



## Green Synthesis of Silver Nano Particles from Plant Extract of *Entada gigas* (Sea Heart)

Vishal Pandey; P.K Dubey; Rajat Pawar

Swami Vivekanand college of Pharmacy, Indore (M.P) India

Received: 30 December 2025

Revised: 15 January 2026

Accepted: 30 January 2026

### ABSTRACT:

Nanoparticles (NP) have been shown to have various useful applications. They are generally synthesized using chemical processes involving hazardous chemicals. Therefore, green synthesis of NPs using natural products can be an environmentally friendly alternative. The green synthesis of silver nanoparticles from the extract of different plant parts has gained a wide range of engrossment among the researchers due to its unique optical and structural property. The aim of this study is green synthesis of silver nanoparticles from the ethanolic seed extract of Sea heart (*Entada gigas*). The formation of synthesized AgNPs were studied using different analytical methods, including ultraviolet-visible (UV-VIS) spectroscopy, Particle size analysis, Zeta potential analysis.

**Keywords:** silver nanoparticles, Ethanolic seed extract *Entada gigas*, Green Synthesis and Characterization.

### 1. INTRODUCTION:

Nanotechnology is a known field of research since last century. Since "nanotechnology" was presented by Nobel laureate Richard P. Feynman during his well famous 1959 lecture "There's Plenty of Room at the Bottom" (Feynman, 1960), there have been made various revolutionary developments in the field of nanotechnology. Nanotechnology produced materials of various types at nanoscale level.<sup>1</sup> The word "nano" is used to indicate one billionth a meter or  $10^{-9}$ . The term Nanotechnology was coined by Professor Norio Taniguchi of Tokyo Science University in the year 1974 to describe precision manufacturing of materials at the nano meter level. "Nano" is a Greek word synonymous to dwarf meaning extremely small. Nanoparticles are beginning viewed as fundamental building blocks of nanotechnology.<sup>2</sup>

Nanoparticles can be broadly grouped into two, namely, organic nanoparticles which include carbon nanoparticles (fullerenes) while, some of the inorganic nanoparticles include magnetic nanoparticles, noble metal nanoparticles (like gold and silver) and semiconductor nanoparticles (like titanium oxide and zinc oxide) There is a growing interest in inorganic nanoparticles of noble metal nanoparticles (Gold and silver) as they provide superior material properties with functional versatility. Due to their size features and advantages over available chemical imaging drug agents and drugs, inorganic particles have been examined as potential tools for medical imaging as well as for treating diseases.<sup>3</sup>

NPs are not simple molecules itself and therefore composed of three layers i.e. (a) the surface layer, which may be functionalized with a variety of small molecules, metal ions, surfactants and polymers. (b) The shell layer, which is chemically different material from the core in all aspects, and (c) The core, which is essentially the central portion of the NP and usually refers the NP itself owing to such exceptional characteristics, these materials got immense interest of researchers in multidisciplinary fields. Furthermore, costly purification steps may be necessary if the complete removal of residual chemicals is required.<sup>4</sup>

Nanotechnology is the synthesis of particles with at least one dimension in the range of 1–100 nm. resulting in high surface to volume ratios. As the particle size decreases, not only does the ratio of surface area to volume increase but also the physical, chemical and biological properties of the particles differ compared to their bulk counterparts. Noble-metal nanoparticles exhibit incredible physicochemical, optoelectronic and biochemical characteristics. They are being used for various purposes in industrial and pharmaceutical applications. Despite the existence of numerous metals in nature, only a few of them such as gold, silver, palladium and platinum are synthesized extensively in nanostructure form.<sup>5</sup>

Due to their extraordinary physicochemical properties, metallic nanoparticles (NPs) have been effectively applied in numerous fields, including health care, synthetic biology, and cellular transportation. Amongst various nanoparticles, AgNPs have received particular attention due to their unique morphologies, stability, and controlled geometry. AgNPs have been largely used in various



electronic and sensing devices, coating materials, data packing, and molecular switches. Apart from this, they have also been applied in the diagnosis and treatments of various diseases. Particularly, AgNPs possess excellent antimicrobial activities against several microorganisms which are known to be responsible for several infectious diseases.<sup>6</sup>

Overall, the use of agro-Industrial wastes for the eco-friendly production of nanoparticles seems to be promising, but the relatively few studies on these materials make it difficult to draw definitive conclusions. In particular, little is known about how the nature of the waste affects the size and shape of nanoparticles, and of the possibility to control them by an appropriate selection of the reaction conditions. Using biological systems such as microorganisms, plants, viruses and animal cell cultures is an alternative procedure for preparation of NPs. Biosynthesis of NPs is eco-friendly, time affordable, cost effective.<sup>7</sup>

### 1.1 Nanoparticles:

The prefix nano is derived from Greek word nanos meaning "dwarf" or extremely small. Nanosized materials, known as NPs, possess unique and improved properties because of their larger surface area to volume ratio. NPs can be broadly grouped into two, namely, organic NPs and inorganic NPs which include noble metal NPs (like silver and gold), semi-conductor NPs (like titanium oxide and zinc oxide) Nanotechnology can be applied to medicine, therapeutics, drug delivery and also in treatment for many diseases and disorders. Although nanotechnology is a novel field of research, nanoparticles are known to be used for centuries. For example, Chinese used gold nanoparticles to introduce red colour into ceramic porcelains. The colours in Roman glass artifacts contained metal nanoparticles, used for decoration of cathedral windows.

