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Antifungal, Antiviral, and Antibacterial Activities of Silver Nanoparticles Synthesized Using Fungi: A Review

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Abstract: Nanoparticles (NPs) synthesized from fungi have a significant biocatalytic application, where they were utilized in enzyme immobilization to enriched enzymatic activity. Silver (Ag) NPs produced from fungi was found to have a benign activity in a wound and thermal wound, and function as anti-mosquito and antiviruses. AgNPs were synthesized using cotton fabrics, which displayed an inhibition activity to the development of some bacteria. These silver nanoparticles were prepared through fungi and linked with the main combination and DNA sample of fungi.

Keywords: silver nanoparticles; fungi; antiviral; antibacterial; green preparation.

1. Introduction

Biologically synthesized AgNPs have gained great attention among researchers recently due to their environmentally friendly properties, low most, and non-toxic byproducts during the synthesis process [1]. However, several complicated natural bases are used in this technique, for example, fungus and bacteria. Fungi have been commonly used in nanoparticle preparation techniques due to the bio-active complex that occurs in the source, for example, polysaccharide, vitamin, and protein. These mixtures help plummeting agents with normal stabilizers to create nanoparticles from Ag^+ [2,3]. AgNPs were reported to have antimicrobial activity against a wide range of fungi [4]. This raised the attention of applying AgNPs in various applications, though it is needed to comprehend the mechanism of inhibition via these nanoparticles throughout treatment [5]. The reflection under the electron microscope exhibited that the cells of microorganisms were deceased due to the progression of nanoparticles by the infectious cells' wall [6].

The establishment of depths and barriers on the cells augmented its penetrability by the small nanoparticles, which affected the cytoplasm of cells [7]. Nanoparticles were found to be no longer affecting the fungi inhibition due to the inability to release free silver (Ag+). This occurred because of the release of Ag+ ions throughout the treatment [8]. This observation was recognized by comparing the influence of nanoparticles on fungi incubated with different sizes of Ag^+ particles [9]. Consequently, the capability of particles to release silver ion (Ag^+) is related to the standard oxidation procedure through antimicrobial experiments [10]. This was assumed to be a feature that increases the particles poisonousness and the oxidation procedure. It happens mostly because of the melted oxygen and protons that present in the medium for growth [11,12]. Decreasing the size of the nanoparticles lead to a high antimicrobial action, where a high surface area to volume ratio and high affinity intended that the smaller nanoparticles could quickly release free Ag^+ compared with the bigger size particles [13,14]. Additionally, the stabilizer reduction during the synthesis of AgNPs normally leads to great toxicity of nanoparticles. Stabilizers such as polyvinyl pyrrolidone (PVP) and polyvinyl alcohol (PVA) were used to avoid the accumulation of the nanoparticles and therefore reduce the propensity to form large size particles. The stabilizer also provides an extra impact to the outer component of the nanoparticles with the oxide coating on the surface. This has a great attraction to acting together with the cells and hence producing cells damaged [15,16].

2. Fungi in AgNPs preparation

Various fungi species containing ascomycete and basidiomycete were used to synthesize AgNPs, such as the intracellular and extracellular formation of fungi [17]. In fungi, the aqueous source of the fruiting form, mycelium, broth of mycelium, and fungi, is mainly used in the AgNPs synthesis procedure [18,19]. Furthermore, the fungus extract has irritating nutritive biomolecule complexes; for example, the polysaccharide is comprising of α and β-glucan, peptide (e.g., pleurostrin), hypsin, flavonoid, and lentin [20, 21]. In addition, ascorbic acid can perform as a normal preservative and a reducing agent to nanoparticles. Preparing AgNPs in this way was selected because of its great nutritional gratify, ecologically friendly procedure, little harvesting retro, non- pathogenicity, and non-toxicity. The formed product was prepared safely and cheaply due to the used, reducing agent. Ultimately, the fungus cultivation can be performed to produce healthy fungi, short reaping period, and free insecticide [22,23].

3. Applications of Fungal-synthesis nanoparticles

Nanoparticles synthesized from fungal have significant biocatalytic properties [24, 25]. Figure 1 shows the catalytic influence of biosynthesized nanoparticles formed from fungus, which can be selected by enzyme immobilization. Below are example studies of AgNPs applications:

- The function of fungi as anti-mosquito studies. According to Banu and Balasubramanian [26], the synthesized nanoparticles from pathogenic fungi are active against the dengue vector. In another study by Soni and Prakash, the effect of AgNPs produced from fungi, such as (*F. oxysporum*), against vector insects was recorded [27].
- Sundaramoorthi *et al*., 2009 [28] have discovered the wound healing ability of nanoparticles formed from fungi in a typical rat trial. It was suggested that AgNPs enhances the wound healing by measuring the ratio of helical reduction and retro of epithelialization in dosage and time.
- Though AgNPs are synthesized by *Lecanicillium lecanii*, using cotton fabrics has displayed an inhibition activity against *S. aureus* and *E. coli* [29]. Textile cotton fabric can be used to avoid bacterial infections in hospitals. This is in consistent with Duran *et al.* [30] findings, where it was confirmed that the use of nanoparticles synthesized from the fungus *F.*

oxysporum and combined into textile cotton fabrics yielded antibacterial activity against *S. aureus* [31].

