Eco-friendly Green Synthesis of Silver Nanoparticles Using *portuluca quadrifida* Plant Extract and Its Biological Activity

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ABSTRACT:

The field of nanotechnology is one of the most active research fields at modern material science. Eco-friendly green mediated synthesis of nanoparticles are the present research in the limb of nanotechnology. The present work focuses on the synthesis of silver nanoparticles using different concentrations of plant extract of PORTULUCA QUADRIFIDA as reducing as well as capping agent. The biosynthesized nanoparticles were characterized by UV-VIS absorption spectrophotometer, Fourier-Transform infrared spectroscopy, X-Ray diffraction techniques. Synthesized nanoparticles are characterized under UV-VIS spectroscopy at the range of 283 to 211 nm. The Fourier-Transform infrared spectroscopy indicates flavonoids as a potential reduced agent. Face centered cubic crystalline structure of the synthesized silver nano particles are confirmed by X-Ray diffraction spectra. Green synthesized Ag NPs showed zone of inhibition against both Gram positive (Staphylococcus aureus, Bacillus subtillis & Micrococcus) and Gram negative (Pseudomonas aeruginosa, Salmonella typhi, Proteus vulgaris & Seratia) bacteria.

Keywords: Antimicrobial activity, SEM, Silver Nano Particles, Portuluca quadrifida, XRD.

1. INTRODUCTION

The study and manipulation of materials at nm length scale, where properties differ significantly from atom as well as bulk is recognized as a new branch of science, better known as nanoscience. Nanoscale materials have high surface area to volume ratio, making them ideal for use in composite materials, drug delivery, catalysis, sensors, data storage and energy storage. Finite size of material entities as compared to the molecular scale makes nanostructured materials harder, less brittle and mechanically strong. Nanoscience and nanotechnology [1-4] is truly interdisciplinary, with an understanding of physics and chemistry of the matter and the processes at nanoscale, .

Metal nanoparticles have remarkable electrical, optical, electronic, physical, chemical and magnetic properties. Besides their usefulness in various fields and their ability to promote surface enhanced optical phenomenon [5]. Gold, silver and platinum nanoparticles are broadly applied in many fields such as manufacture of cosmetic products, tooth paste, medical and pharmaceutical application [6-8]. Another widely used applications are medical devices and implants prepared with silver-impregnated polymers [9-12].

Nanoparticles synthesis is generally carried out by a variety of physical and chemical methods. When compared to various physical and chemical methods, our eco friendly green mediated synthesis is low cost, proficient and fast method for producing nanoparticles. Nowadays, green chemistry procedures are used in various biological systems and plant extract for synthesis of silver nanoparticles [13-15]. The main reason for selection of the green synthesis method is due to its low cost, non-toxic, eco-friendly and also has great advantages. .

PORTULUCA QUDRIFIDA belongs to the family of *PORTULUCACEAE*, which is called *PASALI KEERAI* in Tamil, in most of the languages which is known as *PAALAK*. All parts of *PORTULUCA QUDRIFIDA* are in medicine such as skin diseases, diseases of the kidneys, bladder and lungs, its leaves have the most potential for medicinal value especially in the treatment of asthma, cough, urinary discharges, inflammations, ulcers, bronchitis, hemorroids, abdominal complaints and diabetics, antiscorbutic, antioxidant, anti inflammatory, antibacterial agents [20].

The present work focused on the syntheses of silver nanoparticles by green method using the *PORTULUCA QUADRIFIDA* plant extract and evaluation of antimicrobial activity against both Gram positive (*Staphylococcus aureus, Bacillus subtillis & Micrococcus*) and Gram negative (*Pseudomonas aeruginosa, Salmonella typhi, Proteus vulgaris & Seratia*) bacteria. . The synthesized silver nanoparticles were characterized by using UV-VIS, XRD, FT-IR, SEM analysis [16-21].

2. MATERIALS AND METHODS

2.1 MATERIALS

Analar grade silver nitrate was purchased from Merck. The young *PORTULUCA QUADRIFIDA* plants were collected from nearby sattur , Tamil Nadu. For all experimental work, double distilled water was used.