Nanoparticles of noble metals have applications in electronics, magnetic, optoelectronics and information storage. Among these, silver nanoparticles (Ag- NPs) are found to possess unique characteristics of high antimicrobial activity to develop nano silver-based disinfectant products. Silver nanoparticles (AgNPs) are increasingly used in many fields, including medical, food, healthcare, and industrial purposes, due to their novel physical and chemical characteristics.<sup>8</sup>

#### ➤ Silver Nanoparticles

Silver is a soft, white, lustrous transition metal possessing high electrical and thermal conductivity. It has been known longer than the recorded history due to its medical and therapeutic benefits before the realization that microbes are agents for infections. It is used in many forms as coins, vessels, solutions, foils, sutures, and colloids as lotions, ointments, and so forth. It is the foremost therapeutic agent in medicine for infectious diseases and surgical infections. The benefits of silver are more than the risk factors.<sup>9</sup>

## 2. EXPERIMENTAL WORK AND METHOD:

### ➤ Materials:

Materials	Source
Silver nitrate	Merck specifications pvt. Ltd. Mumbai
Lucky beans ( <i>Entada gigas</i> )	Paudhshala, Dehradun
Methanol (LR grade)	SD-fine Chem. Limited., Mumbai
Acetone (AR grade)	Merck specifications Pvt. Ltd. Mumbai
Silica TLC grade	CDH New Delhi
Anisaldehyde reagent	CDH New Delhi
Ethanol	Hong Yung Chem. Corp. China
Toluene	Merck specifications Pvt. Ltd., Mumbai
Potassium Hydroxide (KOH)	Shah Scientific India, Mumbai
Iron Chloride	Merck specifications Pvt. Ltd., Mumbai
Sulphuric acid	Shah Scientific India., Mumbai
Sodium hydroxide	Hi Media Laboratories Pvt. Ltd., Mumbai

**Equipment:**

EQUIPMENTS	SOURCE
Particle size	Microtrac
UV-Visible spectrophotometer	Lambda 25
Electronic precision balance	Shinko
Electronic precision balance, sensitivity 1.0 mg	200D, Dhona
Hot air oven	BT1-10
Micropipette 0.5-10	VERTEX
Rotary Vacuum evaporation	Scientec SE119, Buchi type
Magnetic stirrer with thermostat	Remi
Shaking Incubator	PLT-145, Tanco
Heating mantle	Bio - Technics India, Mumbai

**2.1 Method:****2.1.1 Herbal Component of Plant:**

**a) Procurement of Plant:** Plant Material i.e. seeds of *Entada gigas* was collected from Paudhshala, serene Doon Valley, (Dehradun). The plant seeds were dried in a hot air oven at 25°C and powdered. Fine powder was obtained and stored in container for future use. The seed of *Entada gigas* was Purchased from Paudhshala. While Silver Nitrate Was Purchased from Merck Specifications Pvt. Ltd., Mumbai.

**b) Preparation of Plant Extract:** The *Entada gigas* extract was prepared using Soxhlet extractor using Ethanol as a solvent. Similarly, *Entada gigas* extract was prepared using methanol as a solvent crude plant extract was prepared by Soxhlet extraction method. About 100 gm of powder material was uniform packed in to a thimble and run in Soxhlet extractor. It was extracted with a solvent for the period of about 48 hours around 28 cycles till the solvent in the siphon tube of an extractor become colour less. The extracts were filtered with the help of filter paper and solvent was evaporated from extract in Rotary evaporator to get the syrupy consistency. Then extracts were kept in refrigerator at 4°C for future experiments.

**c) Phytochemical Screening of Plant Extract of Active Components:** Phytochemicals are chemical compounds formed during the plants normal metabolic processes. These chemicals are often referred to as "Secondary metabolites" which includes tannins, saponins, flavonoids, alkaloids, proteins, steroids, Quinones, terpenoids, cardio glycosides and phenol.

- **Alkaloids-** 1 % HCl was added to the extract in a test tube reacted for 20 minutes, cooled and filtered. About 2 drops of Mayer's reagent was added to the extract. A creamy precipitate was an indication of the presences of alkaloids.
- **Tannins-** Freshly prepared 10% KOH was added to the extract. A dirty white precipitate shows the presences of tannins.
- **Phenolics-** Two drops of 5% FeCl<sub>3</sub> were added to the extract in a test tube. Absence of greenish precipitate indicates the absence of phenolics.
- **Glycosides-** 50% was added to the extract and the mixture heated in boiling water for about 15 minutes. Fehling's solution was then added and the mixtures boiled. A brick-red precipitate was confirmatory for the presence of glycosides.
- **saponins-** Frothing test: The extract was vigorously shaken in the test tube for 2 minutes. No frothing was observed.
- **Emulsion test-** 5 drops of olive oil was added to the extract in the test tube and vigorously shaken. Absence of stable emulsion formed indicates the absence of saponins.
- **Flavonoids-** 10% NaOH was added to the extract. There was no yellow colouration which is indicative to the absences of flavonoids.



- **Steroids-** Salkowski test- 5 drops of concentrated will be added to the extract in a test tube. Red colouration was observed which was indicative for the presence of steroids.
- **Phlobatannins-** The extract was added to 1% HCl. Absence of red precipitate shows negative results.
- **Triterpenes-** Treat the petroleum ether & H<sub>2</sub>SO<sub>4</sub> with the extract and few drops of concentrated sulphuric acid then shake well, no colour appears in indicate disappearances of triterpenes. (Yellow colour).

