

Green Synthesis and Physicochemical Characterization of Platinum Nanoparticles Using Anisochilus Scaber Benth Leaf Extract: Antioxidant And Antidiabetic Activities

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Abstract

Developing an economically viable and environmentally sustainable method for the preparation of metallic nanoparticles remains a priority within the expanding area of nanobiotechnology. The present study reports a simple, reagent free plant mediated synthesis of platinum nanoparticles (PtNPs) using leaf extract obtained from Anisochilus scaber Benth (family: Lamiaceae) as a dual reducing and capping agent. The obtained nanoparticles were comprehensively investigated for their physicochemical characteristics, antioxidant activity and antidiabetic potential. The formation of PtNPs was verified through UV–Visible analysis, XRD analysis, FTIR analysis, SEM analysis, TEM analysis, DLS analysis, zeta potential measurement, and EDX analysis. Antioxidant potential was evaluated by employing DPPH, ABTS, FRAP, H₂O₂ radical scavenging, and NO radical scavenging assays. Antidiabetic potential was evaluated through in vitro inhibition of α -amylase, α -glucosidase, and β -glucosidase enzymes. UV–Vis analysis showed a distinct absorption peak at 240 nm. XRD analysis revealed the cubic crystalline structure with diffraction peaks at $2\theta = 39.6^\circ$, 46.2° , and 67° (JCPDS card No. 01-1190). TEM showed an average core diameter of approximately 94 nm, with a DLS hydrodynamic size of 126 nm (PDI = 0.268). The resulting nanoparticles showed a remarkable zeta potential value of -63.4 mV, reflecting exceptional colloidal stability. EDX confirmed platinum as the predominant elemental constituent (83.18 wt%). The PtNPs demonstrated broad-spectrum, concentration-dependent antioxidant activity, with DPPH IC₅₀ = 95.50 μ g/ml, H₂O₂ IC₅₀ = 71.74 μ g/ml, ABTS IC₅₀ = 81.60 μ g/ml, and NO IC₅₀ = 82.91 μ g/ml. Antidiabetic inhibition IC₅₀ values were determined as 69.11 μ g/ml (α -amylase), 56.35 μ g/ml (α -glucosidase), and 48.26 μ g/ml (β -glucosidase). This study establishes Anisochilus scaber Benth as a potent and previously underexplored phytochemical resource for the green fabrication of colloiddally stable PtNPs with significant antioxidant and antidiabetic potential, contributing a novel plant nanoparticle system to the nanobiotechnology literature.

1. Introduction

Nanotechnology has become one of the fastest growing interdisciplinary research areas owing to its extensive medical applications, environmental sustainability, renewable energy, advanced manufacturing and the development

of functional materials. Among the different classes of nanomaterials, metallic nanoparticles have received widespread research interest owing to their distinctive physicochemical properties, such as a high surface area-to-volume ratio, enhanced surface reactivity, adjustable optical characteristics, and

favourable biocompatibility. These properties have enabled their utilization in diverse biomedical applications such as drug delivery, antimicrobial therapy, biosensing, bioimaging, antioxidant therapy, and cancer treatment [1,2].

Among noble metal nanoparticles, platinum nanoparticles (PtNPs) have attracted increasing scientific attention because of their outstanding catalytic activity, excellent chemical stability, corrosion resistance, and biocompatibility. Platinum-based materials are extensively employed in industrial catalysis, fuel cell technology, electronic devices, and medical applications. Conventional platinum containing drugs including cisplatin and carboplatin remain important chemotherapeutic agents in cancer treatment, however, their clinical application is often limited by dose limiting adverse effects including nephrotoxicity, neurotoxicity, and cytotoxicity. Consequently, the development of eco-friendly platinum nanomaterials has attracted considerable research attention as a potential alternative for biomedical applications [3,4].

A variety of physical, chemical, electrochemical, and photochemical approaches have been developed for the synthesis of PtNPs. However, these approaches frequently depend on toxic reagents, require substantial energy input, and generate environmentally undesirable waste, thereby restricting their biomedical applicability. Green synthesis is increasingly recognized as an environmentally sustainable

that employs naturally derived biological materials, particularly plant extracts as reducing and stabilizing agents during nanoparticle synthesis. Plant mediated nanoparticle synthesis offers several advantages including operational simplicity, cost-effectiveness, environmental compatibility, and does not require additional reducing or stabilizing agents. The phytochemicals present in plant extracts, including flavonoids, phenolic compounds, alkaloids, terpenoids, and quinones, play a crucial role in the reduction of metal ions and stabilization of the synthesized nanoparticles [5].

Anisochilus scaber Benth, a member of the family Lamiaceae, is naturally distributed in South India and has traditionally been employed to treat a variety of health conditions. The plant contains abundant bioactive phytoconstituents, including polyphenols, flavonoids derivatives, terpenes, and other secondary metabolites, which are reported to promote the conversion of metal ions into stable nanostructures during green synthesis. These phytoconstituents, together with the plant's medicinal significance, highlight *Anisochilus scaber* Benth as a valuable natural resource for producing biologically active nanomaterials. Although *Anisochilus scaber* Benth has received limited attention in plant mediated nanoparticle synthesis, its potential for green nanomaterial fabrication has been demonstrated in a recent study involving tellurium nanoparticles [6]. Therefore, the

present study selected *Anisochilus scaber* Benth leaf extract as a naturally derived reducing and stabilizing agent for the synthesis of PtNPs.