2.2 PREPARATION OF PLANT EXTRACT

Fresh plants of *PORT ULUCAQUDRIFIDA* were collected, then washed thoroughly with distilled water several times to remove the dust and dried under shade. The dried plants were cut into small pieces and ground to powder. 5g of *PORT ULUCA QUADRIFIDA* plant powder was boiled in 100 ml of distilled water at 80˚ C for 10 minutes and filtered using whatman No: 1 filter paper. Finally, the prepared extract solution was cooled at 4° C and stored for further synthesis of nanoparticles.

2.3 SYNTHESIS OF SILVER NANOPARTICLES

About 0.1 M of aqueous solution of silver nitrate was prepared and used for the synthesis of silver nanoparticles. Then plant extract of *PORTULUCA QUADRIFIDA* with various concentrations such as 5, 10, 15, 20, 25 ml was added separately to the 10 ml of 0.1 M silver nitrate solution at room temperature. After 20 minutes, the solution was turned from yellow to dark brown color indicating that the formation of silver nanoparticles .

2.4 CHARACTERISATION OF SILVER NANOPARTICLES

The synthesized silver nanoparticles were characterized by UV- visible spectrophotometer in the range of 200 nm to 800 nm.The size of the nanoparticles was calculated from the XRD studies. Morphology of synthesized silver nanoparticles was characterised by SEM analysis. The sample were placed in an evacuated chamber and scanned in a controlled pattern by an electron beam. The synthesized nanoparticles were recorded FT IR in the range of 4000 -500 cm^{-1} to study the functional group present in plant extract.

3.RESULTS AND DISCUSSION

3.1 UV – VISIBLE DIFFUSE REFLECTANCE SPECTRA ANALYSIS

The Ag NPs exhibit yellowish brown or dark brown color in aqueous solution due to excitation of surface Plasmon vibrations in Ag NPs. Reduction of Ag^+ ion to Ag NPs during exposure to the plant extracts could be followed by color change .

Fig. 3.1(a-f) shows the UV-Vis peaks for plant extract and the synthesized Ag NPs for different plant extract concentrations (5, 10, 15, 20 and 25) are absorbed at 283 to 211nm [22]. It shows that the peak is blue shifted when increasing in plant extract concentrations. This observed blue shift is due to the reduction Ag NPs size.

The absorbance of Ag NPs increases when increasing the plant extract concentrations. As the concentration of plant extract is increased, size of the particles decreased due to more number of biomolecules available, which acts as reducing agents. Furthermore, aggregation of NPs may occur due to the formation of these peaks.

The spectrum can exhibit a shift towards the blue end depending upon the particles size, shape and state of aggregation and surrounding dielectric medium [23].

3.2 FT-IR SPECTROSCOPY

The FT-IR spectrum of the extract gives information of the functional groups involved in the reduction of the Ag^+ions to Ag . The FT-IR study identifies the minerals that capped on Ag NPs and some possible biomolecules from PORTULUCA QUDRIFIDA plant extract are changes from Ag^+ to Ag.

The FT-IR spectra of (Fig 3.2a) an aqueous plant extract and (Fig 3.2b-f) synthesized Ag NPs are analysis shown in Fig 3.2. The FT-IR spectrum shows strong peaks at (596.93 and 580.82 per cm), (671.18 and 604.64 per cm), (975 and 699.15 per cm), (1090.67 and 1013.52 per cm), (1309.58 and 1306.65 per cm), (1449.46 and 1165.89 per cm), (3736.82 and 3353.98 per cm) respectively.

The strong band at (596.93 and 580.82 per cm) correspond to NO_2 in deformation aromatic nitro compound and C-O=O carboxylic group in bending vibration. The band at (671.18 and 604.64 per cm) corresponds C-Cl stretching vibration in alkyl group. The strong peak at (975 and 699.15 per cm) corresponds to C-H bending vibration. The peak at (1090.67 and 1013.52 per cm) is due to C-O stretching vibration in carboxylic group and flavanones. The characterized peak is observed at (1309.58 and 1306.68 per cm) C-N stretching vibration in amine group [24].

