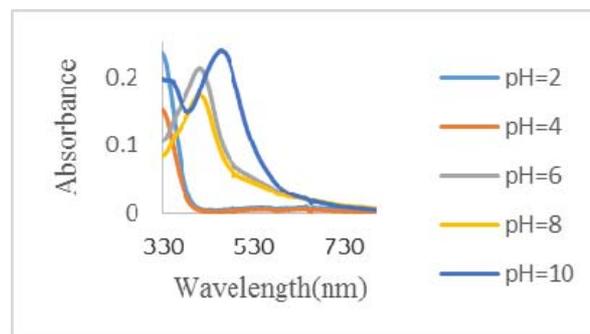So, the extract volume of *Dermaneh* was selected 8 mL.



Fig. 3 – Effect of pH on Silver nanoparticles synthesis by *Dermaneh* extract (5 ml of extract solution, 95 ml of 0.001 M Silver nitrate, time: 30 min, stirring rate 150 rpm).
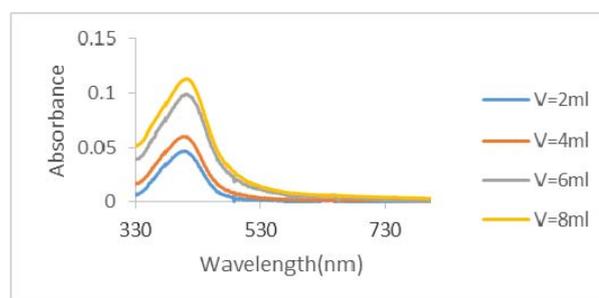


Fig. 4 – Effect of *Dermaneh* extract solution on Silver nanoparticles synthesis (pH of the solution was 10, 95 ml of 0.001 M Silver nitrate, time: 30 min, stirring rate 150 rpm).

### Effect of metal salt concentration

According to Fig. 5, the obtained results from UV-Vis spectra showed that by increasing the metal salt concentration, the SPR bands for all samples appeared at 416 nm and became sharper thus smaller and highly dispersed silver nanoparticles were formed. Similar results have already been reported on the effect of metal salt concentration on the formation of metal nanoparticles.[35] The required concentration of silver nitrate for the improvement of reaction was selected 0.01 M.
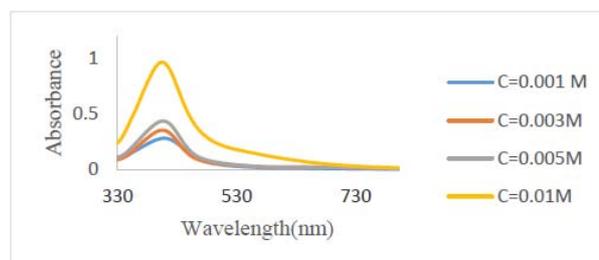


Fig. 5 – Effect of nitrate solution concentration on Silver nanoparticles synthesis by *Dermaneh* extract (pH of the solution was 10, 8 ml of the *Dermaneh* extract, time: 30 min, stirring rate 150 rpm).

## Effect of temperature

Fig. 6 shows the UV-Vis spectra regarding the effect of temperature on the synthesis of silver nanoparticles using *Dermaneh* extract at different temperatures. It can be clearly seen that as the temperature of reaction increased, the SPR bands became sharper. The results from the four mentioned temperatures showed a similar response, with a variation in the maximum. Similar results were reported by Piñero *et al.*[36] According to the obtained results, 80 $^{o}$C was selected as the optimum temperature for this study.
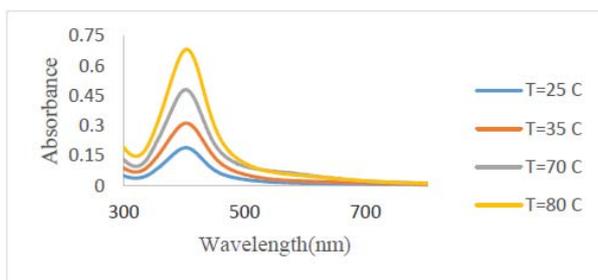


Fig. 6 – Effect of temperature on Silver nanoparticles synthesis by *Dermaneh* extract (pH of the solution was 10, 8 ml of the *Dermaneh* extract, 0.01 M Silver nitrate, time: 30 min, stirring rate 150 rpm).

