ORIGINAL RESEARCH PAPER
Volume - 15 | Issue - 04 | April - 2026 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

PHYTO-ASSISTED SYNTHESIS OF PALLADIUM NANOPARTICLES USING THE AQUEOUS LEAF SOURCE OF ENDOSTEMON VISCOSUS (ROTH); CHARACTERIZATION AND EVALUATION OF ANTIBACTERIAL, ANTI-OXIDANT, AND ANTICANCER EFFICACY

Botany

Jayachandra. Nagadasari Research Scholar in Botany, Department of Botany, SVU College of Sciences,Sri Venkateswara University,Tirupati, Andhra Pradesh, India -517502

Vijaya. Tartte* Professor of Botany, Department of Botany, SVU College of Sciences,Sri Venkateswara University,Tirupati, Andhra Pradesh, India -517502*Corresponding Author

ABSTRACT

Background: In recent years, the green synthesis of metallic nanoparticles has established itself as a leading environmentally friendly technology. This study confidently presents an innovative approach for the eco-friendly, biological production of palladium nanoparticles (PdNPs) utilizing plant extracts. In this study we synthesized PdNPs using with Endostemon viscosus which is act capping and stabilizing agent.**Aim:** The aim of the study was to monitor the potentiality of green synthesized Ev-PdNPs on microbial cell proliferation, DPPH antioxidant activity, and Cancer activity on selected human cell lines.**Methodology**a). Characterization: Synthesized Ev-PdNPs were characterized by UV-visible Spectrophotometer, X-ray diffraction (XRD), Dynamic Light Scattering (DLS), Zeta Potential, FT-IR, and the size, shape and morphology of the Palladium nanoparticles were analysed with the HR Transmission Electron Microscopy (TEM).b). Application of PdNPs: The biologically synthesized Ev-PdNPs were applied to evaluate antibacterial with disc diffusion method, antioxidant by dose dependant, and anticancer activities efficacy. **Results:** Produced synthesized PdNPs showed significant antibacterial activity against four bacteria i.e. E. coli, K. pneumonia, B. subtilis and S. aureus in comparison with PdCl2 solution, aqueous leaf extract, and Streptomycin used as standard drug. The Ev-PdNPs magnificent Antioxidant and anti-cancer (on selected human cell lines i.e., MDA-MB-231, SK-OV-3, PC3, PANC- 1, and HeLa) activities exhibited. The synthesized nanoparticles revealed tiny nanoparticles as well as no agglomeration was seen between the nanoparticles. **Concluson:** The results of this study present a remarkable opportunity for pharmacologists and phytochemists to identify novel active compounds. This research is poised to drive the development of ground-breaking therapeutic agents, significantly enhancing the efficacy of various medicinal applications. Green-synthesized Ev-PdNPs stand to play a crucial role in creating new drug alternatives that surpass conventional therapies. Furthermore, in the realm of pharmaceuticals, pharmacognosy is instrumental in accurately diagnosing a variety of diseases.

KEYWORDS

Green Synthesis, Characterization, Anti-bacterial, Anti-cancer, Anti-oxidant, Endostemon viscosus

INTRODUCTION

Noble metal nanoparticles, such as silver, platinum, gold, and palladium, exhibit unique physical, chemical, optical, and thermodynamic properties at the nanoscale [K. Watanabe *et al.,* 2006]. These characteristics enable a variety of applications, including catalysis [Cheong S et al., 2010], sensors [Li Z *et al.,* 2011], magnetic recording [Aktas B *et al.,* 2007], biotechnology [Tkachenko AG *et al.,* 2003], and drug delivery [Ghosh P *et al.,* 2008]. Palladium nanoparticles, in particular, are extensively used in both heterogeneous and homogeneous catalysis due to their high surface-to-volume ratio [H. Chen et al., 2010; Gopidas *KR et al.,* 2003]. Another significant property of palladium nanoparticles is surface plasmon resonance (SPR), which is advantageous in sensing, chemo-optical transducers, and plasmonic wave guiding [Tobisika P *et al.,* 2001]. Palladium nanoparticles, commonly known as PdNPs catalysts, have gained a lot of attention because of its useful uses in bio science, biomedicine, and pharmacy.

