A STUDY ON BIOSYNTHESIS OF GOLD AND SILVER NANOPARTICLES AS PHOTOCATALYSTS IN PHOTOCHEMICAL REACTION AND ITS BIOMEDICAL APPLICATIONS

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ABSTRACT

In the present study, Biosynthesis of Gold and Silver Nanoparticles as Photocatalysts in Photochemical Reaction and its biomedical applications is studied. Among the various methods of synthesis of metallic nanoparticles, Photocatalysts in Photochemical Reaction methods have assumed significance in view of the advantages such as cost-effectiveness, non-toxic and eco-friendly nature etc., and these methods are more convenient in pharmaceutical and biomedical applications.

Keywords: *Nanoparticles, Biosynthesis, Gold, Silver, Photocatalysts, Photochemical Reaction, biomedical applications.*

Introduction

NPs are a big spectrum of materials with dimensions >100 nm that may be utilized a variety of applications, including medical, pharmaceutical, manufacturing and materials, environmental, electronics, energy collecting, and mechanical sectors, due to their varied characteristics. The remarkable characteristics of metallic NPs have been to the growth of a variety of synthesis methods, with gold and silver NPs produced from plant extracts drawing researchers' interest in their hunt for antibacterial compounds appropriate for agriculture. Furthermore, these efforts are seen as low-cost procedures that prevent toxic-producing goods while also improving agricultural activity. A kilogram of AgNPs costs approximately USD 4 million, whereas a kilogram of raw silver costs around USD 14,000, according to estimates.

Raveendran et al. disclosed a earliest methods for green metal NP synthesization in 2009. They used a hot aqueous starch solution, a green silver nitrate reduction agent (AgNO3) and a green glucose reducing agent. Researchers like as Iravani and Kumar et. al. subsequently produced high-quality review papers on the manufacture of metallic NPs which use green chemistry extracts. Since then, other research groups have been tried to produce metal NPs using different plants and their structures.

As a consequence of the nanotechnological boom, novel chemical, physical, and biological techniques for the synthesis and manufacturing of metal NPs have been created. As a consequence, the uniqueness of this article consists in detailing the applicable green synthesis of gold and silver nanoparticles from plant extracts, as well as their antimicrobial agents' ability to combat fungal and bacterial pathogens that may cause plant, foodborne, and waterborne, illnesses in the agricultural sector. The following article also provides a variety outline of the contribution of gold and silver nanoparticles to the treatment of water and the development of "environmentally friendly" nanofertilizers, nanopesticides and nanomedicinal products.

Nanotechnology

Nanotechnology is the field of contemporary material science, focus on the study of design, production, characterization & application of materials with nano scale. It is the most emerging technology dealing with the atom size ranging from 1-100nm. Tremendous growth of nanotechnology has open up novel avenues in material science and engineering field. The initiation of nanotechnology has boon to the mankind & universal interest because of its potential. Nanotechnology is an incredible broad and truly multidisciplinary evolved from the convergence of diverse fields like chemistry, physics, biology, material science, mechanical engineering and medicine (Fulekar 2010; Muhammed Jamil Ahmed 2014; Mansoori et al. 2008; Siavash Iravani 2011). That is science miniaturization & carried out on the nanometer scale, in the order of 10-9 meter which is tiny and one hundred thousandth of the thickness of a human hair.

Nanotechnologies are broadly classified as (1) *Dry* (2) *Wet* and (3) *Computational* Nanotechnology. Dry nanotechnology is related with surface science & physical chemistry and it provides importance on the fabrication of items by using inorganic materials namely metals and semiconductors. Either, nanotechnology is correlated with biological system that is living organism such as enzymes, membranes and cellular compounds. Computational nanotechnology is related with modeling and stimulating the complex nanometer sized structures (Ill-Min Chung et al. 2016). The astonishing physicochemical and the biological properties of nanoparticles relative to bulk material, which drives towards new applications viz., synthesis of drugs, drug delivery, catalysts, light emitters, biomedical sciences tools, sensors, optoelectronic and magnetic devices (Avinash et al.2009). Nanotechnology is getting global attention because of their ample applications, as shown in Figure 1.