## Effect of time

The effect of time on biosynthesis of Ag-NPs using *Dermaneh* extract can be seen by UV-Vis spectra reported in Fig. 7. A small weak and broad peak appeared at 408 nm after 10 min of stirring, indicating that few nanoparticles were formed. By increasing the time from 10 min to 20, 45, 65, 100 and 1020 min, absorption bands became sharper and sharper and a clearly visible peak after 1020 min at 411 nm was observed (Fig. 7) due to the enhanced formation rate of Ag-NPs. Thus, the optimum time for the improvement of reaction was considered 1020 min, which is in accordance with previous reports.[37, 38]

## SEM analysis

The surface morphological characterizations of silver nanoparticles were done using SEM (KYKY-EM3200 ). In Fig. 8, SEM image clearly confirmed the presence of poly-dispersed and spherical shape of silver nanoparticles with a size of 41–88 nm. The results obtained from SEM analysis were very similar to the findings of other researchers.[39-41]
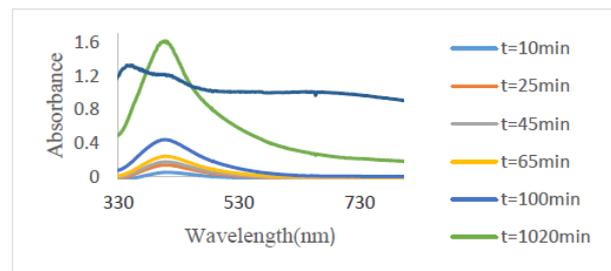


Fig. 7 – Effect of time on Silver nanoparticles synthesis by *Dermaneh* extract (pH of the solution was 10, 8 ml of the *Dermaneh* extract, 0.01 M Silver nitrate, temperature 80˚C, stirring rate 150 rpm).
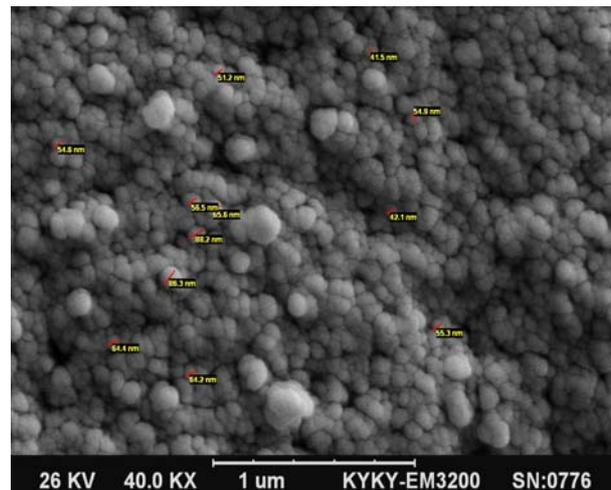


Fig. 8 – SEM image of AgNPs synthesized using by *Dermaneh* extract.

## XRD analysis

X-ray diffraction (XRD) analyses were carried out with a GNR MPD 3000 made Italy diffractometer using a Cu anode ($\lambda$ = 1.54056 Å). The diffractograms were recorded at 2θ in the range 9˚ - 80˚, with counting time 0.5 seconds and step size of 0.02˚. In Fig. 9, the XRD pattern clearly shows cubic structure which matches the values (38.4389), (44.5207), (64.7785), (77.7046) corresponded to the hkl planes (1 1 1), (2 0 0), (2 2 0), (3 1 1), respectively. All the peaks matched well with the standard JCPDS file 87-0717. The appearance of sharp peaks indicated the crystalline nature of the synthesized AgNPs. There were four peaks with a low intensity at around 29.9˚, 32.4˚, 48.8° and 56.8° (Fig. 9), confirming the formation of a small amount of (AgCl) impurities. Similar results have been reported by Babu *et al.*,[39] Tippayawat *et al.*[40] and Meena and Chouhan.[42]

The Debye–Scherrer equation was applied to determine average crystallite diameter size from

the full width at half-maximum of the diffraction peaks:

$$D = K\lambda/\beta cos\theta \qquad (1)$$

where D is the crystallite diameter size in nm, λ- denotes X-ray wavelength, β- is full width at half-maximum (FWHM), and θ- is Bragg's angle of reflection. Average size of the biosynthesized nanoparticles was found to be about 20 nm. Table 1 represents the sharper peaks details for silver nanoparticles size calculation.

