Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 19s (2025)
https://www.jneonatalsurg.com

OPEN ACCESS

Green Synthesis Of Titanium Dioxide Nanoparticles By Using Ethanolic Leaf Extract Of Jatropha Curcas L.

Kishor Dadaso Madane[1], Sandeep Ravindra Kane[2*], Shrinivas Krishna Mohite[3], Shailaja Jaykumar Kamble[4], Akshada Vivek Deshmukh[5], Avani Krushnaji Shewale[6]

[1]Research scholar, Rajarambapu College of Pharmacy, Kasegaon, Maharashtra. Rajarambapu college of Pharamcy Kasegaon, Shivaji University Kolhapur.
[2*,4,6]Assistant professor, Rajarambapu College of Pharmacy, Kasegaon, Maharashtra. Rajarambapu college of Pharamcy Kasegaon, Shivaji University Kolhapur.
[3]Professor, Rajarambapu College of Pharmacy, Kasegaon. Maharashtra, Rajarambapu college of Pharamcy Kasegaon, Shivaji University Kolhapur.
[5]Assistant professor, Ashokrao Mane College of Pharmacy, PethVedgaon, Ashokrao Mane College of Pharamcy Peth Vedgaon. Shivaji University Kolhapur.
***Corresponding Author-**
Dr. Sandeep Ravindra Kane
*Assistant professor, RCP Kasegaon Maharashtra India.
Email ID: drsrkane@kesrcp.com

Cite this paper as: Kishor Dadaso Madane, Sandeep Ravindra Kane, Shrinivas Krishna Mohite, Shailaja Jaykumar Kamble, Akshada Vivek Deshmukh, Avani Krushnaji Shewale (2025) Green Synthesis Of Titanium Dioxide Nanoparticles By Using Ethanolic Leaf Extract Of Jatropha Curcas L.. *Journal of Neonatal Surgery*, 14 (19), 1066-1073

ABSTRACT

The current study presents a green, eco-friendly approach for the synthesis of titanium dioxide (TiO_2) nanoparticles using ethanolic leaf extract of Jatropha curcas L., a medicinal plant rich in bioactive compounds. Traditional chemical and physical synthesis methods often involve hazardous reagents and energy-intensive processes; in contrast, this biological method offers a sustainable alternative. The leaves were extracted via Soxhlet apparatus using ethanol as solvent, and the resulting extract was employed in the reduction and stabilization of TiO_2 nanoparticles. The synthesized nanoparticles were characterized using GC-MS, DLS, zeta potential, SEM, and XRD techniques. GC-MS analysis confirmed the presence of twelve major phytochemicals, such as (+)-2-Bornanone, caryophyllene, alpha-pinene, and flavonoids, which are known for their antioxidant and antimicrobial properties. DLS analysis revealed an average particle size of 125 nm with a PDI of 0.410, indicating moderate monodispersity. Zeta potential analysis showed a negative surface charge of -35.2 mV, confirming high colloidal stability. SEM images revealed rough, wrinkled surfaces suggesting high surface reactivity, while XRD analysis confirmed the crystalline anatase phase of TiO_2. Antioxidant activity assessed via DPPH assay demonstrated a significant dose-dependent response, with a maximum inhibition of 73.57% at 100 µg/mL and an IC_{50} value of 75.08 µg/mL, comparable to ascorbic acid.

Keywords: Fluoroquinolones (FQs), Antibacterial agents, Anticancer activity, Urinary tract infections (UTIs), Antimicrobial agents, Antioxidant

