THE SCIENCE WORLD
A Monthly e Magazine
ISSN:2583-2212
Jan 2024 Vol.4(1), 467-470

Popular Article

Green Synthesis of Nanoparticles

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https://doi.org/10.5281/zenodo.10612388

Introduction

Nanotechnology is a novel and developing field of study with a wide range of applications. It involves the synthesis and application of materials called nanoparticles which are having dimensions of 1-100nm. Nowadays, the production of nanoparticles (NPs) is accomplished by a broad range of physico–chemical methods. But for medical and biological applications where the purity of the NPs is crucial, biogenic reduction of metal precursors to produce matching NPs is more cost-effective, environmentally benign, and free of chemical impurities.

The term "green synthesis" describes the sustainable and environmentally friendly processes used for producing nanoparticles like Silver Nanoparticles (Ag NPs), Gold Nanoparticles (Au NPs), Copper Nanoparticles (Cu NPs), Zinc Oxide Nanoparticles (ZnO NPs), Iron Oxide Nanoparticles (Fe_2O_3 or Fe_3O_4 NPs), Titanium Dioxide Nanoparticles (TiO_2 NPs), Zirconia etc from natural sources like microbes, plant extracts, and other renewable resources. This strategy is becoming more and more popular since it has a number of benefits over traditional chemical approaches, such as less toxicity, less energy usage, and the use of reagents that are good for the environment.

Green synthesis has the following benefits:

- Environmentally friendly: Using natural sources lessens the negative effects that chemical synthesis techniques have on the environment.
- Biocompatibility: Because green-synthesised nanoparticles are frequently more

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Published 28.01.2024

biocompatible, they can be used in biomedical applications.

- Cost-Effective: Since green synthesis does not require costly chemicals, it may be more economical.

The process of creating green nanoparticles encompasses a range of techniques that make use of sustainable and natural resources. Here are a few typical techniques from various sources:

- **Plant extracts**: Plant extracts (leaves, stems, and roots) are made and used either straight away or after additional processing. Some examples include the extracts from tea, neem, and aloe vera leaves. The plant extracts' bioactive components serve as capping and reducing agents.

- **Microorganisms**: Through their metabolic activities, certain bacteria (Escherichia coli), fungus (Aspergillus), and algae can create nanoparticles. Enzymes and metabolites released by microorganisms serve as reducing agents, causing the creation of nanoparticles.

- **Biopolymers:** Both stabilising and reducing agents, such as chitosan, starch, and cellulose, are derived from natural polymers. The functional groups on biopolymers aid in the reduction of metal ions and provide stability to the formed nanoparticles.

- **Green Solvents**: Use of environmentally friendly solvents, such as water, supercritical fluid, as reaction media rather than hazardous organic solvents, facilitates the reduction of metal ions by acting as a medium for the process.

- **Algae-Mediated Synthesis**: Algae, such as diatoms or seaweeds facilitate the synthesis of nanoparticles by the reduction of metal ions and stabilization of nanoparticles.

- **Synthesis Mediated by Enzymes:** The reduction of metal ions is catalysed by enzymes, namely reductases and lyases by providing selectivity and control over the process with their role as biocatalysts.

- **Sunlight-Mediated Synthesis:** The reduction of metal ions is fueled by sunlight, as a source of energy to power the synthesis process.

- **Waste-Derived Synthesis:** Reducing agents are made from waste materials, such as food scraps for example banana peels or agricultural byproducts to synthesise nanoparticles in an economical and sustainable manner.

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A general overview of the green synthesis process:

1. **Selection of Green Agents:** Plant extracts, microorganisms, biopolymers etc.
2. **Reduction of Metal Precursors**: Typically, metal salts, such as silver nitrate, gold chloride, or copper sulfate, are used as precursors.
3. **Stabilisation and Capping:** The bioactive compounds in the green agents serve as stabilising and capping agents, avoiding the agglomeration of nanoparticles, in addition to reducing metal ions.
4. **Optimisation of Reaction Conditions**: To regulate the size, form, and stability of the nanoparticles, parameters such as pH, temperature, and reaction time are optimised.
5. **Characterization**: Various methods, including UV-Vis spectroscopy, X-ray diffraction (XRD), transmission electron microscopy (TEM), and dynamic light scattering (DLS), are used to characterise the synthesised nanoparticles.

Applications: Some of the applications of nanoparticles are mentioned below:

- As Antimicrobial Agents
- In Wound Healing
- In Catalysis
- For Drug Delivery
- As Biosensors
- In Electronic Devices
- In Magnetic Resonance Imaging (MRI)
- For Environmental Remediation
- As Dental Materials

Conclusion

Nanotechnology is an emerging field of study which is mainly based on the synthesis of nanoparticles. Among the various methods involved in the synthesis of nanoparticles green synthesis is found to be the most suitable method to avoid environmental damage as well as to produce stable nanoparticles. However, challenges such as reproducibility, scalability, and precise

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Published 28.01.2024

control over the synthesis process still need to be addressed for widespread adoption of green synthesis methods. Researchers are actively working on improving these methods and exploring new green sources for the synthesis of nanoparticles.

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Published 28.01.2024