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Characterization and Antifungal Activity of Silver Nanoparticles Mediated by Fungi

Liqaa Y. Mohsen [1] Rafal Ahmed Lilo[2] Zeena Hadi Obaid Alwan[3]

1- Department of Biology, Collage of Science, University of Babylon, Iraq, sci.liqaa.mohsen@uobabylon.edu.iq
2- Department of Biology, Collage of Science, University of Babylon, Iraq sci.rafal.ahmed@uobabylon.edu.iq
3- Department of Biology, Collage of Science, University of Babylon, Iraq sci.zeena.hadi@uobabylon.edu.iq
*Corresponding author email: sci.liqaa.mohsen@uobabylon.edu.iq

التوصيف والنشاط المضاد للفطريات لجسيمات الفضة النانوية التي تتوسطها الفطريات

لقاء يحيى محسن[1] رفل احمد ليلو[2] زينه هادي عبيد علوان[3]
1- كلية العلوم قسم علوم الحياة ،جامعة بابل،العراق
2- كلية العلوم،قسم علوم الحياة،جامعة بابل،العراق
3- كلية العلوم،قسم علوم الحياة،جامعة بابل،العراق

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Abstract:

Background:

Nanotechnology is quickly becoming one of the most essential and transformative areas of science. Physical, chemical, mechanical, and biological approaches are all used to create nanoparticles. Plants or microorganisms are frequently used in biological methods of metal ion reduction because they are clean, nontoxic, safe, biocompatible, and ecologically friendly. Fourir transform infra-red spectroscopy (FT–IR), scaning electron microscopy (SEM), and X-ray diffraction spectroscopy were described to analyze the nanoparticles generated (XRD). Nanoparticles (NPs) made from fungi have a diverse range of bio catalytic techniques, including enzyme immobilization for increased enzymatic activity. Silver (Ag) NPs made from fungi were discovered to have a benign effect in a wound and a thermal wound, and to have anti-mosquito, antibacterial, and antifungal properties.

Keywords: Fungi, Nanoparticles, characterizations of nanoparticles

الخلاصة:

أصبحت تقنية النانو بسرعة واحدة من أكثر مجالات العلوم أهمية وتحويلية. تُستخدم الطرق الفيزيائية والكيميائية والميكانيكية والبيولوجية لإنشاء الجسيمات النانوية. غالبًا ما تستخدم النباتات أو الكائنات الحية الدقيقة في الأساليب البيولوجية لتقليل أيونات المعادن لأنها نظيفة وغير سامة وآمنة ومتوافقة حيويًا وصديقة للبيئة. تم وصف التحليل الطيفي للأشعة تحت الحمراء (FT-IR) والمسح المجهري الإلكتروني (SEM) والتحليل الطيفي لحيز الأشعة السينية لتحليل الجسيمات النانوية المتولدة (XRD). تحتوي الجسيمات النانوية (NPs) المصنوعة من الفطريات على مجموعة متنوعة من تقنيات التحفيز الحيوي ، بما في ذلك تثبيت الإنزيم لزيادة النشاط الأنزيمي. تم اكتشاف أن الفضة (Ag) NPs المصنوعة من الفطريات لها تأثير حميد في الجرح والجروح الحرارية ، ولها خصائص مضادة للبعوض ومضادة للبكتيريا ومضادة للفطريات.

الكلمات المفتاحية: الفطريات ، الجسيمات النانوية ، توصيف الجسيمات النانوية

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Introduction

Nanotechnology is a current study field concerned with the design, production, and manipulation of particles having one-dimensional shapes spanning from 1 to 100 nanometers. Nanoscopic materials' production, as well as research and applications of their unique physicochemical and optoelectronic properties, have opened up new fundamental and practical horizons. Medical insurance, beauty products, food industry, environmental safety, technicians, optics, biological sciences, chemical industries, devices, space industries, biomedical applications, electricity science, optoelectronics, materials science, single electron transistors, light emitters, nonlinear optical devices, and photo electrochemical applications are just a few of the fields where nanomaterials is gaining traction [1]. In fields like solar energy conversion, catalysis, medicine, and water treatment, nanomaterals are considered to be the key to a variety of technological and environmental concerns. The ever-increasing demand for nanomaterials must be supplied using green synthesis processes as part of global efforts to reduce hazardous waste. The form and size of a nanoparticle are determined by several factors [2]. Drexler, who promoted the serious implications of nano-scale occurrences and devices through speeches and books like Motors of Creation: The period of nano science (1986) and nano systems: genomic machinery, industrial production, and data processing [3], expanded on the basic idea of this definition in the 1980s, and the term took on its current meaning. A nitrate-dependent reductase and an extracellular shuttle quinone mechanism decrease the metal ions. The potential for numerous technical applications of this nano technological design based on fugal biogenesis of nanoparticles is significant, including its great potential as an antibacterial substance.