Palladium is a member of platinum group that is considered as one of expensive noble metals and its high material cost generally restricts its wide applications. Palladium nanoparticles have also been used as a catalyst in hydrogenation of alkenes, alkynes, allyl and benzyl alcohols and hydrogenolysis of allylic and benzylic ethers (Shaik, M.R *et al.,* 2017). Several methods have been developed and refined for the synthesis of metal nanoparticles (chemical, physical, and biological). However, many of these approaches rely on toxic chemicals, requiring extreme temperature, energy, and pressure, which may result in toxic by-products, which leads to disrupt the environmental health. In contrast, utilizing non-toxic biomolecules to synthesize palladium (Pd) nanoparticles under mild reaction conditions, without hazardous chemicals, represents a greener and more environmentally friendly alternative (Huang, X *et al.,* 2010). To overcome all these errors scientists were, in this regard there was grabbed easy, one-step method is greener way with assisted plant material, which considered an alternative approach due to eco-friendly and cost-effective by using a little amount of plant sources. Though, among these approaches for the synthesis of nanoparticles, utilizing plant extracts has enticed substantial consideration, due to easy sampling and cost efficiency enabling the large scale biosynthesis of NPs (Khan, M et al., 2014).

Plant biomolecules are considered the most effective reducing agents for synthesizing palladium nanoparticles (PdNPs) from Pd (Iftikhar et al., 2020; Sarkar et al., 2022), as they enable eco-friendly and green synthesis processes (Al Radadi et al., 2022). These biomolecules not only make the synthesis sustainable but also improve control over the size, shape, and dispersion of the nanoparticles, owing to the presence of biologically active compounds. Furthermore, they act as capping agents, coating nanoparticles to further reduce their size and enhance stability (El Marghani et al., 2021; Info, 2019). Previously PdNPs were prepared through green methods successfully using *annona squamosa* L peel extract (Roopana *et al.,* 2012), banana peel extract (Ahok *et al.,* 2010), *Cinnamom zeylanicum* bark (Sathishkumar *et al.,* 2009), broth of *Cinnamom camphora* leaf (Yang *et al.,* 2010) and gum acacia (Keerthi *et al.,* 2011). *Origanum vulgare* L. Extract (Mohammed Rafi S *et al.,* 2017).

Endostemon viscosus (Roth) M.R.Ashby, commonly known as Sticky Wild Basil, is part of the Lamiaceae family. This perennial medicinal herb is found across South Asian countries, especially in India and Thailand, with a significant presence in the Western and Eastern Ghats of South India. It grows as a subshrub from a woody base and is characterized by its finely velvet-hairy, four-angled branchlets. The leaves are decussate, elliptic to nearly round, measuring up to 2 x 1.5 cm, with a flat base and leaf stalks that can be up to 1 cm long. The flowers of *Endostemon viscosus* are found in whorls of six on a trichotomous raceme, with flower-cluster stalks extending up to 9 cm and having ovate bracts. Each flower stalk is about 0.5 cm. The pinkish flowers feature hairs along the throat and consist of four didynamous stamens with 2 mm filaments and two-celled anthers. Their disk is anteriorly developed, and the erect nut-lets are enclosed in a crescent-shaped calyx (Okaiyeto et al., 2018). Traditionally, this plant has been used by folk practitioners to treat conditions such as hypertension, hepatitis/jaundice, and fever. The medicinal properties attributed to *Endostemon viscosus* have found support in studies conducted by various researchers, reflecting the claims of tribal communities in the Western and Eastern Ghats (Chin et al., 2008).

Material and Methods

Collection of pant material

The healthy leaves of selected traditional medicinal plant species *Endostemon viscosus* were gathered from Tirumala hills, Tirupati, Andhra Pradesh, India (Fig.1). The collected material was cleaned thrice using running tap water for thrice, and once with distilled water to remove any impurities on the surface of the leaves. After cleaning,

the leaves were shade-dried for 10-15 days and then ground into a fine powder using an electrical blender.