Excessive production of reactive oxygen species induces oxidative stress which contributes to the development of numerous chronic conditions such as cancer, diabetes, cardiovascular diseases, and neurodegenerative disorders. Antioxidants play an important function in scavenging free radicals and preserving the structural and functional integrity of cellular components. Diabetes mellitus represents a chronic metabolic disease marked by persistently elevated blood glucose levels caused by impaired insulin secretion, reduced insulin sensitivity, or a combination of both. The inhibition of carbohydrate-hydrolyzing enzymes including α -amylase and α -glucosidase has been recognized as a valuable therapeutic approach for controlling postprandial hyperglycemia. Therefore, the development of novel antioxidant and antidiabetic agents from environmentally sustainable sources remains an important area of biomedical research [7,8].

Numerous investigations have demonstrated the successful formation of PtNPs employing plant derived extracts that function as natural reducing and capping agents. Kumar et al. synthesized stable PtNPs using polyphenol-rich plant extracts and demonstrated their excellent physicochemical properties [9]. Thirumurugan et al. reported the biosynthesis of PtNPs using *Azadirachta indica* leaf extract,

highlighting the role of phytochemicals in nanoparticle formation and stabilization [10]. Furthermore, recent studies have emphasized the applicability of biogenic PtNPs for antioxidant, antimicrobial, anticancer, as well as other therapeutic applications. These findings indicate that medicinal plants represent promising resources for the sustainable synthesis of functional platinum nanoparticles [11].

Although platinum nanoparticles have been produced with the aid of different extracts obtained from plants, reports on the utilization of *Anisochilus scaber* Benth for the synthesis of PtNPs remain limited. Based on the available literature, a comprehensive investigation of PtNPs synthesized with *Anisochilus scaber* leaf derived extract, including detailed physicochemical characterization, evaluation of colloidal stability, antioxidant activity, and broad-spectrum antidiabetic potential, has not yet been reported. Accordingly, the objective of this study was to synthesize platinum nanoparticles through an eco-friendly green synthesis approach using *Anisochilus scaber* leaf extract. The obtained PtNPs underwent characterization using UV–Visible analysis, FTIR analysis, XRD analysis, SEM analysis, TEM analysis, DLS analysis, zeta potential analysis, and EDX analysis. Furthermore, the antioxidant activity of the obtained nanoparticles was assessed by employing DPPH, ABTS, FRAP, H_2O_2 , and nitric oxide

scavenging assays, while their antidiabetic potential was investigated through the combined examination of α -amylase, α -glucosidase, and β -glucosidase enzyme inhibition.

2. Materials and Methods

2.1 Materials Required:

Platinum chloride, Distilled water, Plant extract

2.2 Preparation of Leaf Extract

Freshly collected *Anisochilus scaber* Benth leaves were thoroughly washed under running tap water to remove debris, followed by double distilled water before shade drying. The shade dried leaf was finely crushed into powder. The powdered sample (10 g) was mixed with 100 ml of double distilled water by heating at 60°C for 20 min. After the extract reached room temperature, it was filtered and collected for subsequent nanoparticle synthesis.

2.3 Synthesis of Platinum Nanoparticles

Figure 1 shows the schematic representation of green synthesis of PtNPs using *Anisochilus scaber* Benth leaf extract



Figure 1 Schematic illustration of synthesized PtNPs using *Anisochilus scaber* Benth leaf extract

3. Results and Discussion

3.1 UV-Vis Analysis

The UV–Vis absorption spectrum exhibited a characteristic absorption peak at 240 nm, suggesting the formation of PtNPs (figure 2). This spectral band is associated with the interband electronic transitions of platinum and suggests the conversion of Pt(IV) ions into elemental platinum (Pt^0) mediated by phytoconstituents in the leaf extract. Observation of this absorption feature, in the absence of additional sharp peaks, is consistent with the formation of nanoscale platinum particles. The observed UV–Vis absorption behavior supports the synthesis of PtNPs [12]. Comparable UV–Visible absorption features have been reported for plant-mediated platinum nanoparticles, with absorption peaks at 295 nm observed for PtNPs synthesized using *Atriplex halimus* and *Cichorium intybus* leaf extracts

[13,14]. The observed shift to a lower absorption wavelength (240 nm) may be associated with differences in the phytochemical constituents of the *Anisochilus scaber* leaf derived extract and the resulting surface chemistry of the prepared platinum nanoparticles.

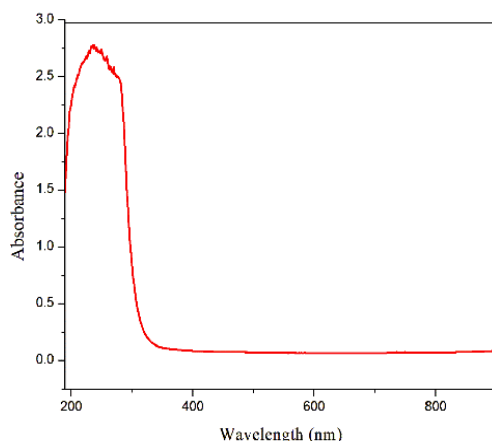


Figure 2 UV-Vis absorption spectrum of the sample showing characteristic absorbance peak

3.2 X-RAY Diffraction Analysis

Figure 3 demonstrates the XRD pattern of the synthesized PtNPs. The diffraction peaks observed at 2θ values of 39.6° , 46.2° , and 67° were indexed to the (111), (200), and (220) crystallographic planes respectively, which are indicative of cubic platinum. The observed diffraction pattern closely matches the standard platinum data reported in JCPDS card No. 01-1190, indicating the formation of crystalline PtNPs.