Nanoparticles

A "nanoparticle" is a particle with a size in at least one of the three dimensions in the range of 1nm-100nm. Individual atoms/molecules and bulk materials in this length scale have significantly different mechanical, biochemical, and antimicrobial properties than nanoparticles in this size range. Metals, metal oxides, silica, non-oxide ceramics, polymers, organics, carbon, and biomolecules are the most common materials used to make nanoparticles. Nanoparticles come in a variety of shapes and sizes, including rounds, discs, platelets, tubes, and other shapes and sizes. Surface alterations to nanoparticles are often suited to the needs of the applications for which they will be investigated. The enormous diversity of nanoparticles (Figure 1), resulting from their wide chemical nature, shape and morphologies, the medium in which the particles are present, the state of particle dispersion, and, most importantly, the numerous possible surface change to which nanoparticles can be subjected, has made this an active field of science in recent years.[4].

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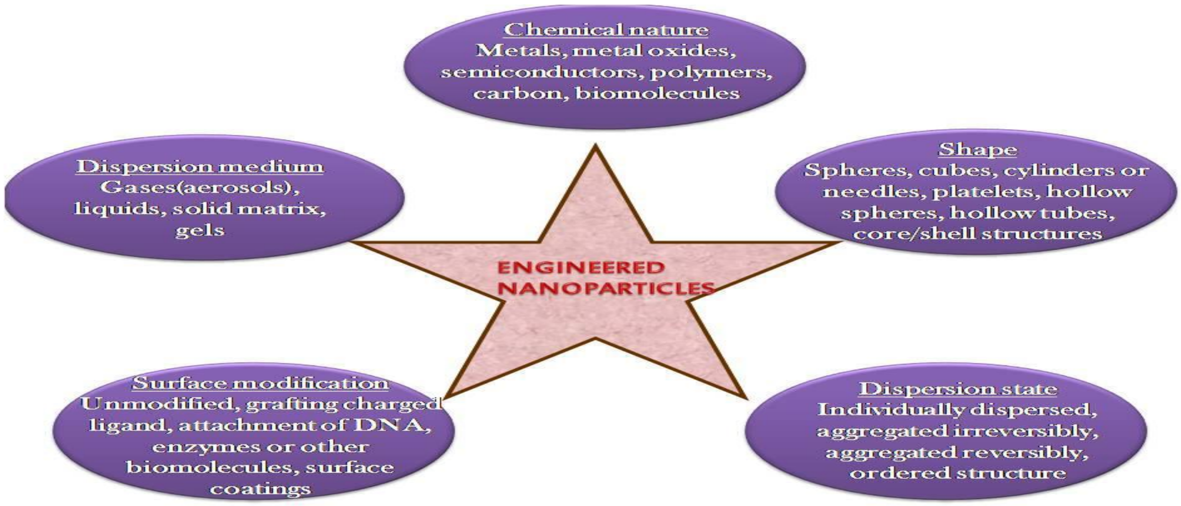

Figure1: Different properties contributing to the diversity of nanoparticles.

Types of nanoparticles

Organic and inorganic nanoparticles are the two types of nanoparticles. Inorganic nanoparticles include magnetic nanoparticles, noble metal nanoparticles (such as gold and silver), and semiconductor nanoparticles, whereas organic nanoparticles include carbon nanoparticles (fullerenes) (like titanium dioxide and zinc oxide). Inorganic nanoparticles, which have higher material qualities and functional diversity than chemical imaging pharmaceutical agents and pharmaceuticals, have been investigated as potential instruments for medical imaging and disease treatment due to their size features and advantages over chemical imaging pharmaceutical agents and pharmaceuticals. They make great imaging and drug delivery systems when mesoporous silica and molecular machines are combined. Imaging, pharmaceutical administration, and biological target thermotherapy have all used gold nanoparticles. Inorganic nanoparticles (metallc and semiconductor nanoparticles) have inherent optical properties that could aid in the transparency of polymer-particle composites. As a result, researchers exploring optical properties in composites have taken an interest in inorganic nanoparticles. The size-dependent color of gold nanoparticles has been used to tint glass for millennia [5].