### 2.1.2 Nano silver Component of Plant:

- Procurement of Chemicals:** Silver Nitrate (AgNO<sub>3</sub>) was used as purchased from Merck Specification Pvt, Ltd., Mumbai.
- Preparation of 1×10<sup>-3</sup>Silver Nitrate Solution:** 1×10<sup>-3</sup>solution of silver Nitrate was prepared by dissolving 0.169g of silver nitrate in sufficient water to produce 1000mL.
- Preparation of Plant Extracts Solution:** A solution of plant extract was prepared by dissolving extract in minimal quantity of organic solvent, to get slurry. The prepared slurry was mixed by a homogenizer in water to get a suspension. The stock solution of 30mg/30mL was prepared from ethanolic extract of *Entada gigas*. From the stock solution different dilutions are prepared ranging from 40, 60, 80 and 100µg/mL, using water as diluents.
- Biosynthesis of Nano- Silver Particles:**100mL aqueous solution of 1×10<sup>-3</sup> silver Nitrate was mixed with plant extract solution of different concentration in Silver Nitrate Solutions. In Silver Nitrate Solution plant extract was added followed by intermittent stirring at room temperature. By mixing both solutions, Ag<sup>+</sup> ions were aggregated and clustered together to form monodispersed nanoparticles as a transparent sol in aqueous medium. The solution was yellow. The solutions were stirred repeatedly after so up to brown dark colour appeared for approximately after an hour. It keeps in observation until it became stable. At this point this solution of Ag nanoparticles was so stable that it did not change colour for as long a period of time without any stabilizing agent. similar procedure was followed for every dilution i.e. 100µg/mL. after every interval sampling was done and studied by UV-Vis analysis for the formation no of particles with time.

## 3. RESULTS AND DISCUSSION

**3.1 Preparation of Plant Extracts:**The plant extract of *Entada gigas* was prepared by drying the samples in a hot air oven at 25°C and blended into the powder. The powder was extracted with methanol/ethanol solvent by Soxhlet extractor for 48hours and filtered. Extraction was repeated until obtaining colourless extract, all extracts were combined and the solvent was evaporated under hot air oven. Finally, the percentage yield of the crude extract was calculated. The obtained crude extract was sticky and viscous dark yellowish semisolid.

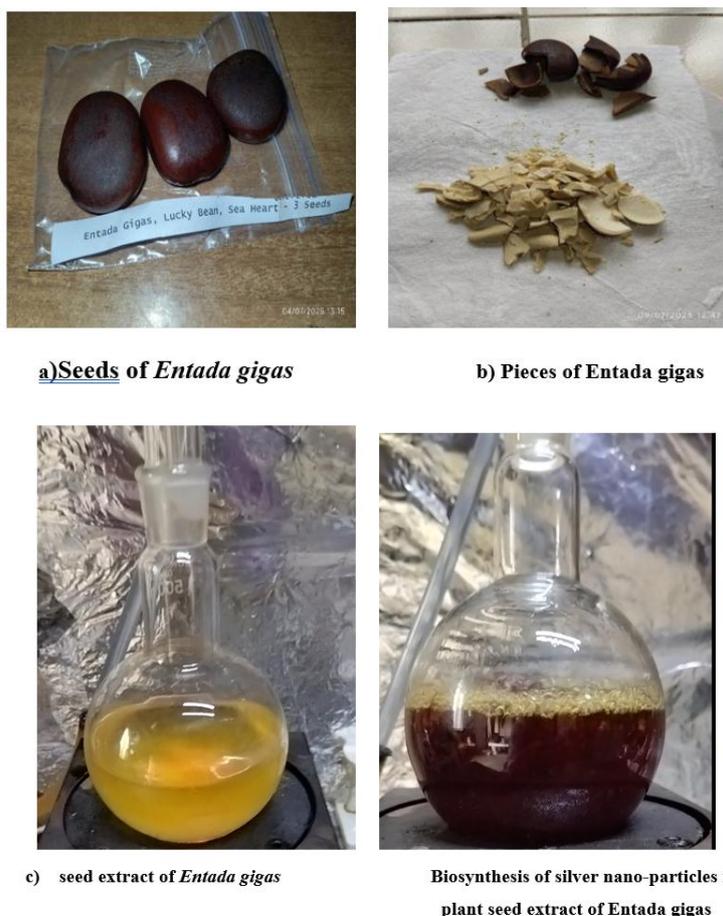
- ❖ The percentage yield of crude extract was calculated by following equation:

$$\% \text{ Yield} = \frac{\text{Weight of crude extract} \times 100}{\text{Weight of dry Powder}}$$

- ❖ The percentage yield of batches of Ethanolic extract of *Entada gigas*& methanolic extract of *Entada gigas*, were 15.29%.

**Table 3.1.1: Percentage Yield of Plant Extract:**

Plant extract	Weighedof powder	Weight of crude Extract	% Yield
	(gm)	(gm)	
Ethanolic extract of <i>Entada gigas</i>	100	15.29	15.29



**Figure 3.1.1: Procurement of plant seed:**

### 3.2 Phyto - Chemical Studies:

- Ethanollic extract of *Entada gigas* were subjected to various chemical tests for the preliminary determination of Phytoconstituents.
- Ethanollic extract of *Entada gigas*, was mixed with equal proportion of alcohol and water (to get hydro alcoholic sample) before subjected to various chemical test. Results of phytochemical studies were shown in below table.
- Above studies confirms the presence of **Glycosides, Tannins Steroids and Terpenoids, Saponins, Phenol, Flavonoids, Protein and amino acid** in methanolic extract of *Entada gigas*.