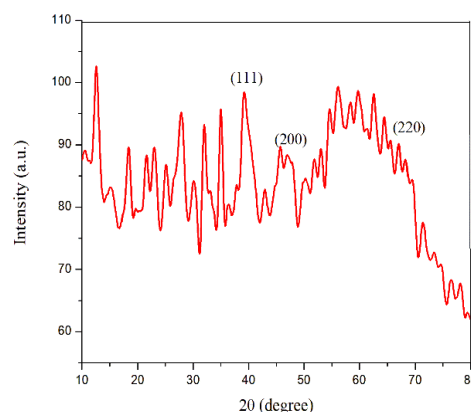


Figure 3 XRD Pattern of PtNPs showing their characteristic crystalline peaks

3.3 FTIR Spectral Analysis

FTIR analysis was performed to determine the phytochemical functional groups of *Anisochilus scaber* leaf extract associated with the synthesis of PtNPs. The FTIR characteristics of the synthesized PtNPs is presented in Figure 4. The broad absorption band centred at 3414 cm^{-1} , assigned to O–H and N–H stretching vibrations, indicates the presence of phenolic compounds, flavonoids, tannins, and proteinaceous biomolecules [15]. These hydroxyl- and amino containing phytochemicals are likely involved in the reduction of Pt (IV) ions through electron donation and subsequently adsorb onto the nanoparticle surface, contributing to colloidal stability. The absorption band at 1632 cm^{-1} , corresponding to C=O stretching vibrations of carbonyl containing compounds or amide I groups, further suggests the possible participation of flavonoids and proteins in metal ion coordination and nanoparticle capping.

Additional bands observed at 1386, 1248, and 1056 cm^{-1} are attributed to C–N and C–O stretching vibrations, indicating the presence of amino and oxygen containing phytochemicals that may further contribute to surface adsorption and stabilization of the synthesized nanoparticles [16,17]. The weak band at 2924 cm^{-1} corresponds to aliphatic C–H stretching vibrations, whereas the absorption near 633 cm^{-1} may be associated with low-frequency skeletal vibrations or possible C–Cl stretching modes [18]. Overall, the FTIR analysis indicates that hydroxyl, carbonyl, amino, and other oxygen-containing functional groups present in *Anisochilus scaber* leaf extract collectively contribute to the synthesis of PtNPs by participating in Pt (IV) reduction and subsequent nanoparticle capping and stabilization.

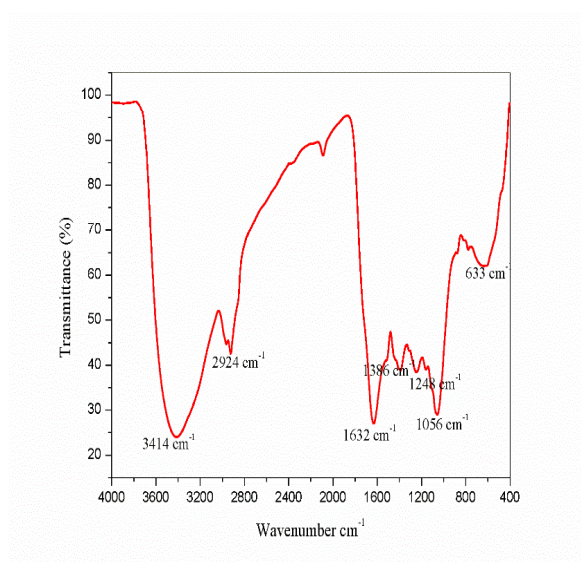
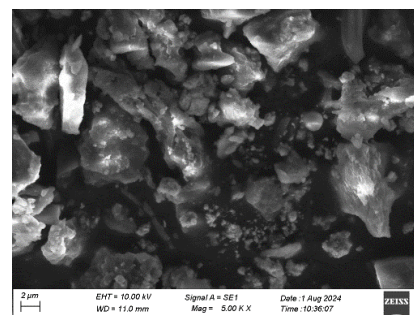


Figure 4 FTIR analysis of PtNPs indicating the presence of functional groups

3.4 SEM Analysis

SEM micrographs were examined to

determine the particle morphology and surface structure of synthesized nanoparticles. Figure 5 shows the SEM micrograph of synthesized PtNPs. The SEM micrographs revealed predominantly irregular and quasi-spherical particles with a tendency to form aggregated clusters. An average particle size of 126 nm was determined from the analysis. The nanoparticles also exhibited a heterogeneous surface texture and non-uniform distribution. The observed morphological features may be attributed to the contribution of phytochemical constituents during the reduction and stabilization of PtNPs. The morphological features observed in the present study are broadly comparable with those reported for *Cordyceps* flower-derived PtNPs, which also exhibited irregular quasi-spherical particles with phytochemical capping [19]. In contrast, *Xanthium strumarium* derived PtNPs showed a distinct cubic to rectangular morphology with an average particle size of 22 nm [20], highlighting the influence of the plant extract on nanoparticle growth and morphology.



