Int. J. Nano Dimens., 13 (2): 244-255, Spring 2022

ORIGINAL ARTICLE

Phytofabrication of Silver nanoparticles using *Abrus precatorius* L Seed extract and their antioxidant and antibacterial activity

Murugeswaran Santhiya Selvam[1], Pious Soris Tresina[2], Gnana raj Gnana Priyanka Beula[3], Veerabahu Ramasamy Mohan [2, *]

[1] Research Scholar (19212232262039), PG & Research Department of Botany, V. O. Chidambaram College, Thoothukudi, Tamil Nadu, India, Affiliated to Manonmaniam Sundaranar University, Tirunelveli, Tamil Nadu, India

[2] Ethnopharmacology Unit, Research Department of Botany, V. O. Chidambaram College, Thoothukudi, Tamil Nadu, India

[3]Research Scholar (18112232262009) PG & Research Department of Botany, V. O. Chidambaram College, Thoothukudi, Tamil Nadu, India

Received 26 October 2021; revised 08 December 2021; accepted 23 December 2021; available online 02 January 2022

Abstract

The present investigation evaluates the potential of aqueous seed extract of *Abrus precatorius* L. for the bio-synthesis of silver nanoparticles (AgNPs). The structure of AgNPs was authenticated by the changes in colour as well as the UV-vis spectroscopy, which showed an absorbance maxima peak at 441 nm. The scanning electron microscope (SEM) investigation proved the particle shape as well as the X-ray diffraction (XRD) that validated the crystalline character of AgNPs. The AFM study also corroborated the surface morphology of manufactured AgNPs. Fourier Transform Infrared (FTIR) approved the presence of alcoholic, and the phenolic groups co-operated an imperative reduction role in the synthesis method. *In vitro,* the antioxidant action of both *A. precatorius* seed extract and AgNPs were scrutinized by DPPH assay. It illustrates the antibacterial activity against the gram negative bacteria *Salmonella paratyphi* as well as the *Escherichia coli*. Compared to other NPs, the AgNPs synthesized in this study were smaller in size that exhibited a higher level of antioxidant and antibacterial activity. From the consequences, it is proposed that green synthesized AgNPs could be employed successfully in future biomedical applications.

Keywords: *Abrus Precatorius; Antibacterial Activity; DPPH Radical Scavenging; Silver Nanoparticles; X-ray Diffraction.*

How to cite this article

Santhiya SelvamM., Soris Tresina2 P., raj Gnana Priyanka Beula G., Ramasamy Mohan V. Phytofabrication of Silver nanoparticles using Abrus precatorius L Seed extract and their antioxidant and antibacterial activity. Int. J. Nano Dimens., 2022; 13(2): 244-255.

INTRODUCTION

In the 21st century, nanotechnology is expected to be the foundation of many biotechnology innovations and is also considered to be the upcoming industrial revolution. Nanomaterials are called a "wonder of modern medicine" and extracted much attention over the past few decades [1]. Nanomaterials are of great significance because of their superior physicochemical and biological characteristics over their bulkiness phase. The size of these nanostructured materials (1-100 nm) recommends a higher surface to volume ratio which leads to high surface reactivity [2]. This distinct property allowed them to be utilized in vast applications in many fields ranging from material science to biotechnology [3]. The metals such as gold, silver and copper have been employed extensively for the fusion of stable dispersion of nanoparticles, which are highly competent in the fields such as biological labeling, photonics and Surface Enhanced Raman Scattering

* Corresponding Author Email: *vrmohanvoc@gmail.com*

(SERS) detection [4-6].

Researchers are discovering green synthesis of Ag nanoparticles to decrease the exercise of toxic and hazardous reactants and formation of by-products figured during the reaction. The green synthesis of the AgNPs being used in medicinal plants does not require any toxic materials, and it is simple and eco-friendly that produces NPs with high efficacy. In addition to this, silver nanoparticles (AgNPs) are non-toxic to eukaryotic cells together with humans, but it has high toxicity beside prokaryotic cells such as microorganisms like bacteria, viruses and fungi [7]. The AgNPs have exceptional chemical, optical, electrical, magnetic and mechanical properties. These unique characteristics of the AgNPs are of interest to researchers in examining its applications in nanomedicine such as antiplasmodial, sensing and imaging, antimicrobial, targeted drug delivery, antifungal, antiplatelet, anticancerous and wound healing [8-15]. The advancement in the synthesis of silver nanoparticles has enlarged a strong impact on numerous scientific areas. Plants contain many phyto constituents that give numerous benefits, including antimicrobial, anticancer and antioxidant activity and the synthesis of the AgNPs with plant sources improves the efficacy with a small quantity. Several works previously reported that the extracts of plants are used for the production of silver nanoparticles such as *Andrographis serpyllifolia* [9]; *Pistacia atlantica* [16]; *Sara asoca* [17]; *Rosa chinensis* [18] *Cinnamomum tamala* [19], *Michelia champaca* [20]; *Cestrum nocturnum* [21]; *Eriobotrya japonica* [22] and *Annona muricata* [23] To the best of understanding of the researchers, till date, nobody has used *Abrus precatorius* seed extract for the blend of silver nanoparticles.

Abrus precatorius is a member of the Fabaceae family and known in a variety of communities with diverse names. The names comprise cat's eye, bead tree, rosary pea and jeoquirity bean. The leaves of *Abrus precatorius* in the Ayurvedic medicine are laxative, expectorant and aphrodisiac medicine. The seeds are known to be purgative, emetic, tonic, antiphlogistic aphrodisiac and antiophthalmic [24]. In the current study, an effort has been made to blend silver nanoparticles using aqueous seed extract of *Abrus precatorius.* The classification was done using UV, FTIR, SEM, XRD and AFM investigation. The synthesized silver nanoparticles have also been estimated for their antioxidant and antibacterial activities.

MATERIALS AND METHODS

Collection of the seed material

The seeds of *Abrus precatorius* L.*,* which belongs to the family Fabaceae, were gathered from the campus of V. O. Chidambaram College, Tuticorin, Tamil Nadu, India.