1. INTRODUCTION

The fluoroquinolones (FQs) are one of the most often utilised classes of antibacterial medicines in the world due to their excellent physicochemical and pharmacokinetic characteristics. Following oral administration, late-generation drugs have good half-lives (levofloxacin: 13 hours) and exceptional bioavailability (levofloxacin: 99%) [1–3]. Due to their high synthesis flexibility and ease of usage with a range of methods and building blocks, quinolone derivatives make it easier to construct and test a wide range of flexible chemical structures [4,6,7]. Research on the fluoroquinolone structure activity relationship (SAR) led to the development of therapeutically beneficial analogues with improved antibacterial qualities [3,8]. Recent research has shown that some derivatives of ciprofloxacin (CIP) and norfloxacin (NOR) have more anticancer activity than their parent medications in a range of cancer cell lines [3,5,9]. Antibiotic therapy is necessary for urinary tract infections (UTIs), one of the most prevalent bacterial illnesses with a high percentage of morbidity in the general population [10]. Because fluoroquinolones (FQs) have a range of action that includes enteric Gram-negative bacilli, they have been widely utilised as an empirical therapy for UTI [11], that is, before the aetiology and antibiogram have been verified [12]. As soon as the bacteria causing the diseases and their antibiogram are identified [12], they are recommended as guided treatment [11] due to their several advantageous pharmacokinetic characteristics. Additionally, complex UTIs can be treated with FQs in conjunction with shorter antibiotic regimens [11,13,14]. Complex fluoroquinolone resistance can be caused by changes in enzymes, target-protection proteins, increased efflux pump production, or mutations in one or more target-site genes [15].

When the main binding is changed, the secondary target becomes a target, and fluoroquinolones will bind to it notwithstanding their preference [16]. They will go after either Both Gram-positive and Gram-negative bacteria use DNA

hydrothermal, electrochemical, and precipitation techniques. However, each of these methods has certain limitations. For instance, the sol–gel process is time-consuming, often requiring several hours to days for nanoparticle formation. The hydrothermal method involves complex chemical reactions and is primarily synthetic in nature. The precipitation method poses challenges in controlling particle size, as rapid precipitation can lead to the formation of larger, less uniform particles. In contrast, microbial synthesis offers a cost-effective and environmentally friendly alternative. This biological approach operates under mild conditions and avoids the use of hazardous chemicals, making it a sustainable method for nanoparticle production [6].

Table 1 Reservoirs of TiO2. Source

States of India	Resources of ilmenite minerals (million tonnes)	Resources of rutile minerals (million tonnes)
Odisha	96.44	4.47
Tamil Nadu	179.02	8.00
West Bengal	2.05	0.19
Andhra Pradesh	163.05	10.25
Jharkhand/Bihar	0.73	0.01
Gujarat	2.77	0.02
Kerala	145.70	8.41
Maharashtra	3.74	23.00

The extraction of Leaf of *Jatropha curcas* L. brings commercial importance to the plant [7,8]. Jatropha latex has some ethnomedical uses like wound healing and blood coagulation activities [9]. Jatropha curcas L. (Euphorbiaceae), also known as '*Mafengshu*', '*Xiaotongzi*' in Chinese, is cultivated for the medical purpose and widely spread in tropical regions over the world. *Guangxi Herbal Medicine* recorded that it was astringent, slightly cold and toxic, and has the effect of dissipating blood stasis and swelling, stanch bleeding, relieving pain, and preventing itching. Previous studies showed that the chemical components from *J. curcas* were diterpenoids, sesquiterpenes, lignans, and flavonoids [10,11].

2. MATERIAL AND METHODS

Material

Collection and Preparation of Sample

Leaf of the Jatropha curcas plant was collected from surrounding of local area of Kasegaon, Maharashtra, India, and was authenticated at the Department of Botany, Sadguru Ghadge Maharaj College, Karad, India. Then it has been washed with distilled water to avoid any microbial growth.

Chemicals

TiO (OH)2 analytical grade was purchased from Sigma-Aldrich (USA). All the aqueous solutions were prepared in triple distilled de-ionized water. All other chemicals and reagents were from standard commercial sources and of highest quality available.

Extraction and Preparation of Plant Extracts

A 25 g powdered sample of the Jatropha curcas leaves was placed into a thimble, which was then loaded inside the Soxhlet extractor. A 500 mL round-bottom flask with a condenser was attached to the Soxhlet extractor and filled with the ethanol. The extractor was then set up on a heating mantle. The solvent started to evaporate as it moved through the Soxhlet extractor to the condenser after being heated by the heating mantle. Next, drips of the condensed solvent started appearing in the Soxhlet extractor holding the thimble that contained the plant sample. The solvent with extract was recycled back to the round-bottom flask once the solvent level reached the siphon. This process continued until the designed period for the extraction had finished, and then the solution of the extract was given time to cool down at ambient temperature [12]. Following that, the extract was concentrated via a rotary evaporator after being filtered using Whatman No.1 filter paper. The dried extract was then kept chilled at 4 °C for further testing.