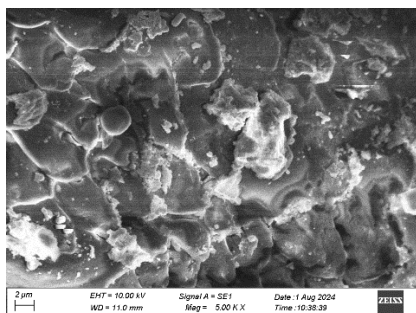


Figure 5 SEM image revealing the morphological features of synthesised PtNPs

3.5 DLS Analysis

DLS analysis provided particle size distribution for the synthesized PtNPs (Figure 6). The mean hydrodynamic size was found to be 126 nm, with a PDI value of 0.268. The PDI value suggests a relatively narrow particle size distribution, indicating moderate uniformity among the synthesized PtNPs [21].

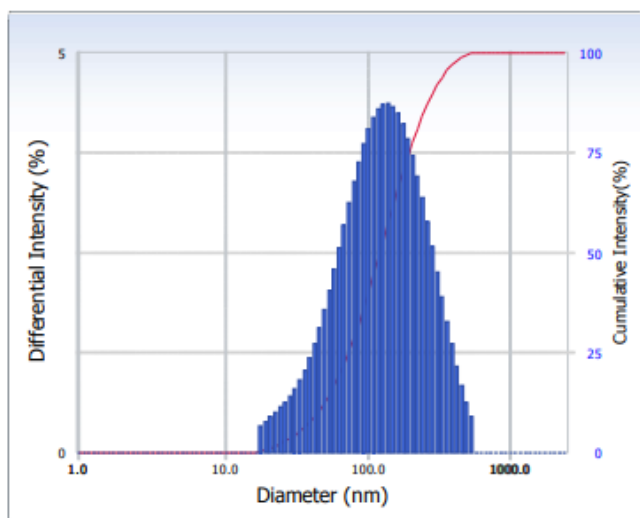


Figure 6 DLS analysis of synthesised PtNPs

3.6 Zeta Potential

The surface charge and colloidal stability of the resultant PtNPs were evaluated using zeta potential analysis, as illustrated in Figure 7. The measured zeta potential was -63.4 mV, indicating strong electrostatic repulsion

between particles and excellent colloidal stability in aqueous suspension. The observed value is substantially higher in magnitude than that reported for platinum nanoparticles synthesized using water hyacinth extract (-0.0536 mV), which exhibited a near-neutral surface charge and comparatively limited electrostatic stabilization [22]. The markedly higher negative zeta potential obtained in the present study suggests effective surface capping by phytochemical constituents from the plant extract, resulting in enhanced electrostatic stabilization of the nanoparticles in dispersion. Although some particle agglomeration was observed in the SEM images, this is likely attributable to particle association during sample drying rather than instability in suspension. The high negative surface charge observed in the present study demonstrates that the biosynthesis approach produced PtNPs with excellent dispersion stability, which is beneficial for preserving nanoparticle functionality in aqueous systems and may improve their suitability for subsequent catalytic and biomedical applications.

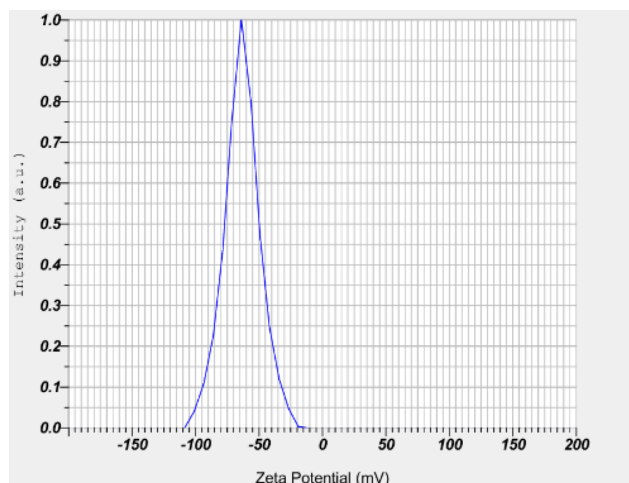
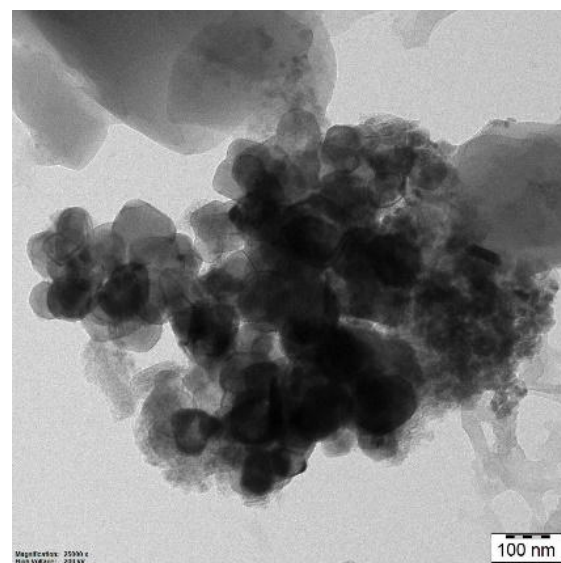