Preparation of extract for phytochemical screening (Cold maceration method)

Needed quantity of powder was weighed and shifted to Stoppard flask and mixed with water (aqueous) until the powder was fully submerged. The flask was shaken every hour for the first six hours. Followed by this, the extract was filtered using Whatman No.1 filter paper. The extract was subjected to qualitative tests for the identification of diverse phytochemical constituents as per criterion procedure [25].

Green Synthesis of Nanoparticles

Preparation of Mature Seed Extract (Reducing Agent)

Using a glass beaker, twenty gram of grown-up seed powder was heated in 100 mL. double distilled water for 20 minutes. Subsequent to boiling, the extract was sieved using Whatman No. 1.

Preparation of Precursor

Precursors for silver nanoparticle ($AgNO_3$) was obtained from Hi-media Chemicals, India and arranged afresh. With twice distilled water, precursor for organizing silver nanoparticle was 1 mM of silver nitrate.

Synthesis of Silver Nanoparticles

The aqueous solution 10 mL of mature seed extract was purposely added to 20 mL of 1 mM solution of silver nitrate below permanent 20 minutes stirring. The solution was set aside warm for 24 hours at room temperature. In the beginning, colourless solution changed into pale yellow colour. Followed by the process after 24 hours, the colour turned from pale yellow to reddish brown. This indicates the arrangement of silver nanoparticles. It is exposed that aqueous silver ions could be condensed by aqueous extract of entire plant to make exceptionally stable silver nanoparticles in water. At 9000 rpm, the colloidal solution is centrifuged thereby the supernatant was gathered. It is further protected for analysis.

Characterization of the synthesized silver nanoparticles

UV – Vis spectroscopy

Absorption of spectroscopy in the UV-visible spectral section is Ultraviolet-visible spectroscopy (UV-vis). The silver nanoparticles were distinguished in a Shimadzu V 650 UV- vis spectrophotometer. The scanning progression for the samples was 300-700 nm. As a blank orientation, the double distilled water was employed.

Fourier Transform Infra-red Spectroscopy (FTIR)

By employing a Fourier Transform Infrared Spectrophotometer (FTIR Thermo-scientific iS5), the nanoparticles were differentiated. Two milligrams of the sample were combined with 100 mg Potassium bromide (KBr) after which, they were condensed to arrange a salt disc roughly 3mm in diameter. The disc was kept directly in the sample holder. The FTIR spectra were ensured in the absorption range between 400 and 4000 cm^{-1}.

Scanning Electron Microscope (SEM) analysis

Morphological investigation of the synthesized nanoparticles was passed out not using scanning electron microscope (SEM) (Carlzeiss Microscopy GmbH, Germany model EVo18) equipped with 15kv acceleration voltage.

X-Ray Diffraction (XRD) analysis

By making use of the XRD, the particle size as well as nature of the silver nanoparticles was created. This action was performed Using Shimadzu XRD – 6000/6100 model with 30 kv, 30 mA with Cukα radians at 2θ angle. The X-ray powder diffraction is a rapid analytical practice mainly employed for phase arrangement of a crystalline substance. This can also offer information on unit cell dimensions. The analyzed substance is specifically ground, and the normal bulk composition is approximated out. The particle or grain dimension of the particles on the silver nanoparticles was instituted by applying Debye Sherrer's equation.

$$D = 0.94 \lambda / B \cos \theta$$

AFM analysis

Surface topology of the manufactured silver nanoparticles was found by 1µm x 1µm Atomic Force Microscopy (AFM Nanosurf 2) scrutiny, 0.01 g produced nanoparticles were merged with 20 mL of acetone and sonicated for 5-10 minutes ultrasonicator. On a clean glass slide, the solution was poured. Added to the same, this was permitted to dry until all the acetone got evaporated. Then, this glass slide was investigated using the Atomic Force Microscopy in a noncontact mode and the captured image was directed by using the XEI software.

Antioxidant activity

The antioxidant activity of *A. precatorius* seed extract in addition to biosynthesis AgNPs were evaluated *in vitro* method. Ascorbic acid is utilized as a standard control.

DPPH radical scavenging activity

The hydrogen atom or electron donation facility of the compounds was evaluated from the bleaching of the purple coloured methanol solution of 2, 2-Diphenyl-1-picrylhydrazyl (DPPH) [26]. The spectrophotometric analyze utilizes the stable radical DPPH as a reagent. 1 mL of diverse concentration of the finest compounds (12.5, 25, 50, 100 and 200 µg/mL) was poured to 4 mL of 0.004% (w/v) methanol solution of the DPPH. Succeeding to 30 min incubation period at room temperature, the absorbance was computed beside blank at 517 nm. The percent of inhibition (%) of free radical production from the DPPH was calculated by the following equation.

$$\text{Radical scavenging activity} = \frac{(Ac-As)}{Ac} \times 100$$

Here, (Ac) is the absorbance of the control radical holding all reagents excluding the test compound and (As) is the absorbance of the test compound. Tests were performed in triplicate.

Antibacterial assay

Antibacterial action of synthesized nanoparticles was found by making use of disc diffusion technique [27]. *Bacillus thuringiensis, Streptococcucs faecalis, Salmonella paratyphi* and *Escherichia coli* the test bacteria were acquired from the Research Laboratory, Department of Microbiology, Bharathidasan University, Tiruchiapalli, and Tamil Nadu. The bacterial cultures incubated overnight were extended over the newly made Muller-Hinton agar plates. The 6 mm sterile disc (Hi media) was kept back at the centre and diverse

concentrations of manufactured nanoparticles (40 µg/mL 80 µg/mL and 100 µg/mL) was transmitted on disc and placed on the plate. The tetracycline disc (reference or positive control), $AgNO_3$ solution without extracts and seed aqueous extract were also reserved. It is further incubated at 37 ˚C for 24hour and subsequent to incubation the zone of inhibition was determined.

RESULTS AND DISCUSSION

Phytochemical Screening of Aqueous Extract

The distribution of different phytochemical constituents in aqueous seed extract of *A. precatorius* was estimated qualitatively and the outcomes are present in Table 1. The presence of alkaloid, flavonoid, saponin, steroid, phenol, tannin, glycoside and xanthoprotein has been validated in the aqueous seed extract of *A. precatorius*. When *A. precatorius* seed extract was added to $AgNO_3$ solutions, these phytochemicals reduce Ag^+ ions into Ag atoms which then join to form AgNPs. The phytochemicals also serve as capping agents and thus defend and stabilize the nanoparticles by avoiding agglomeration.

