STRUCTURAL AND LUMINESCENCE CHARACTERIZATIONS OF SILVER NANOPARTICLES (AgNPs) VIA FACILE GREEN SYNTHESIS USING PONGAMMIA PINNATA LEAVES EXTRACT

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Abstract

The expansion of dependable and ecologically-friendly methods for the green synthesis of nano-particles is an in-expendable necessity in the field of recent emerging nano-technology. Without using of any further reducing or stabilising chemicals, the Pongammia Pinnata Leaves Extract (PPLE) is used in this study to create silver nano-particles. This process is effective, safe, and sustainable. UV-Visible Spectroscopy, X-ray Diffraction (XRD), Fourier Transform Infrared Spectroscopy (FTIR), Transmission Electron Microscopy (TEM), Dynamic Light Scattering (DLS) and Scanning Electron Microscopy (SEM) were used to examine the formation of Silver nano-particles (AgNP's). UV-VIS Spectrum of as-prepared AgNP's shows a characteristic absorption peak at 420 nm. FTIR studies ensured that the existence of -C=O, C-O-C and -O-H groups were identified in the as-prepared AgNP's. The XRD peaks 32.36^o, 38.27 ^{o}, 44.31^o, 64.03^o and 77.83^o which were attributed to the plane of crystals (111), (200), (220), (020) and (311) respectively shows crystal nature with a face-centered cubic structure of AgNP's. SEM micrographs depicted the well dispersed silver Nano-particles ranging 60-160 nm. TEM micrographs confirmed the homogeneous nature of green synthesized silver nano-particles ranging 20-25 nm. The DLS analysis showed AgNP's drifted widely from 10-120 nm with standard particle size of 75.8 nm. The green route synthesis of AgNP's shows significant industrial dye effluent removal capacity, antibacterial, antifungal and antiplasmodial activities.

Keywords: *PongammiaPinnata leaves Extract, Silver nano-particles, DLS, SEM, TEM, Antibacterial activity.*

1. INTRODUCTION

In Nano-technology, materials are modified at the atomic level to achieve special qualities that may be effectively manipulated for the desired applications [1]. An important study platform in this area is the synthesis of nanoparticles (NPs) employing a variety of methodologies with various types of chemical proportions, sizes, forms, and controlled dispersities. [2-3]. Numerous research is done on metal nano-particles because their distinctive electrical, optical and catalytic characteristics. A wide range of study has concentrated on adjusting their physico-chemical features that requires controlling their size and form. This is done in order to exploit and maximize chemical or physical attributes of nano sized metal particles [4-6]. Several approaches, including physical, chemical, biological, and hybrid ones, can be used to create nano-particles. (Figure 1) [7–9]. The majority of these methods, however, are quite costly and also involve the usage of dangerous toxic materials that might endanger biological systems and the environment. As a result, an affordable, alternative, and environmentally benign method of nano-particle synthesis is urgently needed. [10-11].