Figure 7 Zeta potential distribution of synthesised PtNPs showing surface charge stability

3.7 TEM Analysis

TEM analysis was performed to evaluate the size and morphological characteristics of the synthesized PtNPs, as presented in Figure 8. TEM analysis provided a more precise assessment of the core particle dimensions, revealing spherical nanoparticles exhibiting an average diameter of about 94 nm. The difference between the TEM core size (~94 nm) and the DLS hydrodynamic diameter (126 nm) is physically meaningful and expected. TEM images particles in the dry, dehydrated state and therefore measures only the inorganic metallic core, whereas DLS measures the hydrodynamic diameter in solution, which includes the inorganic core, the phytochemical capping layer, and the associated hydration shell surrounding the particles [23]. The observed size discrepancy is likely due to the adsorption of plant-derived biomolecules at the nanoparticle surface, thereby producing a larger

apparent particle size compared with the metallic core. Comparable TEM–DLS size discrepancies have been reported for broccoli extract-mediated PtNPs (TEM: ~14.83 nm; DLS: ~136.9 nm), where the considerably larger hydrodynamic diameter was attributed to extensive biomolecular capping [24]. In contrast, the relatively smaller difference between the TEM and DLS measurements observed in the present study, together with the highly negative zeta potential (−63.4 mV), suggests that the synthesized PtNPs possess an effective phytochemical capping layer that provides excellent colloidal stability without excessive surface coating. Such a balance between surface stabilization and limited hydrodynamic enlargement may be advantageous for applications requiring stable nanoparticle dispersions while maintaining greater accessibility of the platinum surface.



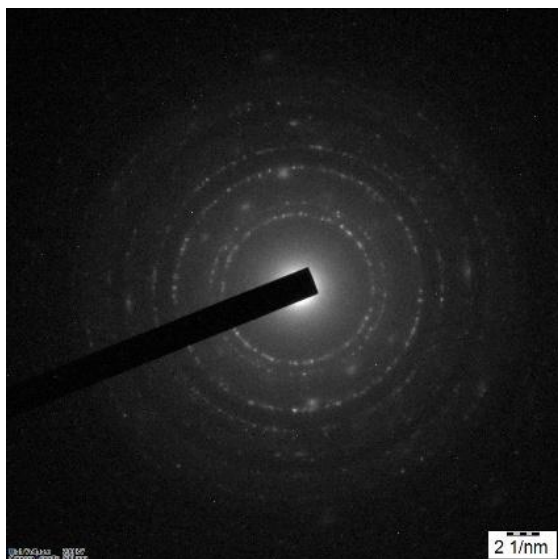


Figure 8 TEM micrograph illustrating the structural features of the synthesized PtNPs

3.8 EDX Analysis

The elemental distribution of the synthesized PtNPs was analyzed using EDX characterization, as presented in Figure 9. The spectrum indicated platinum as the major constituent, suggesting the formation of PtNPs. A minor oxygen signal was also observed, which may be associated with surface bound biomolecules from the plant extract and adsorbed oxygen containing species on the nanoparticle surface. Trace signals of nickel and titanium were additionally detected, which may arise from residual impurities, instrumental background, or contributions from the synthesis environment. Compared with typical reports on green synthesized platinum nanoparticles, which often show higher contributions of surface associated elements due to strong phytochemical capping, the present sample exhibits a relatively higher dominance of platinum signal, indicating a greater proportion

of metallic content. The elemental distribution is summarized in Table 1.

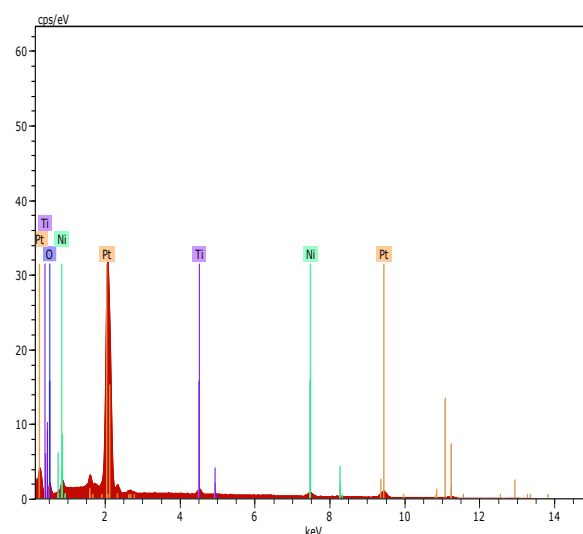


Figure 9 EDX spectrum of PtNPs

Table 1 EDX micro analysis of the PtNPs via Anisochilus scaber Benth leaf extract

Element	Weight %	Atom %
Pt	83.18	39
O	8.17	46.74
Ni	6.4	9.98
Ti	2.24	4.28

3.9 Anti-Oxidant Activity

The antioxidant potential of PtNPs synthesized using *Anisochilus scaber* Benth leaf extract was evaluated using five radical scavenging assays (DPPH, FRAP, H₂O₂, ABTS and Nitric oxide (NO)), across a concentration interval of 10 - 500 µg/ml. The inhibition percentages and IC₅₀ results are consolidated in table 2. Figure 10 shows the antioxidant properties of the prepared PtNPs.