Characterization of Silver Nanoparticles

UV-Vis Spectroscopic Analysis

Reaction was seen as the colour changed from light-yellow to dark brown within 24hours of the addition of reaction mixture. Fig. 1 illustrates the difference in colour of extract and created silver nanoparticles (AgNPs). During the reaction time, the changing colour of reaction mixture is the primary indication of nanoparticles synthesis [28]. The brown colour formation is the characteristic of AgNPs formation. The changes in colour owing to size of nanoparticles also depend on their Surface Plasmon resonance (SPR) [29, 30]. Moreover, UV-vis analysis monitoring the process of the reaction while reduction of Ag^+ was also confirmed the formation of AgNPs. The UV-vis Spectroscopic peak at 441 nm was scrutinized and confirmed AgNPs synthesis (Fig 2). Parallel results were observed by AgNPs using *Citrus sinensis* peel extract [31] and

Table 1. Preliminary phytochemical screening of aqueous seed extract of *A. precatorius.*

Phytochemicals	Aqueous extract
Alkaloid	+
Anthraquinone	-
Catechin	-
Coumarin	-
Flavonoid	+
Phenol	+
Saponin	+
Steroid	+
Tannin	+
Terpenoid	-
Sugar	-
Glycoside	+
Xanthoprotein	+

+ Present - Absent

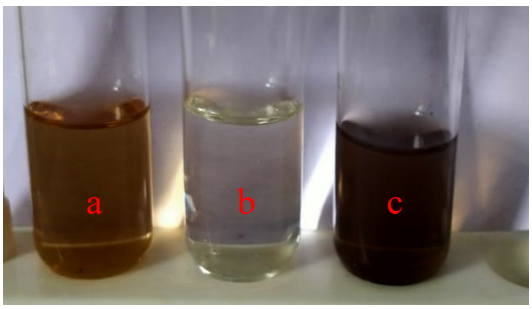


Fig. 1. Synthesis of silver nanoparticles from *A. precatorius* a-Plant extract, b- Silver, nitrate c- Silver nanoparticles.

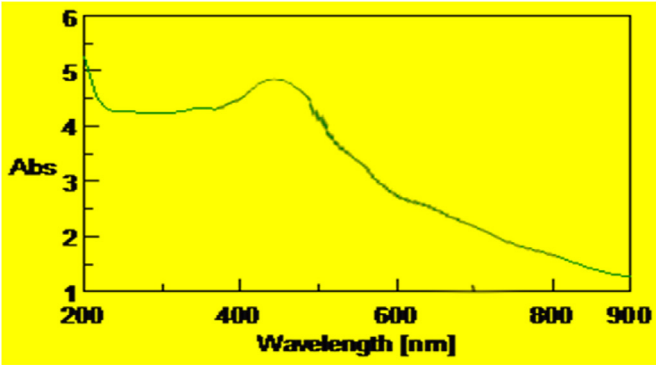


Fig. 2. UV-visible spectrum of silver nanoparticles of *A. precatorius* seed.

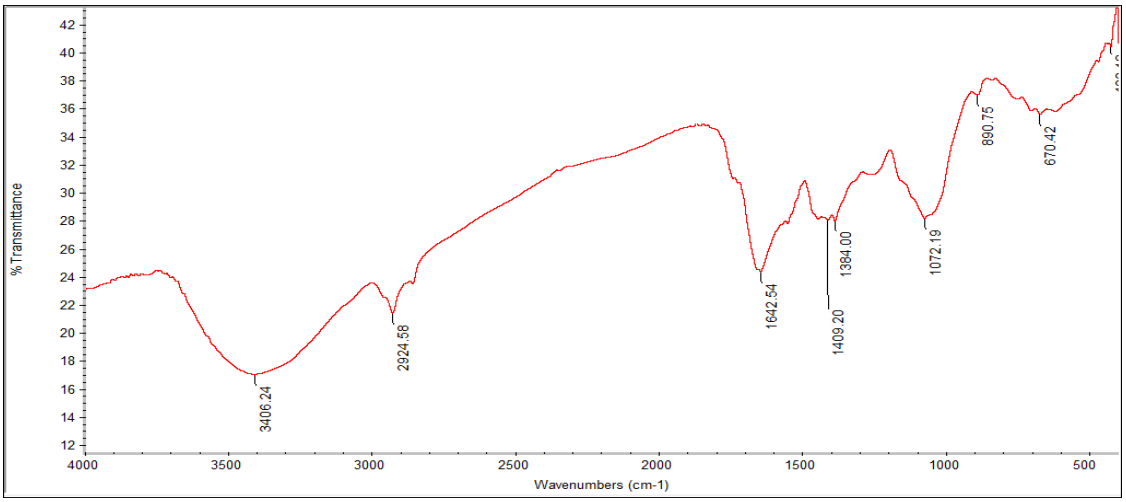


Fig. 3. FT-IR spectrum of seed powder of *A. precatorius.*

Aerva lanta flower extract [32]. The characteristic peak around 400-450 nm is exact for AgNPs. The shifting of peak from shorten wavelength to higher wavelength indicates the formation of smaller to higher nanoparticles, correspondingly [30].

FT-IR Analysis

The functional groups of seed and synthesized silver nanoparticles were identified by using the FT-IR spectroscopy. This is identified between the scan ranges 400 and 4000 cm^{-1}. The FTIR spectrum obtained for seed (Fig. 3) shows number of absorption peaks like 3406 cm^{-1} for O-H stretch of alcohols/phenols, 2924 cm^{-1} for OH widen of carboxylic acid, 1642 cm^{-1} for N-H bend of secondary amine, 1409 cm^{-1} for C-C stretch aromatics, 1384 cm^{-1} for C-H rock of alkanes, 1072 cm^{-1} for C-N stretch of aliphatic amines, 890 cm^{-1} for CH "oop" of aromatics and 670 cm^{-1} for C-Br stretch of alkyl halides. The FT-IR spectrum of synthesized AgNPs (Fig 4) shows the 3841 cm^{-1} for OH stretch of hydroxyl, 3394 cm^{-1} for OH stretch of alcohol/phenols, 2924 cm^{-1} for O-H stretch of carboxylic acid 2853 cm^{-1} for C-H stretch of alkanes, 1618 cm^{-1} for N-H bend of secondary amine, 1338 cm^{-1} for C-H rock of alkanes 1216 cm^{-1} for C-O stretch of esters and ethers, 1071 and 1034 cm^{-1} for C-N stretch of aliphatic amines, 826 and 748cm^{-1} for C-H "oop" of aromatic 668 and 550 cm^{-1} for C-Br of alkyl halides. The FT-IR results confirmed the various functional groups which are present on the surface of bioactive compounds. This functional group is responsible for the capping of silver nanoparticles and stable in nanosize [21]. The slight variation in the peak for capped AgNPs is observed (Table 2) that shows the interaction of biomolecules in the extract with the surface of prepared samples [33].

