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Green Synthesis of Silver Nanoparticles Using *Tectona Grandis* Extract at Room Temperature and their Antimicrobial Studies

Avani Thakar[1*], Vikram N. Panchal[1*], Bansari Patel[2*], Piyush Vyas[2*]

[1*]Faculty of Science, Gokul Global University, Sidhpur-384151
[2*]Chemistry Division, Sheth M. N. Science College, Patan-384265, Gujarat, India
E-mail: Vikrampanchal1988@gmail.com

ABSTRACT
The Silver is a valuable metal that transpires naturally, greatest regularly as a lifeless or in mixture with other elements. A queous *T. grandis* plant extract was applied in the existing enquiry as a dropping and plugging agent in the biogenesis of silver nanoparticles (AgNPs). Nanoparticles were scrutinized consuming diverse systems like UV-visible spectral analysis, FTIR, X-ray diffraction technique, and TEM technique. Consuming disc diffusion technique, the created silver nanoparticles displayed notable antibacterial potency alongside particular animal. AgNPs confirmed broad spectrum antibacterial exploit as an outcome at lower meditations, and they may afford an active therapeutic alternate in the coming like, progress of novel antibacterial drugs. This investigation recognized a quick and eco-friendly green synthetic method for creating stable silver nanoparticles.

KEYWORD: *Terminalia grandis*, AgNPs, Antibiotics, Antimicrobial Activity, XRD, FTIR, TEM

INTRODUCTION

Nanotechnology is a guideline of discipline which transactions with mechanical, misuse and usage of things ranging among 5-100 nm. The matter of nanotechnology is one of the greatest go-ahead seeks currently in modern factual science and technology.[1,2] In current eras, metal nanoparticles have gathered historic interest in frequent domains straddling from resources science to biotechnology.[3] Metal nanoparticles which have a great thorough surface area and high portion of shallow atoms been painstaking lengthily because of their distinguishing physic chemical characteristics including visual properties, catalytic action, magnetic possessions and antibacterial properties.[4] When generating nanoparticles, academics frequently have problems directing size/shape vacillation and accomplishing mono disparity in count to the toxicity topics. The preservation of bacterial cell principles and lack of involved sanitization courses are this system's main assistances. As the standing of nanotechnology and biotechnology has adult completed the past uncommon centuries, it has converted gradually compulsory to produce new tools for the construction of nanoparticles.[5-7]

AgNPs have been lengthily cast-off as an antibacterial manager in biological bids. Therefore, there is a necessity for a globally friendly and real-world method of creating AgNPs. Microbes and plant extracts have been intentional as looming environmentally outgoing substitutes to chemical and physical developments for the green amalgamation of nanoparticles.[8] unavoidably, hominid conduct of the created silver na noparticles is mandatory, and they must be available at lower costs for effective use. In this schoolwork, we described engaging *T. grandis* seed extract as a dipping agent to create silver nanoparticles expending a green technique.

These soundings have used normal items as dropping agents, such as monaural saccharides or plant cuttings. Bestowing to plentiful studies, the construction of nanoparticles via microbiological means is substantially gentler than consuming plant extracts and other chemical dipping mediators. When the nanoparticles might be fashioned more swiftly and biologically in the response vessels, their salable practicability would increase. In universal, all biological schemes are rich in reductase enzymes, and olive plants are no exemption. This mechanism has been subjugated in the past, and the existing challenge is to use olive seeds to reduce silver nitrate salts to metallic silver and olives, which have a benefit due to their distinctive antimicrobial stuffs.

T. grandis, occasionally identified as wood, teak, or sagun, may be convenient medically. Equipment, breakfronts, and melodious devices are all normally made expending it.[9,10] It too has anti-hemolytic anemia potency and is charity to treat anemia. Its stones are revered as a hair tonic, and it has been suggested that they enhance the quantity of hair follicles in the antigenic point. It has antioxidant abilities in its leaves, bark, and wood, with wood unveiling the maximum shyness of DPPH.[11,12]

In this study, silver nitrate was renewed to AgNPs consuming *T. grandis* seed extract. The fashioned nanoparticles were then characterized using XRD, TEM, and FT-IR analysis. The produced nanoparticles antimicrobial efficiency was observed against representative human pathogenic bacteria.

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MATERIAL AND METHOD

Collection of Plant Material

Garden-fresh *T. grandis* were developed from dissimilar area of Northern Gujarat. The detached mockups were arranged to confiscate bad eminence, sodden in tap water, eroded and rinsed underneath seriatim water. They remained cut, dried, pulverized, warehoused in antibacterial complaint and used for extra studentships.