Uses of Nanoparticles

The physical and chemical properties of materials generated in the form of very small particles are radically altered. The fraction of surface molecules in the nano-dimension is large compared to bulk molecules, which improves the particle's activity in the nano-dimension as well as its normal properties like heat treatment, mass transfer, catalytic activity, and so on. Metal nanoparticles, on the other hand, are more useful in the industry than non-metal nanoparticles. Nanoparticles enable numerous key advancements in the fields of biosensors, medicine, and bio nanotechnology, particularly in the field of:- (Dosage forms ,as anticancer drugs agents and diagnostic imaging tools (Gold nanoparticles)).Nano materials and nanostructures are increasingly being used in medical applications, such as imaging and medicine administration to

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cells, tissues, and organs. Many drug-loaded nanomaterials interact with organs and tissues before being absorbed by cells. Several studies have shown that entrapping pharmaceuticals in colloidal nanomaterial, such as micelle structures, can control and improve drug distribution throughout tissues, cells, and even cell organelles. Protein and enzyme immobilization, biological separation, enzyme - linked Immunosorbent assay, medication delivery, and nanosensors are all applications for magnetic nanoparticles [6]. Since of their small size, magnetic nanomaterials are crucial because they can only support small magnetic fields. Their capacity factor as recording media in the fabrication of arrays of Four nm diameter FePt nanomaterials with an extraordinarily diameters in the range has gotten a lot of attention. Figure.2

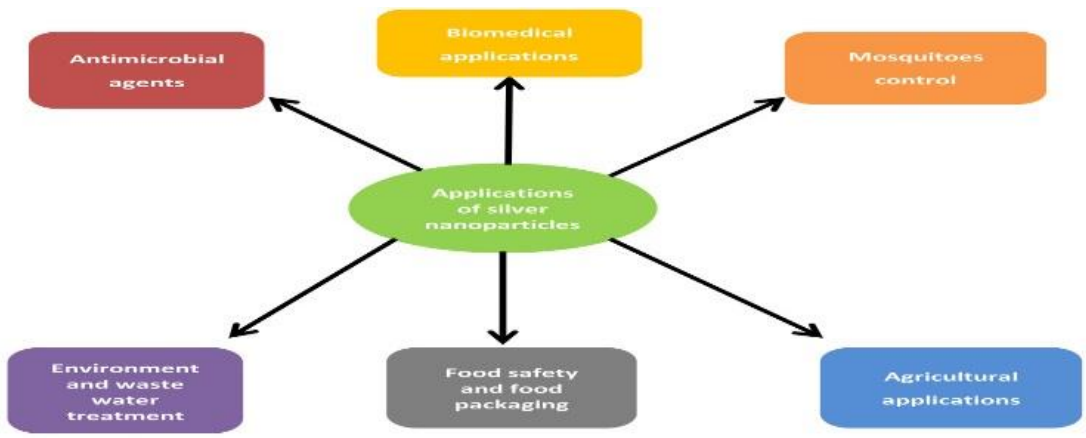

Figure 2: Overview of silver nanoparticle applications

Nanoparticles

Silver nanomaterials' particular properties benefit microbiological uses, diagnostic substances, synthetic fibers, thermal superconducting components, beauty products, and electrical devices (e.g., size and shape-dependent visual, electrical, and electromagnetic capabilities).A range of chemical and physical procedure have been used to produce and stabilize silver nanoparticles [7]. The most extensively utilized chemical techniques for the creation of silver nanoparticles are due to the decomposition with several chemical reducing agents, electromechanical approaches, biophysical reduction, and radiolysis. With a growing interest in creating nanoparticles in environmentally friendly ways, nanoparticle synthesis has recently emerged as one of the most exciting scientific disciplines (green chemistry). Green synthesis methods compose mixture polyoxometalates, polymers, Tollens, microbial, and radiation procedures, which have advantages over standard methods that involve environmentally harmful chemical agents. Furthermore, we cover the uses of AgNPs and their incorporation into other materials, as well as the molecular elements of silver nanoparticle antibacterial properties [8].

Manufacturing of silver nanomaterials by fungi:

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Fungi, as contrast to bacteria, can able to produce more nanomaterials because they can release more proteins, which results in higher nanoparticle output right away [9]. The manufacture of silver nanoparticles by fungus is said to comprise the following steps: trapping of Ag^+ ions on the surface of the fungal cells, followed by the decrease of the Ag^+ ions by enzymes present in the fungal system [10]. Extracellular enzymes like naphtha and anthrax quinones are thought to have a role in the reduction process. Nanoparticle formation in *F. oxysporum* can be mediated by a shuttle quinine extracllular mechanism and a NADPH-dependent nitrate reductase [11]. Though the exact mechanism underpinning fungi's manufacture of silver nanoparticles is unknown, the above-mentioned event is thought to be to blame. When opposed to plant extracts, using microbes to make silver nanoparticles has a significant disadvantage: the process is extremely slow. As a result, producing silver nanoparticles from plant extracts becomes a realistic option.