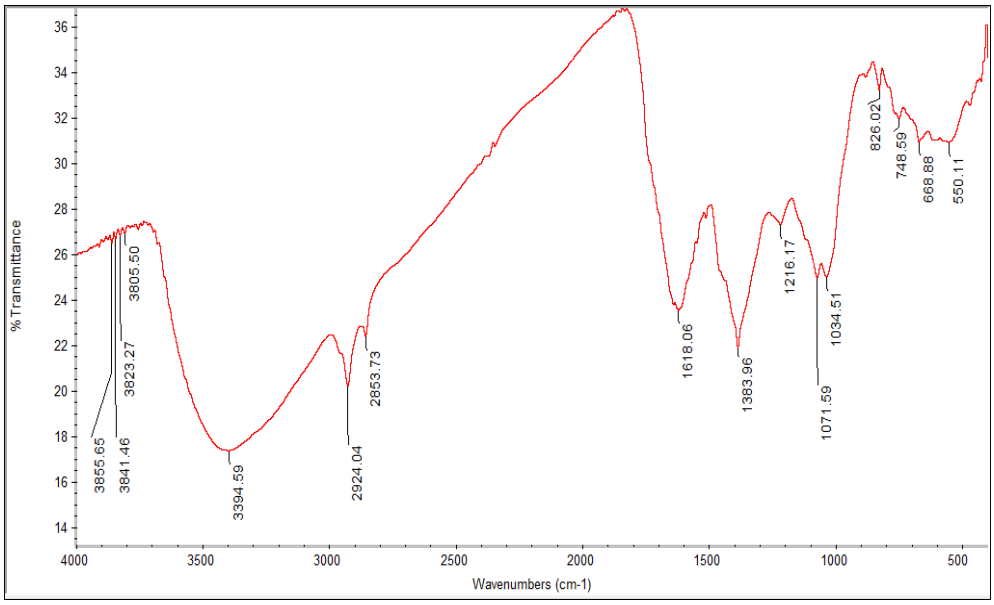


Fig. 4. FT-IR spectrum of silver nanoparticles of *A. precatorius* seed.

Table 2. FT-IR analysis of powder and synthesized nanoparticles of *Abrus precatorius* seed.

S. No.	Frequency (cm^{-1})	Chemical Bond	Phytoconstituents Present	Peak Observed (Seed Powder)	Peak Observed (AgNPs)
1.	3850-3500	O-H Stretch	Hydroxyl group	-	3841
2.	3500-3200	O-H Stretch	Alcohols or Phenols	3406	3394
3.	3300-2500	O-H Stretch	Carboxylic acid	2924	2924
4.	3000-2850	C-H Stretch	Alkanes	-	2893
5.	1650-1550	N-H bend	Secondary amine	1642	1618
6.	1600- 1585	C-C stretch (in ring)	Aromatics	-	-
7.	1500-1400	C-C stretch	Aromatics	1409	-
8.	1390-1350	C-H rock	Alkanes	1384	1383
9.	1360-1290	N-O Symmetric Stretch	Nitro Compound	-	-
10.	1320-1000	C-O stretch	Esters, Ethers	-	1216
11.	1250-1020	C-N stretch	Aliphatic amines	1072	1071, 1034
12.	910-665	N-H wag	1°, 2° amines	-	-
13.	900-675	C-H “oop”	Aromatics	890	748, 826
14.	690-400	C-Br Stretch	Alkyl halides	670	668, 550

Scanning Electron Microscopy (SEM) Analysis

To analyze the morphology and the growth, features of the prepared nanoparticles scanning electron microscopy were employed. Fig. 5 represents the SEM image of AgNPs synthesized using *A. precatorius* seed extract. The picture substantiates the flake like structure to the AgNPs with granular nature. From the SEM images, the crystalline size of AgNPs synthesized using *A. precatorius* seed extract was found to be 9 to 15 nm range.

X-Ray Diffraction (XRD) Analysis

The XRD pattern illustrated a number of Bragg reflections that may be manifested on the basis of face-centered cubic structure of silver. The XRD analysis proved that the silver particles outlined in the experiments were in the form of nano structures, as supported by the peaks at 2θ values of 28.03°, 32.42°, 38.39°, 44.52°, 46.26°, 57.71°, 64.78°, and 77.65°, matching to (200) (210) (210) (211) (211) and (220) Bragg reflections correspondingly in Fig. 6 related to (111) (111) crystalline and amorphous organic stages. It was found that the average size from the XRD data and using the Debye- Scherrer equation was around 9.60 nm.

Atomic Force Microscopy (AFM) Analysis

By using 1µm X 1 µm Atomic Force Microscopy

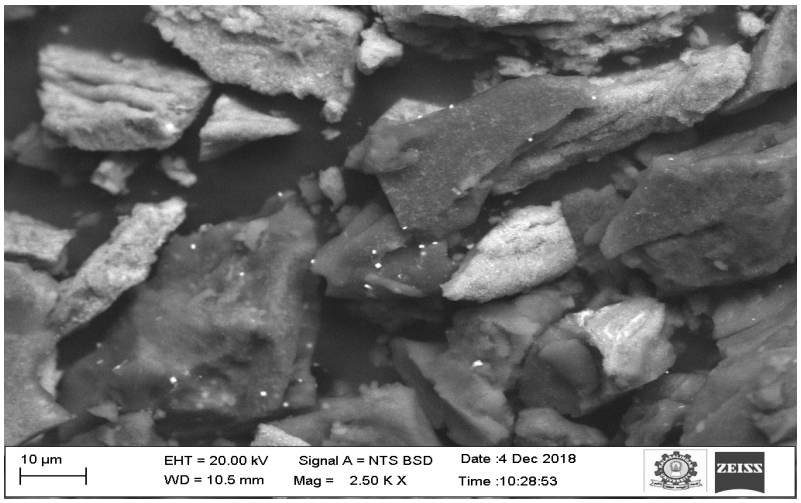


Fig. 5. SEM image of silver nanoparticles of *A. precatorius* seed.