The strong band at (1449.46 and 1165.89 per cm) aromatic C=C stretching vibration [25]. The broad band at (3736.82 and 3353.98 per cm) is OH stretching vibration in alcohols. Some peaks appeared in the FT-IR spectrum of plant extract, which were disappeared in FT-IR spectra of green synthesized Ag NPs. This disappeared peaks indicates the phytochemical present in the plant extract, which is involved in reduction of Ag NPs [26-28].

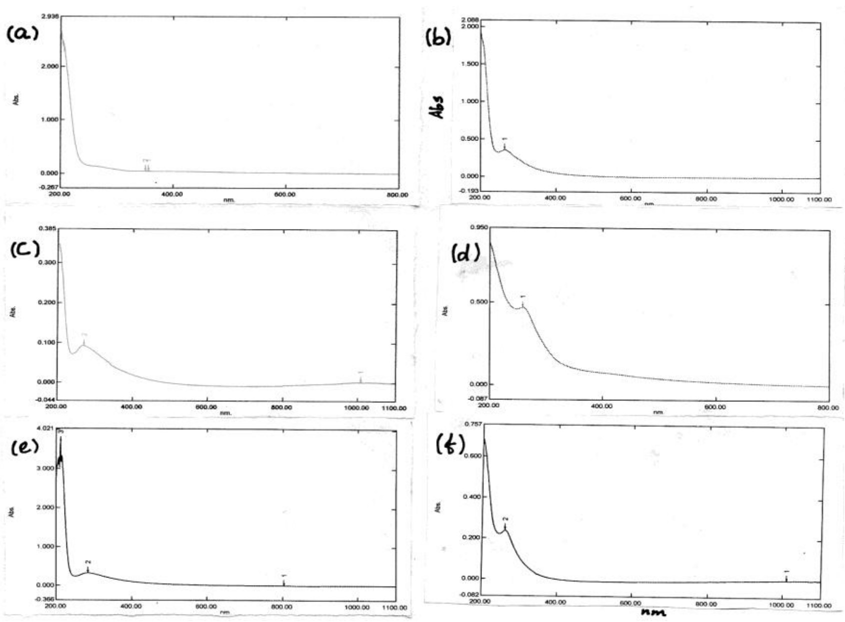


Figure : 3.1(a) UV-VISIBLE Spectra of Plant Extract and 3.1(b-f) UV-VISIBLE Spectra of Synthesized Ag NPs using various concentrations of *PORTULUCA QUADRIFIDA* Plant Extract