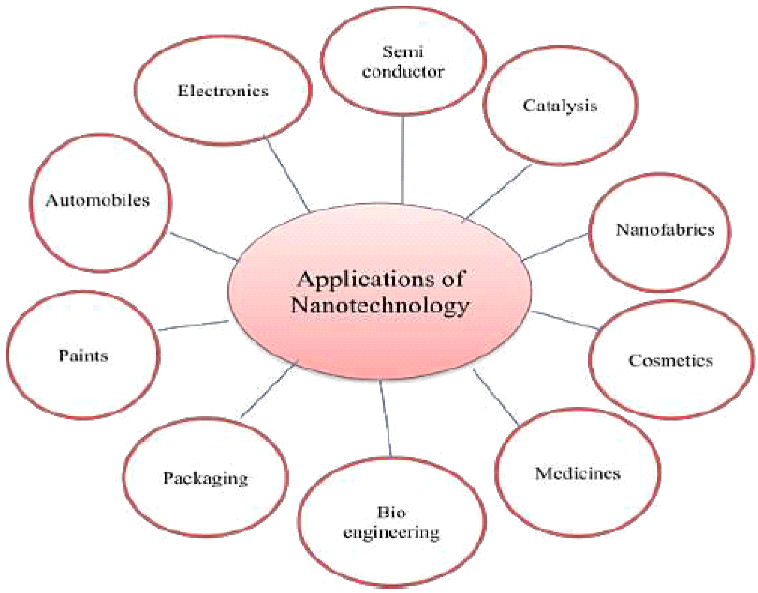

Figure 1: Genaral applications of Nanotechnology

Nanotechnology is a powerful technology. Its whole list of the potential applications is too vast and varied to discuss in detail, but sure, it's one of the greatest values will be lead to new and effective applications at every fields of science. The enhanced properties created by this technology will surely help in saving energy and environment & get better the quality of human's life style.

According to Mahdihassan (1985), the Chinese were utilizing red colloidal Gold as longevity alchemy drug. Weigleb 's History of Alchemy (1777), from 2500 BC, they used colloidal gold. The mediaeval alchemist has drawn the ethnicity of Eastern alchemy & required a form of metals which might be consumed internally, aurum potable (drinking gold) & luna potable (drinking silver) that they used as life's elixirs (http:/www.colloidalgold, httpwww.horusmedia). History claims the first recipe for colloidal gold was given by the great physicist Moses (Daniel and Astruc 2004). The drinkable gold found applications in treating conditions such as melancholy in the early 17th century, since gold "made one's heart happy" (Gole and Murphy , 2004). Gold compounds like gold sodium are at rest in utilize today

Thiomalate (Myochrysine) & gold thioglucose (Solgonal) continue to be used for rheumatoid arthritis treatment (Murphy et al . 2008). Also Silver colloid has some medicinal uses that go back centuries. In the early 1990s people would place silver coins in bottles of milk to prolong the freshness of the milk (Nowack et al . 2011). The medicine Hippocrates father wrote that silver would have beneficial healing & antimicrobial properties.

In 1818, Jeremias Benjamin Richters provided an answer for the various colours seen in drinkable gold specifying that the pink or purple colour was due to the finest degree of subdivision while the yellow colour arises because of the aggregation of very fine particles (Fulhame 1794). Colloidal gold & silver have been utilised as a colourant since earlier days (Turkevich 1985). The "Purple of Cassius" glass-colorant is a colloid with gold nanoparticles & tin oxide coagulation (Daniel 2004)

Nanoparticles

Nanoparticle is a solid particle that has minimum one mass in the nanorange (1-100nm). These solid particles can be in the shape of spherical, tubular or irregular & could exist in the term of fused, aggregated or agglomerated state. The prefix 'nano' is derivative from the Greek termed '*nanos*' which means 'little old man' or 'dwarf'. A DNA molecule is 2.5nm wide, a protein approximately 50nm, and a flu virus about 100nm, a red blood cell is approximately 7000nm wide and a human hair is approximately 10000nm thick. The size of nanoparticles(NPs) is smaller than bulk materials & larger than individual atoms or molecules. So it can act as an intermediate between the bulk materials & atomic and molecular structure. Nanoparticles' key features are their tiny size and high surface-to-volume ratio (Shobha et al. 2014; Thakkaret al. 2010)