Figure1. Vegetative plant parts of *Endostemon viscosus*

Plant Extract preparation

25 g of weighed plant material was placed into a 250 ml conical flask, and 100 ml of milli-Q water was added. The mixture was shaken well for 5 minutes, then heated in a water bath at 100°C for 20 minutes. After cooling to room temperature, the extraction was filtered using Whatman No. 1 filter paper. The extracted solution was stored in an amber-colored bottle until the synthesis process at room temperature.

Preparation of 1 mM $PdCl_2$ solution

10 g of $PdCl_2$ was purchased from Sigma Aldrich, Bangalore, India. 1mM $PdCl_2$ solution was prepared by using 100 ml of milli-Q water in a sterile Erlenmeyer conical flask. Then the solution was stored in an amber-coloured bottle and kept in the refrigerator until the synthesis.

Phyto-synthesis of Palladium nanoparticles (PdNPs)

20 ml of aqueous leaf extract of the *Endostemon viscosus* was added to prepared 1 mM $PdCl_2$ solution, which was then heated in a water bath at 60-80°C. The colour change of the solution from light yellow to dark brown indicated the successful synthesis of silver nanoparticles from the leaf extract. This solution was subsequently used for characterization as well as evaluating its antibacterial, antioxidant, and anticancer activities.

Characterization

The synthesized PdNPs were analysed for the characterization by the advanced tools such as i.e., UV-Vis spectrophotometer Nano drop range from190-750 nm, Fourier Transform Infrared (FTIR), Dynamic Light Scattering (DLS) Malvern-Zeta analyser, X-ray diffraction (Shimazdu XRD-6000),and TEM (Transform electron Microscope) HF-3300 advanced 300 kV TEM from Hitachi.

Antibacterial Activity

The antibacterial study was conducted using a standard protocol based on the disc diffusion assay [Anonymous, 1996]. Clinically isolated bacterial strains were obtained from the Department of Microbiology at Sri Venkateswara University in Tirupati. Biologically synthesized EvL-PdNPs were tested for antibacterial activity against two gram-positive bacteria (*Bacillus subtilis* and *Staphylococcus aureus*) and two gram-negative bacteria (*Klebsiella pneumoniae* and *Escherichia coli*). For the experiment, 20 µl of plant extract, silver nitrate (AgNO3), AgNPs, and streptomycin were applied to separate sterile Whatman No. 1 filter paper discs (7mm in diameter) and allowed to dry before being placed on a nutrient agar medium. The entire process was carried out in triplicate and incubated at 37°C for 24 hours. The results were recorded by measuring the diameter of the inhibition zones in centimetres.

DPPH activity of (EvL-PdNPs)

The antioxidant activity of EvL-PdNPs was effectively tested using the DPPH (2, 2-Diphenyl-1-picry Hydrazyl radical Scavenging activity) method, following the established protocol of Subramanian et al. (2013). A 1 mM DPPH stock solution was prepared by dissolving 4 mg of DPPH in 100 mL of methanol. For the assay, 2 mL of this DPPH stock was combined with 1 mL of a methanolic solution of EvL-PdNPs at two distinct concentrations (50 and 100 µg/mL). After a precise incubation of 30 minutes at room temperature, absorbance (RSA) was accurately measured against a blank at 517 nm. The DPPH assay results were clearly defined as IC50 values, and the entire assay was conducted in triplicates to ensure reliability. The DPPH scavenging activity of EvL-PdNPs was calculated using the appropriate formula, confirming their potent antioxidant capabilities.

% of formula = [(Absorbance of control - Absorbance of sample)/ Absorbance of control] X100.