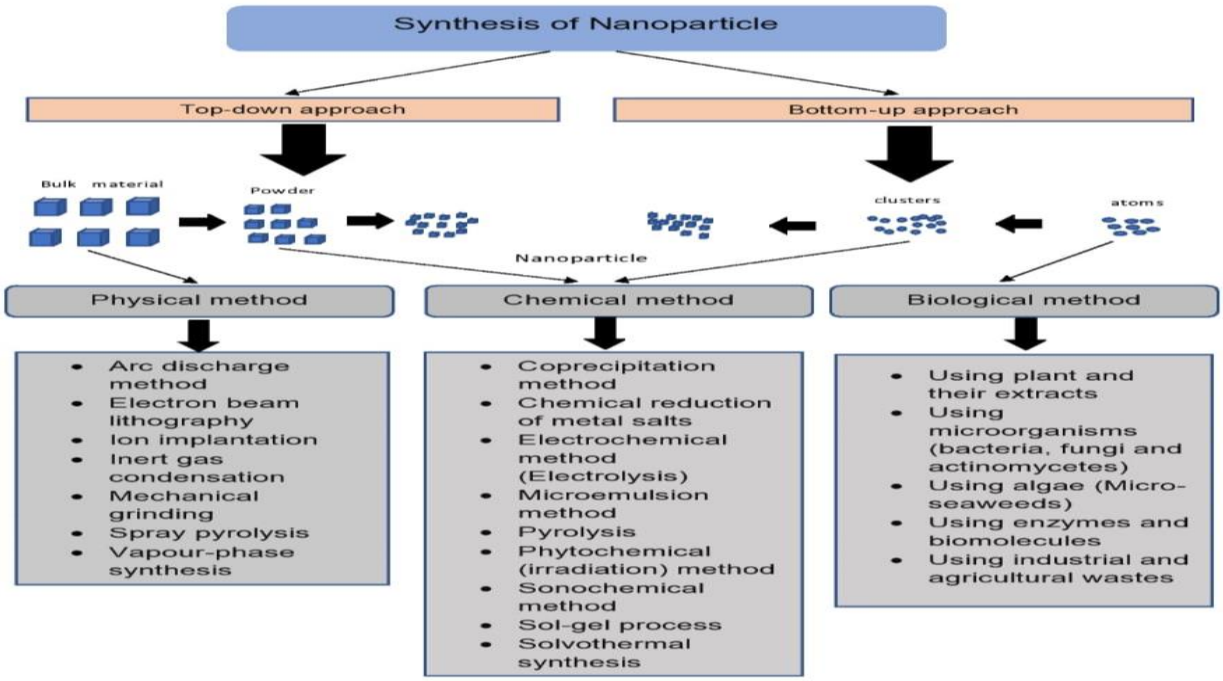

Figure 1. Various approaches and methods of synthesizing Nano-particles

Recently, phytonanotechnology has created much attraction among the researchers to synthesis of well-dispersed Nano-particles and is a quick, easy, stable, and economical process. The benefits of phytonanotechnology include biocompatibility, scalability, and the potential for medicinal applications when synthesising Nano-particles utilising water as a reducing agent [12]. As a result, the significant need for nano-particles with implementation in the biomedical, materials science, dye adsorption and environmental fields can be satisfied by using plant-derived Nano-particles made from widely available plant components and

their harmless nature [13]. A review of past research indicates that silver (Ag) and gold (Au) can be synthesised from plant extracts found in seeds and leaves [14-16].

A biological process had been followed by Shankar et al., to synthesize the AgNP's from a Geranium leaf concentrate (Pelargonium graueolens) [17]. Bimetallic silver/gold Nano-particles were synthesized from a Persimmon (Diopyros kaki) leaf concentrate and investigated by Song et al., [18]. Sathishkumar et al., has synthesized silver nano-particles from Cinnamon zeylanicum bark concentrate and studied their bactericidal potential [19]. A room temperature synthesis of silver Nano-particle from Calotropisprocera flower extract has been demonstrated by Ananda Babu et al. [20].

Pongammiapinnata plants are rich in vitamins, saponins, flavanoids, phenols and alkaloids among other biologically active substances. P. pinnata leaves were chosen because of its beneficial effects on keloid tumours, hypertension, pectoral illnesses, anaemia and its antibacterial, antiulcer, antifungal, anti-inflammatory and antioxidant characteristics [21-22].

P. Pinnata leaves are a natural, affordable, and renewable resource that can be used to create metal oxide Nano-particles in an aqueous media without the need of harmful solvents or hazardous materials [23].

Many research works have been done on AgNP's. AgNP's are used in a variety of fields because of their unique properties, including rapid biomedical diagnosis, scanned imaging, drug delivery, regeneration of tissues, and the progression of new medical products, as well as the textile, food, and cosmetic industries, as well as the fields of catalysis, sensors, biology, coatings, plasmonics, optoelectronics, anti-microbial activities, DNA sequencing, SERS, clean water technology, energy production, and storage of information. Because of their exceptional protection against a variety of pathogens and therapeutic properties, AgNP's are also utilised as anti-infection agents, sedatives, travel agents, treatment plants, agriculture, etc. AgNP's have also been used in inks, pastes, electronic gadgets, adhesive, etc. due to their strong conductivity. [24-38].Since this concentrates from Pongammia Pinnata Leaves worked as both a reducing and stabilising agent, the focus of the current work is on the synthesis of novel AgNP's using a faster, one-step, and ecologically friendly process.