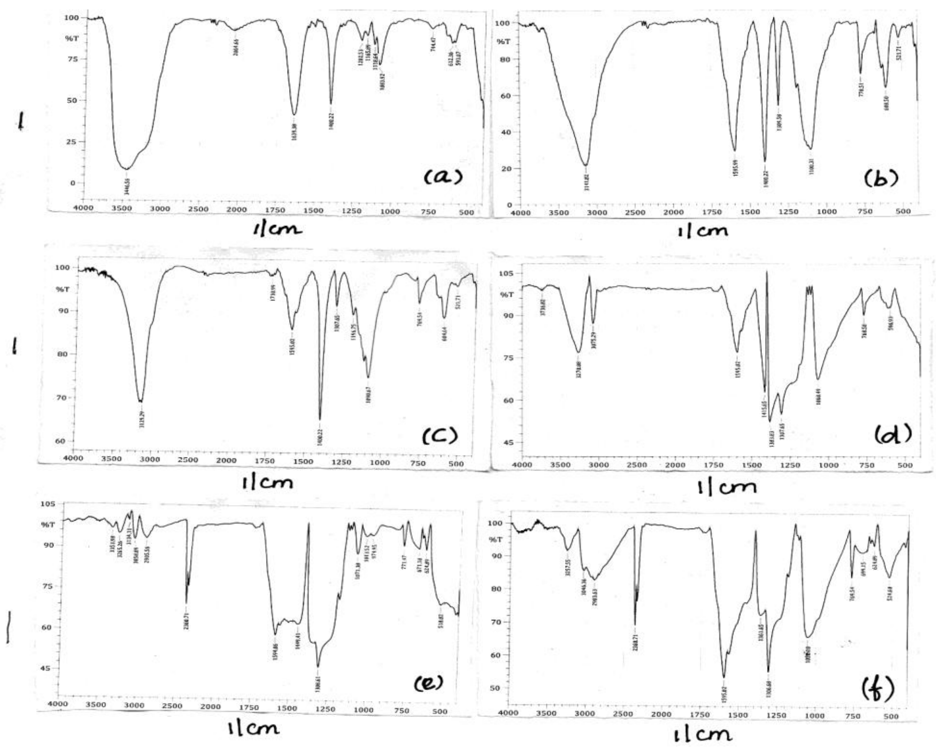


Figure: 3.2 (a) FT-IR Spectra of Plant Extract and

3.2 (b-f) FT-IR Spectra of Synthesized Ag NPs using various concentrations of *PORT ULUCA QUADRIFIDA* Plant Extract

3.3 X- RAY DIFFRACTION ANALYSIS

The XRD patterns of synthesized Ag NPs using *PORTULUCA QUADRIFIDA* plant extract are shown in figure.3.3 (a-e). XRD pattern of the synthesized Ag NPs exhibits the face centered cubic structure corresponding to the four reflection peaks are observed with 2ϴ values of 17˚ 51`, 29˚ 45`, 34˚ 18` and 56˚ they are indexed to the (100), (110), (111) and (221) crystal planes. The XRD peaks intensity of Ag NPs increases with increasing the plant extract concentration (5, 10, 15, 20 and 25ml). It reveals that the decrease in crystalline size with increase of concentration. The average crystal size of the Ag NP is calculated from FWHM of the diffractions peaks using Scherrer's equation.

$$D = k \lambda / \beta \, COS\theta$$

Where, D – Particle in size,

k – Scherrer's coefficient,

ISBN:978-93-87793-61-3

λ – Wavelength of X-ray source (1.5406nm),

β – full width half maximum (FWHM) and

ϴ – diffraction angle

The Ag NPs size is calculated in the range of 27 to 15 nm for different concentration of plant extract (5, 10, 15, 20 and 25ml). Similar results were reported in Ag NPs using Artemisia annua extract (Basavegowda et al) [29] and vitexnegundo extract (Anandalakshmi et al) the synthesized Ag NPs size range is 35 to 20 nm [6].

