Journal of Advances and Scholarly Researches in Allied Education
Vol. 17, Issue No. 1, April-2020, ISSN 2230-7540

A Study on Biologically Synthesized Nanoparticles their Applications in Nanomedicine

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Abstract – Nanomedicine is the application of nanotechnology in the field of medicine. Nanoparticles are distinguished by their enormous surface area that facilitates interaction with a variety of functional ligands. Metallic nanoparticles have also been used for medicine delivery, diagnostic imaging, labeling, and biosensors since they are compatible with biological systems. Metallic nanoparticles created using biological agents including fungus, plants, bacteria, and other microorganisms are very stable.

Keywords – Nanoparticles, Nanomedicine, Applications,

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INTRODUCTION

Nanotechnology is a current and active research areas in modern science. Nanoparticles are distinguished from larger particles in parent materials by their smaller size, shape, and dispersion (Song and Kim, 2008). The biological entities of manufactured nanoparticles may grow proportionately with an increase in specific surface area because to their enhanced surface energy and catalytic reactivity. Although there are many ways to make nanoparticles, biological techniques offer the benefit of being less harmful and ecologically benign.

In many respects, biogenic nanoparticles outperform chemical nanoparticles. The biogenic method, alternatively, employs low-cost chemicals and a more acceptable "green" route that is both less energy-intensive and environmentally friendly than chemical methods (Bhattacharya and Mukherjee, 2008).

Nanoparticles:

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Nanoscience and Nanotechnology:

Nanotechnology is the manipulation of matter at the macromolecular, molecular, or atomic level to produce and control things on the nanometre scale, while Nanoscience is the study of any phenomena on the nanometre scale, which is generally defined as less than 100 nm. The aim of nanotechnology & nanoscience is to provide the groundwork for the creation of new materials, gadgets, and systems with unique characteristics and functionalities due to their tiny scale.

For the very last two decades, nanoparticles (NPs) have fascinated the scientific community owing to their intriguing optical and electrical characteristics that are not present in their bulk counterparts. NPs are crystalline particles with sizes ranging from 1 to 100 nanometers with a typical atomic count of fewer than 1,000. From galactic dimensions to the nanoworld, objects exist on a range of length scales. NPs take on new properties at such tiny sizes that are directly proportionate to their size. The exciton radius determines the size below which significant quantum confinement occurs. Because of the large surface-to-volume ratio and size-dependent changes in the electronic structure, the properties of NPs alter with particle diameter. The electron-hole pair is "restricted" by the grain's border when the radius of a nanocrystal approaches that of an exciton's Bohr radius.

Chemistry of nano-materials:

Chemistry was able to develop processes for'managing' atoms and molecules, which made it a successful science. The average atom diameter is around 1 Angstrom (A0), or 0.0000001 millimeter in order of magnitude. They're clearly too little to handle or touch on their own. The atomic model is logically transformed throughout the handling. Chemists were able to see into the features of individual atoms or the molecules they were made up of by knowing the reactivities of the elements and compounds.

Characterization of nanoparticles:

The physic-chemical characterization of generated nanoparticles is an important step in the biosynthesis of nanoparticles. The information on shape, size, homogeneity, surface area, and other characteristics provides useful knowledge about nanoscale systems as well as insight into nanoparticle synthesis control for future commercial applications.

UV-Visible Spectroscopy:

The attenuation of light beam after it pass by a sample or after reflection from a sample surface is measured using UV - Visible spectroscopy. The UV - Visible spectra have a broad range of characteristics and are particularly useful for quantitative measurements; however, they are only marginally useful for sample identification. Metallic nanoparticles are known to come in a broad range of hues. Mie was the first to mathematically explain the genesis of this hue by solving Maxwell's equation for the absorption and scattering of electromagnetic radiation by microscopic metallic particles (known as Lorenz-Mie solution or Mie Scattering), which he published in 1908.

X-ray Diffraction:

A essential methods for establishing the crystal structure of solids, including lattice constants and geometry, identifying unknown materials, and detecting the orientation of single crystals and defects, among other things, is X-ray diffraction (XRD). Non-amorphous materials have a crystal lattice made up of repeating regular planes of atoms. A monochromatic X-ray is directed onto a sample in XRD analysis, and the interaction between these planes of atoms and X-rays results in diffracted rays being emitted. Different minerals diffract X-ray beams differently depending on the atomic composition and structure of the crystalline lattice, as well as their arrangement.

Transmission Electron Microscopy (TEM):

The TEM's main function is to photograph thin films of a solid material at high resolution for nanostructural and compositional research. The biologically synthesized nanoparticles were drop-coated on a carbon-coated TEM grid for transmission electron microscopic analysis, and their size and morphology were analyzed at high voltage (Dhas *et al.*, 2012; Senapati *et al.*, 2012; Venkatesan *et al.*, 2014; Khalil *et al.*, 2012).