Table 2 Antioxidant activity (% inhibition) of PtNPs at various concentrations

Concentration (µg/ml)	DPPH (%inhibition)	FRAP (% inhibition)	H ₂ O ₂ (% inhibition)	ABTS (% inhibition)	NO (% inhibition)
500	72.86	88.51	81.96	83.23	56.57
250	66.56	57.47	74	80.49	50.53
100	63.17	49.68	61.13	78.67	44.01
50	59.29	43.05	54.96	72.83	39.48
10	52.56	33.96	34.07	69.57	29.23
IC ₅₀ (µg/ml)	95.50	-	71.74	81.60	82.91

All five assays showed a concentration dependent enhancement in antioxidant response, with the highest scavenging percentage recorded at a concentration of 500 µg/ml and the minimum response at 10 µg/ml (Table 1). This consistent trend across mechanistically distinct assays confirms that the antioxidant capacity of PtNPs scales reliably with concentration. The activity is attributed to the phytochemical constituents of *Anisochilus scaber* Benth leaf extract retained on the nanoparticle surface, which function as hydrogen-atom donors and electron-transfer agents to neutralize free radicals.

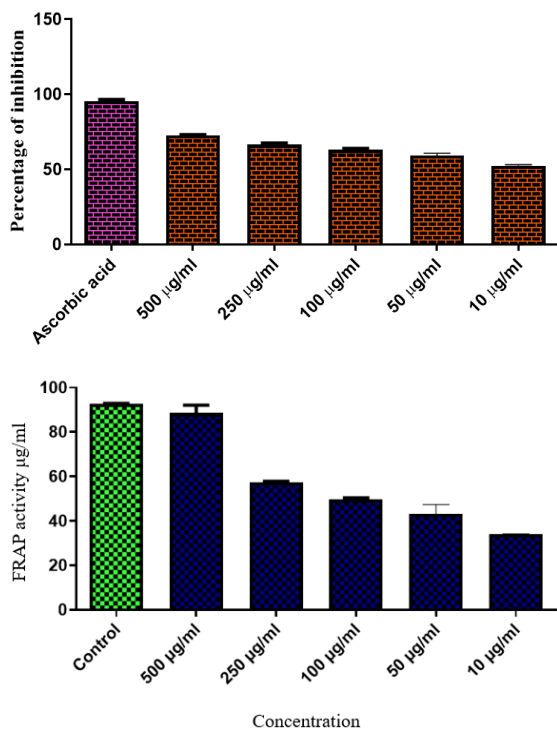
Among the assays, ABTS scavenging showed the highest inhibition (69.57–83.23%), indicating electron-transfer capacity, while NO scavenging was comparatively modest (29.23–56.57%), suggesting lower reactivity toward nitrogen centred radicals. The FRAP assay reflected significant reducing ability, with 88.51% inhibition at 500 µg/ml, demonstrating effective Fe³⁺ to Fe²⁺ reduction. DPPH and H₂O₂

assays showed intermediate responses, exhibiting IC₅₀ values of 95.50 and 71.74 µg/ml respectively.

Comparable antioxidant activities have been reported for other plant-mediated platinum nanoparticles. Atriplex halimus-derived PtNPs exhibited a DPPH IC₅₀ of approximately 36 µg/mL, indicating stronger DPPH radical scavenging than that observed in the present study (Eltaweil et al. [13]). Similarly, Cordyceps flower-derived PtNPs demonstrated concentration-dependent DPPH scavenging activity, although only a single antioxidant assay was evaluated (Liu et al. [19]). In contrast, *Nymphaea tetragona*-mediated PtNPs were primarily assessed using ABTS and FRAP assays, demonstrating effective electron-transfer antioxidant activity (Yisen Zhang et al. [25]). Variations in antioxidant performance among these studies may be attributed to variations in phytochemical composition, nanoparticle dimensions, morphology, surface properties, along with synthesis conditions. Compared with these previous reports, the present study employed five complementary antioxidant assays (DPPH, ABTS, FRAP, H₂O₂, and NO), thereby providing a holistic evaluation of the antioxidant performance of *Anisochilus scaber*-mediated PtNPs through multiple radical scavenging and reducing mechanisms.

The broad spectrum radical scavenging activity observed across hydrogen atom transfer (DPPH, H₂O₂), electron-transfer (ABTS,

FRAP), and reactive nitrogen species (NO) assays collectively indicates the antioxidant potential of the synthesized PtNPs. These findings support further research into oxidative stress associated biomedical applications.