- Fayaz *et al*. in 2009 [32] confirmed that the nanoparticles synthesized from *T. viride* and combined into a tinny film of sodium alginate increased antibacterial activity of the carrot. Compared to the control sample, an enhancement in their life was observed.
- Different PCR analyses have been prepared by Bharde *et al.* [33] for the fast detection of pathogenic fungus from little DNA concentrated. This bio-link nano PCR analysis has exposed high specificity and sensitivity compared to the conventional technique.
- The strain of multi-resistant bacteria has grown at a remarkable ratio and represents the main threat to new medicine [34]. The appearance of antibiotic resistance is the importance of multiple interactions of factors, which include the evolution and range of resistance mechanisms [35,36]. The increase in antibiotic resistance is produced by the common wrong usage habits of antibiotics for humans and animals. Throughout the past decade, knowledge about nano-medicine has been increased due to the high efficiency of many nano-associates against pathogenic microorganisms. The progression of non-toxic approaches for synthesizing nanoparticles will be the main step in nanotechnology to document their application in nanomedicine [37,38].
- Determination of AgNPs with an antifungal agent, like fluconazole, mixture outcome was studied against a number of pathogenic fungi [39,40]. The fungi enabled the synthesis of AgNPs and showed antifungal action [41].
- There are a number of reports that showed the influence of fungal AgNPs on various viruses [42,43]. The findings showed that the nanoparticles reduced the structure of HIV that penetrates the human cells.

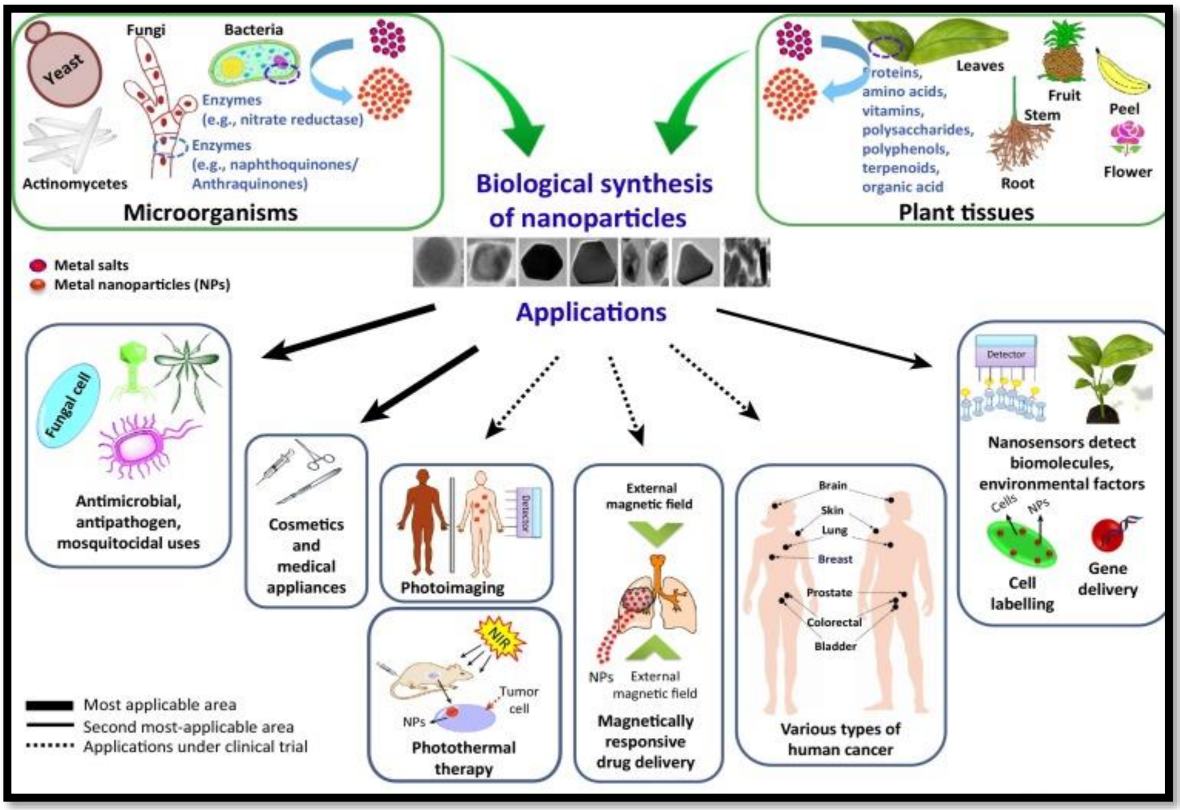

Figure 1. Scheme of biological synthesis of nanoparticles.

Figure 2. Applications of Fungal-synthesis nanoparticles.

4. Conclusions

Biosynthesis of nanoparticles is a fast and substitutional biochemical syntheses technique that has remarkable importance because of its friendliness to environmental, feasibility, and a wide range for applications. It is considered economical in different applications, particularly as antifungal, antiviruses, and antibacterial activity. $AgNO_3$ was used as a raw material to prepared silver nanoparticles, which was successfully synthesized through the fungus and showed antifungal activity. The NPs used in treatment applications on fungal, bacterial, and viral infections to humans was found effective and promising.

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Conflicts of Interest

The authors declare no conflict of interest.

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