Anticancer studies of PdNPs (Cell proliferation assay using SRB (Sulforhodomine-B)

Different human cancer cell lines, including MDA-MB-231, SK-OV-3, PC-3, PANC-1, and HeLa, were purchased from the American Type Culture Collection. The SRB assay is a quantitative colorimetric method used to determine cell survival and proliferation by measuring cellular protein content. Cells were grown in Dulbecco's Modified Eagle's medium with non-essential amino acids and 10% fetal bovine serum (FBS). The PC-3 cell line was maintained in RPMI medium supplemented with glutamine and non-essential amino acids. All cell lines were cultured in a humidified atmosphere containing 5% CO2 at 37°C. Cells were trypsinized when they were sub-confluent in T75 flasks or 90 mm dishes, and then seeded into 96-well plates at a concentration of 1×10^4 cells/mL in complete medium one day prior to treatment. The cells were incubated with varying concentrations of palladium nanoparticles (EvL-PdNPs) ranging from 12.5 to 100 µg/mL in triplicate for 48 hours to assess the potency of the compounds.

Results and Discussion

Ultraviolet- Vissible (UV-Vis) Spectroscopy analysis of EvL-PdNPs

When the aqueous leaf extract of *Endostemon viscosus* was mixed with a 1 mM solution of $PdCl_2$, the colour changed from transparent yellow to a deep brown. This colour change is a primary and valuable technique for confirming the synthesis of Palladium nanoparticles (PdNPs). UV-Vis spectroscopy analysis showed a broad peak at 327 nm (Fig. 2), which is attributed to the Surface Plasmon Resonance (SPR) mechanism of the PdNPs in the prepared samples. SPR refers to collective oscillations of conduction electrons on the surface of the material. This clearly shows that the O. vulgare L. extract functions as both a stabilizing and bio-reductant agent, while its phyto-molecules also enhance the surface of PdNPs. These results are consistent with previous work (Sunita Choudhary *et al.,* 2024).

X-ray diffraction (XRD)

X-ray diffraction analysis was conducted using a Shimadzu XRD-6000 to confirm the crystalline nature, average size, and degree of crystallinity of the Ev-PdNPs. XRD is a powerful characterization technique for both qualitative and quantitative analysis of nanoparticles. The peaks observed at 2θ values of 40.44°, 45.99°, 68.08°, 81.73°, and 86.83° correspond to the Bragg reflections of 222, 111, 200, 220, and 311, respectively, indicating the presence of a face-cantered cubic structure typical of Palladium nanoparticles (Ev-PdNPs), as shown in Figure 3. The X-ray diffraction results clearly indicate that the formed particles are indeed PdNPs. The highest Bragg reflection was observed at 2θ = 40.44°, which allowed for the determination of the Full Width at Half Maximum (FWHM) value. Using the Debye-Scherrer equation, the average sizes of the nanoparticles were calculated to be 10 nm and 38 nm. These kinds of results confirmed in the reduction and stabilization of PdNPs from *Salmalia Malabarica* gum (Kondaiah et al., 2024).

$D = k\lambda/\beta \cos\theta$

Where D is diameter of NPs, k is the Scherrer constant, λ is the wave length of X-ray radiation source, β is full width half maximum value of XRD diffraction lines and θ is the half diffraction angle-Bragg angle.

FT-IR

Green synthesized nanoparticles were analyzed utilizing Fourier Transform Infrared (FT-IR) spectroscopy, with a scan range of 4000-500 cm-1. The ALPHA ECO-ATR interferometer, produced by Bruker in Ettlingen, Karlsruhe, Germany, was employed to identify the phytochemicals that are instrumental in the capping and stabilization processes. By the FT-IR spectrum broad peaks obtained from synthesized PdNPs exhibited at 3286 O-H Stretch H bonded alcohol and phenol, 1637 bond assigned for N-C alkane, 1008 stretch C-N aliphatic amines, and 597 C-br stretch alkyl halides (Fig. 4). FT-IR spectroscopy is an economical and effective tool for assessing the role of biomolecules in the synthesis and stabilization of biosynthesized Ev-PdNPs Smilar types of results acquired with the PdNPs from *Pimpinella tirupatiensis* plant aqueous extract (Narasaiah *et al.,* 2017).

