IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 10, March 2026
Impact Factor: 8.2

Plant-Derived Nanoparticles in Cervical Cancer: From Green Synthesis to Targeted Nanotherapy

Naziya S. Jummal , Dr. Sajid F. Shaikh, Pankaj S. Gaikwad , Mehreen M. Dawre
Department of Chemistry
D. G. Tatkare Mahavidyalay of Arts, Science, Commerce I.T and Management, Mangaon-Raigad
Anjuman Islam Janjira, Degree College of Science, Murud-Janjira Raigad, Maharashtra, India
sajidoshaikh@gmail.com

Abstract:,*Cervical cancer continues to pose a significant global health challenge, particularly in resource-limited regions where early diagnosis and treatment facilities are inadequate. Conventional treatment strategies such as chemotherapy and radiotherapy are often limited by adverse side effects, non-specific targeting, and the emergence of drug resistance. In this context, plant-mediated nanoparticles have gained considerable attention as a safer and more sustainable alternative.*

These nanoparticles are synthesized using plant extracts rich in bioactive compounds that function as natural reducing and stabilizing agents, eliminating the need for toxic chemicals. The present review explores the potential of plant-derived nanoparticles in cervical cancer management, including their applications in targeted drug delivery, diagnostic imaging, and direct anticancer activity. Various nanoparticles such as silver, gold, and zinc oxide have demonstrated notable cytotoxic effects against cervical cancer cell lines by inducing oxidative stress, promoting apoptosis, and disrupting cellular proliferation pathways.

Although encouraging results have been reported in preclinical studies, challenges related to large-scale production, reproducibility, and clinical translation remain. Nevertheless, plant-based nanoparticles offer a promising and eco-friendly platform for the development of advanced cancer therapeutics.

Keywords: Cervical cancer, Green synthesis, Nanoparticles, HeLa cells, SiHa cells, Anticancer activity, HPV

I. INTRODUCTION

Cervical cancer ranks among the most common malignancies affecting women worldwide and remains a leading cause of cancer-related mortality, particularly in developing nations. The high incidence in these regions is largely attributed to inadequate screening programs, limited awareness, restricted access to HPV vaccination, and delayed diagnosis. Despite being largely preventable, the disease continues to impose a substantial public health burden.Current therapeutic approaches, including surgical intervention, chemotherapy, and radiotherapy, are widely used depending on disease progression. However, commonly used chemotherapeutic agents such as cisplatin and paclitaxel often suffer from limitations including poor selectivity, systemic toxicity, and the development of resistance. Similarly, radiotherapy may lead to unintended damage to surrounding healthy tissues, resulting in long-term complications. These drawbacks highlight the urgent need for alternative treatment strategies that are both effective and less toxic.Nanotechnology has emerged as a powerful tool in oncology, offering innovative solutions for drug delivery and disease management. Due to their nanoscale size and modifiable surface properties, nanoparticles can enhance drug bioavailability and enable targeted delivery to tumor tissues through mechanisms such as the enhanced permeability and retention effect.In recent years, green synthesis of nanoparticles using plant extracts has gained increasing importance. This approach avoids the use of hazardous chemicals and relies on naturally occurring phytochemicals such as flavonoids, alkaloids, and phenolic compounds, which facilitate nanoparticle formation and stabilization. In addition to their role in synthesis, these biomolecules contribute to the biological activity of nanoparticles.

DOI: 10.48175/IJARSCT-35023

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 10, March 2026
Impact Factor: 8.2

Plant-derived nanoparticles, particularly metallic and metal oxide types, have demonstrated significant anticancer effects in cervical cancer models. Studies have shown their ability to induce programmed cell death, generate reactive oxygen species, and inhibit tumor growth in cell lines such as HeLa and SiHa. Furthermore, these nanoparticles can be engineered as carriers for drugs and genetic material, opening new avenues for advanced therapeutic strategies.

II. LITERATURE REVIEW

Zinc Oxide Nanoparticles (ZnO NPs):ZnO nanoparticles synthesized using *Solanum nigrum* exhibited strong anticancer activity against HeLa cells via apoptosis induction. Characterization techniques such as UV-Vis, SEM, TEM, XRD, and FTIR confirmed nanoparticle formation. Cytotoxicity assays (MTT, DAPI staining) revealed dose-dependent cell death, along with increased expression of p53 and caspases and suppression of β-catenin signaling. Similarly, ZnO nanoparticles synthesized using *Gracilaria edulis* demonstrated cytotoxic effects against SiHa cells with an IC□□ value of 35 µg/mL. The mechanism involved ROS-mediated mitochondrial apoptosis, confirmed through staining assays and flow cytometry.