GCMS

GC-MS analysis was carried out with an SHIMADZU QP 2010T which composed of an auto sampler and gas chromatography interfaced to a mass spectrometer (GC-MS) instrument employing the following condition: capillary column −624 ms (30 m×0.32 mm×1.8 m) operating in an electronic modeat70eV;helium(99.99%) was used as the carrier gas at a constant flow of 1.491 mL/min and injection volume of 1.0 mL, injector temperature of 140 °C, and ion source temperature of 200 °C. The oven temperature was programmed from 45 °C. Mass spectra were taken at 70 eV [13].

Synthesis of TiO2 Nanoparticles

1 mM aqueous solution of titanium dioxide (TiO_2) was stirred at room temperature (25 °C) for 2 hours to achieve uniform dispersion. Following this, 10 mL of the prepared plant extract was slowly added to 20 mL of the TiO_2 solution under continuous stirring. The reaction mixture was maintained at 25 °C and stirred for an additional 4 hours. A visible color change to green or dark purple indicated the biosynthesis of TiO_2 nanoparticles via reduction by phytochemicals present in the extract [14].

Characterization of Nanoparticles

Dynamic Light Scattering (DLS)

The spectroscatterer RiNA, GmbH class3B was used to determine DLS measurements (the main size) of the TiO2 NPs. The dried powder was scattered in distilled water and all analyses were performed at 20℃ for ten cycles. The experiments for DLS were repeated three times. The non-destructive morphological analysis technique of dynamic light scattering had been applied in phytocomponent analysis. It is highly useful for the accurate sizing of chemical and physical materials that are synthesized using plant phytochemicals [15].

Zeta Potential

The Zeta Potential of Nanoparticles is a typical method for determining the surface charge property of Nanoparticles. It reflects a particle's electrical potential and is influenced by the particle's composition as well as the medium in which it is scattered. The Zeta Potential was analyzed using Malvern Zeta analyzer. The sample was placed in cuvette with necessary dilutions and it was then kept in analyzer to determine the Zeta potential [16].

SEM

SEM was used to characterize the morphology and particle size of AgNPs. A thin film of oven-dried GT AgNP sample was prepared and used over a carbon-coated copper grid via a TESCAN MIRA-3 instrument operated at an accelerated voltage of 20 kV [17].

XRD

XRD technique is used to study the crystalline or amorphous nature and the structure of the synthesized TiO2 NPs. Then the powdered sample was placed on a Shimadzu XRD-6000 and set in the range of $5\text{-}50^0$ at a 2ɵ angle [18].

Antioxidant Activity of Nanoparticle:

The antioxidant activity of the synthesized nanoparticles was evaluated using the DPPH (1,1-diphenyl-2-picrylhydrazyl) free radical scavenging assay. In this method, 1 mL of nanoparticle samples at varying concentrations (20, 40, 60, 80, and 100 µg/mL) was transferred into separate test tubes. To each sample, 1.5 mL of 0.1% methanolic DPPH solution was added, and the mixture was incubated in the dark for 30 minutes to allow the reaction to occur. Following incubation, the color change from purple to yellow was observed, indicating the reduction of DPPH radicals by antioxidants present in the sample. The absorbance of each mixture was measured at 510 nm using a colorimeter.

3. RESULT AND DISCUSSIONS

GCMS

The GC-MS chromatogram of the ethanolic leaf extract of *Jatropha curcas* revealed the presence of multiple bioactive compounds, each identified by their specific retention times and peak areas. A total of twelve significant phytoconstituents were detected, indicating the chemical complexity and therapeutic potential of the extract.