2. RESOURCES AND TECHNIQUES

2.1 RESOURCES

PongamiaPinnata Leaves were gathered in IIT Madras campus, Tamilnadu. Analytical grade sample was used without any additional purification in addition to deionised water, Silver Nitrate ($AgNO_3$), Sodium hydroxide (NaOH), Ethanol (C_2H_5OH).

2.2 TECHNIQUES

2.2.1 Making of Pongamia Pinnata Leaves Extract.

Fresh PongamiaPinnata Leaves are collected and then washed repeatedly with tap water and again by distilled water to get rid of the dust. After being dried for 5 to 10 days at room temperature in a covered area, the clean, fresh leaves are pulverized in a professional blender. The fine powder is stored at room temperature for further use. In a 250 ml of conical flask, 10 grams of leaf extract powder were taken and to this 100 ml of double distilled water

is added and it is heated at $80^{O}C$ for 30 minutes. Then the solution was strained using Whatman filter paper and kept aside for further process. The obtained Concentrate was in pale brown colour and adjusted the pH at 11 by adding 0.1M of sodium hydroxide solution.

2.2.2. Preparation of Silver Nanoparticles.

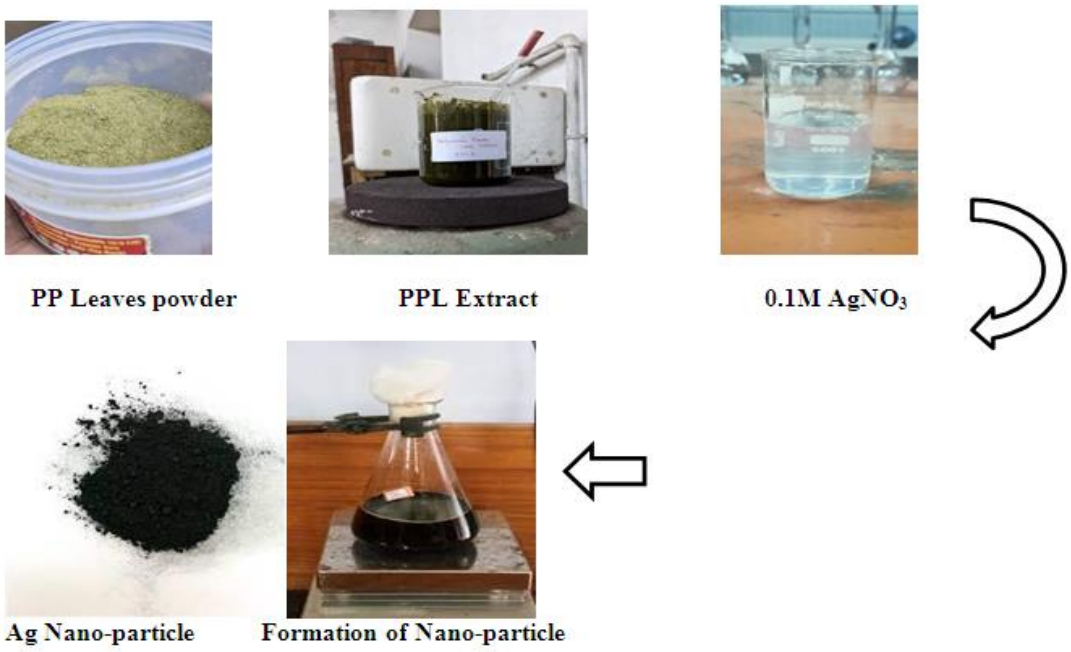

Figure 2. Green approach to synthesizing Silver Nano-particles

50 ml of Pongamia Pinnata leaves Extract were placed in a 250 ml conical flask, and 100 ml of 0.1 M AgNO3 solution were gradually added at room temperature under static condition. The colour change was observed and the time taken for the reaction to occur was noted. As soon as silver nanoparticles (AgNPs) forms(figure.2), the colour of the solution changes from pale brownish to reddish-brown. Further the solution is centrifuged and the precipitate is Concentrated and dried in electrical oven for 24 hours at $100^{O}C$. The green synthesized AgNP's is formed at uniform particle size and stored for further characterization and uses.