Particle size and Zeta potential

Dynamic Light Scattering (DLS) is an advanced technique used to analyze the surface charge, size, and size distribution of nanoparticles. This method relies on the interaction between the Brownian motion of spherical particles and the light passing through a colloidal solution

(Saxena *et al.,* 2010). The Zeta potential is employed to assess the stability, dispersion, and aggregation levels of biologically synthesized nanoparticles by examining the repulsive effects resulting from fluctuations in charge densities. In this study, the EV-PdNPs exhibited an average size of 15.5 nm, a negatively charged Zeta potential of −22.6 mV, and a polydispersity index of 0.313 (Fig.5).

TEM

Synthesized Ev-PdNPs can be characterized utilizing Transmission Electron Microscopy (TEM), a technique that facilitates quantitative analysis of synthesized nanoparticles, including assessments of particle size, size distribution, and morphology. In TEM, an electron beam is transmitted through a specimen, which must be positioned on carbon-coated copper grids, typically achieved by applying a single drop of the reaction mixture. TEM is recognized as an advanced analytical tool, offering enhanced spatial resolution compared to Scanning Electron Microscopy (SEM) and enabling comprehensive analysis of nanoparticles. High-Resolution Transmission Electron Microscopy (HR-TEM) has demonstrated, at a scale of 50 nm, that these nanoparticles are notably small, spherical in shape, and exhibit a size range of 10 to 38 nm, with an average diameter of 23.16 nm and inter layer distance was 0.205nm (Fig.6). Importantly, these minuscule nanoparticles exhibited no physical contact and displayed no signs of agglomeration. The results accordance with previous finding; in which synthesized PdNPs were spherical in shape and average diameter of 10 to 20 nm in *Gymnema sylvistre* leaf extract (Kadam *et al.,* 2020).

Application of the Ev-PdNPs

Anti-bacterial activity

The efficacy of bio-fabricated Ev-PdNPs was rigorously evaluated against four selected bacterial strains: two gram-positive bacteria (*Bacillus subtilis* MTTC-441 and *Staphylococcus aureus* MTTC-731), and two gram-negative bacteria (*Klebsiella pneumoniae* MTTC-741 and *Escherichia coli* MTTC-443). Streptomycin was used as a positive control, silver solution served as a negative control, and plant extract was used for comparison. The results unequivocally demonstrated significant antibacterial activity against gram-negative bacteria, with noteworthy efficacy also observed against gram-positive strains. This study clearly highlights the potential of Ev-PdNPs as an effective antibacterial agent. The zone of inhibition was exhibited in the table (Figure 7&8). Among the activity revealed about that the highest zone of inhibition was observed on *Escherichia coli* followed by *Klebsiella pneumoniae* with synthesized Ev-PdNPs. The results were consistent with previous studies on PdNPs synthesized using plant species such as *Quercus dalechampii*, *Q. frainetto*, and *Q. petraea* (Coman NA *et al.,* 2024).

DPPH Antioxidant activity

The antioxidant activity of the synthesized Ev-PdNPs was assessed using the DPPH method. This activity is dependent on the ability to reduce the DPPH radical, which is a hydrogen-donating antioxidant. The IC50 values for the in vitro antioxidant activity of the aqueous extract from *Endostemon viscosus* leaves, along with the biosynthesized Ev-PdNPs, are summarized in the table (Table1& Fig.9). The results indicate that the DPPH antioxidant activity increased with higher concentrations of the test samples. Plants are rich in bioactive compounds, such as flavonoids and tannins, which belong to the phenolic compound category. These compounds, along with other polyphenols, represent a significant group of phytochemicals that act as primary antioxidants and free radical scavengers [Alvur *et al.,* 2022; Ko *et al.,* 2022]. The maximum free radical scavenging activity was monitored in the EvL- PdNPs with 57.80% at 100 µg/mL concentrations and lowest activity was seen 46.07% at 50µg/mL respectively. Similar results have been reported in previous studies using PdNPs synthesized from *Cassia absus* seed extract (Sandip Gondake P *et al.,* 2022).