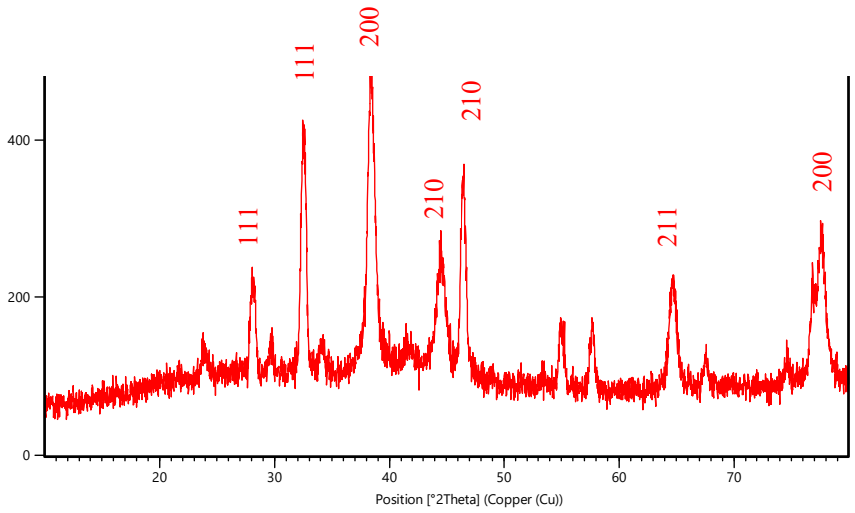


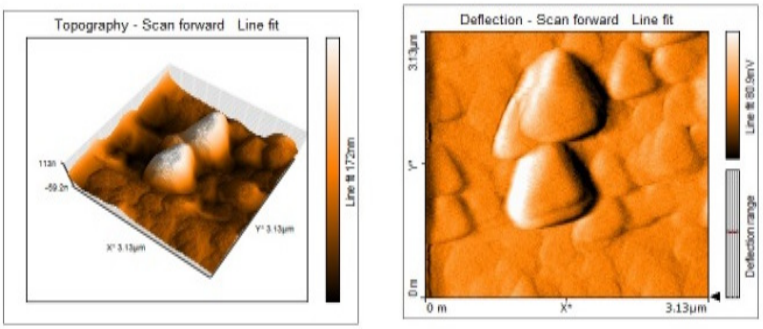
Fig. 6. XRD pattern of synthesized silver nanoparticles of *A. precatorius* seed.

(AFM) analysis, surface topology of the synthesized AgNPs was studied. The AFM was employed as the chief method to monitor AgNPs dissolution and agglomeration model. The topography matrix data ought to be indulged in each profile line (2D) or over all profile expanding the study of surface (3D). The topography of micrographs clearly designates that the formulated AgNPs possess pyramid in shape (Fig 7 a, b). 3D images show the height of the nanoparticles and no further agglomeration were confirmed by the AFM.

Antioxidant activity

In the current study, the antioxidant potential of silver nanoparticles synthesized by *A. precatorius* seed extract was assessed. This is done by using the DPPH scavenging assay (Fig 8). The DPPH assay was extensively used to estimate antioxidants properties of compounds for searching free radicals.

In this study, the DPPH radical scavenging action was increased on the basis of a dependent method. Similarly, dose dependent activity was found out in the AgNPs using *A. precatorius* seed extracts. When the AgNPs and standard ascorbic acid showed 69.36% and 81.36%, then DPPH radical is scavenging activity respectively at 200µg/mL. The DPPH IC_{50} value for AgNPs is 29.46 µg/mL, and standard ascorbic acid IC_{50} is 32.94 µg/mL. This study showed a dose dependent radical scavenging



(a) 2D Topography (b) 3D Topography

Fig. 7. AFM structure of silver nanoparticles of *A. precatorius* seed.

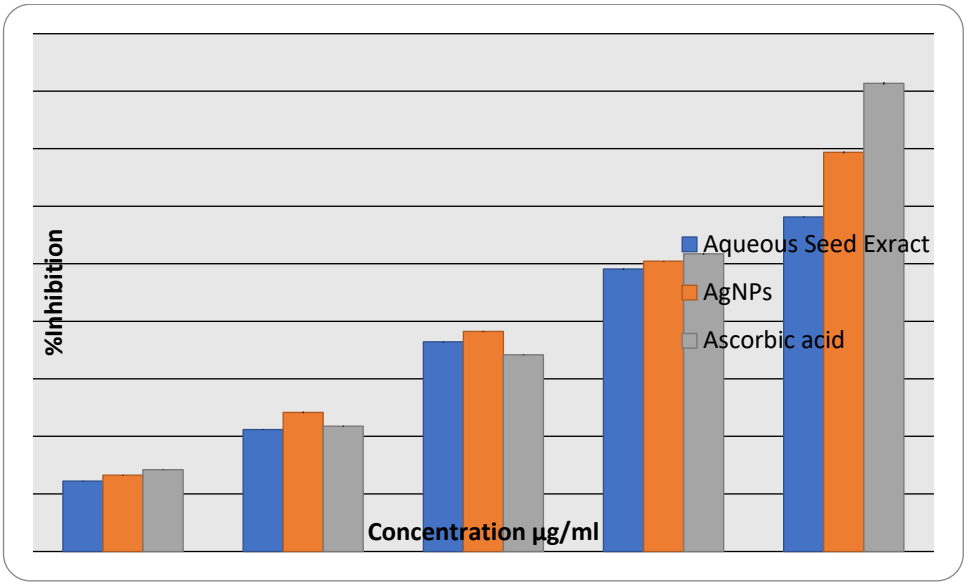


Fig. 8. DPPH radical scavenging activity.

Table 3. DPPH radical scavenging activity of synthesized AgNPs compared with other previously synthesized silver nanoparticles.