2.3 Characterization of Silver Nano-particles

2.3.1 UV-Visible spectrophotometric analysis

The early step of Nano-particle generation was confirmed by UV-Visible is spectroscopic study of synthesized Ag nano-particles. The produced Ag Nano-particles were examined with an Elico SL210. UV-Visible Spectrophotometer utilising a scan UV-Visible Spectrophotometer in the range 190 nm to 800 nm.

2.3.2 FT-IR Spectroscopic analysis

The FT-IR spectrometer was utilized to study about the functional group of the plant Concentrate and greenly produced Ag Nano-particles. The study of peaks at particular wave

numbers is the foundation of the spectroscopic method. According to FT-IR data, both the plant Concentrate and the produced Nano-particles contain functional groups. Utilizing Perkin Elmer equipment, the FT-IR characterization was carried out between the frequency range of 400 and 4000 cm^{-1}.

2.3.3 X-ray diffraction analysis (XRD)

The crystal structure and average size of the particle of the produced adsorbents were investigated. XRD pattern was measured by X-ray diffractometer (BRUKER D8 ADVANCE) of characteristics AgK radiation (λ=1.541Å) in the range 4º to 80º at a scan rate of 0.02º per/min with time constant of 2 minutes.

2.3.4. Scanning Electron Microscopy (SEM)

The porosity, particle size distribution and of the adsorbents are all detailed by the SEM examination. Using JEOL-6390LA equipment, the surface morphology of as-prepared AgNP's was captured.

2.3.5 Transmission Electron Microscopy (TEM)

For determining the particles measurement and morphological identities of AgNP's and other metal nano-particles, TEM (JEOL –JEM 2100) is recognised as the best electron microscopy technique.

2.3.6 Dynamic Light Scattering (DLS)

The average size of the produced Ag Nano-particles was determined using DLS (Spectroscatter 201).

3. RESULTS AND DISCUSSION

3.1. Characterization study of the green synthesized silver nano-particles.

Water-soluble components in Pongamia Pinnata leaf Concentrate were performing an important function in the formation of AgNPs from silver monovalent ions. The colour change confirmed preliminary evidence of Nano-particle formation. The homogeneous mixing of leaf Concentrate and aqueous $AgNO_3$ solution turned pale brown to reddish-brown.

3.1.1. UV- Vis Absorption Spectroscopy of Silver Nano-particles.

Using the concentrate from Pongamia Pinnata leaves, the green method for producing Ag Nano-particles was disclosed. Metal Nano-particle production in aqueous solution can be verified using UV-Vis spectroscopy [39]. The UV-Vis spectrum of colloidal solution of AgNP's was shown in figure 3. At 420 nm, a broad band appeared, signifying the production of AgNP's [40–41].