(a)

(b)

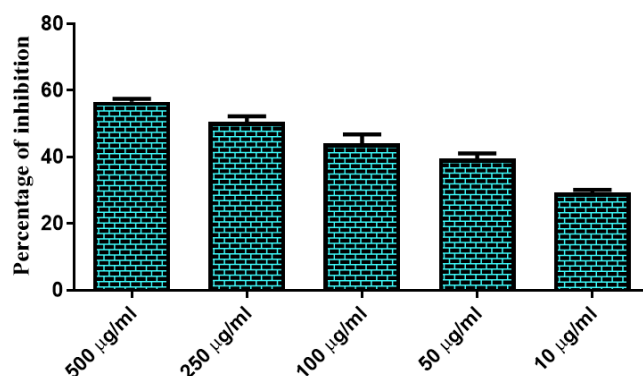
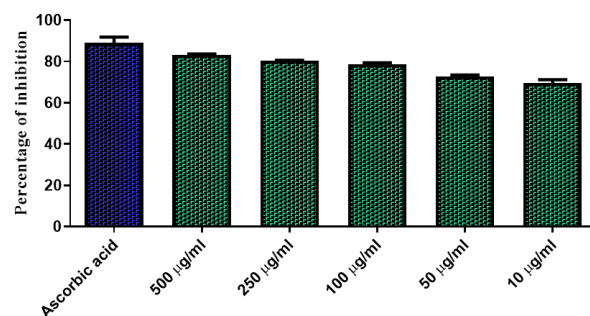
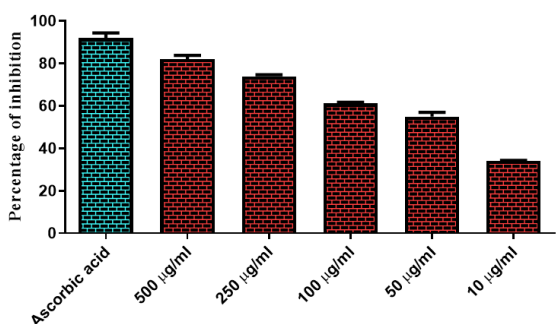


Figure 10 Antioxidant activity of PtNPs: (a) DPPH assay (b) FRAP assay (c) H₂O₂ assay (d) ABTS assay (e) NO assay

2.10 Anti diabetic

The antidiabetic potential of PtNPs synthesized with *Anisochilus scaber* Benth leaf extract was evaluated through inhibition on key carbohydrate hydrolyzing enzymes, namely α -amylase, α -glucosidase and β -glucosidase, over a concentration range of 10 to 500 µg/ml. The percentage inhibition values and IC₅₀ results are presented in table 3. Figure 11 shows the antidiabetic activity of synthesized PtNPs.

Table 3 Antidiabetic activity (% inhibition) of synthesized PtNPs at various concentrations

Concentration (µg/ml)	α -amylase (% inhibition)	α -glucosidase (% inhibition)	β -Glucosidase (% inhibition)
500	54.92	83.71	76

250	54.28	80.14	75.03
100	52.46	75.16	71.64
50	24.56	69.71	60.26
10	21.28	56.05	42.82
IC ₅₀ (µg/ml)	69.11	56.35	48.26

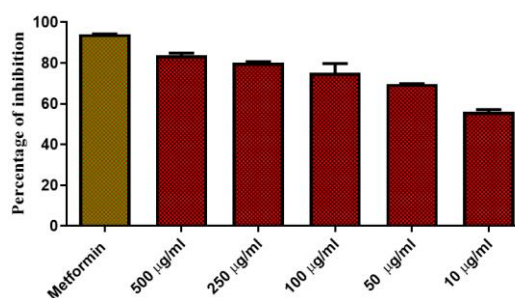
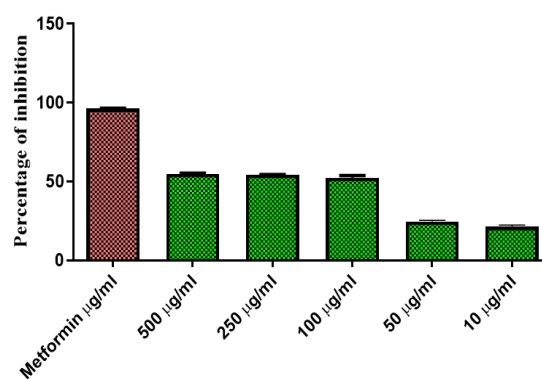
The antidiabetic potential of PtNPs synthesized using *Anisochilus scaber* Benth leaf extract was evaluated by assessing the inhibition of α -amylase, α -glucosidase, and β -glucosidase, at concentrations between 10 and 500 µg/ml. All three enzyme assays exhibited a concentration dependent response, with inhibitory activity increasing as the PtNPs concentration increased from 10 to 500 µg/ml. IC₅₀ values were determined to be 69.11 µg/ml, 56.35 µg/ml and 48.26 µg/ml for α -amylase, α -glucosidase, and β -glucosidase respectively, indicating effective suppression of enzymes that regulate carbohydrate metabolism.

Among the three enzymes, α -glucosidase exhibited the highest inhibition (56.05–83.71%), followed by β -glucosidase (42.82–76.00%), whereas α -amylase showed comparatively lower inhibition (21.28–54.92%). The lower IC₅₀ values obtained for α -glucosidase and β -glucosidase indicate greater enzyme sensitivity to the synthesized PtNPs under the present in vitro conditions. Preferential inhibition of glucosidase enzymes may be advantageous because these enzymes contribute significantly to the final stages of carbohydrate digestion and glucose release.

The observed enzyme inhibitory activity

is likely associated with phytochemical constituents adsorbed onto the nanoparticle surface, which could promote binding between the synthesized PtNPs and the target enzymes, resulting in reduced catalytic activity. Furthermore, the high surface area of the nanoparticles may enhance these interactions, contributing to the concentration-dependent inhibitory effects observed in the present study.