*Table 1*

Crystal parameters of AgNPs synthesized by Dermaneh extract in XRD pattern

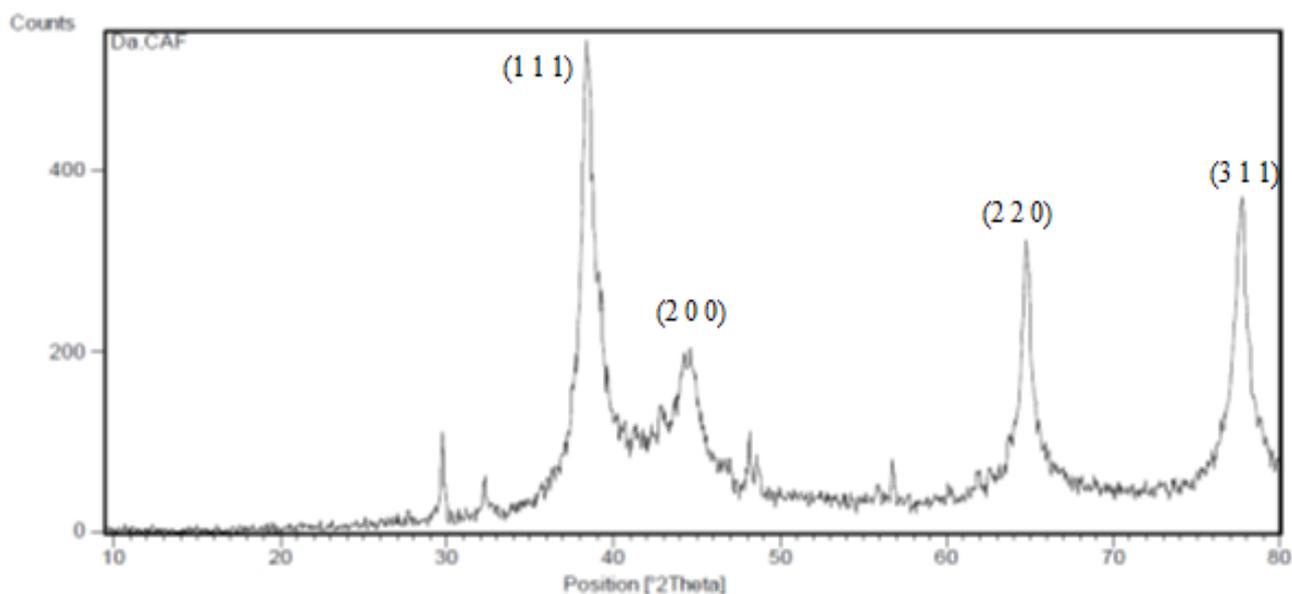| No. | Position [°2Theta] | FWHM [°2Theta] | h k l | d-spacing (°A) | size (nm) |
|---|---|---|---|---|---|
| 1 | 38.4389 | 0.4133 | 1 1 1 | 2.35888 | 21.25 |
| 2 | 64.7785 | 0.4723 | 2 2 0 | 1.44451 | 20.80 |
| 3 | 77.7046 | 0.5760 | 3 1 1 | 1.23188 | 18.49 |
| | | | | | Ave.= 20.18 |



Fig. 9 – X-ray diffractograms of Silver nanoparticles synthesized using by *Dermaneh* extract.
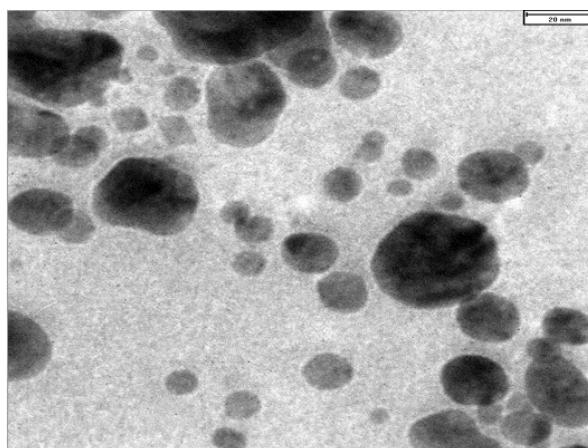


Fig. 10 – TEM image showing shape and size characteristics of AgNPs synthesized at the optimized condition.