Among the identified compounds, (+)-2-Bornanone was the major constituent, showing the highest peak area (835,989) at a retention time of 13.426 minutes. This compound, commonly known as camphor, is well-known for its antimicrobial and anti-inflammatory properties. Caryophyllene, a sesquiterpene with notable anti-inflammatory and anticancer potential, was observed at a retention time of 20.998 minutes with a significant peak area of 129,317. Other notable constituents included Alpha-pinene (RT 6.841, peak area 6,583) and Camphene (RT 7.314, peak area 19,449), both of which are monoterpenes known for their antioxidant and antimicrobial effects. Additionally, the presence of flavonoids such as 3,5,7-trihydroxy-2-(4-hydroxyphenyl)-4H-chromen-4-one and 3,3’,4’,5,7-pentahydroxyflavone at retention times 21.287 and 24.464 minutes, respectively, highlights the strong antioxidant potential of the extract. Fatty acid derivatives including Hexadecanoic acid, methyl ester (RT 33.386) and Methyl stearate (RT 37.702) were also detected, contributing to the anti-inflammatory and

emollient properties of the extract. Other minor constituents such as Naphthalene, Neophytadiene, and a tetracyclic diterpene at RT 24.800 further support the pharmacological richness of the plant.

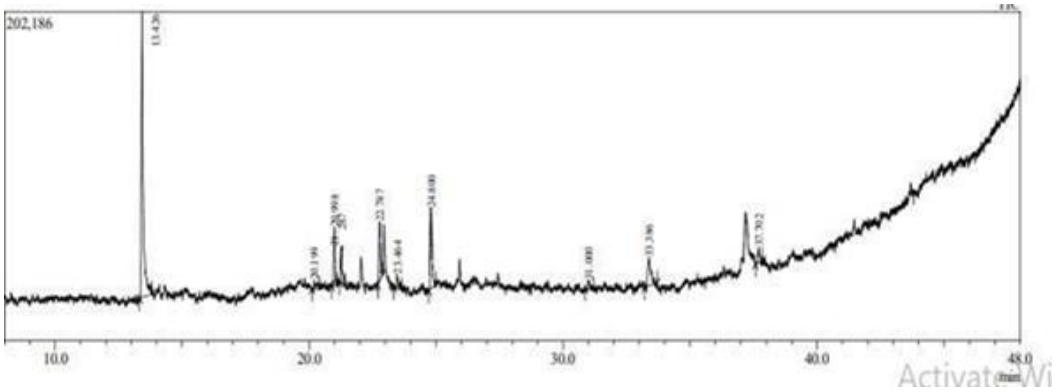

Figure1: GCMS of Jatropha curcas

Table2: GCMS analysis of Jatropha curcas.

Retention time	Peak area	Name
6.841	6583	Alpha pinene
7.314	19449	Camphene
13.426	835989	(+)-2-Bornanone
20.199	25280	Naphthalene
20.998	129317	Caryphyllene
21.287	90383	3,5,7 trihydroxy-2-(4hydroxyphenyl)-4H-chromen-4one
24.464	44750	3,3',4',5,7 pentahydroxyflavone
24.800	206707	(1aR,3aS,7S,7aS,7bR)-1,1,3a,7 Tetramethylde
31.000	20527	Neophytadiene
33.386	13484	Hexadecanoic acid, methyl ester
37.702	33417	Methyl stearate

Particle size

Dynamic light scattering (DLS) revealed a Z-average size of 125 nm with a polydispersity index (PDI) of 0.410, indicating moderate uniformity in particle size. The narrow, symmetric distribution curve suggests a monodisperse population with limited aggregation. This nanoscale dimension confirms the efficiency of the green synthesis method using *Jatropha curcas* extract and is suitable for drug delivery, photocatalysis, and sunscreen due to the high surface area-to-volume ratio.

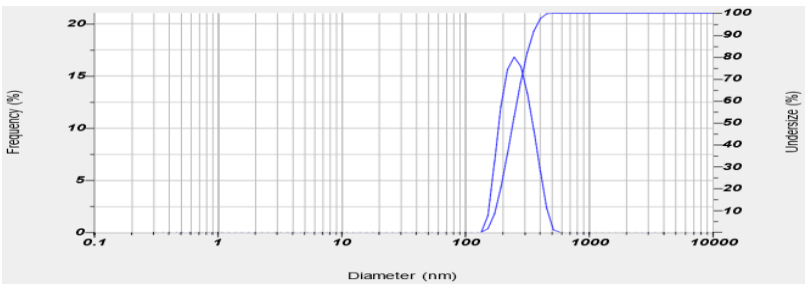

Figure2: Particle size of Nanoparticle

Zeta potential

The synthesized TiO_2 nanoparticles showed a zeta potential of -35.2 mV, indicating strong electrostatic repulsion between particles. This value suggests a highly stable colloidal suspension with minimal risk of aggregation. The negative charge is likely due to phytochemicals in the extract, which act as natural capping and stabilizing agents.