Gold Nanoparticles (AuNPs): Gold nanoparticles synthesized from *Catharanthus roseus* showed potent anticancer activity against HeLa cells. Characterization confirmed particle sizes of 25–35 nm. These nanoparticles induced ROS-mediated mitochondrial apoptosis, regulated Bax/Bcl-2 protein expression, and activated caspase pathways. The reported IC□□ value was as low as 5 µg/mL, indicating high therapeutic potential.

Silver Nanoparticles (AgNPs): Silver nanoparticles synthesized using *Catharanthus roseus*, *Nepeta deflersiana*, and *Ginkgo biloba* extracts demonstrated significant anticancer effects.

- *Catharanthus roseus*-derived AgNPs showed strong cytotoxicity and anti-metastatic activity in HeLa229 cells.
- *Nepeta deflersiana* AgNPs induced ROS generation, lipid peroxidation, mitochondrial dysfunction, and apoptosis.
- *Ginkgo biloba* AgNPs activated the mitochondrial apoptotic pathway via cytochrome c release and caspase activation.

These studies highlight the selective toxicity of AgNPs toward cancer cells while sparing normal cells.

Mechanism:

Plant-based nanoparticles exhibit anticancer activity through multiple interconnected biological pathways. One of the primary mechanisms involves the generation of reactive oxygen species, which leads to oxidative stress and subsequent mitochondrial dysfunction. This process ultimately triggers apoptosis through activation of caspase enzymes.

Additionally, these nanoparticles can interfere with normal cell cycle progression, causing arrest at specific phases and thereby inhibiting uncontrolled cell division. DNA damage and disruption of transcriptional processes further contribute to cancer cell death. Some nanoparticles also demonstrate the ability to inhibit angiogenesis, thereby restricting tumor growth by limiting blood supply. Moreover, their anti-metastatic properties help prevent the spread of cancer cells to distant organs.

Applications in Cervical Cancer Therapy:

Plant-based nanoparticles have diverse applications:

Targeted Drug Delivery: Improved solubility, stability, and tumor-specific delivery

Theranostics: Combined diagnostic and therapeutic applications

Photodynamic Therapy: Enhanced ROS generation using photosensitizers

Gene Delivery: Efficient transport of siRNA, miRNA, and CRISPR systems

Combination Therapy: Co-delivery of drugs and phytochemicals for synergistic effects

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 10, March 2026
Impact Factor: 8.2

III. CONCLUSION

Plant-based nanoparticles have emerged as a promising alternative in the field of cancer therapeutics, particularly for cervical cancer. Their environmentally friendly synthesis, combined with enhanced biocompatibility and reduced toxicity, makes them attractive candidates for biomedical applications.These nanoparticles exhibit significant anticancer activity through various mechanisms, including oxidative stress induction, apoptosis, and inhibition of tumor progression. Furthermore, their role as drug delivery vehicles enhances the effectiveness of conventional therapies while minimizing adverse effects.Despite these advantages, several challenges must be addressed before clinical implementation, including standardization of synthesis methods, large-scale production, and comprehensive safety evaluation. Continued research integrating nanotechnology, plant science, and clinical studies will be crucial for translating these findings into practical medical applications.

REFERENCES

[1] Transformative potential of plant-based nanoparticles in cancer diagnosis and treatment: bridging traditional medicine and modern therapy.

[2] Shaikh Sajid F, Jadhav Bhagvan V & Patil Rajendra P (2018). Photocatalytic activity OF Zn-Co-ferrite nanoparticle synthesized using lemon as green binding agent by Sol-Gel method. Indo American Journal of Pharmaceutical Sciences, 5(1), 89-93.

[3] Bray F, Ferlay J, Soerjomataram I, Siegel RL, Torre LA, Jemal A. Global cancer statistics 2018. *CA Cancer J Clin.* 2018;68(6):394–424.

[4] S.F. Shaikh, B.V. Jadhav, R.P. Patil, & J.S. Patil (2021). Study of application of Zn0. 5Mn0. 5Fe2O4NPs prepared via sol-gel method for dyestuff industry in waste water puri-fication. Research Journal of Chemistry and Environment, 25, 113-117.

[5] Iravani S. Green synthesis of metal nanoparticles using plants. *Green Chem.* 2011;13(10):2638–2650.

[6] Singh J, Dutta T, Kim KH, Rawat M, Samddar P, Kumar P. Biogenic synthesis of nanoparticles and their applications. *J Nanobiotechnol.* 2018;16:84.