Synthesis of Silver Nanoparticles

The *T. grandis* extract was willing by evaluating 10 g of *T. Chebula* in 500 mL tumbler along with 100 mL of distilled water and preserved at 60°C for 10 min before emptying it. The solution was sieved by 0.45 µm Milipore sheath filter and shadowed by 0.2 µm Millipore casing riddle. For synthesis of Ag-nanoparticles, 100 mL of $AgNO_3$ (1 mM) was countered with 12 mL of the *T. Chebula* extract in Erlenmeyer flask at room temperature. Some color variations of the explanation were pragmatic.

Antimicrobial evaluation

Agar-well-diffusion method elective by Arodiya *et al.* charity to appraise the antimicrobial potency of *T. grandis* extracts, Antibiotics, and their recipes. Agar broadcasting was equipped by consuming Muller Hinton Agar. The agar plate external was injected by scattering the particular bacteriological (*S. aureus, B. subtilis, P. aeruginosa, E. coli, A. niger* and *C. albicans*) completed the complete agar shallow. Then, wells, a distance of 8 mm were stamped with an antiseptic cork bit and 50 µL of the confirmed solution at looked-for meditations announced into the well. Then, agar plates were raised at 37 °C for 24 hrs. The zone of hindering was charity to direct the antimicrobial potency in mm.

RESULT AND DISCUSSION

The reaction mixture's colour altered from colorless to brown when exposed to sunlight, which is evidence that AgNPs were fashioned by the reduction of AgNO3 during behavior with the *T. grandis* seed extract (**Figure 1**). The growth of Ag-nanoparticles was further established by consuming UV-visible, XRD, FTIR and TEM.

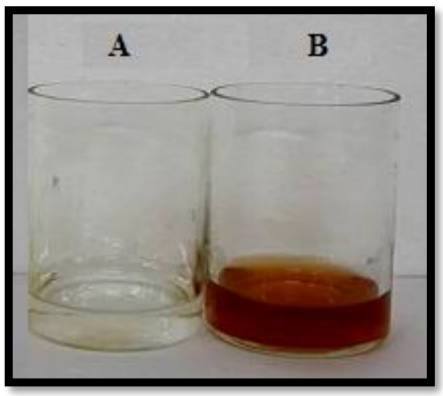

Figure 1. Aqueous solution of $AgNO_3$ with *T. grandis* extract (**A**) before adding the *T. grandis* extract and (**B**) after addition of *T. grandis* extract at 10 min.

The surface plasmon ambiance of the seed extracts were thrilled and their absorption spectrum at numerous wavelengths from 360 to 720 nm displayed a peak at 429 nm, which is what provided the brown colour its look. In *T. grandis*, Uv-vis ghostly analysis was apprehended after pauses of 20 min, 6 and 12 h subsequent the beginning of answer. The fashioned nanoparticles shape, size, structure, and morphology all have an impression on the SPR band. Due to their SPR, silver nanoparticles have unusual and bumpy visual assets that be contingent on the shape and size spreading of the particles that stabilize them, the surface-adsorbed elements, and the medium's dielectric constant. The globular silver nanoparticles subsidize to the 450 nm interest bands in the UV-vis spectra, affording to previous research. Round 429 nm, AgNPs' SPR band characteristics were exposed (**Figure 2**). This strappingly advocates that the AgNPs were spherical, and the TEM discoveries of this work funding this. As the time agreed, the peak lessened. The mono isolated nature of the elements in rescheduling is demonstrated by slender peaks. The nanoparticles don't thicket organized over time, as displayed by the slim peak at 12 h, demonstrating both the stability and mono dispersity of the biosynthesized AgNPs.

X-ray diffraction was used to regulate the phase of the fashioned nanoparticles, and the relevant XRD outlines are displayed in **Figure 3**. Moreover, the ensuing particles in the AgNPs have discrete cubic face peaks. The deflected concentrations are verified using the 2θ range. The range is between 30 and 80 °. The Bragg reflections may be allied to the plane of the fcc phase of silver at a strong peak of 38.5 ° matching to 111, 200, 220 and 311. Consuming the Debye-formula, Scherrer's d = 0.89/Cos, where d is the particle size, is the X-ray wavelength (1.5426), is the full-width at half maxima of the most noteworthy peak of the spreading pattern, and 2 is the Bragg angle, one can regulate the size of the particulate's crystals.