Anti-cancer study of PdNPs

Biologically synthesized Ev-PdNPs (*Endostemon viscosus* Palladium nanoparticles) were evaluated against various human cancer cell lines, including MDA-MB-231 (an epithelial breast cancer cell line), SK-OV-3 (ovarian cancer), PC3 (human prostate cancer), PANC-1 (human pancreatic cancer), and HeLa (human epithelial cervical cancer). The experiment used a cell proliferation assay with the Sulforhodamine B (SRB) colorimetric method. In this study, cell controls, standard controls (Doxorubicin), and different concentrations of plant-mediated nanoparticles (12.5µg/ml, 25µg/ml, 50µg/ml, and 100µg/ml) were administered to the growing cell lines in a concentration-dependent manner. The cytotoxicity results indicated that the aqueous leaf extract PdNPs of *Endostemon viscosus* showed promising effects. The assay demonstrated that the small-sized nanoparticles could easily enter cells through endocytosis. Once inside, they interact with cellular proteins, resulting in changes to cellular structure and chemistry. Moreover, these non-aggregated nanoparticles are efficient in producing reactive oxygen species (ROS) within the cells. Elevated levels of ROS can induce cellular stress, leading to DNA damage and morphological changes in the cells, ultimately resulting in cell death (Alvur *et al.,* 2022; Ko *et al.,* 2022). The highest activity was seen against MDA-MB-231 inhibition was60.66% (Ev-PdNPs) at 100µg/ml; followed by SKOV-3 inhibition was 63.63% at 100µg/ml; at lower concentration also same cell lines was showed better activity than other performed cell lines (Fig. 10&11). These types of results accordance with previous work by PdNPs of *Punica granatum* Peel extract (Anusha Ramasamy *et al.,* 2025).

CONCLUSION

A greener approach has replaced traditional, toxic methods for synthesizing nanoparticles, enabling nanoparticle formation with minimal chemicals and a small volume of aqueous leaf extract from *Endostemon viscosus (Roth)*. The synthesized EvL-PdNPs were characterized using advanced techniques such as UV-Visible spectroscopy, FT-IR, DLS (zeta potential), TEM, and XRD. Upon adding colourless PdCl2 solution to the plant extract, a deep brown colour developed, indicating nanoparticle formation. UV-Visible spectroscopy revealed an absorption peak at 327 nm, confirming the presence of palladium nanoparticles. DLS and zeta potential studies showed the nanoparticles were stable and evenly distributed, with an average size of about 15.5 nm and a zeta potential of −22.6 mV. FT-IR analysis indicated that phytoconstituents in the extract facilitated the reduction and stabilization of palladium ions, leading to PdNP formation. TEM analysis confirmed predominantly spherical nanoparticles, averaging 23.16 nm in size, with a range from 10 to 38 nm. EDS analysis verified palladium as the major element, while XRD patterns demonstrated the crystalline nature and average size of the EvL-PdNPs. Collectively, these studies showed the nanoparticles were small, spherical, and well-characterized. The antibacterial activity of EvL-PdNPs was tested against two Gram-positive bacteria (*Bacillus subtilis* MTTC-441 and *Staphylococcus aureus* MTTC-731) and two Gram-negative bacteria (*Klebsiella pneumoniae* MTTC-741 and *Escherichia coli* MTTC-443), all of which exhibited significant susceptibility. The EvL-PdNPs also demonstrated effective, dose-dependent antioxidant activity in DPPH assays. Anticancer activity was evaluated in five human cancer cell lines (MDA-MB-231, SK-OV-3, PC3, PANC-1, and HeLa), showing notable results at higher concentrations. In summary, the EvL-PdNPs exhibited potent antibacterial, antioxidant, and anticancer activities. Plant-based synthesis offers several advantages, including a cleaner working environment, improved health and environmental safety, minimal waste, and the production of stable nanoparticles. This work suggests plant-assisted nanoparticles could be used in future disease treatments, with their small size allowing for further development as efficient drug delivery systems. The green-synthesized EvL-PdNPs demonstrate significant potential for pharmaceutical applications as drug candidates.