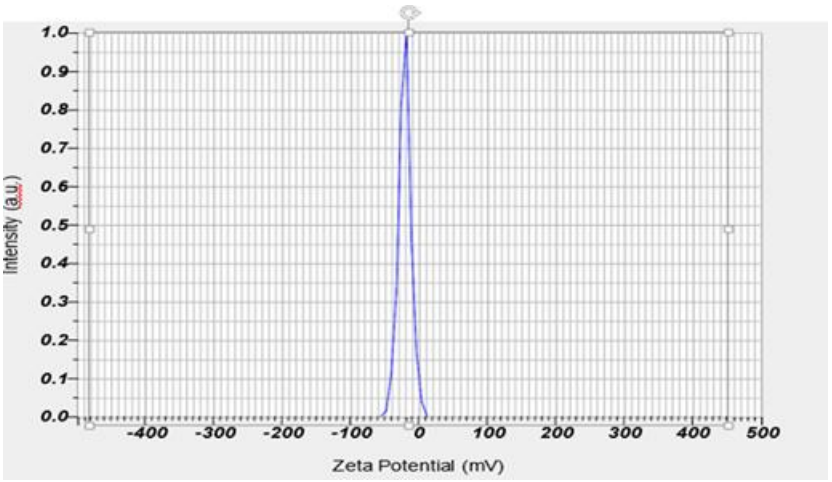

Figure 3: Zeta Potential of Nanoparticle

SEM

Surface morphology of prepared nanoparticle was analyzed by scanning electron microscope (SEM) characterization. Superficial morphology of prepared TiO2 nanoparticles was explained by using scanning electron microscope (SEM), and results are reputed as Figure. The images display microspheres with a rough, wrinkled texture and shrinkage, suggesting successful polymer coating. Visible surface pores and residues imply an even distribution of the plant-extract-capped nanoparticles within the matrix. The rough external appearance may result from the drying or coating process, indicating non-spherical morphology and possibly high surface reactivity. Such morphology is favorable for enhanced interaction with target molecules in catalytic or biomedical applications.

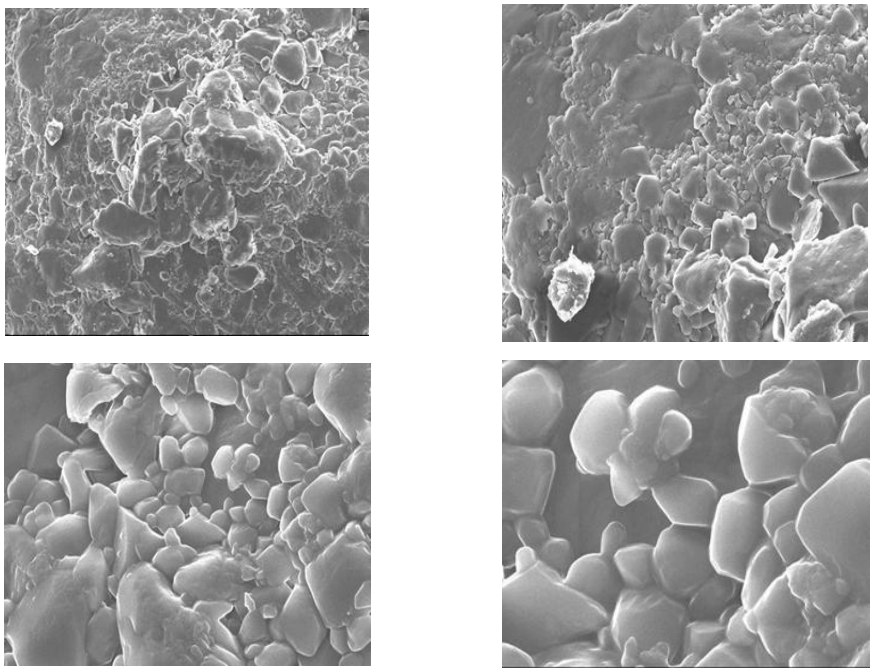

Figure 4: SEM of Particle Size

X-ray Diffraction (XRD) Analysis

XRD analysis confirmed the crystalline nature of the green-synthesized TiO_2 nanoparticles. Peaks observed at $2\theta = 25.3°$,