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The biomolecules explicitly bound to the synthesized AgNPs were characterized and called using FTIR analysis. In direction to create a pellet, the KBr was shared with the biologically created silver nanoparticles and the pulverized seeds. **Figure 4** shows the FTIR spectra of *T. grandis* synthesized seed extract AgNPs succeeding their reply with $AgNO_3$. Conferring to the FTIR results, there are absorption bands at 3454, O-H stretching, 2086, Silicon compounds, 1631, >C=C< stretching and 1383, C-O stretching of alcohols. The FTIR analysis revealed that the synthesized AgNPs contained amides, carboxyl and phenols groups.

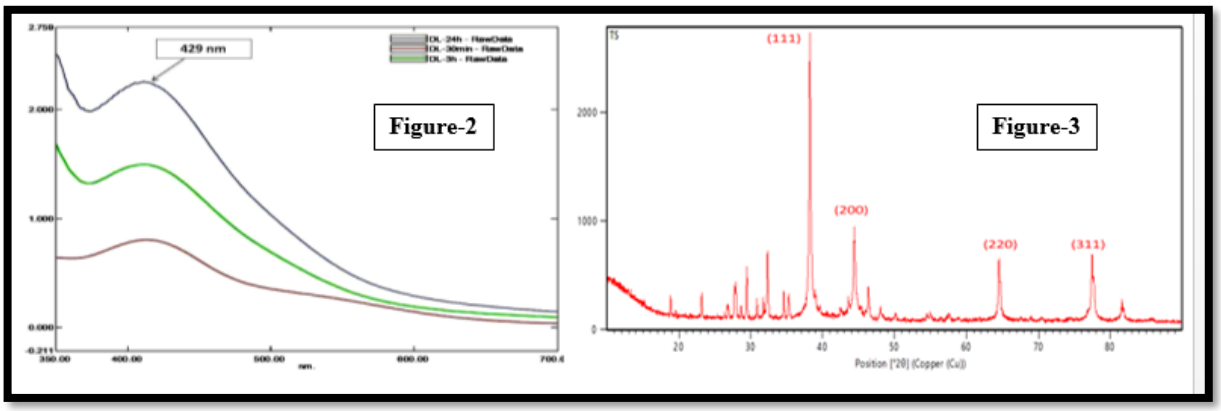

Figure 2. UV-visible spectra of AgNPs at different time. **Figure 3.** XRD pattern of AgNPs synthesis using *T. grandis*.

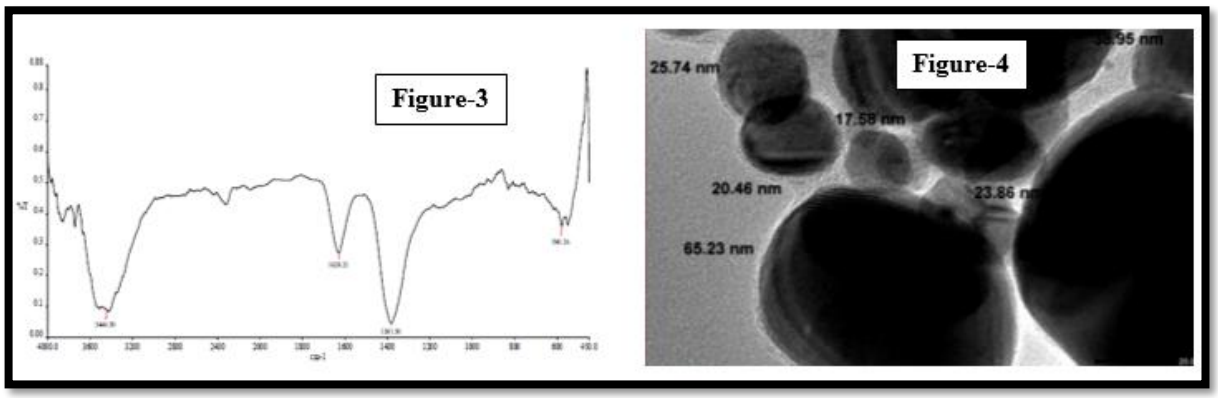

Figure 4. FTIR spectrum of AgNPs of *T. grandis*. **Figure 5.** TEM image of AgNPs of *T. grandis*.

