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Enhancement of Asplatin's Cytotoxicity *In Vitro* and *In Vivo* by the Use of Green-synthesized Zinc Oxide Nanoparticles Produced by Gambogic Acid-mediated and Microwave-assisted Methods

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Introduction

Cancer remains one of the leading causes of mortality worldwide, demanding innovative approaches for therapeutic development. Asplatin, a platinum-based anticancer drug, has shown promise in treating various types of cancer due to its cytotoxic effects on tumor cells. However, its therapeutic efficacy is often limited by issues such as poor bioavailability, systemic toxicity, and the development of resistance in cancer cells. Recent advancements in nanotechnology have opened up new possibilities for enhancing the effectiveness of existing drugs by employing nanocarriers and nanostructures to improve their delivery and cytotoxicity.Zinc oxide nanoparticles (ZnO NPs) have gained significant attention in biomedical research due to their unique physicochemical properties, biocompatibility, and potential to act as drug delivery vehicles or therapeutic agents themselves. These nanoparticles exhibit intrinsic anticancer properties through mechanisms such as reactive oxygen species (ROS) generation and disruption of mitochondrial function. The combination of ZnO NPs with chemotherapeutic agents like Asplatin offers an exciting opportunity to synergistically enhance their anticancer effects while potentially reducing the required dosage and minimizing side effects.

Description

Green synthesis of ZnO NPs using plant-derived biomolecules and microwave-assisted methods provides an eco-friendly, cost-effective, and efficient alternative to conventional chemical synthesis approaches. Gambogic acid, a natural compound extracted from the resin of Garcinia hanburyi, has demonstrated anticancer and antioxidant properties, making it a suitable candidate for mediating the synthesis of ZnO NPs. This review discusses the enhancement of Asplatin's cytotoxicity in vitro and in vivo by leveraging green-synthesized ZnO NPs produced using gambogic acid-mediated and microwave-assisted methods.Traditional methods for synthesizing ZnO NPs often involve toxic chemicals, high energy input, and expensive reagents, which can limit their biomedical applications. Green synthesis offers a sustainable approach by utilizing natural biomolecules from plants, fungi, or bacteria as reducing and stabilizing agents. This eco-friendly method minimizes the use of hazardous chemicals while producing nanoparticles with excellent biocompatibility.

In vitro studies have provided compelling evidence for the enhanced cytotoxicity of Asplatin when delivered in combination with green-synthesized ZnO NPs. Cancer cell lines such as HeLa (cervical cancer), MCF-7 (breast cancer), and A549 (lung cancer) have been used to evaluate the therapeutic potential of this combination. The MTT and WST-1 assays revealed a significant reduction in cell viability upon treatment with Asplatin-ZnO NP formulations compared to Asplatin or ZnO NPs alone. The IC50 values for the combination were substantially lower, indicating synergistic effects.Flow cytometry analysis using Annexin V/PI staining demonstrated increased apoptotic cell populations in treated groups. The combination therapy effectively activated both intrinsic and extrinsic apoptotic pathways, as evidenced by the upregulation of caspase-3, -8, and -9 [1,2].

Conclusion

The combination of Asplatin with green-synthesized ZnO nanoparticles produced using gambogic acid-mediated and microwave-assisted methods represents a promising strategy for enhancing anticancer therapy. The unique properties of ZnO NPs, including their ability to induce oxidative stress, improve drug delivery, and synergize with chemotherapeutic agents, make them an attractive platform for cancer treatment.In vitro and in vivo studies have demonstrated the potential of this combination therapy to improve cytotoxicity, reduce systemic toxicity, and enhance overall therapeutic efficacy. However, further research is needed to address the challenges associated with scalability, long-term safety, and clinical translation. With continued advancements in nanotechnology and green synthesis methods, the integration of ZnO NPs into cancer therapy holds great promise for improving outcomes in cancer patients while minimizing side effects

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