48.0°, 54.0°, and 62.6° correspond to the anatase phase of TiO_2 (with Miller indices (101), (200), (105), and (204) respectively). The absence of additional peaks indicates high phase purity and no contamination from other TiO_2 polymorphs like rutile or brookite. This anatase form is particularly desirable due to its superior photocatalytic and antimicrobial properties.

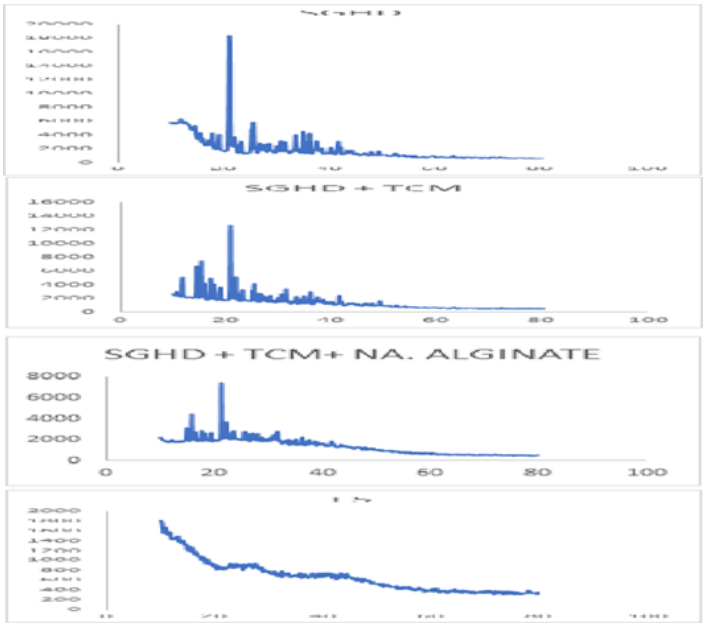

Figure 5: XRD

Antioxidant Activity

The antioxidant activity of the synthesized nanoparticles was evaluated using the DPPH assay, which revealed a notable dose-dependent inhibition of free radicals. At a concentration of 100 µg/mL, the nanoparticles demonstrated a 73.57% inhibition, which is comparable to the standard antioxidant, ascorbic acid, showing 82.90% inhibition. The IC_{50} value was determined to be 75.08 µg/mL, indicating a strong antioxidant capacity. These findings suggest that the bioactive phytochemicals from *Jatropha curcas* are effectively retained on the surface of the titanium dioxide nanoparticles, thereby enhancing their free radical scavenging activity.

