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Review article

Bio-Nanotechnology and Nanoparticles Applications in Biology

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Abstract: ***Nanotechnology****: It is an application to study the basic principles of molecules and compounds that do not exceed one hundred nanometers in size and to engineer them for use in useful applications such as in the field of medicine to treat cancerous diseases and various microbial infections and in the field of engineering, chemistry, physics and other sciences. Numerous bacteria strains that are resistant to antibiotics have arisen as a result of the careless and overuse use antibiotics. As a result, the use of nanoparticles has emerged as a competitive substitute for antibiotics in the fight against the evolution of bacterial drug resistance. In addition to having strong antimicrobial properties that may act by weakening already-existing antimicrobial mechanisms, many organic and inorganic nanomaterials also have unique physical and chemical properties that make them important for the quick, sensitive, and selective detection of microbial infections. Furthermore, compared to traditional antibiotics, nanoparticles have less negative effects. In addition, the incorporation of antimicrobial nanomaterial in medical devices can prevent microbial adhesion and infection, also it used as vaccine adjuvants and/or delivery vehicles can evoke more efficient immune responses against microbial infection. The process of microbial production of nanoparticles (NPs) involves a bottom-up approach. Defense mechanisms for detoxification, such as the oxidation/reduction of metal ions, the creation of metal phosphates, carbonates, and sulfides, or the volatilization of metal ions, function as vital survival procedures.*

.**Keywords:** ***Nanomaterial, Nanotechnology, Bio-Nanotechnology***

1.Introduction

Nanotechnology: It is an application to study the basic principles of molecules and compounds that do not exceed one hundred nanometers in size and to engineer them for use in useful applications such as in the field of medicine to treat cancerous diseases and various microbial infections and in the field of engineering, chemistry, physics and other sciences. Bio-Nanotechnology is the subfield of nanotechnology that entails creating it through atomic-level engineering while taking biological precursors into account [1]. Although it has potential design and alters the atomic level complexity of produced entities, it is closely tied to biotechnology. When bio-nanotechnology equipment is evolved to the atomic scale, it can clearly complete the three-dimensional molecular task—or, to put it broadly, it can combine individual control methods with its framework [2].

Biosynthesis of nanoparticles is a new and environmentally friendly research area that could be expanded in future research [3]. The production of NPs by microorganisms follows a bottom-up strategy in which detoxifying defense systems function as vital survival processes involving the oxidation and reduction of metal ions, generation of forms of metal phosphates, carbonates and sulfides or volatilization of metal ions [4].

Use of nanotechnology in the field of medicine is known as Nano medicine [5] which has led to a qualitative leap in the field of pharmaceutical industries and biotechnology. Additionally, it has demonstrated incredible promise in treating nearly all facets of microbial infections. Furthermore, nanomaterials have special chemical and physical characteristics that contribute to the quick, accurate, and targeted identification of microbial diseases, also there are many organic and inorganic nanomaterial which possess strong antimicrobial properties that may act by weakening existing antimicrobial mechanisms furthermore, nanoparticles less adverse effects than those of traditional antibiotics. Furthermore, antimicrobial nanomaterials can be included into medical devices to stop microbial adherence and infection. They can also be employed as vaccine adjuvants and/or delivery systems to boost immune responses against microbial infection [6]. Consequently to the indiscriminate and excessive use of antibiotics, many microbial strains that are resistant to them have emerged. Thus, the use of nanoparticles has become a viable alternative to antibiotics for the purpose of solving the problem of the emergence of bacterial resistance to multiple drugs. Microbes possess several mechanisms of antibiotic resistance involving a rise in the microbial cell's creation of an antibiotic competitive inhibitor, a decrease in absorption, and an increase in drug efflux and alteration of the substrate to which the antibiotic binds [7]. In addition, the treatment of chronic diseases caused by biofilm-forming or intracellular microbes is a major challenge (Mycobacterium leprae, Chlamydia, Listeria, etc)[8].

Some types of nanoparticles:

1. **Silver nanoparticles (AgNo3)**

Silver has been used since ancient times as an antimicrobial, on its own or in combination with other technologies [9].It has been known since ancient times that silver ions possess strong bactericidal effects and a wide range of antimicrobial activities [10]. Because of the important qualitative properties of silver nanoparticles (such as size and shape depending on the optical, electrical and magnetic properties) that could potentially integrate applications of antimicrobials, biosensors, composite fibers, superconducting refrigerants and cosmetic products [11], Additionally, it has been demonstrated that silver nanoparticles function as antimicrobials in wound dressings [12], topical anti-infection creams and anti-cancer medicines [13,14] . Since AgNo3 causes the bacterium to produce K+ ions, the bacterial plasma, also known as the cytoplasmic membrane, is a major target site for silver ions since it is linked to numerous crucial enzymes and DNA [15].

2. Gold nanoparticles (AuNPs)

An excellent option for biomedical applications are gold nanoparticles because of their ability to synthesize, stabilize, actuate, little toxicity and simple detection [16], Gold nanomaterials are stable and have the advantage of being somewhat inert in biology, resulting in a reduced in development rate, biocompatibility and have low toxicity [17] which have been synthesized by different methods as physical chemical and biological. Several yeasts, fungal, actinomycetes strains as well as viruses have been used to synthesize gold nanoparticles [18].