Name of the plant	Plant part	DPPH activity	Reference
Abrus precatorious	seed	69.36%	
Andrographis serpyllifolia	leaf	68.27%	[9]
Calophyllum tomentosum	leaf	90%	[38]
Cestrum nocturnum	Leaf	29.55%	[21]
Chenopodium murale	Leaf	65.43%	[34]
Elephantopus scaber	Leaf	85.90%	[39]
Avicennia officinalis	Leaf	74.85%	[40]
Xylocarpus granatum	Bark	100%	
Momordica charantia	Fruit	49.7%	(41)
Avera lantana	Flower	54.14	(32)
Carissa carandas	Leaf	34.81	(42)

Table 4. Antibacterial activity of synthesized AgNPs of *A. precatorius* seed.

Zone of Inhibition (mm)						
Name of the Bacterial Pathogen	Tetracycline 30mcg/ disc	Aqueous extract100µg	AgNPs 100µg	AgNPs Different Concentration		
				40 µg	80 µg	100 µg
Bacillus thuringiensis	26	3.20	9.10	6.00	9.80	12.30
Streptococcus faecalis	24	3.40	7.20	6.50	10.30	11.50
Salmonella paratyphi	25	2.80	8.50	7.50	10.50	13.50
Escherichia coli	22	3.80	7.20	6.70	9.50	13.00

Table 5. Antibacterial activity of synthesized AgNPs compared with other previously synthesized silver nanoparticles.

Name of the plant	Plant part	Microorganism	Zone inhibition nm	Reference
Abrus precatorious	Seed	*Bacillus thuringiensis*	12.30	
		Streptococcus faecalis	11.50	
		Salmonella paratyphi	13.50	
		Escherichia coli	13.00	
Avera lantana	flower	*Staphylococcus aureus*	14	[32]
		Bacillus subtilis	14	
		Escherichia coli	11	
		Klebsiella pneumoniae	12	
Neurada Procumbens	leaf	*Klebsiella pneumoniae*	>17	
		Acinetobacter baumannii	<14	
		Escherichia coli	12-14	
Abelmoschus esculentus	flower	*Bacillus subtilis*	12	[44]
		Staphylococcus aureus	13	
		Staphylococcus epidermidis	12	
		Streptococcus pyogenes	13	
		Klebsiella pneumoniae	14	
		Escherichia coli	13	
		Pseudomonas aeruginosa	11	
		Proteus vulgaris	16	
		Salmonella typhimurium	12	
		Shigella sonnei	14	
Andrographis serpyllifolia	flower	*Staphylococcus aureus*	16	[9]
		Lactobacillus	20	
		Enterococcus	18	
		Escherichia coli	18	
Calophyllum tomentosum	leaf	*Pseudomonas aeruginosa*	8	[38]
		Escherichia coli	7	
		Staphylococcus aureus	16	
		Klebsiella aerogenes	16	
Cestrum nocturnum	leaf	*Citrobacters*	36	[21]
		Salmonella typhii	28	
		Enterococcus faecalis	15	
		Escherichia coli	23	
		Proteus vulgaris	26	
		Vibrio cholerae	41	

action of the AgNPs. The DPPH radical scavenging activity of presently synthesized AgNPs of *A. precatorius* was compared with the DPPH radical scavenging activity of previously synthesized silver nanoparticles (Table 3). The plant extract encloses certain bioactive compounds like phenolic and flavonoid that are chief agents for the antioxidant motion [35].

Antibacterial Activity

The *A. precatorius* seed extract that derived AgNPs was additionally studied on the basis of its antibacterial activity in opposition to four bacterial strains two gram positive (+) and two gram negative (-); namely, *Bacillus thuringiensis* (+) *Streptococcus faecalis* (+), *Salmonella paratyphi* (-) and *Escherichia coli* (-). The results demonstrated that the green synthesized AgNPs had revealed bactericidal action against all the strains in a dose reliant fashion (Table 4). Based on the consequences, the gram negative bacteria displayed the large diameter of the reserve zone contrasted to the gram positive bacteria. The antibacterial activity of presently synthesized AgNPs of *A. precatorius* was comparable with the antibacterial activity of previously synthesized silver nanoparticles (Table 5).

An imperative factor for the antibacterial effectivity of compounds is bacterial cell structure. The current study shows that gram negative bacteria are more vulnerable to the AgNPs compared to gram positive bacteria. This is due to the disparities in the structure of cell membrane and cell wall connecting gram positive and gram negative bacteria [36]. Negatively altered bacterial cell membranes and cell wall are the chief sites of attachment for positively altered the AgNPs. Silver nanostructures aggregate on the bacterial cell surface and therefore disturb its functions. Yet the AgNPs are also able to go through the bacterial cell membrane and consequently enter the cytoplasm where highly reactive silver ions are discharged from their surface. As Ag+ ions released intracellular play a vital role in bactericidal activity [37]. Four different possible routes were reported for the antimicrobial mechanism of action of the AgNPs. These include (i) interaction between the AgNPs and the surface of the cell wall and membrane. (ii) The AgNPs penetration into the cell and damage to intercellular organelles. (iii) The AgNPs induced cellular toxicity and oxidative stress caused by the generation of ROS and free radicals, and (iv) The AgNPs regulation of the signaling pathways that inhibit proliferation [45].

CONCLUSION

The present study demonstrated the AgNPs which have been successfully synthesized using *Abrus precatorius* seed extract. The UV-vis, FT-IR, XRD, SEM and AFM analysis were used to confirm the formation of the AgNPs by green method. The UV-vis spectra confirm the formation of green synthesized silver nanoparticles based on the surface Plasmon resonance study. The phytochemical were responsible for reducing and capping of the AgNPs which was confirmed by the FTIR spectra. The SEM results revealed flake like structure to the AgNPs with granular nature. The average size of the AgNPs was determined by the XRD analysis. The surface morphology of the AgNPs was studied by the AFM. From the results, it is obvious to know that the silver nanoparticles from *Abrus precatorius* seed extract also have the capability to inhibit the growth of gram negative bacteria like *Salmonella paratyphi* and *Escherichia coli*. *In vitro* antioxidant action by DPPH analyze has exposed the AgNPs produced by the *A. precatorius* seed extract exhibited biggest activity.