➤ **Table 3.2.1: Phyto chemical studies:**

Test Performed	Entada gigas
Tannins	+
Phenolic compound	+
Glycosides	+
Saponin	+
Flavonoids	+
Phlobatannins	-
Terpenoids	+
Steroids	+
Protein	+
Amino acid	+



(+) Present, (-) Absent

### 3.3 UV —Visible Spectral Analysis of Nano silver Particles:

particles were confirmed by taking UV-vis spectrum. The bio aggregation of Ag<sup>+</sup> in aqueous solution was monitored by periodic sampling of aliquots (0.2mL) of the suspension. The sample was diluted with 2mL deionized water and subsequently measuring UV-Vis spectra of the resolution diluents. Change the 1Nm EGA max was observed, which indicates was carried out as a function of bio aggregation time at room temperature on Lambda 25 UV spectrophotometers. There was a gradual increase in colour development in the reaction mixture (silver nitrate solution + plant seed extract).

#### ❖ For *Entada gigas* extract:

- Different concentration of ethanolic extract of *Entada gigas* was added to  $1 \times 10^{-3}$  silver nitrate solution. There was a gradual increase in colour development due to the particle size, dielectric medium and chemical surroundings.
- SampleEG1(1mM) shows a shift in max with increase in reaction time. There was increase in intensity of the peak showing at 280 nm.
- The colour change was from light yellow to brown. There was peak after 24hrs and 48hrs period showing stability. Hence further analysis was done.
- In sample EG2, it was observed that with time there is shifting in peak intensity at 280 nm due to the surface Plasmon resonance (SPR) phenomenon of silver nanoparticles. But after 24hrs, characteristic peak due to SPR was not observed. The sample was rejected.

#### ➤ Table 3.3.1: Observation of colour development in sample of *Entada gigas* with time:

S.no	Sample code	Colour intensity		
		15min	30min	1hr
1	EG1	Yellowish Brown	Yellowish Brown	Reddish Brown
2	EG2	Yellowish Brown	Reddish Brown	Reddish Brown

#### ➤ Table 3.3.2: UV-Spectrophotometric Data of Nano silver from *Entada gigas* extract:

S.no.	Absorption (Å)	Concentration (g/M)	Wavelength (nm)
			24 hrs
1	0	0	0
2	2.4213	1	280.42