Scanning Electron Microscopy (SEM):

The SEM operates on the concept of using kinetic energy to generate signals from electron interactions. Secondary electrons, backscattered electrons, and diffracted backscattered electrons are all types of electron used to observe crystalline elements and photons. The main function of the secondary electrons produced by the specimen is to detect the shape and topography of the specimen, while the backscattered electrons reveal contrast in the composition of the specimen's components. (H. Nejc and colleagues, 2012).

Energy Dispersive X-ray Spectroscopy (EDX):

This is a commonly used technique for determining the chemical composition of a material. This method detects X-rays that are produced when beam of electron interacts with a sample. In a nutshell, the sample is bombarded with electrons, and the atoms on the surface eject their outer-shell electrons.

Fourier Transform Infrared Spectroscopy (FTIR):

This is used to examine the functional groups associated with the test materials. The analyst will require a frequency spectrum to identify the observed interferogram signal that cannot be immediately understood (a plot of the intensity at each individual frequency). It's essential to be able to "decode" the various frequencies. This may be accomplished using the Fourier transformation, a well-known mathematical method. This transformation is performed by the computer, which subsequently provides the user with the necessary spectral information for analysis.

Biosynthesis of nanoparticles:

A broad range of microorganisms have recently been reported as being capable of producing nanoparticles. However, researchers are currently investigating the development of refined protocols and the applicability of biologically synthesized nanostructures. Silver and gold, among the various metal nanoparticles, are the most studied metals due to their potential applications in biomedical treatment. Both unicellular and multicellular organisms are employed to make different metal nanoparticles, and both are deemed ecologically acceptable. Fungi are a most studied groups of microbes because of their ability to produce useful reducing agents that are involved in the synthesis.

SYNTHESIS OF NANO-STRUCTURED MATERIALS:

Physical Methods:

For the synthesis of commercial nanostructures materials, several different physical methods are currently in use. The first and most widely used technique is the **inert-gas evaporation technique**, It requires evaporating a precursor substance, such as a single metal or a compound, in a low-pressure gas to form atom clusters. When evaporating atoms or molecules collide with molecules or gas atoms near a cold-powder collecting surface, they condense into atom clusters. To prevent aggregation and coalescence, clusters must be disinterested from the deposition zone once they have formed. The clusters are subsequently pushed out of the gas condensation chamber using natural convection or forced gas flow. This approach has the benefit of being simple to vary particle size by changing the removal speed, and the particle do not readily merge since they are concentrated in the precursor sites. This method is useful when a large number of particles are required but the particle size does not need to be uniform.

Chemical Methods:

Occasionally, solution chemistry (wet chemistry) is employed to make the precursor, which is then converted into nano-phase particles via non-liquid phase chemical processes. Precipitation of solid from solution is a common method for producing small particles. Reactions in aqueous or non-aqueous solutions containing soluble or suspended salts are used in the usual procedure. The precipitate is formed by homogeneous or heterogeneous nucleation after the solution is supersaturated with the product. Once produced, the nuclei's growth is usually accomplished by diffusion. The rate at which the nuclei grow after creation is crucial if monodispersed particles evolve. In order to produce microscopic particles, the chemicals used, the pH and chemical concentration of the solution, as well as the reaction temperature, are all critical.

General physico-chemical methods for preparation of nano-sized material:

A number of methods, such as attrition and pyrolysis, may be used to create nanoparticles.

Antibacterial activity of nanoparticles:

Ahmad and colleagues (2013) reported the first biological synthesis of AuNPs and AgNPs using *Candida albicans*. UV-Visible spectroscopy, XRD, and TEM were used to describe the nanoparticles, as well as their antimicrobial activity against *Staphylococcus aureus* and *Escherichia coli*. AuNPs and AgNPs had average particle sizes of about 5 and 30 nm, respectively, according to the TEM results. When compared to AuNPs, silver nanoparticles had the most bactericidal activity against both pathogens.

Li and colleagues (2010) studied the effect of AgNPs on *Escherichia coli* ATCC 8739 and their mechanism of action at the cellular and sub-cellular levels. AgNPs at a concentration of 10 g/mL inhibited the entire growth of (107 cfu/mL) *Escherichia coli* cells in the medium, according to the findings. The impact of AgNPs on *Escherichia coli* also confirmed that higher concentrations of AgNPs inhibit respiration chain dehydrogenases, resulting in lower enzyme activity. In the SEM micrograph of AgNPs treated *Escherichia coli*; they found many pits and few gaps with severe damage, compared to the untreated, which showed a normal and smooth structure. Overall, the authors suggest that AgNPs may harm bacterial cells by damaging their structure, then acting on the membranous enzyme, causing cell lysis.

Few studies have previously been conducted to determine the mechanism of action of AgNPs against various bacterial cells. When silver ions were used to treat *E. coli* and *S. aureus*, it is thought that DNA lost its replication ability and proteins became inactive. The appearance of small dense granular over the cell wall and inside the cells was confirmed by X-ray microanalysis and TEM analysis. The presence of sulfur and silver in the granular area further confirmed Ag^{+}'s potential antibacterial activity (Feng *et al.*, 2000).