## TEM analysis

TEM measurements were performed on Philips, Model CM120 instrument operated at an accelerating voltage 120 kV. The TEM images of colloid nanoparticles are shown in Figure 10. It is observed that the morphology of nanoparticles is often poly-dispersed, spherical and cubic, which is in settlement with the shape of the SPR band in the UV–Vis spectra. The average particle size calculated for nanoparticles was 20 nm. This result is in agreement with the shape of the SPR band as well as the particle size calculated from XRD analysis.

## FTIR analysis

Fourier transform infrared (FTIR) spectra of the samples were obtained using Perkinelmer

Spectrum 2, in the diffuse reflectance mode operating at a resolution of 4 $cm^{-1}$ in KBr pellets. FTIR spectra of *Dermaneh* extracts taken before and after synthesis of silver nanoparticles were analyzed in terms of the possible functional groups responsible for the formation of silver nanoparticles. FTIR spectra were obtained to identify the possible biomolecules in the plant extract responsible for predicting their role in nanoparticle synthesis and the reduction of silver ions as well as the capping agents responsible for the stability of biogenic nanoparticle solution. The FTIR spectra indicated the existence of various functional groups at different positions. Figs. 11(a) and 11(b) show the FTIR spectra of plant extract before and after synthesis, representing prominent absorption band at around 3413 $cm^{-1}$, 1619, 1348, 1080, 797, 485 $cm^{-1}$.
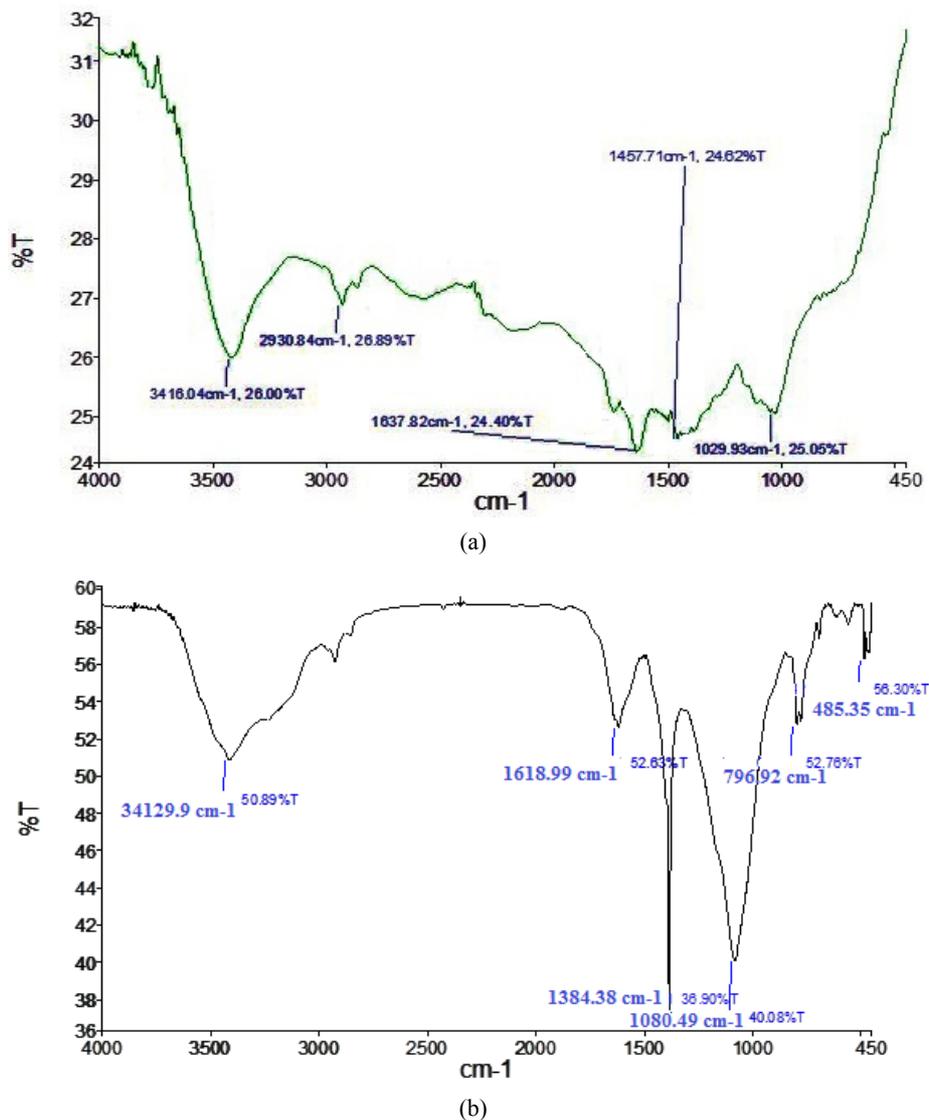


(a)



(b)

Fig. 11 – FT-IR spectroscopy of (a) *Dermaneh* extract (b) Silver nanoparticles synthesized using by *Dermaneh* extract.