Methods of nanoparticles production by fungi

It has been revealed that eukaryotic organisms like fungus can biosynthesize and produce nanoparticles using their dissimilatory features. Important fungi have been shown to create extracellular substances that act as materials for their own survival when subjected to environmental obstacles such as harmful chemicals (like metalic ions), predators and temperature change. During the fungus's creation of metal nanoparticles, the mycelium is exposed to the metal salt solution. To guarantee its own survival, the fungus produces enzymes and metabolites. Hazardous metal ions can be transformed to non-toxic metallic solid nanoparticles by the catalytic influence of an extracellular enzyme and fungal metabolites. Hydrogenase was discovered in *Fusarium oxysporum* [12], *Trichoderma reesei* [13], and *Trichoderma viride* using culture filtrate that was found aerobically or anaerobically in a medium containing glucose and salts modified with nitrate [14]. It was discovered that the nitrate reductase enzyme is required for ferric iron reduction. Many fungi with these properties can decrease Au (III) or Ag in general (I). Aside from these extracellular enzymes, Fusarium oxysporum contains a large number of naphtha quinnes and anthrax quinones with excellent redox characteristic, which could represent as electron shuttles in metal reductions.

Characterization of AgNPs

1- Ultraviolet – Visible (UV-Vis) Spectroscopy

This technique is the main method to verify the synthesis of AgNPs that are stable in nature. Surface plasmon resonances (SPRs), which shift to longer wavelengths with raising particle size, are widely known to dominate the optical absorptin spectra of metal nanoparticles. It is also widely known that the absorbance of AgNPs is mostly determined by particle size and shape. In general, as the symmetry of the nanoparticles increased, the number of SPR peaks dropped. [15] found that the position and shape of plasmon absorption are affected by properties, as well as the dielectric constant of the surrounding medium. The creation of AgNPs as a spectroscopic signature was investigated by the appearance of SPR peaks at 430-460 nm [16].

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2- Scanning Electron Microscopy (SEM)

The SEM examination evaluates the size, form, morphology, and elemental composition of manufactured AgNPs by focusing a beam of high-energy electrons on the surface of a solid specimen of AgNPs. The signals created by electron-sample interactions were shown as pictures, revealing information on the AgNPs sample's external morphology (texture), chemical composition, and orientation. [17, 18].

3- X- Ray diffraction (XRD)

This method is achieved to demonstrate the phase composition, crystal structure, texture, and orientation of a material. The X-rays pass through a material, and the pattern created offers information on the unit cell's size and shape. Light diffracts at different angles because the atoms have a crystal structure and are grouped in a periodic grid. When an X-ray passes through a crystal, it creates a diffraction pattern, which reveals information on the atomic arrangement within the crystal. The XRD determines the type and purity of silver nanoparticles [19].

4- Fourier Transform Infrared (FTIR) Spectroscopy

The FTIR instrument is used to identify potential biomolecules that act as reducing, capping, and stabilizing agents for AgNPs in the given samples . Its principle is being used to evaluate the removal efficiency with biomolecules when green manufacturing nanoparticles using aqueous plant extract, as well as the bonding connection between them. Adsorbing infrared light in a certain wave number range is also useful for detecting the vibration properties of chemical functional groups of green produced AgNPs[20].

Antifungal activity

The rate of growth of useful fungi was decreased by varying concentrations of AgNPs, and their effect was positively related to the time of exposure and AgNP concentrations . Ionic or nanoparticle silver's antifungal activity offers a lot of potential for suppressing spore-producing fungal plant diseases. Synthetic fungicides may be more hazardous to humans and animals than silver. Multiple modes of action that target a wide variety of microbe biological pathways provide a significant benefit in terms of minimizing the development of resistance, which has become more relevant in the chemical management of many plant fungal infections [21].

Conclusions

The current review focused on silver nanoparticle production methods, description, and antifungal efficacy. Furthermore, antifungal activity of certain fungi for which efficacy has been

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scientifically proven, therapeutic agents in biomedicine, mosquito control, environmental and wastewater treatment, agriculture, food safety, and food packaging are all potential applications of silver nanoparticles produced by various methods. As a result, employing fungus to synthesize silver nanoparticles has various advantages, including eco-friendliness, biocompatibility, and cost-effectiveness. Silver nanoparticles, it is assumed, will play a vital role in many nanotechnology-based processes due to their unique features.

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Conflict of interests.

There are non-conflicts of interest.

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