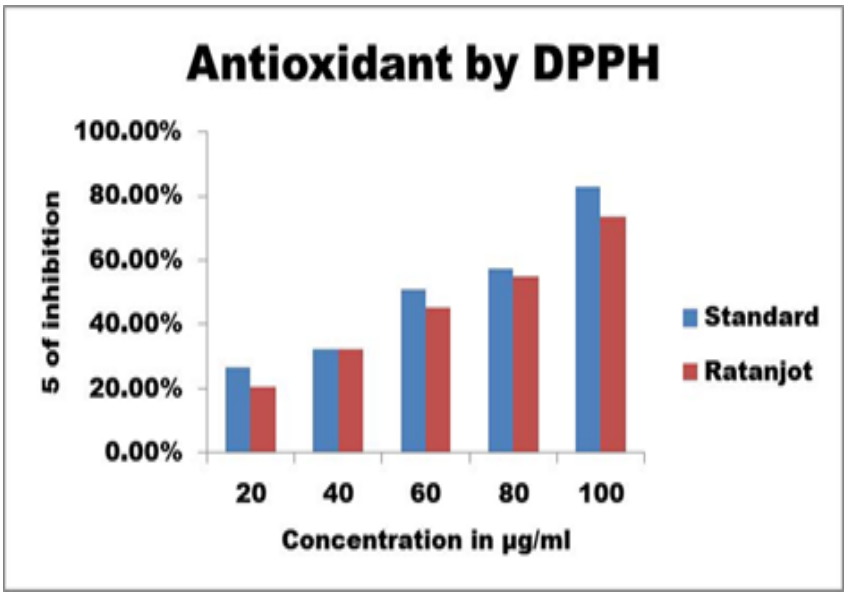

Figure 6: Antioxidant activity of Nanoparticle

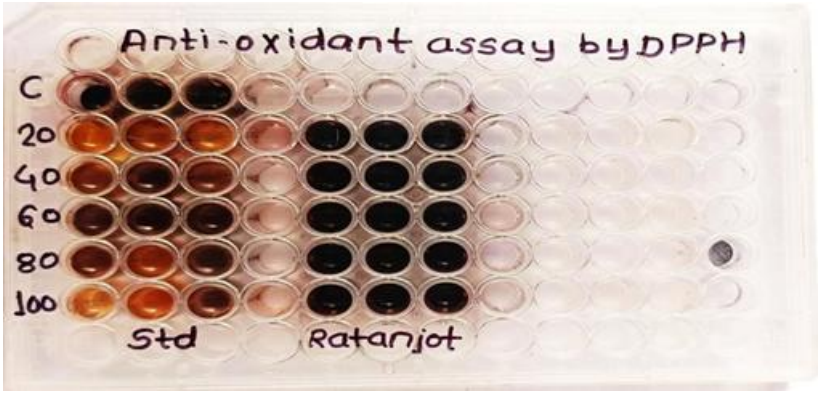

Figure 7: Antioxidant assay by DPPH

4. CONCLUSION

The study successfully demonstrates a cost-effective, sustainable, and green synthesis route for titanium dioxide nanoparticles using *Jatropha curcas* ethanolic leaf extract. The nanoparticles showed favorable physicochemical properties, significant antioxidant potential, and promising characteristics for biomedical and environmental applications..

REFERENCES

1. 1. Chandran SP, Chaudhary M, Pasricha R, Ahmad A, Sastry M. Synthesis of gold nanotriangles and silver nanoparticles using Aloe vera plant extract. Biotechnol Prog [Internet]. 2006;22(2):577–83. Available from: http://www.ncbi.nlm.nih.gov/pubmed/16599579
2. Faraz A, Faizan M, Fariduddin Q, Hayat S. Response of Titanium Nanoparticles to Plant Growth: Agricultural Perspectives. In 2020. p. 101–10. Available from: http://link.springer.com/10.1007/978-3-030-33996-8_5
3. . Batley GE, Kirby JK, McLaughlin MJ. Fate and risks of nanomaterials in aquatic and terrestrial environments. Acc Chem Res [Internet]. 2013 Mar 19;46(3):854–62. Available from: http://www.ncbi.nlm.nih.gov/pubmed/22759090
4. Piccinno F, Gottschalk F, Seeger S, Nowack B. Industrial production quantities and uses of ten engineered nanomaterials in Europe and the world. J Nanoparticle Res [Internet]. 2012 Sep 19;14(9):1109. Available from: http://link.springer.com/10.1007/s11051-012-1109-9
5. . Lai Y, Wang L, Liu D, Chen Z, Lin C. TiO 2 -Based Nanomaterials: Design, Synthesis, and Applications. J Nanomater [Internet]. 2015 Jan 5;2015(1). Available from: https://onlinelibrary.wiley.com/doi/10.1155/2015/250632
6. Waghmode MS, Gunjal AB, Mulla JA, Patil NN, Nawani NN. Studies on the titanium dioxide nanoparticles: biosynthesis, applications and remediation. SN Appl Sci [Internet]. 2019 Apr 7;1(4):310. Available from: http://link.springer.com/10.1007/s42452-019-0337-3
7. . Riayatsyah TMI, Sebayang AH, Silitonga AS, Padli Y, Fattah IMR, Kusumo F, Ong HC, Mahlia TMI. Current Progress of Jatropha Curcas Commoditisation as Biodiesel Feedstock: A Comprehensive Review. Front Energy Res [Internet]. 2022 Jan 14;9. Available from: https://www.frontiersin.org/articles/10.3389/fenrg.2021.815416/full
8. . Ruatpuia JVL, Halder G, Vanlalchhandama M, Lalsangpuii F, Boddula R, Al-Qahtani N, Niju S, Mathimani T, Rokhum SL. Jatropha curcas oil a potential feedstock for biodiesel production: A critical review. Fuel [Internet]. 2024 Aug;370:131829. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0016236124009773
9. . Hudlikar M, Joglekar S, Dhaygude M, Kodam K. Green synthesis of TiO2 nanoparticles by using aqueous extract of Jatropha curcas L. latex. Mater Lett [Internet]. 2012 May;75:196–9. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0167577X12002042
10.. Wang Y, Zhou D, Bai X, Meng Q, Xie H, Wu G, Chen G, Hou Y, Li N. Chemical constituents from leaves of Jatropha curcas. Chinese Herb Med [Internet]. 2023 Jul;15(3):463–9. Available from: http://www.ncbi.nlm.nih.gov/pubmed/37538861
11.. Cavalcante NB, Diego da Conceição Santos A, Guedes da Silva Almeida JR. The genus Jatropha (Euphorbiaceae): A review on secondary chemical metabolites and biological aspects. Chem Biol Interact [Internet]. 2020 Feb;318:108976. Available from:

https://linkinghub.elsevier.com/retrieve/pii/S0009279719303497

12.. Mokaizh AA Bin, Nour AH, Alazaiza MYD, Mustafa SE, Omer MS, Nassani DE. Extraction and Characterization of Biological Phytoconstituents of Commiphora gileadensis Leaves Using Soxhlet Method. Processes [Internet]. 2024 Jul 26;12(8):1567. Available from: https://www.mdpi.com/2227-9717/12/8/1567

13.. Suman TY, Rajasree SRR, Jayaseelan C, Mary RR, Gayathri S, Aranganathan L, Remya RR. GC-MS analysis of bioactive components and biosynthesis of silver nanoparticles using Hybanthus enneaspermus at room temperature evaluation of their stability and its larvicidal activity. Environ Sci Pollut Res [Internet]. 2016 Feb 6;23(3):2705–14. Available from: http://link.springer.com/10.1007/s11356-015-5468-5

14.. Ansari A, Siddiqui VU, Rehman WU, Akram MK, Siddiqi WA, Alosaimi AM, Hussein MA, Rafatullah M. Green Synthesis of TiO2 Nanoparticles Using Acorus calamus Leaf Extract and Evaluating Its Photocatalytic and In Vitro Antimicrobial Activity. Catalysts [Internet]. 2022 Jan 30;12(2):181. Available from: https://www.mdpi.com/2073-4344/12/2/181

15.. Al Masoudi LM, Alqurashi AS, Abu Zaid A, Hamdi H. Characterization and Biological Studies of Synthesized Titanium Dioxide Nanoparticles from Leaf Extract of Juniperus phoenicea (L.) Growing in Taif Region, Saudi Arabia. Processes [Internet]. 2023 Jan 14;11(1):272. Available from: https://www.mdpi.com/2227-9717/11/1/272

16.. Nilam U Metkari, Sunita S Shinde, Supriya S Kore, Sipora S Gaikwad, Pallavi B Tanwade OBT. Development and Optimization of Nanoparticulate Drug Delivery System of Telmisartan by DoE Approach. Indian J Nov Drug Deliv. 2023;15(2):76–83.

17.. Widatalla HA, Yassin LF, Alrasheid AA, Rahman Ahmed SA, Widdatallah MO, Eltilib SH, Mohamed AA. Green synthesis of silver nanoparticles using green tea leaf extract, characterization and evaluation of antimicrobial activity. Nanoscale Adv [Internet]. 2022;4(3):911–5. Available from: https://xlink.rsc.org/?DOI=D1NA00509J

18.. Javed B, Raja NI, Nadhman A, Mashwani Z ur R. Understanding the potential of bio-fabricated non-oxidative silver nanoparticles to eradicate Leishmania and plant bacterial pathogens. Appl Nanosci [Internet]. 2020 Jun 28;10(6):2057–67. Available from: http://link.springer.com/10.1007/s13204-020-01355-5.