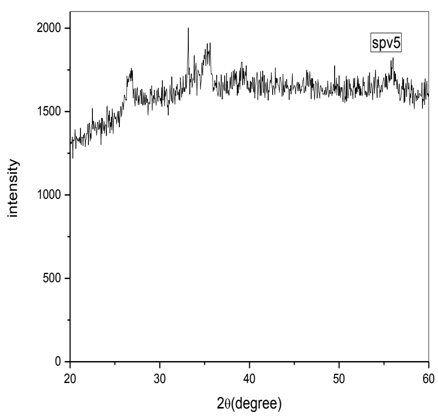


Fig 3.3 (a) 5ml

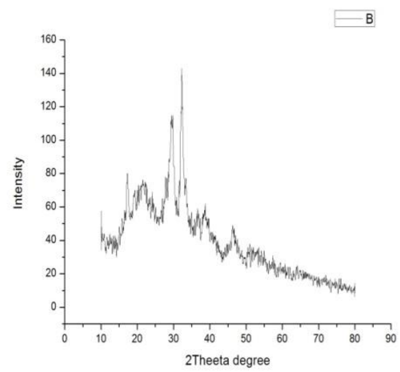


Fig 3.3 (b) 10ml

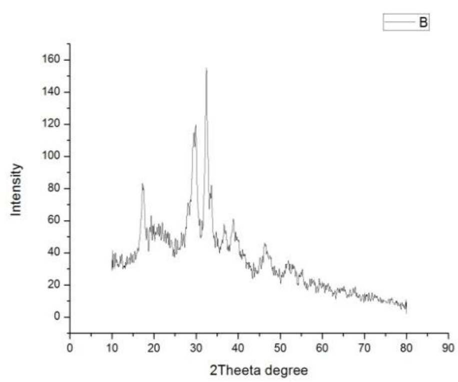


Fig 3.3 (c) 15ml

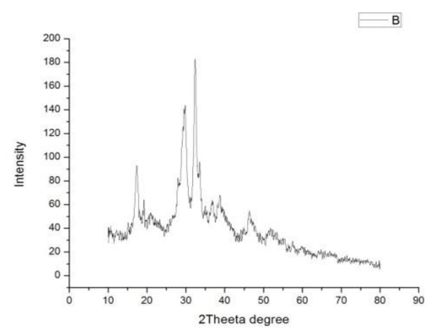


Fig 3.3 (d) 20ml

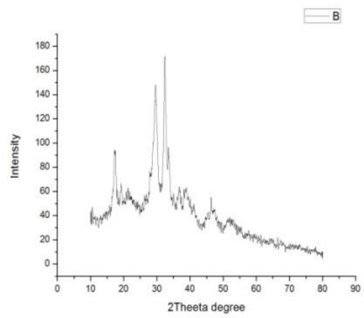


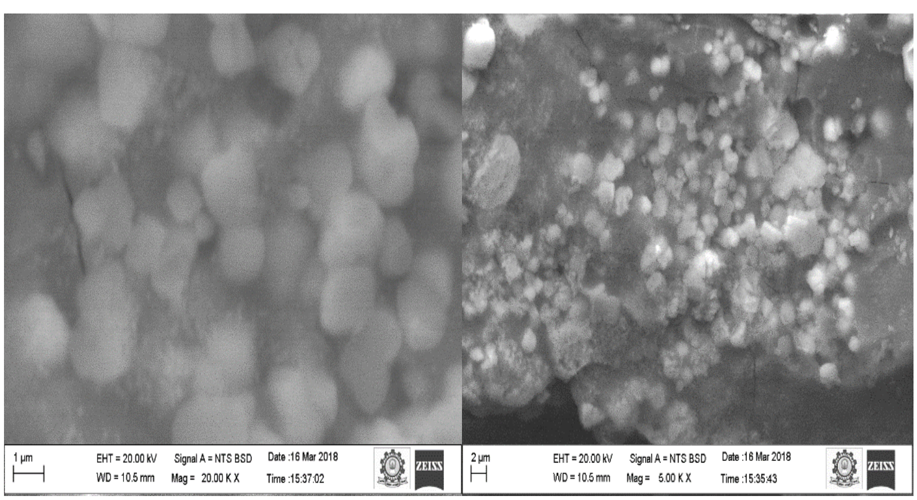
Fig 3.3 **(e) 25ml**

Figure: 3.3 (a-e) XRD diffraction pattern of the Ag NPs prepared in different concentrations of *PORTULUCA QUADRIFIDA* plant extract

3.4 SCANNING ELECTRON MICROSCOPY

Morphology of synthesized silver nanoparticles was characterised by SEM analysis. The sample were placed in an evacuated chamber and scanned in a controlled pattern by an electron beam. Interaction of the electron beam with specimen produces the SEM images of Ag NPs are shown in figure 3.4. It can be view that the Ag NPs formed well dispersed and evenly distributed in all direction.

Fig 3.4 shows different magnification of SEM images of the green synthesized Ag NPs using *PORT ULUCA QUADRIFIDA plant* extract. It shows that the synthesized Ag NPs are in spherical shape. Furthermore, the particle size is observed to be 15 to 27 nm [30,31].



