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Fungal Marvels 3. Fungi and Nanotechnology

Nanoscience is concerned with science at the scale 1-100 nanometers – larger than atoms or molecules – but still very small objects. Things this small have unusual properties. Nanotechnology is the study of synthesis, properties and application of nanoparticles that can be used across all the other science fields, such as chemistry, biology, physics, materials science, and engineering. In recent time Nanoparticles are widely used in various fields such as electronics, cosmetics, biomedical, and biotechnology. Basically, four types of nanoparticles have been synthesized: Carbon Based Materials, Metal Based Materials, Dendrimers and Composites. The large surface-to-volume ratio of nanoparticles, their ability to easily interact with other particles, and several other features make them attractive tools in scientific research.

Nanoparticles can be synthesized by physical methods such as attrition, pyrolysis, and using some wet chemical methods. The physical and chemical methods have serious drawbacks such as high cost of production; require high energy input and generation of toxic by-products. To overcome this, several biological methods are employed in the synthesis of nanoparticles. The biological methods are generally cost effective, nontoxic, and ecofriendly. Of the biological methods (plant, algae, bacteria and fungi including yeasts), **yeast and filamentous fungi are most useful because they are most cost effective and majority of them produce and secrete the nanoparticles extracellular and therefore easier for isolation and purification.** Filamentous fungi are preferred because they grow in the form of mycelial mesh which helps them to bear flow pressure and agitation and other conditions to which microbes are subjected to in a bioreactor used for large scale production.

Of all the nanoparticles silver nanoparticles (AgNP) and gold nanoparticles (AuNP) are of great interest to science for their multifarious application in molecular biology and biotechnology. Fungus produced AgNPs are now used as antibacterial, antifungal, antiviral, anti-inflammatory, anti-angiogenic, and anti-cancer agents. A large number of fungi are now used for synthesis of AgNPs in the lab. and industry. Different species of genera like *Trichoderma, Fusarium, Aspergillus, Penicillium, Rhzoctonia, Pleurotus, Phoma* produce AgNPs extracellularly, while *Verticillium* sp. And *Neurospora crassa* produce intracellularly. Different species of *Verticillium, Nuerospora, Aspergillus* and yeasts produce AuNPs extracellularly.

The basic principle is that many fungi when exposed to metal salts such as $AgNO_3$ or $AuCl_4$-produce extracellular nitrate or nitrite reductase enzyme and other reducing substances like napthaquinone and anthraquinone. The reductase enzyme causes ionization of $AgNO_3$ as shown below:

$$AgNO3 \longrightarrow Ag+ \; + \; NO_3- \quad Ag+ \text{ is the modified to } Ag^{o}$$

The nutrient broth for culturing the fungus is supplemented with $AgNO_3$ for AgNPs and with $AuCl_4$- for AuNPs. Since the useful application of NPs is dependent on their size shape and stability, and NPs produced by different fungi are diversely variable, **many more fungi are to be tested for the production of newer and more useful NPs of different types.** Uncontrolled use of Ag NPs in biomedicine may lead to severe toxicity to humans and animals. Nanoparticles of Cd, Pb, Hg, and Ti, however, are highly toxic and harmful for animals, especially mammals and plants. (Bioterrorism with NPs should be under deep surveillance system, especially unrestricted production of NPs in unlicensed production centers if any.)

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