ACKNOWLEDGEMENT

The authors recognize Kalasalingam University, Krishnankovil for providing their support to bring out the SEM analysis and the Department of Physics, Manonmaniam Sundaranar University, Tirunelveli to bring out the XRD study.

DISCLOSURE STATEMENT

No probable conflict of interest was accounted by the authors.

REFERENCES

[1] Gunalana S., Sivaraja R., Rajendranb V., (2012), Green synthesized ZnO nanoparticles against bacterial and fungal pathogens. *Prog. Nat. Sci. Mater.* 22: 693-700.

[2] Geonmonond R. S., Da Silva A. G. M., Camargo P. H. C., (2018), Controlled synthesis of nobel metal nanomaterials: motivation, principles and opportunities in nanotechnology. *An. Acad. Bras. Cienc.* 90: 719-744.

[3] Selim Y. A., Azb M. A., Ragab I., Abd El Azim M. H. M., (2020), Green synthesis of zinc oxide nanoparticals using aqueous extract of Deverra tortuosa and their cytotoxic activities. *Sci. Rep.* 10: 3445-3451.

[4] Smith A. M., Duan M., Rhyner N. M., Ruan G., Nie S. A., (2006), A systematic examination of surface coatings on the optical and chemical properties of semiconductor quantum dots. *Phys. Chem. Chem. Phys.* 8: 3895-3903.

[5] Kearns G. J., Foster E. W., Hutchison J. E., (2006), Substrates

for direct imaging of chemically functionalized SiO_2 surfaces by transmission electron microscopy. *J. Anal. Chem.* 78: 298-303.

[6] Sadeghi B., Mohammadzadeh M., Babakhani B., (2015), Green synthesis of gold nanoparticles using *Stevia rebaudiana* leaf extracts: Characterization and their stability. *J. Photochem. Photobiol. B: Biol.* 148: 101-106.

[7] Hussain I., Singh N. B., Singh A., Singh H., Singh S. C., (2016), Green synthesis of nanoparticles and its potential application. *Biotechnol Lett.* 38: 545-560.

[8] Mishra A., Kaushik N. K., Sardar M., Sahal D., (2013), Evaluation of antiplasmodial activity of green synthesis silver nanoparticles. *Colloids Surf. B. Biointerf.* 111: 713 -721.

[9] Palithya S., Kotakadi V. S., Pechalaneni J., Challagundla V. N., (2018), Biofabrication of silver nanoparticles by leaf extract of *Andrographis serpyllifolia* and their antimicrobial and antioxidant activity. *Int. J. Nano Dimens.* 9: 398-407.

[10] Kanwar R., Rathee J., Salunke D. B., Mehta S. K., (2019), Green nanotechnology driven drug delivery assemblies. *ACS Omega.* 5: 8804-8815.

[11] Lee K. S., El-Sayed M. A., (2006), Gold and silver nanoparticles in sensing and imaging: sensitivity of plasmon response to size, shape and metal composition. *J. Phys. Chem.* 110: 19220-19225.

[12] Mekky A. E., Farray A. A., Hmed A. A., Sofy A. R., (2021), Antibacterial and antifungal activity of green synthesized silver nanoparticles using *Spinacia oleracea* leaves extracts. *Egyp. J. Chem.* 64: 3-6.

[13] Sadeghi B., Gholamhoseinpour F., (2015), A study on the stability and green synthesis of silver nanoparticles using *Ziziphora tenuior* (Zt) extract at room temperature. *Spectro Acta Part A: Mol. Biomol. Spect.* 134: 310-315.

[14] Sadeghi B., Jamali M., Kia Sh., Amini Nia A., Ghafari S., (2010), Synthesis and characterization of silver nanoparticles for antibacterial activity. *Int. J. Nano Dimens.* 1: 119-124.

[15] Chinnasamy G., Chandrasekharan S., Kob T. W., Bhatnar S., (2021), Synthesis, characterization, antibacterial and wound healing efficacy of silver nanoparticles from *Azadirachta indica. Front Microbiol.* 12: 611560.

[16] Sadeghi B., Rostami A., Momeni S. S., (2015), Facile green synthesis of silver nanoparticles using seed aqueous extract of *Pistacia atlantica* and its antibacterial activity. *Spect Acta Part A: Mol. Biomol. Spect.* 134: 326-332.

[17] Fatema S., Shirsat M., Farooqui M., Arif P. M., (2019), Biosynthesis of silver nanoparticle using aqueous extract of *Saraca asoca* leaves, its characterization and antimicrobial activity. *Int. J. Nano Dimens.* 10: 163-168.

[18] Bangale S., Ghotekars., (2019)., Biofabrication of silver nanoparticles using *Rosa chinensis* L extract for antibacterial activities. *Int. J. Nano Dimens.* 10: 217-224.

[19] Nahar K., Aziz S., Bashar M. S., Haque Md. A., Al. Reza S. Md., (2020), Synthesis and characterization of silver nanoparticles from *Cinnamomum tamala* leaf extract and its antibacterial potential. *Int. J. Nano Dimens.* 11: 88-98.

[20] Daphedar A., Ritti M., Patil N., Patil S., Kakkalameli S., Taranath T. C., (2020), Synthesis and characterization of silver nanoparticles from fruit extract of *Michelia champaca* L. their antioxidant and antibacterial activity. *Int. J. Nano Dimens.* 11: 267-276.

[21] Keshari A. K., Srivastava R., Singh P., Yadav V. B., Nath G., (2020), Antioxidant and antibacterial activity of silver nanoparticles synthesized by *Cestrum nocturnum. J. Ayu Inkegra Med.* 11: 37-44.

[22] Jabir M. S., Hussien A. A., Soliman G. M., Yaseen N. Y., Dewar Y. H., Alwahibi M. S., Soliman D. A., Rizwana H., (2021a), Green synthesis of silver nanoparticles from *Eribotrya japonica* extract: A promising approach against cancer cells, proliferation, inflammation, allergic disorders and phagocytosis induction. *Artit. Cells. Nanomed Biotech.* 49: 48-60.