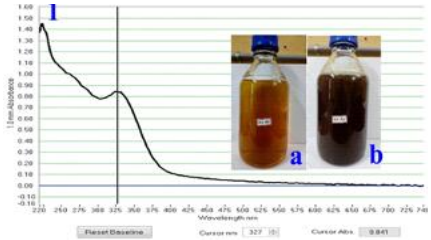


Figure 2. Uv-graph Synthesis of AgNPs from *Endostemon viscosus* leaves acquired by UV-Vis Spectroscopic analysis

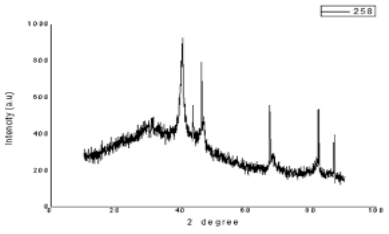


Figure 3. XRD pattern analysis of leaf sourced biologically synthesized PdNPs of *Endostemon viscosus*

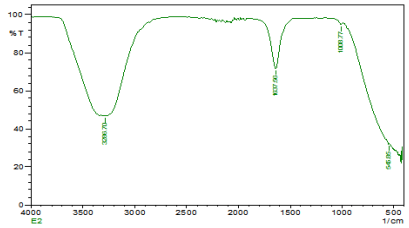


Figure 4. Fourier- Transform Infra-Red (FT-IR) spectra of bio-synthesized PdNPs from *Endostemon viscosus*

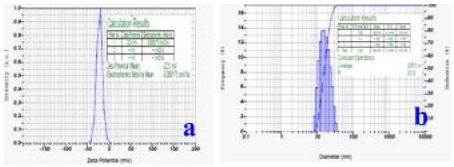


Figure 5. Synthesis of AgNPs from *Endostemon* viscous leaves acquired a) Particle size and b) Zeta potential of the synthesized PdNPs.

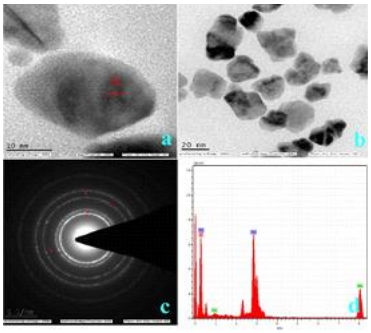


Figure 6. TEM images of *Endostemon viscosus PdNPs*
a). At 10 nm range 10nm, b). At 20 nm PdNPs are spherical in shape
c). At 51 nm beam of TEM d). EDAX analysis

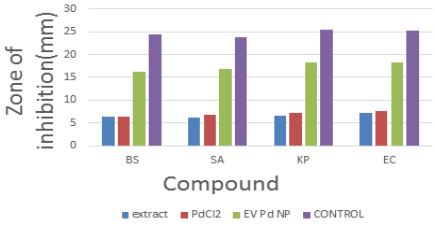


Figure 7. Antimicrobial activity of PdNPs from *Endostemon viscosus*

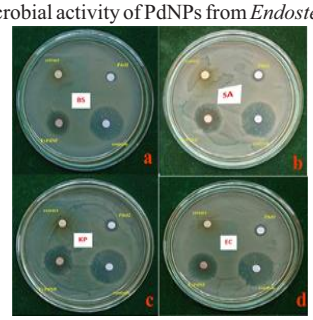


Figure 8. Antimicrobial activity of *Endostemon viscosus* (Zone of inhibition in mm)
a). B. sabtilis b). S. aureus c). K. pneumonia d). E. coli

Table 1. DPPH activity of PdNPs from *Endostemon viscosus*

SNO	Compounds	% of inhibition 50µ/mL	% of inhibition 100µ/mL
1	Ascorbic acid	52.48±0.44	77.54±0.4
2	Ev PdNPs	46.07±0.34	57.80±0.31
3	EvL-Plant aqueous extract	27.17±0.25	47.88±0.50

Figure 9. Graphical representation- DPPH anti-oxidants activity of EvL-PdNPs from *Endostemon viscosus*