This method was charity to examine the size and shape of the synthetic *T. grandis* AgNPs. The TEM picture of AgNPs is displayed in **Figure 5**. The predictable particle size from the XRD analysis is well-aligned with the portrait, which displays round AgNPs with a middling size of 20-60 nm. AgNPs were synthesized from *T. grandis* extract and were rotund in landscape. The AgNPs were 20 nm in size. Deprived of accumulation, the nanoparticles were mono-dispersed.

Antimicrobial Evaluation

Table-1: Antibacterial potency of *T. grandis* Ex. with selected antibiotics

Combination	**Acetone Extract**				**Ethanol Extract**				**Methanol Extract**			
Conc. in 1000 µg/ml	***S. a.***	***B. s.***	***P. a.***	***E. c.***	***S. a.***	***B. s.***	***P. a.***	***E. c.***	***S. a.***	***B. s.***	***P. a.***	***E. c.***
Pure Ex.	16	15	14	18	13	12	13	17	12	10	10	12
Ex.+ Amoxicillin	43	40	30	32	40	38	32	35	41	39	25	30
Ex.+ Ciprofloxacin	40	38	33	36	38	35	33	34	39	36	31	32
Ex.+ Ceftazidime	15	13	11	20	11	11	11	19	16	12	10	21
Ex.+ Erythromycin	34	31	25	30	37	34	30	31	36	34	25	28
S.a.=S. aureus, B. s.=B. subtilis, P. a.=P. aeruginosa, E.C.=E. coli												

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Methanol/ethanol/acetone extracts of crushed *T. grandis* bark were verified for their antibacterial things on their own and in combination with particular antibiotics (Amoxicillin, Ceftazidime, Ciprofloxacin and Erythromycin).In contradiction of tested bacterial species, all three quotations exhibit potent antibacterial potency. Acetone extract shows zone of inhibition between 14 mm to 18 mm for particular bacterial nation for 1% w/v (25 µg/ml) attention ethanol extract displays zone of inhibition amongst 12 mm to 17 mm for particular bacterial culture. Methanol extract show zone of inhibition amongst 10 mm to 12 mm for precise bacterial strain. All three extracts showed powerful antibacterial activity against *E. coli* species. Amoxicillin meaningfully reduced the growing of *S. aureus* and *B. subtilis*, its mixture with all three extracts also displays noteworthy growth shyness in contradiction of these two species midst all examined bacteria. An amalgamation of acetone extract with amoxicillin displays 43 mm, 40 mm, 30 mm, and 32 mm of ZOI against *S. aureus, B. subtilis, P. aeruginosa,* and *E. coli,* individually, at 1% w/v concentration. The mixture of amoxicillin with methanol and ethanol cuttings also displayed lower activity than with acetone extract, parallel to pure extracts. Ciprofloxacin when syndicate with extract it is displayed that the mixture have higher reserve effect contrary to all stain. All three solvent extract and its grouping shows synergic effect in contradiction of respective bacterial beliefs. When extract collective with Ceftidizime it has good confrontation potential in contradiction of all four microbial culture. Pure extract and blend has good fighting probable. Methanol, ethanol and acetone exctract and its amalgamation have good synergic outcome against bacterial culture. 1% w/v solution have good conflict potential against *E. coli* almost 06-mm to 21-mm. Erythromycin and its mixtures with all three extracts display higher activity in contradiction of *S. aureus* and *B. subtilis* and lower activity against *P. aeruginosa*. Grouping of erythromycin with acetone extract unveiled 34 mm, 31 mm, 25 mm and 30 mm while ethanol extract showed 37 mm, 34 mm, 30 mm, and 31 mm, and with methanol extract illustration 36 mm, 34 mm, 25 mm, and 28 mm of ZOI against *S. aureus, B. subtilis, P. aeruginosa,* and *E. coli* correspondingly at 1000 µg/ml absorption. All data shown in **Table 1**.

Table-2: Antibacterial potency of Silver nano particles (AgNPs) with selected antibiotics

Combination (Conc. in 1000 µg/ml)	***S. a.***	***B. s.***	***P. a.***	***E. c.***
Pure AgNPs	18	17	15	20
AgNPs + Amoxicillin	45	48	33	35
AgNPs + Ciprofloxacin	44	40	30	31
AgNPs + Ceftazidime	25	20	17	25
AgNPs + Erythromycin	37	32	27	31
S.a.=S. aureus, B. s.=B. subtilis, P. a.=P. aeruginosa, E.C.=E. coli				