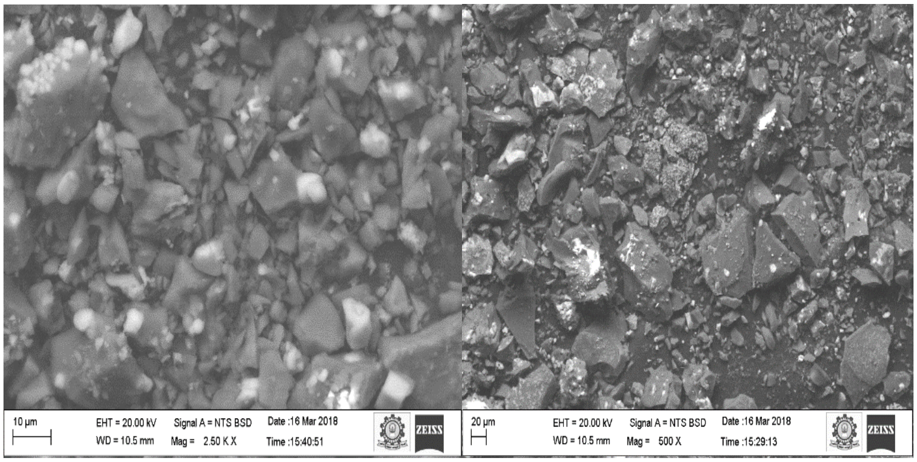
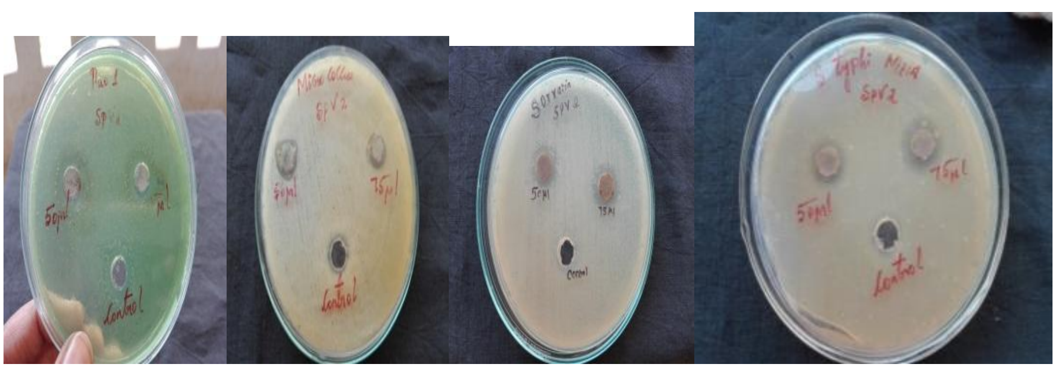


Figure 3.4 SEM images of green synthesized Ag NPs using *PORTULUCAQUADRIFIDA* Plant Extract

3.5 ANTIMICROBIAL ACTIVITY

The plant extract and mediated silver nanoparticles were tested for respective antimicrobial activities towards both gram positive and gram negative bacterial strains showing the Zone of Inhibitions given in table 3.1. The maximum zone of inhibition was measured on the synthesized Ag NPs using 10ml of 75µl of *PORTULUCA QUADRIFIDA* plant extract [32,33].



(a) (b) (c) (d)

(e) (f) (g)

Organisms	Bacteria Type	Zone of Inhibition of 50µl (mm)		Zone of Inhibition of 75µl (mm)	
		5ml	10ml	5ml	10ml
Pseudomonas aeruginosa (Fig .a)	-ve	3	11	4	12
Proteus Seratiaa (Fig .b)	-ve	1	4	2	5
Salmonella Typhi(Fig .c)	-ve	2	2	1	4
P.Vulgaris (Fig .d)	-ve	-	-	-	-
B.Substillis (Fig .e)	+ve	-	-	-	-
S.aureus (Fig .f)	+ve	-	-	-	-
Micrococcus (Fig .g)	+ve	1	3	3	2

4. CONCLUSION

Silver nano particles were synthesized using *PORTULUCA QUADRIFIDA* plant extract by eco friendly green method. The formation of Ag NPs was confirmed by UV-VIS absorption spectroscopic analysis. The functional group present in the plant extract has been confirmed by FT-IR. The polyphenols of plant extract were mainly responsible for the reduction of Ag^{+} ion to Ag NPs. The synthesized Ag NPs were analyzed using FT-IR, UV-VIS, XRD & SEM. XRD pattern of Ag NPs confirms the synthesized particles are in face centered cubic crystalline structure and the sizes of Ag NPs are in the range of 27.62-15.05nm. SEM analyses shows the synthesized Ag NPs is in spherical shape. Ag NPs were effective utilized for the antimicrobial activity study. The maximum ZOI was found to be more in gram negative bacteria when compared to gram positive bacteria. The *PORTULUCAQUADRIFIDA* plant may be effectively utilized for the product of Ag NPs with economically for many pharmaceutical applications.

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