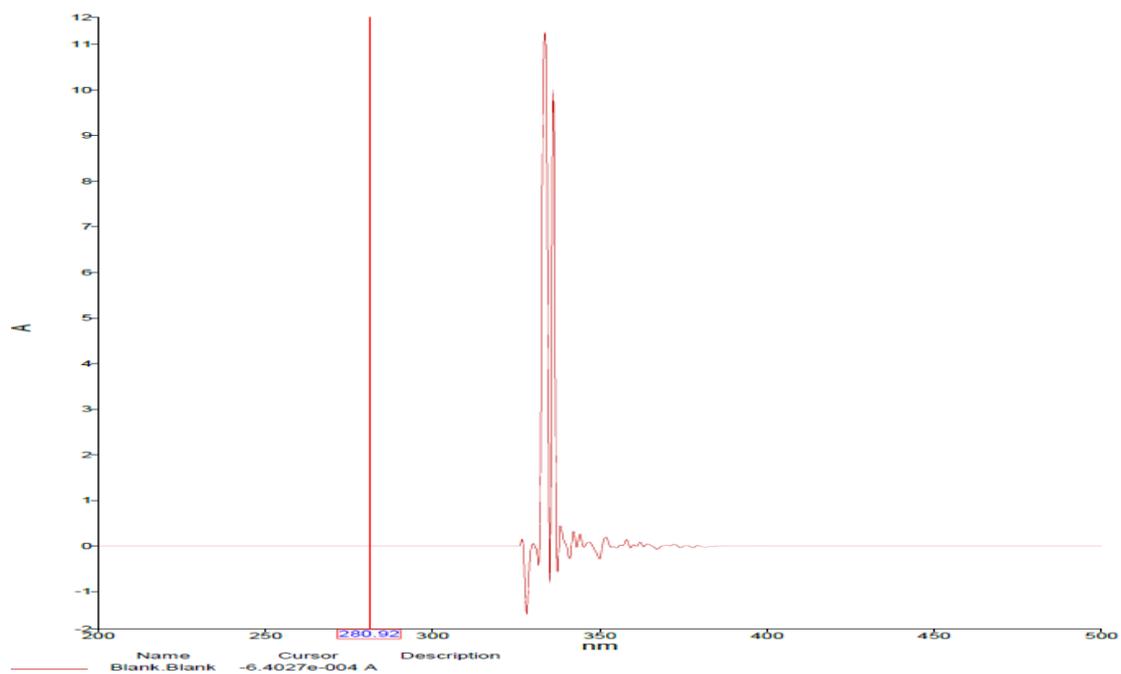


Figure 3.3.1: UV Spectroscopy of blank sample

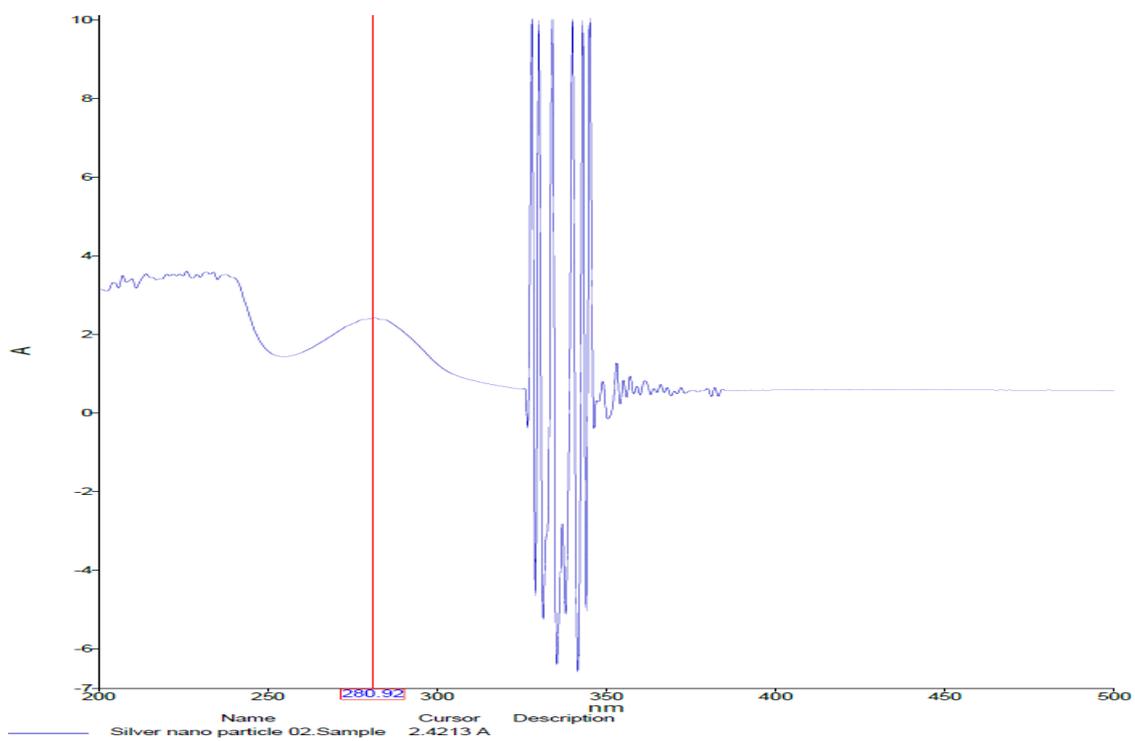


Figure 3.3.2: UV Spectroscopy of 1 M *Entada gigas* sample

1. **Zeta potential:** Zeta potential is the electric potential at the boundary (slipping plane) between a charged particle's surface and the surrounding fluid, indicating the net surface charge and predicting colloidal stability by measuring electrostatic repulsion between particles; high absolute values (e.g.,  $>|30|$  mV) suggest good stability, while low values mean particles might clump (flocculate), crucial in industries from food to pharma.

- The test result show that the zeta potential of the test sample found to be **75.3 mv**.
- This indicating that size of particles in sample are unstable at nano range.

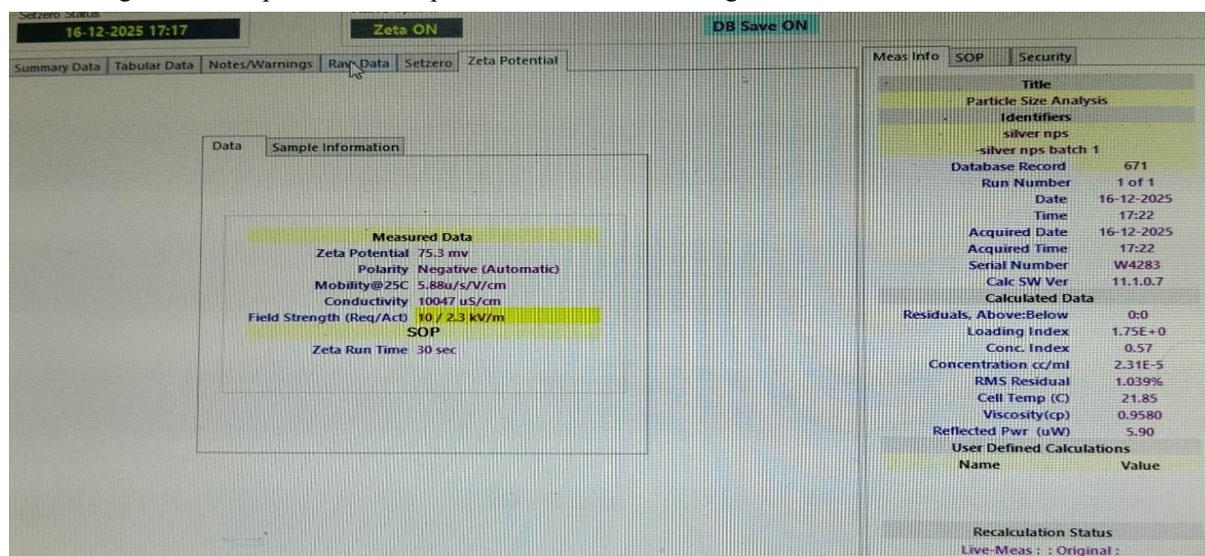


Figure 3.4.1: Zeta potential analysis

### 3.5 Particle Size Analysis:

Size of the synthesized silver was determined using microtrac total solution in particle characterization measurements in nanotechnology laboratory of Shri G.S. Institute of Technology and Science Department of Pharmacy. Fig 7.8 shows the Particle Size Distribution Analysis of *Entada gigas* extract. This result shows a wider hydrodynamic size range for silver nanoparticles; approximately 5 to 100 nm. On the other hand, the results show that the sizes of silver nanoparticles are influenced by a number of factors including reaction temperature and extract concentration.

#### ❖ For Sample *Entada gigas*:

- when sample of *Entada gigas* extract with 5 mM silver nitrate solution, particle size analysis was performed. On this analysis lower temperature was 20°C and higher temperature was 30°C.
- **Average number of particles** having size of **4460nm** and **minimum particles** were found to be size of **568nm** and **maximum particles** found in range of **1662nm**.
- Around 95% of particle having size of 510nm.
- refractive index of sample was 1.33.
- Lower temperature viscosity was 1.002 cP and higher temperature viscosity was 0.797cP.
- Because the sample was unstable so that it was show is the different particles size range.