Pure Silver nanoparticles acetone/ethanol/methanol extract shows zone of inhibition between 15 to 20 mm for particular bacterial nation for 1% w/v for precise bacterial strain. **(Table 2)** all three extracts showed powerful antibacterial activity against *E. coli* species. Amoxicillin meaningfully increase the growing of all strains its mixture with all three extracts also displays noteworthy growth shyness in contradiction of these all species midst all examined bacteria. An amalgamation of silver nanoparticles with amoxicillin displays 45 mm, 48 mm, 33 mm, and 35 mm of ZOI against *S. aureus, B. subtilis, P. aeruginosa,* and *E. coli,* individually, at 1% w/v concentration. The mixture of amoxicillin with silver nanoparticles also displayed higher activity than with parallel to pure extracts. Combination of ciprofloxacin and silver nanoparticles when syndicate with displayed 44 mm, 40 mm, 30 mm, and 31 mm of ZOI to all stain. Ciprofloxacin and silver nanoparticles grouping shows synergic effect in contradiction of respective bacterial beliefs. When silver nanoparticles combine with Ceftidizime it has good confrontation potential in contradiction of all four microbial culture. Pure extract and blend has good fighting probable. As per and its amalgamation have good synergic outcome against bacterial culture. 1% w/v solution have good conflict potential against *E. coli* almost 17 mm to 25 mm. Erythromycin and silver nanoparticles display higher activity in contradiction of *S. aureus* and *B. subtilis* and lower activity against *P. aeruginosa*. Grouping of erythromycin with 37 mm, 32 mm, 27 mm, and 31 mm of ZOI against *S. aureus, B. subtilis, P. aeruginosa,* and *E. coli* correspondingly at 1000 µg/ml absorption.
As the awareness of all three extracts increased, the activity of their mixtures with used antibiotics also somewhat plunged. Same result shown in silver nanoparticles combine with bioactive drugs.

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Antifungal Evaluation

Table-3: Antifungal potency of *T. grandis* Ex. and AgNPs with selected antibiotics

Combination	***T. grandis* Ex. with selected antibiotics**		**AgNPs with selected antibiotics**	
Conc. in 1000 µg/ml	***A. n.***	***C. a.***	***A. n.***	***C. a.***
Pure Ex.	15	14	21	15
Amphotericin-B	27	21	29	28
Fluconazole	18	16	23	19
A.n.= A. niger, C.a.=C. albicans				

All extracts show effective antifungal potency in contradiction of the fungus *A. Niger* and *C. albicans*. All extracts exhibited somewhat higher activity touching *C. albicans* than against *A. niger.* Pure as well as AgNPs extract display 15 mm, 14 mm and 21 mm, 15 respectively in fungi of ZOI in contradiction of *A. niger* and *C. albicans,* separately, at 1% w/v deliberations **(Table 3)**. Amphotericin-B displayed higher inhibitory activity alongside *A. niger* than *C. albicans*, and its combinations with extracts behave the slightly higher than standard drug. Combinations of Amphotericin-B with *T. grandis* extract show 27 mm and 21 mm of ZOI against *A. niger* and *C. albicans,* respectively, at 1 %w/v concentrations. Other hand combinations of Amphotericin-B with AgNPs extract show 29 mm and 28 mm of zone of inhibition against *A. niger* and *C. albicans*, at 25 µg/ml concentrations. Methanol.

The combination of fluconazole with *T. grandis* extract revealed 18 mm and 16 mm, of ZOI against *A. niger* and *C. albicans,* individually at 1% concentrations. AgNPs extract displayed 23 mm and 19 mm of zone of inhibition in contradiction of *A. niger* and *C. albicans,* exclusively of ZOI against *A. niger* and *C. albicans,* separately at 1% concentrations**.**

CONCLUSIONS

In the current study, a one pot, forthright, energy-efficient, cautiously viable, and environmentally friendly method for the synthesis of AgNPs was traditional consuming water as a flush and non-toxic, renewable aqueous extract of *T. grandis* seed as dropping, capping, and stabilizing agents in its place of harsh, copied plummeting coating agents. *T. grandis* seed aqueous extract facilitated AgNPs were characterized expending UV-vis spectrometry, XRD, and TEM, and the outcomes inveterate the construction of round shaped AgNPs with an estimated average size of 20-60 nm. The manufactured AgNPs confirmed amazing antibacterial potency with ZOI alongside the pathogenic bacteria production it ideal for medical and relaxing submissions.

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Conflict of Interest
The authors confirm that this article's content has no conflict of interest.

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