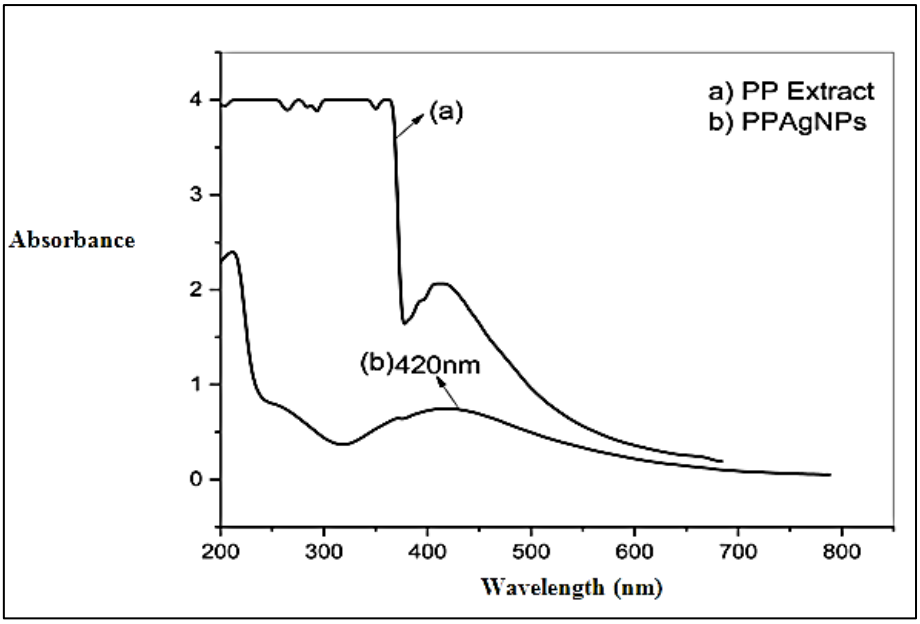

Figure 3. - UV-Vis spectra of (i) PPLE and (ii) PPLAgNP's

3.1.2 Fourier Transform Infrared (FT-IR) Spectroscopy

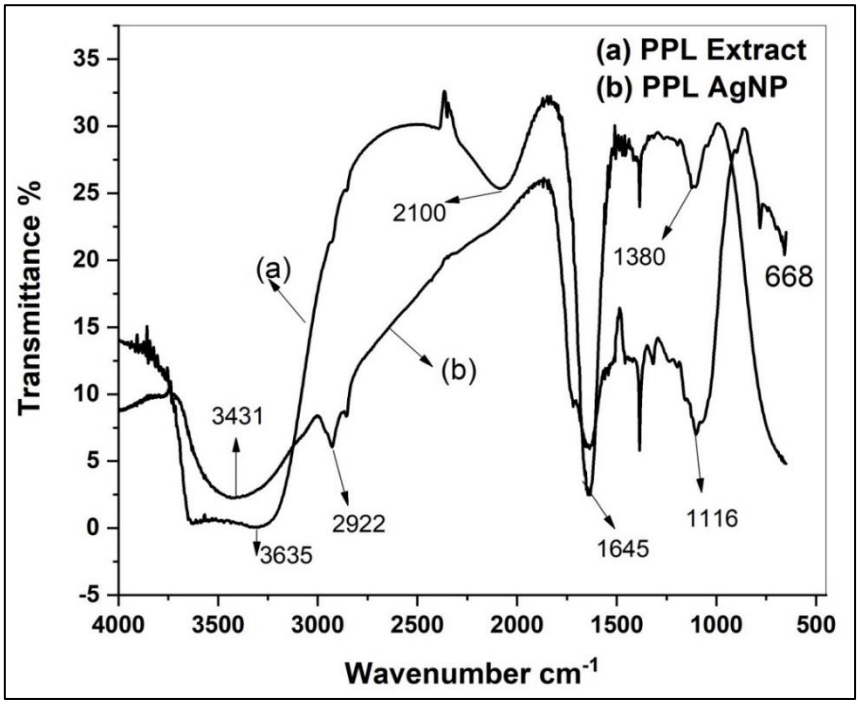

Figure 4. FTIR Spectra of a) PPL Concentrate and b) PPLAg NPs

The FT-IR study was done to analyse the main functional groups that are present in the Pongamia Pinnata leaf concentrate and are in charge of producing AgNP's(Figure:4). The reduction of silver ions to AgNP's may be caused by these functional groups. The role of various functional groups in PongamiaPinnata leaves Concentrate in the reducing and stabilising processes of Nano-particle production was assessed using the spectrum of leaves Concentrate as a control. Investigation was done on the absorbance bands at 3635, 2100,

1645, 1380, and 1116 cm^{-1} in leaves Concentrate. The hydroxyl group elements O-H stretching vibration caused a broad band at 3635 cm^{-1}. The peaks at 1645 and 1380 could be attributed to bonds comprising -NH_2 groups of protein amino acids and -C=O groups of flavonoids and tannin respectively.

