Design and recent development in novel trashnomics Nanoparticle from recycled biological and food waste

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Abstract

The objective of this research was to produce nanoparticles through the biosynthesis method using extract derived from bio/food peels (BPE) and to investigate their various activities. Recently, the environmentally friendly synthesis of nanoparticles has gained significant attention due to its cost-effectiveness, simplicity, eco-friendly nature, biocompatibility, and versatile applications compared to traditional chemical and physical methods. The synthesis of metallic and nonmetallic nanoparticles using various biomolecules sourced from microorganisms and plants has been successfully demonstrated and extensively documented. This review focuses on the green synthesis of metallic nanoparticles, specifically utilizing diverse agricultural wastes, enzymes, and biologically derived pigments. This compilation aims to highlight the growing significance of these bio-resources in nano-biotechnological applications.

Keywords: Agro-wastes; Enzymes; Green synthesis; Nanoparticles; Pigments; Peel; Metallic nanoparticles.

INTRODUCTION

Nanotechnology has been a rapidly advancing field with various applications in medicine, including drug delivery systems, tissue engineering, and diagnostics. Nanotechnology has gotten a lot of attention in recent years. Nanotechnology categorizes materials within the 1–100 nm diameter range. Scientists have been investigating innovative materials and manufacturing methods to create sophisticated nano-composites tailored for medical purposes.

In contemporary times, the preferred method for synthesizing nanoparticles involves utilizing biological waste. This approach is favored for its safety, cleanliness, cost-effectiveness, and the ease with which production can be scaled up.

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Recycled biological agro-waste, such as agricultural byproducts or plant-based waste, can offer a sustainable and environmentally friendly source of raw materials for nanocomposite production. The idea of utilizing such waste materials in nanocomposite manufacturing aligns with the principles of green chemistry and circular economy.

Diverse metal nanoparticles, including silver and gold nanoparticles, are created through the action of microorganisms such as bacteria and fungi [4]. Studies have demonstrated that metal nanoparticles synthesized by plants exhibit greater stability compared to those generated by microorganisms.

Agro waste can include:

- Crop residues: This includes leftover plant parts such as stems, leaves, husks, and stalks after harvesting crops like rice, wheat, maize, sugarcane, etc.
- Food processing waste: Waste generated during the processing of agricultural products, such as peels, pomace (pulp), shells, and seeds. Examples include fruit peels, vegetable scraps, coffee grounds, and nutshells.
- Animal waste: Waste materials produced from livestock farming, such as manure, poultry litter, and slaughterhouse waste.
- Forest residues: Waste generated from forestry activities, including tree branches, bark, sawdust, and wood chips.
- Agro-industrial waste: Waste produced during various agricultural industries, such as rice husk ash, bagasse (sugarcane residue), and oilseed cakes.

Agro waste, can serve as a sustainable and low-cost source for the preparation of Silver and Gold Nanoparticles. silver ions (Ag^+), which can be reduced and stabilized to form AgNPs. This approach aligns with the principles of green chemistry and offers an environmentally friendly alternative to traditional synthesis methods.

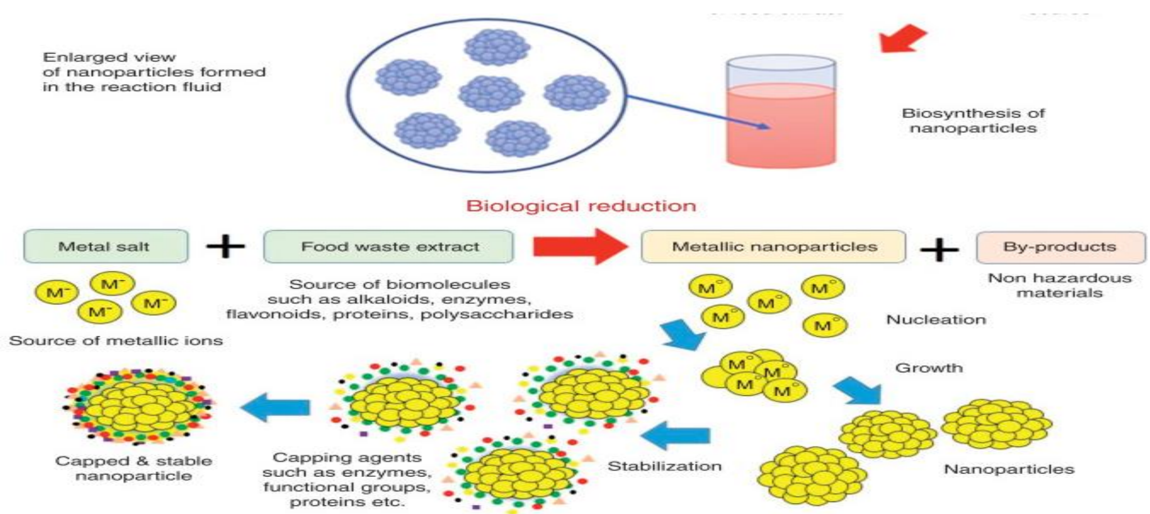
The synthesis of AgNPs from agro waste typically involves the following steps:

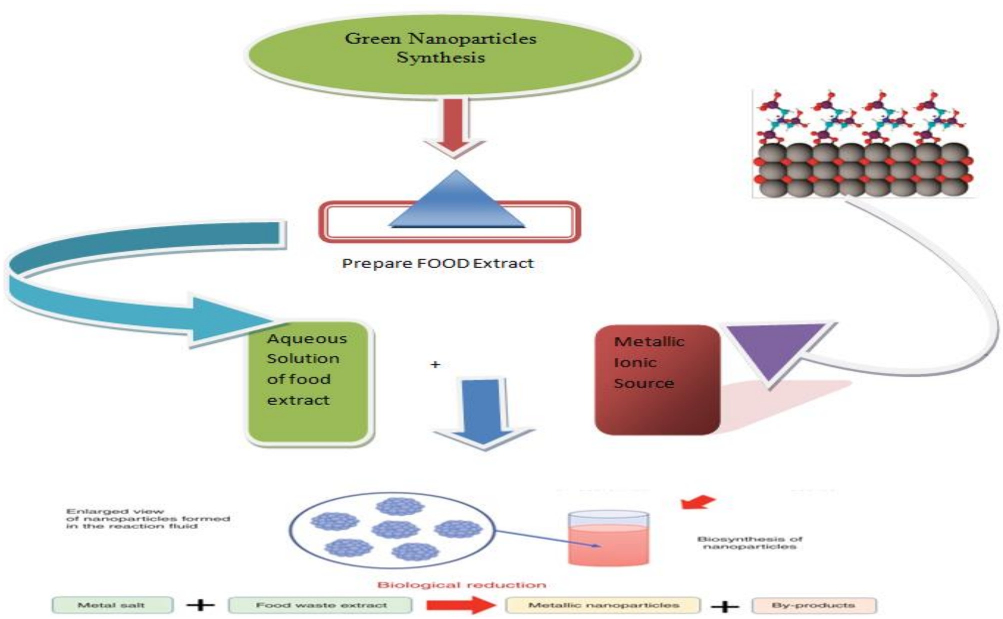
Collection and preparation of agro waste: Agro-waste materials, such as fruit peels, tea leaves, or agricultural residues, are collected and processed to obtain the desired extract or precursor solution.

Extraction of silver ions: The agro-waste extract is mixed with a silver salt solution (e.g., silver nitrate) to facilitate the release of silver ions. The extract acts as a reducing and stabilizing agent.

Reduction and stabilization: The silver ions in the solution are reduced by the components present in the agro-waste extract, leading to the formation of AgNPs. The extract also helps in stabilizing the nanoparticles and preventing their agglomeration.

Characterization: The synthesized AgNPs are characterized using various techniques, such as UV-Vis spectroscopy, transmission electron microscopy (TEM), dynamic light scattering (DLS), and X-ray diffraction (XRD), to determine their size, shape, stability, and other properties.





Extract	Reaction condition	Types of nanoparticles	Size (nm)	Shape	Applications
Pomegranate fruit peel	1 mᴍ $AgNO_3$+5 ml of extract for 24 h	AgNPs	5–50	–	Antibacterial
Rambutan peel extract	1 ml extract+10 ml of 1 mᴍ $AgNO_3$	AgNPs	132.6±42	Triangle, truncated triangle, and hexagonal	Free radical scavenger
Rambutan peel extract	$Zn(NO_3)_2{\cdot}6H_2O$+extract. Reaction at 80°C for 2 h	ZnO nanocrystal	–	–	Antibacterial
Rambutan peel extract	0.1 ᴍ $Ni(NO_3)_2{\cdot}6H_2O$+10 ml extract under magnetic stirring at 80°C for 2 h	NiO nanocrystal	50	–	Antibacterial
Annonasquamosa peel extract	10 ml of extract+80 ml of 1 mᴍ $AgNO_3$ at 25°C and 60°C, 4 h	AgNPs	35±5	Irregular spherical	–
Oak fruit hull extract	40 g/l extract+1 mᴍ $AgNO_3$, pH 9 and temperature 45°C	AgNPs	40	Spherical	Cancer therapy
Cocosnucifera coir extract	80 ml of 1 mᴍ $AgNO_3$+20 ml extract at room temp, 200 rpm, and 1 h	AgNPs	23±2	Spherical	Larvicidal
Punicagranatum peel extract	100 ml extract+40 ml of 1 mᴍ $H_2PtCl_6{\cdot}6H_2O$ at 90°C, 500 rpm for 30 min	Pt-NPs	16–23	Spherical	Catalyst

Figure 01 agro-wastes used for the biogenic production of nanoparticles.

CONCLUSION

The production of metallic nanoparticles through biosynthesis has emerged as a viable alternative to traditional chemical and physical methods. Leveraging agro-wastes in this process offers significant advantages, not only contributing to effective waste management but also enabling the creation of high-value products from inexpensive materials. In addition, microbial and plant-derived enzymes, along with pigments, exhibit promising applications in nanotechnology. These biological components have been effectively employed in synthesizing nanoparticles with exceptional properties. The abundance of biomolecules in these materials can drive the nanoparticle synthesis process, presenting economically feasible methods for large-scale production through innovative green approaches. This review highlights the increasingly important roles that agro-wastes, enzymes, and biological pigments can play in both the synthesis and applications of biocompatible nanoparticles across various domains of human activity.

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