*Table 2*

List of the work related AgNPs synthesis using plant extract

| Plant extraxt | Author | Operating Conditions | Characterization | Size (nm) | shape | Crystal Structure | Year/ Ref. |
|---|---|---|---|---|---|---|---|
| Cheilanthes forinosa Forsk | Nalwade *et al.* | 1 mM, 4 hr, room temp. 10 mL/90 mL | UV-Vis SEM,XRD | ~26.58 | sph. | FCC | (2013) [46] |
| Nephrolepis sexaltata L. fern | Bhor *et al.* | 1mM, 4h, 10 mL/90 mL | UV-Vis SEM,XRD | avg 24.76 | sph. | FCC | (2014) [47] |
| Gelidiella acerosa | Vivek *et al.* | 1 mM, room temp, 10 mL/90 mL | UV-Vis FTIR,SEM TEM,XRD | ~22 nm | sph. | FCC | (2011) [48] |
| Caulerpa racemosa marine algae | Kathiraven *et al.* | 1 mM, 3 hr, room temp. 10 mL/90 mL | UV-Vis FTIR,TEM XRD | 5 - 25 | sph, tri. | FCC | (2014) [49] |
| Ulva fasciata | Rajesh *et al.* | 1 mM, 2 min, room temp. 3 mL/100 mL | UV-Vis FTIR,SEM XRD,EDX | 28 - 41 | sph | cryst | (2012) [50] |
| Abutilon indicum leaf | Ashokkumar *et al.* | 10 mM, 15 min, room temp. 2 to 3.5 mL/30 mL, | UV-Vis FTIR, FS FE-SEM TEM,XRD | 7 - 17 | sph. | FCC | (2015) [51] |
| Pistacia atlantica | Sadeghi *et al.* | 1 mM, 35 min, room temp. 1 mL/10 mL, | UV-Vis FTIR SEM,TEM XRD, ZP EDAX | 10 - 50 | sph. | FCC | (2015) [52] |
| Ziziphora tenuior | Sadeghi and Gholamhosein poor | 0.1 mM, 35 min, room temp. | UV-Vis FTIR, ZP SEM-EDAX TEM,XRD | 8 - 40 | sph. | FCC | (2015) [53] |
| Delphinium denudatum | Suresh *et al.* | 1 mM, 2hr, room temp. 1.5 mL/30 mL, | UV-Vis FTIR,FESEM XRD | <85 nm | sph. | FCC | (2014) [54] |
| Myrmecodia pendan | Zuas *et al.* | 2.5 mM, room temp. 0.3 mL/60 mL | UV-Vis FTIR, XRD SEM,TEM | 10 - 20 | sph. | FCC | (2014) [55] |
| Tinospora cordifolia stem powder. | Anuj and Ishnava | 1 mM, 30 min, room temp. 40 mL/200 mL | UV-Vis FTIR,TEM XRD,EDAX | 60 | sph. | cryst | (2013) [56] |
| Aloe leaf | Zhang *et al.* | 0.1 - 1.5 mM, 20 min, 20 – 40 $^0$C , 0 to 15 mL/1 mL | UV-Vis TEM,XRD | ~20 | sph. | FCC | (2013) [57] |
| Azadirchata indica(neem) | Kirubaharan *et al.* | 1 mM, 90 min, room to 90 $^0$C, 1.25 mL/50 mL | UV-Vis TEM,XRD | 15 - 20 | sph. | FCC | (2012) [58] |
| Artemisia sieberi Besser (Dermaneh) | Rousta and Ghasemi | o.o1M, 1020min, 80 $^0$C 8 mL/95mL | UV- Vis SEM, FTIR XRD, TEM | ~20 | sph. | FCC | This study |

Note: Sph—spherical, Tri—Triangular, FCC—Face centered cubic, Cryst—Crystalline.