AgNP's peaked at 3431, 2927, 1612, 1103 and 668 cm^{-1}respectively. Flavonoids, xanthonoids, and other phenolic compounds which were thought to be the primary reducing agent for silver ions—were found to include OH stretching, as seen by the wider peak at 3338 cm^{-1}. The reduction of the silver ions (Ag^{+}) by OH-based products which were found in leaves is thought to be the cause of the change in OH stretching frequency from higher (in Concentrate) to lower (in Ag NPs) frequency [42–43]. The biomolecule found in the leaf concentrate was in charge of the decrease in silver salt, as evidenced by the production of AgNP's.

3.1.3. X-Ray Diffraction (XRD)

The X-ray diffraction (XRD) research was used to determine and confirm the crystalline structure of the produced AgNP's. (Figure 5) depicts the appearance of a diffraction pattern at 2θ = 32.36º, 38.27º, 44.31º, 64.03º, and 77.83º that corresponds to the monoclinic phase AgNP's planes (111), (200), (220), (020), and (311), respectively. In the diffraction images, no distinctive peak caused by any impurity was seen, pointing to the creation of pure crystalline AgNP's. The Debye-Scherer Equation (1) was used to analyse the average size of crystalline AgNP's [44]. AgNP's are confirmed by a strong peak with the (111) plane diffraction at 2θ = 35.4º and 38.27º. In samples of AgNP's, the average crystallite size is less than 21 nm.

$$D = k\lambda / \beta \cos \theta \qquad \text{--- (1)}$$

Where, k represents shape factor and is about to be 0.89. θ is the diffraction angle, β denotes full width at half maximum, and λ denotes wavelength of X-ray radiation (0.154 nm). The standard crystallite measurement was estimated about to 24.84 nm in size.

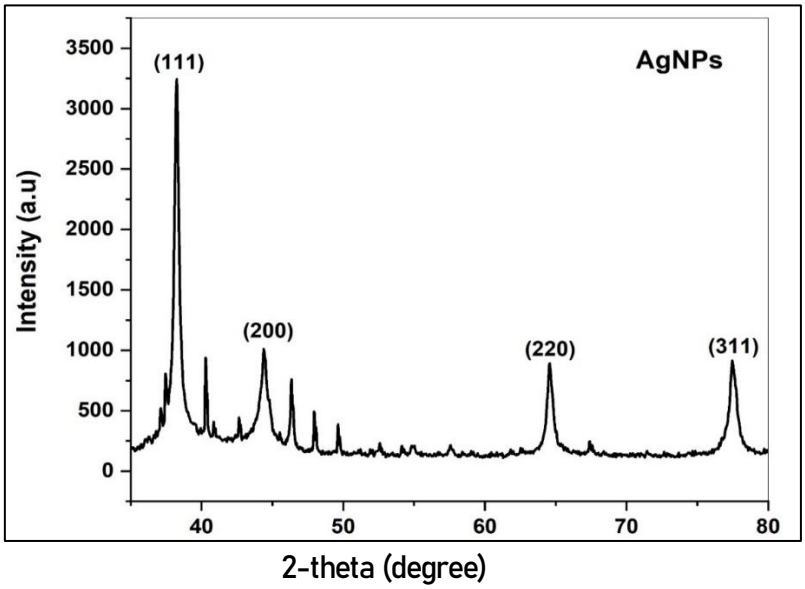

Figure 5. XRD image of Green synthesized Silver Nano-particles

3.1.4. Scanning Electron Microscope (SEM)

The surface morphology of the silver nano-particles is displayed in Fig. 6. According on the image J program's calculations, the diameter of Ag Nano-particles appears to range between 60 and 160 nm.