[23] Jabir M. S., Saleh Y. M., Sulaiman G. M., Yaseen N. Y., Satib U. I., Dewir Y. H., Alwatibi M. S., Soliman D. A., (2021b), Green synthesis of silver nanoparticles using *Annona muricata* extract as an inducer of apoptosis in cancer cells and inhibitor for NLRP3 inflammasome via enhanced autophagy. *Nanomater.* 11: 384-390.

[24] Manoharan S., Balaji R., Aruna A., Niraimathi V., Manikandan G., Babu M. B. V., Vijaya P., (2010), Preliminary phytochemical and cytotoxic property of leaves *Abrus precatorius* Linn. *J. Har. Med. Toxlcol.* 4: 21-24.

[25] Brinda P., Saikala P., Purushothaman K. K., (1981), Pharmacognostic studies on *Merugan Kizhangu. Bull. Med. Eth. Bot. Res.* 3: 84-96.

[26] Mithal A. K., Kaler A., Beneju U. C., (2012), Free radical scavenging and antioxidant activity of silver nanoparticles synthesized from flower extract of *Rhododendron Dausricum*. *Nano Biomedic. Eng.* 4: 118-124.

[27] Bauer A. W., Kirby W. M., Sherris J. C., Turck M., (1996), Antibiotic susceptibility testing by a standardized single disc method. *Am. J. Clin. Pathol.* 45: 493-496.

[28] Patil M. P., Kim G. D., (2017), Eco-friendly approach for nanoparticles synthesis and mechanism behind antibacterial activity of silver and anticancer activity of gold nanoparticles. *Appl. Microbiol. Biotechnol*. 101: 79-92.

[29] Vankatesan J., Kim S. K., Shim M. S., (2017), Antimicrobial, antioxidant and anticancer activities of biosynthesized silver nanoparticles using marine algae *Ecklonia* eava. *Nanomater.* 6: 235-241.

[30] Patil M. P., Palme J., Simeon N. C., Jim X., Lin X., Nagabir D., Kim N. H., Tarte N. H., Kim G. D., (2017), Silver–silver chloride nanoparticles and their antibacterial and anticancer activities. *New. J. Chem.* 41*:* 1363-1371.

[31] Nahar K., Rahamau Md. H., Khan G. M. A., Islam Md. K., Al-Reza S. Md., (2021), Green synthesis of silver nanoparticles from *Citrus sinensis* peel extract and its antibacterial potential. *Asian J. Green Chem.* 5: 135-150.

[32] Palithya S., Gaddam S. A., Kotakadi V. S., Penchalaneni J., Golla N., Krishna S. B. N., Naidu C. V., (2021), Green synthesis of silver nanoparicles using flower extracts of *Aerva lanata* and their biomedical application. *Particu. Sci. Tech.* 10: 919259.

[33] Tudu S. C., Zubko M., Kusz J., Bhattacharjee A., (2020), Structural, morphological and optical characterization of green synthesized ZnS nanoparticles using *Azadirachta indica* (Neem) leaf extract. *Int. J. Nano Dimens.* 11: 99-111.

[34] Abdel-Aziz M. S., Sheheen M. S., El-Nekeety A. A., Abdel-Wahhab M. A., (2013), Antioxidant and antibacterial activity of silver nanoparticles biosynthesized using *Chenopodium murale* leaf extract. *J. Saudi Chem. Soc.* 18: 356-363.

[35] Sriramulu M., Sumathi S., (2017), Photocatalytic, antioxidant, antibacterial and anti-inflammatory activity of silver nanoparticles synthesized using forest edible

mushroom. *Adv. Nat. Sci. Nanosci. Nanotechnol.* 8: 045012-045016.

[36] Dakal T. C., Kumar A., Majumdar R. S., Yadav V., (2016), Mechanistic basis of antimicrobial actions of silver nanoparticles. *Front. Microbiol*. 7: 1831-1837.

[37] Banasink R., Krychowiak M., Swigon D., Thomaaszawicz W., Michalak A., Chylewska A., Ziabka M., Lapinski M., Koscielska B., Narajczyk M., Krolika A., (2020), Carnivorous plants used for green synthesis of silver nanoparticles with broad spectrum antimicrobial activity. *Arab. J. Chem*. 13: 1415-1428.

[38] Govindappa M., Hemashekher B., Arthikala M. K., Rai V. R., Ramachantra Y. L., (2018), Characterization, antibacterial, antioxidant, antidiabetic, antiinflammaory and antityrosinase activity of green synthesized silver nanoparticles using *Calophyllum tomentosum* leaves extract. *Res. in Phy.* 9: 400-408.

[39] Kharat S. N., Mendhulkar V. D., (2016), Synthesis, characterization and studies on antioxidant activity of silver nanoparticles using *Elephantopus scaber* leaf extract. *Mat. Sci. Eng*. 62: 719-724.

[40] Das S. K., Behora S., Patra J. K., Thatoi H., (2019), Green synthesis of silver nanoparticles using *Avicanmia officinalis* and xylocarpus granatum extracts and in vitro evaluation of antioxidant, antidiabetic and antiinflammatory activities. *J. Clu. Sci.* 30: 1103-1113.

[41] Moorthy K., Chang K. C., Wa W. J., Hsu J. Y., Yu P. J., Chiang C. K., (2021), Systematic evalution of antioxidant efficiency and antibacterial mechanism of bitter gourd extracts stabilized silver nanoparticles. *Nanomater.* 11: 2278-2282.

[42] Singh R., Hano C., Nath G., Sharma B., (2021), Green biosynthesis of silver nanoparticles using leaf extract of *Carissa carandas* L. and their antioxidant and antimicrobial activity against Human pathogenic bacteria. *Biomol.* 11: 299-305.

[43] Alharbi F. A., Alarfaj F. A., (2020), Green synthesis of silver nanoparticles from *Neurada procumbens* and its antibacterial activity against multi-drug resistant microbial pathogens. *J. King-Saud. Uni. Sci.* 32: 1346-1352.

[44] Devanesan S., Alsalhi M. S., (2021), Green synthesis of silver nanoparticles using the flower extract of *Abelmoschus esculents* for cytotoxicity and antimicrobial studies. *Int. J. Nanomed.* 16: 3343-3356.

[45] Dakal T. C., Kumar A., Majumdar R. S., Yadav V., (2016), Mechanistic basis of antimicrobial actions of silver nanoparticles. *Front. Microbial.* 7: 01831-01836.