The peaks in the region 3412 cm$^{-1}$ were assigned to O-H stretching vibration, indicating the presence of hydroxyl groups such as alcohol and phenol compounds and aldehyde –C-H- stretching of alkanes while the peaks around 1619cm$^{-1}$ were assigned to C=O stretching vibrations or stretching of alkenes. The peaks in the regions 1348 cm$^{-1}$ to 830 cm$^{-1}$ corresponded to –C-N- stretching vibration of amines or –C-O stretching of alcohols, ethers, carboxylic acids and anhydrides. Absorption band at 1080 cm$^{-1}$ could be assigned to the C–OH stretching vibrations of primary alcohol groups in the *Dermaneh* extracts. The absorption band around 485 cm$^{-1}$ is indicated the presence of alkyl halides [43]. The presence of absorption bands in the *Dermaneh* extract spectrum and absence of the same peak in the silver nanoparticle spectrum indicated the involvement of *Dermaneh* extract in the synthesis of the silver nanoparticles. According to the Figs. 11(a) and 11(b), the shift from higher to lower wave numbers in comparison with the two figures indicated the fabcilitation resonance for the binding and reduction of silver nanoparticles surface.[44]

The appearance of biomolecules in the plant extract (such as flavonoids) confirmed their responsibility for the reduction, capping and stabilization of the newly formed nanoparticles in agreement with literature data.[45]

Finally, the synthesis of silver nanoparticles using different plants was compared to the current study (Table 2). It can be observed that silver nanoparticles were successfully synthesized using *Dermaneh* extract.

## CONCLUSION

In this study, a rapid and eco-friendly synthesis method of silver nanoparticles (Ag-NPs) by Artemisia Sieberi Besser (*Dermaneh*) leaf extract was proposed. The plant extract contained abundant natural biomolecules such as flavonoids and flavones that might play a major role in biosynthesis of Ag-Ps. Different parameters affecting nanoparticles formation and growth such as pH, volume of the extract, silver ion concentration, temperature and time were monitored by UV-Vis spectrophotometer. The synthesized silver nanoparticles were characterized by UV-visible spectroscopy, SEM, XRD, TEM analyses. The formation of silver nanoparticles was confirmed by clearly observing the color change from yellow to brown and corroborated by UV–visible (surface plasmon resonance) analysis. The

results of XRD pattern, SEM and TEM images confirmed the successful synthesis of silver nanoparticles in terms of crystalline nature and morphology (poly-dispersed, spherical and cubic shapes) with an average size of 20 nm. The biomolecules like flavonoids and flavones available in the *Dermaneh* extract, which were responsible for reduction of silver ions to silver nanoparticles, were revealed in FT-IR studies. The results of this study confirmed that green synthesis is an effective and eco-friendly method for producing silver nanoparticles.