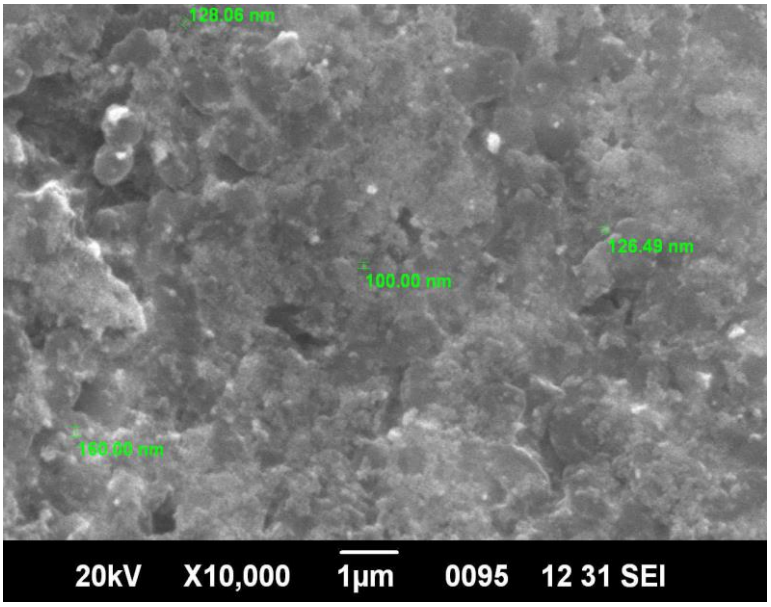

Figure 6. SEM image of Green synthesized Silver Nano-particles

3.1.5 Transmission Electron Microscope (TEM)

Using a TEM, the thorough morphological and size assessments of greenly produced AgNP's were examined. According to the TEM image (Fig.7), the biosynthesized AgNP's were agglomerated, linked to one another, and spherical in shape, which is also consistent with the SEM result. The estimated size of AgNP's is observed between 20 and 25 nm.

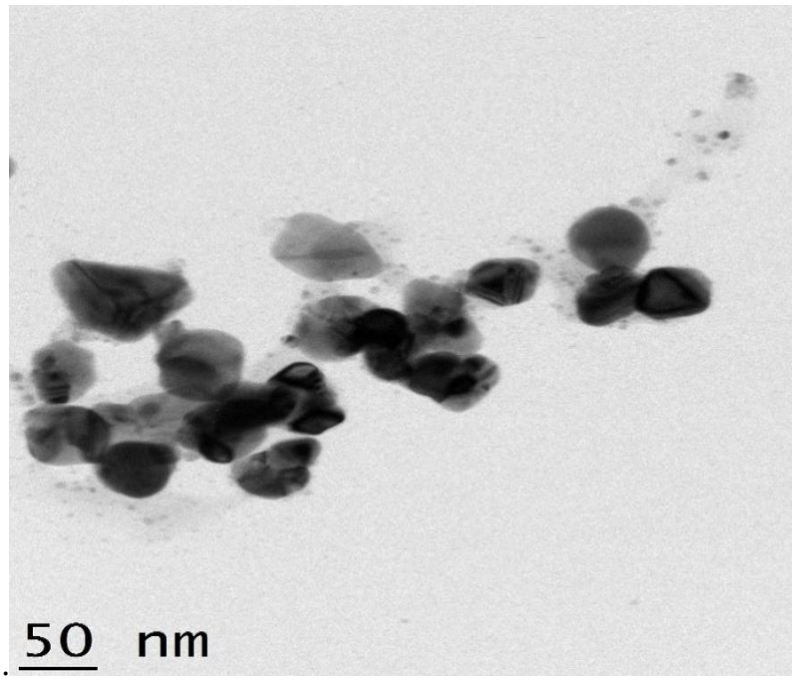

Figure 7. TEM image of green synthesized silver Nano-particles.