Shahverdi *et al.* (2007) investigated the effectiveness of a combination of AgNPs and commercial antibiotics against a variety of pathogenic bacterial strains.

Antifungal activity of nanoparticles:

Most plants are frequently attacked by a wide collection of pathogens during their life cycle, which can result in reduced productivity, severe damage, and high mortality rates if not controlled. Higher plants are thought to number around 250,000 species. Furthermore, most plants are constantly expose to various types of The biotic stress that various organisms via symbiotic or pathogenic interactions. Whenever plants and microbial pathogens interact, the disease can be evaded or inhibited depending on the level of resistance (Lattanzio *et al.*, 2006). Among the various plant infections, fungi-caused diseases have been a major constraints in crop production, causing changes during developmental stages, severe losses, as well as product quality, nutritional value, organoleptic characteristics, and limited shelf life (Agrios, 2004).

In general, synthetic fungicides and soil fumigants were used to control most phytopathogenic fungi that caused infections, but their use in the field has been limited due to their decreasing efficacy, primarily due to the development of resistance. The presence of these chemicals in agroecosystems has harmful effects on the environment and human health, which is another major concern (Harris *et al.*, 2001; Pretty, 2008).

Gajbhiyeet *et al.* (2009) found that AgNPs combined with fluconazole inhibited *Candida albicans*, *Phoma glomerata*, *Phoma herbarum*, *Trichoderma sp.* and *Fusarium semitectum*, in another study. The AgNPs made from *Alternaria alternata* showed increased activity against *Candida albicans* when combined with fluconazole, followed by *Phoma glomerata* and *Trichoderma sp.* Using an agar disc diffusion assay, Narayanan& Park (2014) investigated the impact of Silver nanoparticles on several wood-degrading fungal pathogens, including *Gloeophyllum abietinum*, *Gloeophyllum trabeum*, *Chaetomium globosum*, and *Phanero chaetesordida*. When compared to the chemically synthesized (4 mg/mL) disc, which showed significant inhibitory activity against all of the tested fungi, the disc containing 2 and 4 mg/mL of AgNPs showed only moderate inhibition against all of the tested fungi.

Few researchers have looked into the antifungal activity of AgNPs against various dermatophytes, including the effect of AgNPs, as well as the combination of AgNPs with fluconazole and griseofulvin, against *Trichophyton rubrum*, a clinically isolated dermatophyte pathogen. AgNPs' antifungal activity was measured at a MIC of 10 g/mL, which is lower than griseofulvin's (0.8 g/mL) but higher than fluconazole's (MIC of 40 g/mL). AgNPs' inhibitory activity against *Trichophyton rubrum* was found to be enhanced when they were combined with flocunazole and griseofulvin (Noorbakhsh *et al.*, 2011).

Anticancer properties of nanoparticles:

Noble metal nanoparticles have optical, electronic, and molecular recognition properties that distinguish them from other metallic nanoparticles. Gold and gold nanoparticles are among the noble metals that are valuable, inert, and do not easily oxidize when exposed to oxygen or highly acidic environments. Gold nanoparticles are more stable, sensitive, and consistent than other materials. They have recently been used in applications like heavy metal ion detection and therapeutic agent target delivery. Gold nanoparticles have been synthesized and assembled using physical, chemical, and biological processes. Microorganisms have been use to successfully synthesize, nucleate, and assemble nanomaterials. Nanoparticles may be produced intracellularly or extracellularly by a variety of unicellular and multicellular microorganisms. To obtain greater control over nanoparticle size and polydispersity, the cell filtrate might be employed in extracellular production.

Cancer is a condition in which tissue or cells grow abnormally and divide uncontrollably, resulting in an increase in the number of cell divisions. The fight in opposition to cancer is difficult, especially when it comes to developing therapies for tumors that are rapidly multiplying. Chemotherapy is a treatment option for cancer, but it has a low specificity and is limited by dose-limiting toxicity. It is tough to find therapies and medications for the treatment of many forms of cancer. As a result, traditional methods necessitate a combination of controlled release technology and targeted drug delivery that is both effective and safe. Hep2 cell line, HT-29 cell lines, Vero cell line, and breast cancer line MCF-7 have all recently used silver nanoparticles in anticancer therapy.

CONCLUSION:

Several researchers have investigated transition metal oxides nanoparticles in recent years; transition metal oxides are biocompatible and the most stable materials due to the high oxygen content of the atmosphere in the earth, so oxide nanoparticles, particularly those of transition metals, represented a very important class of materials; further, nano sized nickel oxide is an important class of materials. The nickel oxide was made from nickel hydroxide, as shown by XRD investigations. The nickel oxide nanoparticles were imaged using a high magnification SEM. When compared to published values for bulk NiO particles and NiO thin films, the calculated values are lower than the published values. The qualities were validated by the band gap values. The tiny particles generated were determined to be nickel oxide.

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