Simultaneous evaluation of α -amylase, α -glucosidase, and β -glucosidase provides a broader assessment of the in vitro antidiabetic efficacy of the synthesized PtNPs by examining their inhibitory effects on multiple enzymes responsible for carbohydrate metabolism. Collectively, the present results indicate the in vitro antidiabetic potential of *Anisochilus scaber* mediated PtNPs and support their further investigation through cellular and in vivo studies.



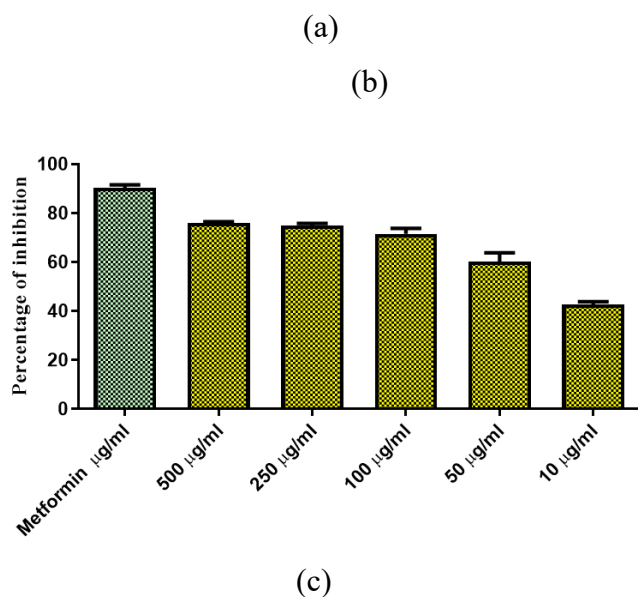


Figure 11 Antidiabetic activity of PtNPs: (a) α -amylase activity (b) α -glucosidase activity (c) β -Glucosidase activity

Table 4 presents a systematic comparison of the physicochemical properties together with biological activities exhibited by the PtNPs synthesized in this work against selected published studies on green-synthesized platinum nanoparticles. This comparison contextualizes the present results and highlights the distinctive contributions of the current investigation.

Table 4 Comparative analysis of synthesized PtNPs: Physiochemical properties and biological activities.

amylase, α -glucosidase, and β -glucosidase),

Plant source	UV-Vis (nm)	Zeta potential (mV)	EDX platinum weight (%)	TEM size (nm)	Biological activity	Ref
Anisochilus scaber Benth	240	-63.4	83.18	94	Antioxidant (5 assays) Antidiabetic (α -amylase, α -glucosidase, β -glucosidase)	[This study]
Cordyceps flower	260	-8.64	2.41	13.34	Antioxidant (DPPH), Antibacterial	[19]
Xanthium strumarium	260-300	-	-	22	Cytotoxicity (HeLa), Antibacterial	[20]
Atriplex halimus	295	-25.4	90	1-3	Antibacterial, Antioxidant (DPPH)	[13]
Cichorium intybus	295	-	-	-	Antioxidant (DPPH, FRAP), Antimicrobial	[14]
Broccoli extract	253	-8.6	-	14.83	Antibacterial, Antioxidant (in vivo), Antidiabetic (α -amylase, α -glucosidase)	[24]
Water hyacinth	286 & 322	-0.053	-	3.74	Eco-friendly synthesis, Limited stability	[22]

As evident from Table 4, the present study demonstrates several notable features compared with the selected reports on green synthesized PtNPs. Among the studies included in this comparison, the synthesized PtNPs exhibited the highest absolute zeta potential (-63.4 mV), suggesting excellent colloidal stability. Furthermore, the present work evaluated the inhibitory activity against three key carbohydrate breakdown enzymes (α -

providing a broader assessment of antidiabetic potential than the comparative studies summarized in Table 4. In addition, the application of five complementary antioxidant assays offers a broad assessment of antioxidant capacity compared with the individual assay panels reported in the selected studies. Although the average TEM particle size (94 nm) is larger than that reported for some plant mediated

PtNPs, the nanoparticles exhibited excellent surface stability, which may be advantageous for maintaining stable dispersions and supporting their potential biological applications.

3. Conclusion

Platinum nanoparticles were successfully synthesized using *Anisochilus scaber* Benth leaf extract through an eco-friendly and sustainable green synthesis approach. UV-Visible spectroscopy indicated the formation of PtNPs, while XRD analysis demonstrated their crystalline nature. FTIR results suggested probable contribution of plant derived reactive functional groups during the reduction and stabilization of platinum precursors. SEM and TEM analyses were employed to examine the morphology of the nanoparticles, while DLS was used to determine their hydrodynamic size distribution. Zeta potential measurements indicated good colloidal stability. The synthesized PtNPs exhibited concentration dependent antioxidant activity in DPPH, FRAP, H₂O₂, ABTS, and nitric oxide scavenging assays. In addition, the nanoparticles demonstrated the ability to inhibit α -amylase, α -glucosidase, and β -glucosidase enzymes. The findings demonstrate the potential of *Anisochilus scaber* leaf extract as a biological resource for the synthesis of PtNPs and provide preliminary evidence supporting their antioxidant and antidiabetic potential. Additional studies are required to investigate the

mechanistic basis and evaluate their biological performance using advanced in cell culture and animal models.

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