3.1.6 Dynamic Light Scattering (DLS)

Dynamic Light scattering (DLS) is the most often applied technique to determine the distribution of AgNP's size in its prepared state. The obtained result AgNP's particle size shows the size variation range lies between 10 and 120 nm with highest size variation around 75.8 nm as shown in fig. 8. Comparatively the size variation diagrams in DLS analysis have good symmetry and reveals the homogeneity of resultant AgNP's.

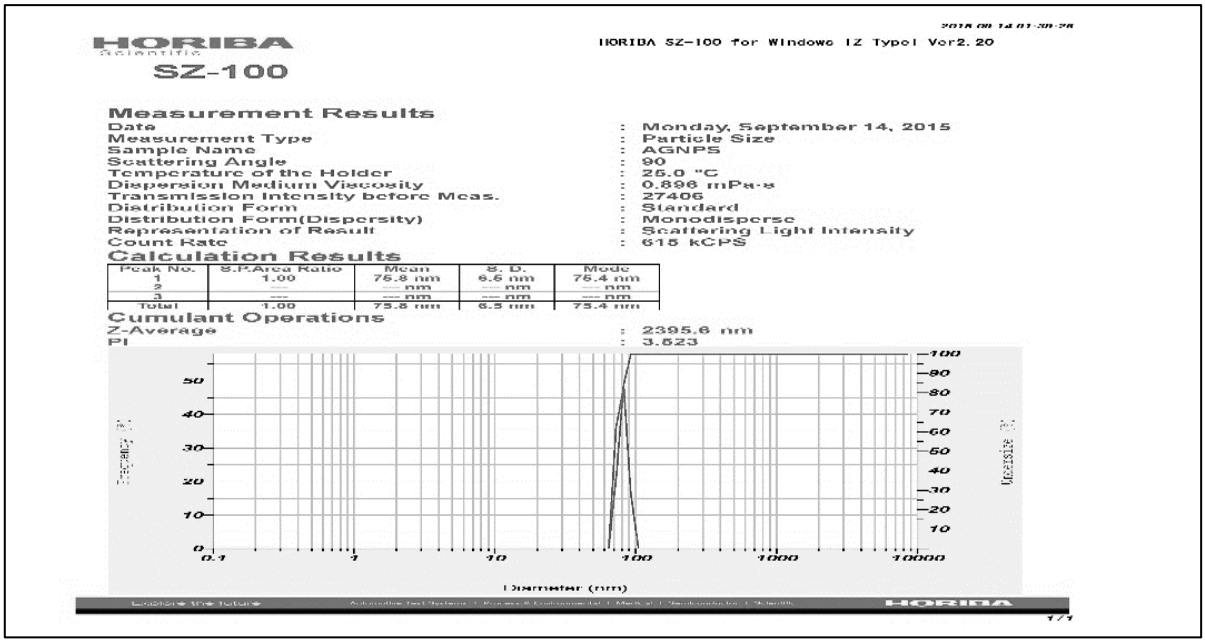

Figure 8. Dynamic Light Scattering Data of AgNP's

4. Conclusion

By utilizing the phyto components found in the PongammiaPinnatta Leaves Concentrate, the current work has successfully illustrated an environment-friendly, green method for production of AgNP's (PPLE). The colour shift of solution observed from pale brown to reddish brown and an absorption peak at 420 nm in the UV-Visible spectral range were the key indicators that silver Nano-particles had formed in the PPLE medium. According to the FTIR spectrum, the phytochemicals in the PPLE fulfil the twin functions of forming and stabilizing AgNP's. The creation of phase-pure AgNP's with fcc symmetry is indicated by XRD analysis. The generation of well-distributed AgNP's with a size variation of 60–160 nm is proved by SEM analysis. The synthesized AgNP's were confirmed by TEM examination to be between 20 and 25 nm in size and to have an aggregation tendency. AgNP's have a size variation of 10 to 120 nm, according to DLS study, with an standard particle measurement of 75.8 nm. As a result, there may be a lot of potential for the environment-friendly and non-toxic, AgNP's to be used in various biological and chemical applications. In comparison to the traditional chemical and physical methods, the PPLE is the promising source for the fusion of AgNP's, according to the overall results.

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