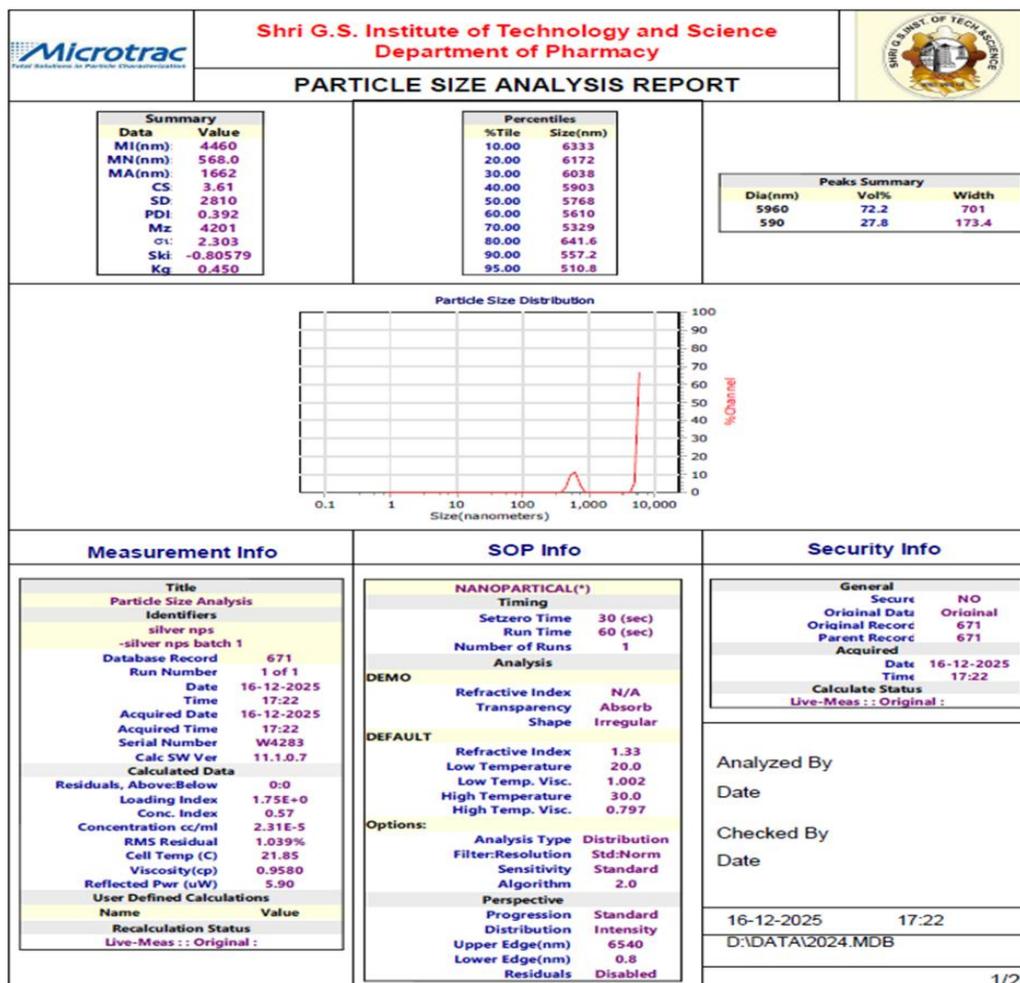


Fig 3.5.1: Particle Size Distribution Analysis

#### 4. SUMMARY & CONCLUSION:

✓ However, understanding the mechanism by biomolecules of these organisms are involved in synthesis is lacking. A progress in this area will green paths in the development of controlled shape and size AgNPs. Moreover, the synthesis of nanostructures of Ag in high yield and in a wide range of shapes is challenging tasks. This requires the understanding of the nuclei formation and the influence of reaction species on nuclei morphology. Thus, have studied synthesis of silver nanoparticles by the extract of *Entada gigas* faster aggregation rate of silver ions into silver particles.

✓ The plant extract was prepared by Soxhlet extractor, the percentage yield of *Entada gigas*, was 15.29%. The Phyto-chemical studies of ethanolic extract of *Entada gigas*, shows absence of phlobatannins. Tannins, glycosides, flavonoids and steroids are present in plants extract.

✓ The aggregation of silver ion was confirmed by colour change from yellow to brown of the solution. The particles thus formed is a subjected to UV- Spectrum analysis, Particle size & zeta potential. The aggregation of the Ag ions through Plant extracts leading to the formation of silver particles of fairly well-defined dimensions. A strong, broad absorption band with a maxima located around 280 nm was observed due to formation of silver particles produced by the herbal extract. This peak is assigned to a surface plasmon, phenomenon that is Well-documented for various metal nanoparticles with sizes ranging from 2 nm to 100 nm.

✓ The particle size of the synthesized silver particles was determined using microtrac total solution in particle characterization measurements in nanotechnology laboratory of Shri G.S. Institute of Technology and Science Department of Pharmacy. The analysis showed a wider hydrodynamic size range for silver particles; In the sample average particle size was found to be 568 nm. During study it is observed *Entada gigas* sample has given nanoparticles at faster rate but found out to be unstable for long period of time. Extracts from bio-organisms may act both as reducing and capping agents in Ag NPs synthesis. The aggregation of Ag<sup>+</sup> ions to form



Ag particles occurs by combinations of biomolecules found in these extracts such as enzymes/proteins, amino acids, polysaccharides, and vitamins, Flavonoids and terpenoids. Proteins in the extract provide dual function of Ag<sup>+</sup> aggregation and shape-control in the nano silver synthesis. The carboxyl groups in aspartic and or glutamine residues and the hydroxyl groups in tyrosine residues of the proteins were suggested to be responsible for the Ag<sup>+</sup> ion aggregation.