## REFERENCES

1. V. Mozaffarian, "A Dictionary of Iranian Plants Names", FarhangMoaser, Tehran, Iran, 1999.
2. H. A. A. Twaij and A. A. Al-Badr, *J. Ethnopharmacol.*, **1988**, *24*, 123–126.
3. B. Behmanesh, G. A. Heshmati, M. Mazandarani, M. B. Rezaei, A. R. Ahmadi, E. O. Ghaemi and S. Bakhshandeh Nosrat, *Asian J. Plant Sci.*, **2007**, *6*, 562–564.
4. M. Mahboubi and N. Farzin, *Iranian J. Microbiol.*, **2009**, *1*, 43–48 .
5. M. Farzaneh, H. Ghorbani-Ghouzhdi, M. Ghorbani and J. Hadian, *Pakistan. J. Biol. Sci.*, **2006**, *9*, 1979–1982.
6. A. R. Khosravi, H. Shokri, M. H. Darabi, A. Kashani, P. Mansouri and A. Naser, *J. Mycol. Méd.*, **2009**, *19*, 17–21.
7. F. Rad, F. Aala, N. Reshadmanesh and R. Yaghmaie, *Indian J. Dermatol.*, **2008**, *53*, 115–118.
8. P. Mansouri, M. Kashanian, R. Bekhradi and H. Hakmat, *Iranian J. Pharmaceut. Res.*, **2004**, *2*, 38–38.
9. A. A. S. Sefidgar, A. A. Moghadamnia, A. AkhavanTafti, M. Sahebjami, M. Heydari and M, Motallebnejad, *Caspian J. Internal. Med.*, **2010**, 47–49.
10. A. Morshedi, M. H. Dashti Rahmatabadi, M. Dehghan Harati, M. A. BagheriaNasab and S. Salami, *J. Med. Plants.*, **2011**, *10*, 48–57.
11. M. Negahban, S. Moharramipour and F. Sefidkon, *Asia-Pacific Entomol.*, **2006**, *9*, 61–66 .
12. M. Negahban, S. Moharramipour and F. Sefidkon, *J. Stored. Prod. Res.*, **2007**, *43*, 123–128.
13. F. Yarahmadi, A. Rajabpour, N. ZandiSohani and L. Ramezani, *Avicenna J. Phytomed.*, **2013**, *3*, 106–111.
14. A. Salahi Ardakani and S. Parhizkar, *Int. J. Med. Arom. Plants.*, **2012**, *2*, 596–602.
15. A. J. Marco, J. F. Sanz-Cervera, F. Sancenon, J. Jakopuvic, A. Rustaiyan and F. Mohamadi, *Phytochemistry*, **1993**, *34*, 1061–1065.
16. P. Weyerstahl, S. Schneider, H. Marschall and A. Rustaiyan, *Liebigs Annalen der Chemie*, **1993**, *2*, 111–116.
17. H. A. Arab, S. Rahbari, A. Rassouli, M. H. Moslemi and F. Khosravirad, *Trop. Anim. Health Prod.*, **2006**, *38*, 497–503.
18. E. K. Elumalai, T. N. V. K. V. Prasad, V. Kambala, P. C. Nagajyothi and E. David, *Arch. Appl. Sci. Res.*, **2010**, *2*, 76-81.
19. M. Gericke and A. Pinches, *Gold Bull.*, **2006**, *39*, 22-28.
20. D. Mandal, M. E. Bolander, D. Mukhopadhyay, S. Sankar and P. Mukherjee, *Appl. Microbiol. Biotechnol.*, **2006**, *69*, 485–492.

21. S. Rajeshkumar, C. Kannan and G. Annadurai, *Int. J. Pharm. Bio. Sci.*, **2012**, *3*, 502 – 510.

22. S. Rajeshkumar, C. Kannan and G. Annadurai, *Drug Invention Today*, **2012**, *4*, 511-513.

23. K. S. Hemath Naveen, G. Kumar, L. Karthik and K. V. Bhaskara Rao, *Arch. Appl. Sci. Res*., **2010**, *2*, 161-167.

24. N. Ahmad, S. Sharma, M. Alama, V. N. Singh, S. F. Shamsid, B. R. Mehta and A. Fatma, *Colloids Surf. B: Biointerf.*, **2010**, *8*,181–86.

25. G. D. Gnanajobitha, G. Annadurai and C. Kannan, *Int. J. Pharma. Sci. Res.*, **2012**, *3*, 323-330.

26. J. Anarkali, D.Vijaya Raj, K. Rajathi and S. Sridhar, *Arch. Appl. Sci. Res.*, **2012**, *4*, 1436-1441.

27. N. C. J. Packia Lekshmi, S. Benarcin Sumi, S. Viveka, S. Jeeva and J. Raja Brindha, *J. Microbiol. Biotech. Res.*, **2012**, *2*, 115-119.

28. J. L. Gardea-Torresdey, E. Gomez, J. Peralta-Videa, J. G. Parsons and H. E. Troiani, *Nano Lett.*, **2002**, *2*, 397–401.

29. M. Singh, S. Singh, S. Prasad and I. S. Gambhir, *Digest J. Nanomater. Biostruct*., **2008**, *3*, 115–122.

30. M. Rai, A. Yadav and A. Gade, *Biotechnol. Advances.*, **2009**, *27*, 76–83.

31. V. Armendariz, I. Herrera, J. R. Peralta-Videa, M. Jose-Yacaman *et al., J. Nanopart. Res.*, **2004**, *6*, 377-82.

32. A. Rai , A. Singh, A. Ahmad and M. Sastry, *Langmuir.*, **2006**, *22*, 736- 41.

33. A. Muhammad, A. Farooq, R. Muhammad, M. Saeed Ashraf Janjua, I. Awais and U. Rashid, *Int. J. Mol. Sci*., **2012**, *13*, 9923-9941.