[7] Patra JK, Das G, Fraceto LF, et al. Nano-based drug delivery systems: Recent developments and future prospects. *J Nanobiotechnol.* 2018;16:71.

[8] B.V. Jadhav, R.P. Patil, & Sajid F. Shaikh (2018). Synthesis and Characterizations of Zinc-Cobalt Ferrite (Zn0.5Co0.5Fe2O4) Nanoparticle Using Green and Organic Chelating Agents Via Sol-Gel Auto Combustion Technique: - Its …, An International, Peer Reviewed, & Referred Quarterly Scholarly Research Journal for Interdisciplinary Studies, 7 (42).

[9] Ahmed S, Ahmad M, Swami BL, Ikram S. Green synthesis of nanoparticles and their biological applications. *J Adv Res.* 2016;7(1):17–28.

[10] B.V. Jadhav, R.P. Patil, & Sajid F. Shaikh (2018). Manganese doped Co-Zn Ferrite Nanoparticle Synthesis and Characterization; Effects of Annealing Temperature on the Size of nanoparticles., Aarhat multidisciplinary International Education research journal. Peer reviewed multidisciplinary journal., 3 (IX).

[11] Al-Sheddi ES, et al. Anticancer potential of green synthesized silver nanoparticles using extract of *Nepeta deflersiana* against human cervical cancer cells (HeLa). *Bioinorg Chem Appl.* 2018;2018:9390784.

[12] Hussein HS, Ngugi C, Tolo FM, Maina EN. Anticancer potential of silver nanoparticles biosynthesized using *Catharanthus roseus* leaves extract on cervical (HeLa229) cancer cell line. 2024.

[13] Ke Y, et al. Photosynthesized gold nanoparticles from *Catharanthus roseus* induce caspase-mediated apoptosis in cervical cancer cells (HeLa). *Artif Cells Nanomed Biotechnol.* 2019;47(1):1938–1946.

[14] AsikGowdhami M, Mohamed Jaabir MS, Archunan G, Suganthy N. Anticancer potential of zinc oxide nanoparticles synthesized via biogenic route using aqueous extract of *Gracilaria edulis*. 2019.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 6, Issue 10, March 2026 Impact Factor: 8.2

[15] Sajid F. Shaikh, Bhagvan V. Jadhav & R. P. Patil (2022). Effects of Annealing Temperature on the Size of Zinc Doped Cobalt Ferrite Nanoparticles Synthesized using Green Binder.International Journal of Advanced Research in Science, Communication and Technology (IJARSCT), 2(3), 86-92.
[16] Lee BJ, Kanaan MHG, Abdullah SS, Ghasemian A. Plant-derived nanoparticles in cancer therapy: Recent advances and future prospects. 2025.
[17] N.M. Patil, M.R. Kadam, C.B. Mane, &Sajid Shaikh(2024). Modification of Graphitic Carbon Nitride for Photocatalytic Application, 12(9), 1400-1410.
[18] Komane MD, Kayoka-Kabongo PN, Rutkowska DA. The use of plant viral nanoparticles in cancer biotherapy—A review. 2025.
[19] Rehan F, et al. Exploring the potential of plant-based nanotechnology in cancer immunotherapy. 2024.
[20] Khan I, Saeed K, Khan I. Nanoparticles: Properties, applications and toxicities. *Arab J Chem.* 2019;12(7):908–931.
[21] Xu F, et al. Green biosynthesized silver nanoparticles induce apoptosis in cervical cancer cells. *Int J Nanomedicine.* 2020;15:7699–7712.
[22] Xu Z, et al. Green biosynthesized silver nanoparticles with aqueous extracts of *Ginkgo biloba* induce apoptosis via mitochondrial pathway in cervical cancer cells. *Front Oncol.* 2020;10:575.
[23] Thomas S, et al. Synthesis and characterization of zinc oxide nanoparticles of *Solanum nigrum* and their anticancer activity via apoptosis in cervical cancer. *Biol Trace Elem Res.* 2022.
[24] Sajid F. Shaikh, Hrushikesh B Jadhav & Pooja P Mehetar (2023). Nanomaterials for Future.International Journal of Emerging Technologies and Innovative Research (IJETIR), 3(3), 128-130.
[25] Liu H, et al. Plant-derived nanovesicles as an emerging platform for cancer therapy. *Acta Pharm Sin B.* 2024.
[26] C.B. Mane, N.M. Patil, M.R. Kadam &Sajid Shaikh(2024). Synthesis and Electrode Performance of g-C3N4-CeO2 Nanocomposites for High- Performance Supercapacitors. Journal of Technology, 12(9), 1390-1399.