- ✓ The following result of particle size determination shows that the particle size ranging from 510 nm to 6333nm which is above the nano range i.e., 100 nm, means the particles formed during the reaction of 1µg/mL plant extract and 1×10<sup>-3</sup> silver nitrate solution is not under the nano range.
- ✓ The zeta potential result shows the particle having charge of 75.3 mv which means the solution is unstable.
- ✓ UV spectroscopy results show absorption peak on 280.92 nm at 2.4213 Å.
- ✓ The silver particles were not stable under nano range while using 1µg/mL *Entada gigas* as herbal drug to synthesis silver nano particles from 1×10<sup>-3</sup> silver nitrate solution.

## 5. REFERENCES:

1. Khan Ibrahim, Saeed Khalid, Khan Idrees "Review Nanoparticles: Properties, applications and toxicities Arabian Journal of Chemistry" (2019) 12,908-931
2. M. Shanmugavadivu, Selvam Kuppusamy and R. Ranjithkumar " Synthesis of Pomegranate Peel Extract Mediated Silver Nanoparticles and its Antibacterial Activity" American Journal of Advanced Drug Delivery [www.ajadd.co.uk](http://www.ajadd.co.uk)
3. Sivakumar S. R., Tamizhazhagan A. and Abdul K. "Synthesis, characterization and anti-bacterial activity of silver nanoparticles from leaf extract of *phyllanthusurinaria.l*" *ejbps*, 2017, Volume 4, Issue 8, 544-553
4. Antonio Zuorro, Annalaura Iannone, Stefano Natali and Roberto Lavecchia" Green Synthesis of Silver Nanoparticles Using Bilberry and Red Currant Waste Extracts Processes" 2019, 7, 193; doi: 10.3390/pr7040193 [www.mdpi.com/journal/processes](http://www.mdpi.com/journal/processes)
5. Pirtarighat Saba, Ghannadni Maryam, Baghshahi Saeid" Green synthesis of silver nanoparticles using the plant extract of *Salviaspinosa* grown in vitro and their antibacterial activity assessment" *Journal of Nanostructure in Chemistry* (2019) 9:1-9 <https://doi.org/10.1007/s40097-018-0291-4>
6. Shaik Mohammed ID Rafi, Khan Mujeeb, Mufsir Kuniyil, Abdulrahman Al-Warthan Hamad Z. Alkathlan, Mohammed Rafiq H. Siddiqui ID, Jilani P. Shaik, Anis Ahamed, Adeem Mahmood Merajuddin Khan, and Syed Farooq Adil," Plant-Extract-Assisted Green Synthesis of Silver Nanoparticles Using *Origanum vulgare* L. Extract and Their Microbicidal Activities Sustainability "2018, 10, 913; doi:10.3390/su10040913 [www.mdpi.com/journal/sustainability](http://www.mdpi.com/journal/sustainability)
7. Mitiku Abambagade Abera, Yilma Belete "A Review on Green Synthesis and Antibacterial Activity of Silver Nanoparticles" *Int. J. Pharm. Sci. Rev. Res.*, 46(1), September - October 2017; Article No. 10, Pages: 52-57
8. Geo S.M. Aniskha, Chandran Subash, G. Murugesan and Yamini S. Lakshmi Sudha "Green Synthesis and Characterization of Silver Nanoparticles: A Review " *ejbps*, 2018, Volume 5, Issue 7 186-191
9. JannathulFirdhouse M. and Lalitha P., "Review Article: Biosynthesis of Silver Nanoparticles and Its Applications" *Hindawi Publishing Corporation Journal of Nanotechnology* Volume 2015, Article ID 829526, 18 pages <http://dx.doi.org/10.1155/2015/829526>
10. Mamillapalli Vani, Atmakuri Amukta Malyada, Khantanneni Padmalatha "Nanoparticles for Herbal Extracts" *Asian Journal of Pharmaceutics* Apr-Jun 2016 (Suppl) 10 (2)
11. Chandran Krishnaraj, *et al* "Green synthesis of Ag and Au NPs decorated rGO nanocomposite for high impedimetric electrochemical sensor as well as enhanced antimicrobial performance against foodborne pathogens". (2024). <https://www.sciencedirect.com/science/article/pii/S1878535223008419>
12. Dharavath Sunitha Baiet *al* "Phytochemical Screening Pharmaceutical Studies and Synthesis of Silver Nano Particles from *NothapodytesFoetida*". (2024) <http://hdl.handle.net/10603/541363>
13. Atram, S G *et al*, "Silver Nanoparticles synthesized from Bark extract of *Morindacitrifolia* and Investigated their Antibacterial and Anticancer activity." (2024). <https://www.researchtrend.net/bfij/silver-nanoparticles-synthesized-from-bark-extract-of-morindacitrifolia-and-investigated-their-antibacterial-and-anticancer-activity-7344#:~:text=Antimicrobial%2C%20Anticancer%2C%20Nanotechnology-,Conclusion,silver%20ions%20to%20silver%20nanoparticles.>
14. Mahak Majeed *et al*, Synergistic effect of plant extract coupled silver nanoparticles in various therapeutic applications- present insights and bottlenecks.(2024) <https://www.sciencedirect.com/science/article/abs/pii/S0045653521029994>
15. Kumar, M. & Kurup, Meena & Jayaprakash, J.. (2024). Design and Optimization of Herbal Formulations in Silver Nanoparticles to Enhance Wound Healing Activity. *Journal of Physics: Conference Series*. 2801. 012014. 10.1088/1742-6596/2801/1/012014.



