Mini Review

Is Green Synthesis of Nanoparticles Using Medicinal Plants the Future of Pharmacology

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ABSTRACT

The increasing focus on sustainability in pharmaceutical development has led to the exploration of green synthesis methods for nanoparticles, particularly through the use of medicinal plants. This mini-review discusses the potential of plant-based nanoparticle synthesis, emphasizing its biocompatibility, environmental sustainability, and effectiveness in drug delivery. Unlike conventional methods that often involve toxic chemicals and harsh reagents, green synthesis uses the natural phytochemicals present in plants, such as flavonoids, terpenoids, and phenolic compounds, to reduce and stabilize metal ions into nanoparticles. This approach not only offers an eco-friendly and cost-effective alternative but also enhances the therapeutic properties of the nanoparticles by retaining the bioactive components of the plants. These green-synthesized nanoparticles have shown promise in various pharmaceutical applications, including drug delivery systems, antimicrobial agents, and treatments targeting oxidative stress-related diseases. However, challenges remain, such as optimizing large-scale production, nanoparticle characterization, and understanding their pharmacokinetics and long-term effects. Despite these hurdles, the use of medicinal plants in nanoparticle synthesis represents a promising direction in pharmacology, offering the potential to create safer, more sustainable, and effective therapeutic agents. As research in this area continues, green synthesis is expected to play an increasingly crucial role in the development of novel pharmaceutical treatments.

Keywords: Green synthesis, Medicinal plants, Nanoparticles, Biocompatibility, Drug delivery

Introduction

Nanoparticles (NPs) have gained significant attention in pharmacology due to their unique properties, which include a high surface area-to-volume ratio, [1] tuneable size, [2] and ability to deliver drugs effectively. [3] Traditional methods of nanoparticle synthesis often involve toxic chemicals that pose environmental risks and limit biocompatibility. [4] In contrast, green synthesis using medicinal plants offers a safer and more sustainable alternative. [5,6] This method not only utilizes the phytochemicals present in plants for the reduction and stabilization of metal ions but also aligns with the principles of green chemistry. [7]

Green Synthesis of Nanoparticles Medicinal Plants as Reducing Agents

Medicinal plants are rich in phytochemicals such as flavonoids, terpenoids, and phenolic compounds, which can serve as effective reducing and stabilizing agents in nanoparticle synthesis. [8] For instance, extracts from plants like Azadirachta indica (neem) [9] and Curcuma longa (turmeric) [10] have been shown to reduce metal salts to their respective nanoparticles while providing stabilizing agents that prevent agglomeration.

Advantages of Green Synthesis:

Biocompatibility: The biocompatibility of nanoparticles generated by plant extracts is higher than that of nanoparticles synthesized through conventional procedures. For pharmaceutical applications, where NP safety is critical, this characteristic is essential. [11]

Environmental Sustainability: By using fewer toxic chemicals and solvents, the green synthesis method lessens pollution in the environment. Additionally, this approach encourages the use of renewable resources. [12]

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Cost-Effectiveness: Plant extract synthesis is often more cost-effective than chemical synthesis, which makes it a feasible choice for large-scale production. [13]

Enhanced Therapeutic Properties: The therapeutic qualities of the plant components themselves may be carried by medicinal plant-derived nanoparticles, potentially providing synergistic effects in medication delivery. [14]

Applications in Pharmacology:
The green-synthesised nanoparticles have demonstrated potential in a number of pharmaceutical uses, such as:

Drug Delivery Systems: By encasing medications, NPs can improve their solubility, stability, and bioavailability. For instance, targeted medication delivery in cancer therapy has been investigated using silver and gold nanoparticles. [15,16]

Antimicrobial Agents: Numerous investigations have documented the antibacterial properties of nanoparticles derived from therapeutic plants, which can serve as substitute therapies for resistant bacterial strains. [17,18]

Antioxidant Activity: Because of their strong antioxidant qualities, green-synthesized NPs have the potential to treat disorders linked to oxidative stress. [19,20]

Challenges and Future Directions:
There are still difficulties in the green synthesis of nanoparticles, despite the encouraging benefits. Important topics that need more research are large-scale manufacturing, characterisation of the nanoparticles, and standardization of synthesis techniques. Furthermore, more thorough in vivo investigations are required to completely comprehend the pharmacokinetics and long-term impacts of these nanoparticles. [21]

Conclusion:
One exciting area of pharmacology is the environmentally friendly manufacturing of nanoparticles utilizing therapeutic botanicals. This approach improves the safety and effectiveness of nanoparticles for medicinal purposes while simultaneously addressing environmental issues related to classical synthesis by utilizing the inherent qualities of plants. Green synthesis is probably going to become more and more important as research goes on in order to create novel pharmaceutical treatments.

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