The positively charged Au (III) ions are electrostatically interacting with the negatively charged bacterial cell wall, causing the gold ions to be carried within the cell during intracellular production by enzymes and biomolecules. During extracellular synthesis, gold ions are retained on the cell membrane by membrane enzymes. These membrane-bound enzymes or the reductase enzymes produced by the microbial cell are capable of completing the synthesis process outside of the bacterial cell [16, 19]

3. Magnetic nanoparticles

Agricultural, energy, engineering, biomedical, and environmental domains have all made use of magnetic nanoparticles (MNPs), a nanomaterial with distinctive and special magnetic properties [20]. As in the use of magnetic nanoparticles (magnetite Fe_3O_4) to remove arsenic from groundwater during the separation and treatment of pollutants from it [21]. Recently, there have been many researches involving different methods for synthesizing MNPs. Various synthetic techniques are employed to achieve the intended dimensions, form, steadiness, and biocompatibility. Typical techniques consist of ball milling, co-precipitation, pyrolysis, hydrothermal, microemulsions, sol-gel method, and biological method for producing MNPs [22]

4. Titanium Dioxide nanoparticles

TiO_2 is among the most prevalent nanomaterials and is widely used in the world [23]. TiO_2 is found in many nanostructures, such as particles, tubes, rods, wires, films, sheets and nanocoatings and also widely used in foodstuffs, coatings, paints, plastics, printing inks, papers, biomedical products and cosmetics [24]. TiO2 NPs uses in photodynamic therapy studies is increasing, as in the application of these molecules as photosensitizing agents, such as in cancer treatment, in the photodynamic inactivation of antibiotic-resistant bacteria, as well as in the creation of bioconjugates using monoclonal antibodies specific to particular cells to treat cancerous tumors, or in the preparation of these molecules as an antibacterial treatment for antibiotic-resistant bacteria [25].

5. Selenium Nanoparticles

Selenium is regarded as a crucial micronutrient required for the well-being of living things. Because of their biocompatibility, bioavailability, and low toxicity, selenium nanoparticles (SeNPs) have drawn the interest of several researchers and are now being employed in a wide range of biomedical applications [26] ,which have many anti-cancer and anti-microbial properties and are therefore widely used in nanomedicine applications [27]. Selenium has the ability to kill bacteria and this is due to its ability to stimulate the oxidation of thiols inside cells, which causes the death of microorganisms [28]. In human, Selenium improves cellular immune responses when available in the form of sodium selenite for patients with head and neck cancer during radiation and surgery. These selenoproteins are required for the function of activated T cells, which are sensitive to reactive oxygen species (ROS), when a deficiency in these proteins occurs it leads to an increase in ROS [29].

The applications of nanotechnology

Nanoparticles are used in many fields and industries, such as in the medical field such as treating cancer, antimicrobial diseases, molecular diagnosis and gene delivery etc, the food field (food manufacturing, filling and packaging) and also in the environmental field, such as in water treatment and other biological and engineering fields as showen in Figure 1[30].

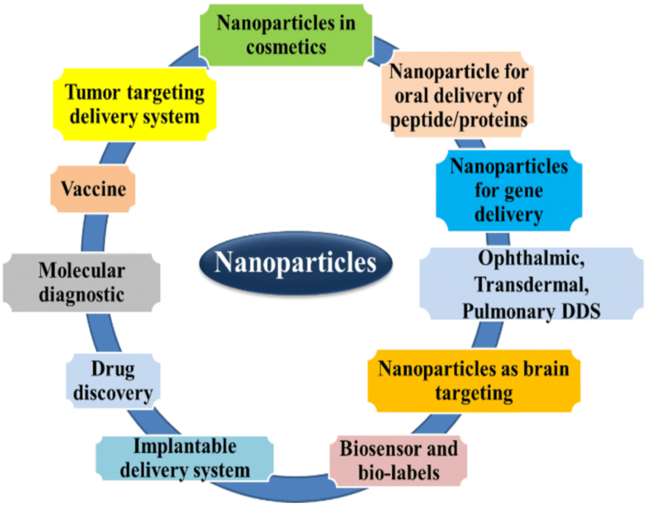

Fig1: Present and future applications of nanoparticles [30]

In medicine, nanoparticles uses in treating infection as in nanoparticle-based antibacterial vaccination and targeted antibiotic delivery [31]. Studies have shown that nanoparticles of gold, silver, and zinc oxide are antimicrobial agents such are bacteria that are resistant to drugs, such *Escherichia coli*, MRSA, *Pseudomonas*, and *Klebsiella*. Numerous other benefits of antimicrobial nanoparticles include enhanced bioavailability, a lower risk of medication toxicity, and near-therapeutic drug accumulation [32].

Nanoparticles are widely used in the field of food manufacturing, which can be summarized into two main groups: nanostructured food ingredients and nanofood sensing. The first covers a wide area from food processing to food packaging. These nanostructures can also be utilized in food processing as filler materials to increase the mechanical strength and longevity of packaging materials, food additives, carriers for the intelligent delivery of nutrients, anti-caking agents, and antibacterial agents. Food nanosensing can be used to accomplish this, enhancing food quality and assessing safety [33].

Nanomaterials are used in many environmental applications, such as in water and wastewater treatment, there are many metal oxides, such as titanium dioxide (TiO_2), zinc oxide (ZnO), and tungsten oxide (WO_3), in addition to other nanoparticles of metal oxides, are well and important in the technologies used in water purification due to their superior ability to improve chemical properties and biological water [34]. Also, many nanomaterials are used in the processes of adsorption, separation, and disposal of pollutants, pathogens, and other dangerous elements which characterized by many unique properties, such as their very specific surface area, Microinterface and treatment potential, nanomaterials have emerged as an important and necessary topic in environmental research [35].

Conclusion:

The current study highlighted the importance of nanotechnology in the field of biology sciences and its applications also, included the most important types of nanoparticles used in the field of medicine, such as treating inflammatory diseases as an alternative to antibiotics or treating cancer, and in gene therapy experiments and the environmental field.

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