34. R. Heydari and M. Rashidipour, *Int. J. Breast Cancer*, **2015**, doi.org/10.1155/2015/846743.

35. S. A. Umoren,I. B. Obot and Z. M. Gasem, *J. Mater. Environ. Sci.*, **2014**, *5*, 907-911.

36. S. Piñero, S. Camero and S. Blanco, *J. Physics: Conference Series.*, **2017**, *786*, 1-8.

37. R. Bo and T. Ren-Cheng, *Adv. Nat. Sci.: Nanosci. Nanotechnol.*, **2017**, *8*, 1-7.

38. A. Tausif, I. Muhammad and A. Mohamad, *Procedia Engineering.,* **2016**,*148*, 467 – 472.

39. S. Ananda Babu and H. Gurumallesh Prabu, *Materials Letters.*, **2011**, *65*, 1675–1677.

40. P. Tippayawat, N. Phromviyo, P. Boueroy and A. Chompoosor, *PeerJ*, **2016**, DOI 10. (2016) 7717/peerj.2589.

41. R. Arunachalam, S. Dhanasingh, B. Kalimuthu, M. Uthirappan, C. H. Rose and A. Mandal, *Colloids and Surfaces B: Biointerfaces.*, **2012**, *94*, 226– 230.

42. P. K. Meena and N. Chouhan, *Research J. Recent Scie.*, **2015**, *4*, 47-52.

43. A. Arunachalam, S. Thomas, N. A. Jose and C. H. V. Lyza, *World Applied Scie. J.*, **2011**, *113*, 1833-1840.

44. N. N. Bonnia, M. S. Kamaruddin, M. H. Nawawi, S. Ratim, H. N. Azlina and E. S Ali, P*rocedia Chem.*, **2016**, *19*, 594 – 602.

45. A. A. Abimbola, "Green synthesis of capped silver nanoparticles and their hybrids: antimicrobial and optical properties", *PhD thesis*, **2017**, Covenant University, Ota, Nigeria.

46. A. R. Nalwade, M. N. Badhe, C. B. Pawale and S. B. Hinge, *J. Biol. Tech.*, **2013**, *4*, 12-18.

47. G. Bhor, S. Maskare, S. Hinge, L. Singh and A. Nalwade, *Asian J. Pharma. Tech. Innovation.*, **2014**, 2-12.

48. M. Vivek, P. S. Kumar, S. Steffi and S. Sudha, *Avicenna J. Med. Biotechn.*, **2011**, *3,* 143-148.

49. T. Kathiraven, A. Sundaramanickam, N. Shanmugam, and T. Balasubramanian, *Appl. Nanoscie.*, **2014**, *5*, 499-504.

50. S. Rajesh, D. P. Raja, J. M. Rathi and K. Sahayaraj, *J. Biopesticides*, **2012**, *5*, 119-128.

51. S. Ashokkumar, S. Ravi, V. Kathiravan and S. Velmurugan, *Spectrochim. Acta A.*, **2015**, *134*, 34-39.

52. B. Sadeghi, A. Rostami and S. S. Momeni, *Spectrochim. Acta A.*, **2015**, *134*, 326-332.

53. B. Sadeghi and F. Gholamhoseinpoor, *Spectrochim. Acta A.*, **2015**, *134*, 310-315.

54. P. Suresh, P. H. Gunasekar, D. Kokila, D. P. Rabhu, D. Dinesh, N. Ravichandran, B. Ramesh, A. Koodalingam and G. V. Siva, *Spectrochim. Acta A.*, **2014**, *127*, 61-66.

55. O. Zuas, N. Hamim and Y. Sampora, *Mater. Lett.*, **2014**, *123*, 156-159.

56. S. A. Anuj and K. B. Ishnava, *Int. J. Pharm. Biolog. Scie.*, **2013**, *4*, 849-863.

57. Y. Zhang, X. Cheng, Y. Zhang, X. Xue and Y. Fu, *Colloid. Surface. A.*, **2013**, *423*, 63-68.

58. C. J. Kirubaharan, D. Kalpana, Y. S. Lee, A. R. Kim, D. J. Yoo, K. S. Nahm and G. G. Kumar, *Industrial Eng. Chem. Research.*, **2012**, *51*, 7441-7446.