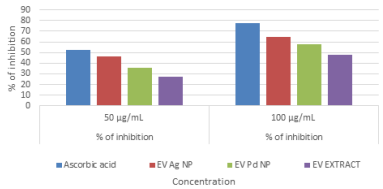


Figure 10. Anti-cancer activity on selected human cancer cell lines by PdNPs synthesized from *Endostemon* Viscous
A). PC-3 B). MDA-MB-231 C). SK-OV-3 D). PANC-1 E). HeLa
a) Cell control, b) Standard control , c) 12.5 µg/ml, d) 25 µg/ml, e) 50 µg/ml and f) 100 µg/ml

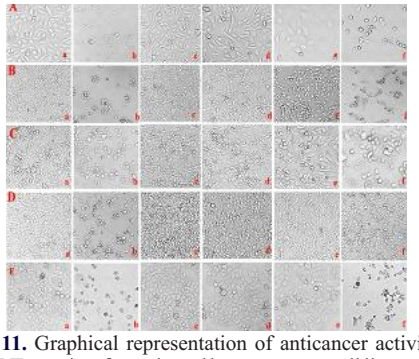
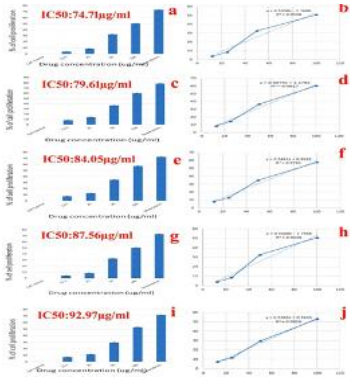


Figure 11. Graphical representation of anticancer activity by using EvL-PdNPs against five selected human cancer cell lines
a,b- PC-3 c,d- MDA-MB-231 e,f- SK-OV-3 g,h- PANC-1 I,j- HeLa



REFERENCES

1. Anusha Ramasamy 1, Vaishnavi Chandramouli 2, Abirami Baskaran 2, Jerrine Joseph 2, Manigundan Kaari 2, Radhakrishnan Manikkam 2, Thangavel Shanmugasundaram 3, Krishna Kadirvelu 3Synthesis and Characterization of Palladium Nanoparticles (PdNPs) Using Punica granatum Peel Extracts and its Evaluation for antimicrobial, Antioxidant and Anticancer Properties: Indian J Microbiol 2025 Jun;65(2):1307-1320. In vitro anticancer activity of PdNPs against A549 and MCF7 cells showed
2. Sandip P. Gondake,Santosh .R, Kshirsagar and Sagar Shinde .I (2022). Synthesis, Characterization and antioxidant/anti-cancer activity of palladium Nanoparticles using Cassia absus seed extract: Bull. Env. Pharmacol. Life Sci., Special Issue [1]:772-777.
3. Coman, NA, Babota M, Nicolescu A, Nicolae-Maranciuc A, Berta L, Man A, Chicea D, Farczadi L and Tanase C (2024). Biosynthesis of Palladium Nanoparticles by Using Aqueous Bark Extract of Quercus dalechampii, Q. frainetto, and Q. petraea for Potential Antioxidant and Antimicrobial Applications. Plants 2024, 13, 3390.
4. Narasaiah P, Kumar Mandal B, Sarada NC (2017). Green synthesis of PdNPs from Pimpinella tirupatiensis plant extract and their application in photocatalytic activity dye degradation; IOP Conf. Series: Materials Science and Engineering 263: (2017) 022013.
5. Kadam J, Madiwale S, Bashte B, Dindorkar S, Dhawal P, More P (2020). Green mediated synthesis of palladium nanoparticles using aqueous leaf extract of Gymnema sylvestre for catalytic reduction of Cr (VI) SN Applied Sciences 2:1854.
6. Kondaiah S Babu P, Ahmed Osman I, Sulaiman Hussaini S, Mohammed Abri Al, N Siva Kumar •. Satya Vijaya Kumar N, Shravan Kumar Reddy S, Kishor Kumar S, Ahmed Fatesh Sal, • Bhagavanth Reddy (2024). Eco friendly synthesis of Salmalia Malabarica gum stabilized palladium nanoparticles: antibacterial and catalytic properties. Biomass Conversion and Biorefinery https://doi.org/10.1007/s13399-024-05443-2.