- [https://www.researchgate.net/publication/382770478\\_Design\\_and\\_Optimization\\_of\\_Herbal\\_Formulations\\_in\\_Silver\\_Nanoparticles\\_to\\_Enhance\\_Wound\\_Healing\\_Activity](https://www.researchgate.net/publication/382770478_Design_and_Optimization_of_Herbal_Formulations_in_Silver_Nanoparticles_to_Enhance_Wound_Healing_Activity)
16. Pandhi, Shikha *et al*, "Study on Green Route for Synthesis of Silver Nanoparticles and Development of a Nanocomposite Film." (2023). <http://hdl.handle.net/10603/517494>
  17. Ahamad, Irshad *et al*, "Synthesis of silver nano particle facilitated by *Anabaena variabilis* for biological applications." (2023). [https://www.researchgate.net/publication/348309158\\_Synthesis\\_and\\_characterization\\_of\\_silver\\_nanoparticles\\_using\\_Anabaena\\_variabilis\\_as\\_a\\_potential\\_antimicrobial\\_agent](https://www.researchgate.net/publication/348309158_Synthesis_and_characterization_of_silver_nanoparticles_using_Anabaena_variabilis_as_a_potential_antimicrobial_agent)
  18. Sreevennela Rao, P *et al*, "Biogenic Synthesis of Silver Nano Particles from *Lepidium Sativum* Seeds Garden Cress and its Pharmacological Applications." (2023) <https://www.iosrjournals.org/iosr-jpbs/papers/Vol16-issue1/Series-2/F1601024656.pdf>
  19. Anita Dhaka *et al*, "Biological synthesis of silver nanoparticles and their anti-herpes simplex virus 1 activity" (2023).
  20. N.S. Alharbi *et al*, "Green synthesis of silver nanoparticles using medicinal plants: Characterization and application". (2022).
  21. Varsha Chandrakar, Kavita Tapadia & Saurabh Gupta *et al*, "Greener production of silver nanoparticles: a sensitive nanodrop spectrophotometric determination of biothiols, Chemical Papers" (2021).
  22. Singh, Sanjay *et al*, "Green synthesis of silver nano particles using root extract of *chlorophytum borivilianum* and assessment of anti-microbial and anti-radiation activity". (2021).
  23. Vetrivel C *et al*, Studies on green synthesis and characterization of silver nanoparticles from *barlerialongifloraleaf* and *ceropegia bulbosa roxb* for environmental and biological applications. The qualitative phytochemical screening of *B. longifloraleaf* and *C. bulbosa* root tuber extracts revealed the presence of different bioactive compounds. (2021)
  24. Thirumagal, N *et al*, Photocatalytic and antibacterial activities of AgNPs from *Mesua Ferrea* seed. The silver nanoparticles have been successfully prepared with *Mesua ferrea* seed extract by biological method. Research Article Published: 24 November 2020 Volume 2, article number 2064, (2020). <https://link.springer.com/article/10.1007/s42452-020-03650-w>
  25. Gomathi, M *et al*, "Green synthesis characterization and antibacterial activity of herbal plants mediated silver nanoparticles against *staphylococcus aureus* and *escherichia coli*." (2020).
  26. Thirumagal, N *et al*, Photocatalytic and antibacterial activities of green synthesized silver nanoparticles. (2020).
  27. Prabavathi J *et al*, "Studies on the gold and silver nanoparticles counteracting the oxidation of drugs by alkaline potassium permanganate solutions effects of drug functionality ionic strength pH micro heterogeneous media and gold silver nanoparticles on reaction rats." (2020).
  28. Kumar Guru Dugganaboyana, antioxidant, antibacterial, antidiabetic potential and genotoxicity of silver nanoparticles using leaf extract of curcuma longa: a novel green approach April 2019 International Research Journal of Pharmacy 10(3):127-135 DOI:10.7897/2230-8407.100391, [https://www.researchgate.net/publication/332597814\\_antioxidant\\_antibacterial\\_antidiabetic\\_potential\\_and\\_genotoxicity\\_of\\_silver\\_nanoparticles\\_using\\_leaf\\_extract\\_of\\_curcuma\\_longa\\_a\\_novel\\_green\\_approach](https://www.researchgate.net/publication/332597814_antioxidant_antibacterial_antidiabetic_potential_and_genotoxicity_of_silver_nanoparticles_using_leaf_extract_of_curcuma_longa_a_novel_green_approach)
  29. Pathak Manish, Tyagi Priyanshu, Punia Amit, Singh Lubhan "Cytotoxic action of silver nanoparticles synthesized from *Phyllanthus fraternus* on hepatic and breast cancer cell lines: A green approach" International Journal of Green Pharmacy, Jul-Sep 2019, 13 (3)229. <https://greenpharmacy.info/index.php/ijgp/article/view/2593>
  30. Sonali Priyadarshini, Sushree Sulava, Rasmita Bhol and Somanatha Jena, "Green synthesis of silver nanoparticles using *Azadirachta indica* and *Ocimum sanctum* leaf extract." current science, vol. 117, no. 8, 25 october 2019

How to cite this article:

Vishal Pandey et al. Ijppr.Human, 2026; Vol. 32 (2): 367-377.

Conflict of Interest Statement: All authors have nothing else to disclose.

This is an open access article under the terms of the Creative Commons Attribution-NonCommercial-NoDerivs License, which permits use and distribution in any medium, provided the original work is properly cited, the use is non-commercial and no modifications or adaptations are made.