The nanoparticles are of strong interest because of their multifunctional properties like electrical conductivity, mechanical strength, magnetic properties, optical properties, catalytic properties & thermal stability etc. The mass, shape & surface area of the nanoparticles plays a massive role on the efficacy for improving fundamental property compared with their bulk counterparts like electrical conductivity, mechanical strength, magnetic properties & thermal stability etc. Nanoparticles serve as the vital building blocks for nanotechnology, using those new and improved techniques has urbanized for the next generation industrial revolution. Novel applications of nanoparticles are increasing rapidly on various fields including electrochemical sensor, biosensor, medicine, targeted drug delivery, healthcare, agriculture and treatment of wastewater.

Methods of synthesizing nanoparticles

The experimental synthetic protocol for nanoparticles is a main aspect of developing nanotechnology in a growing manner.

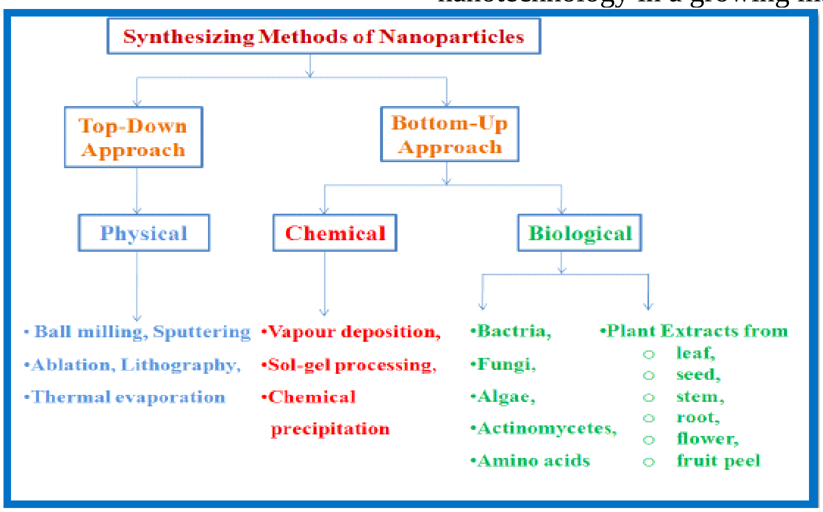

Figure 2: Various methods used in nanoparticle synthesis

Basically, preparation of nanoparticles and the fabrication of nanostructures could achieved by two approaches namely "Top-down approach" and "Bottom-up approach". Figure 1.3 shows the preparation approaches for nanoparticles.

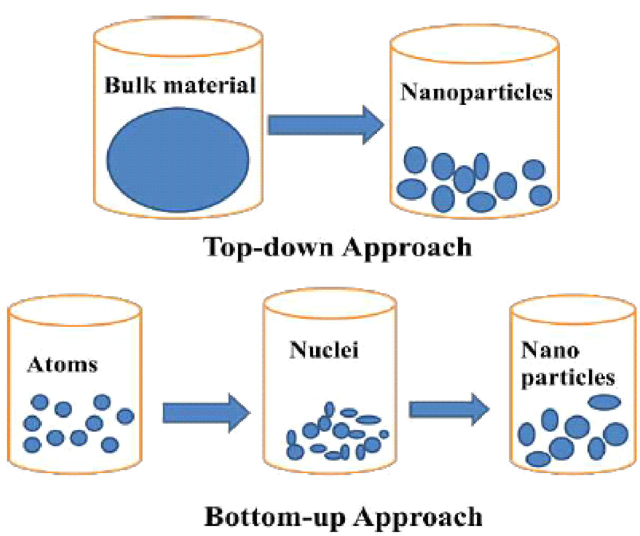

Figure 3: Preparation approaches for nanoparticles

Given in Figure 3, Top-down approach presents to a carving or successive cutting of a suitable material into particles at nano scale. Bottom-up, or self assembly refers to structured the material with nano scale from the bottom: atom-by-atom, molecule-by-molecule, or cluster bycluster. In the preparation of nanoparticles, lithographic techniques like grinding and milling are the typical examples for top-down method whereas colloidal dispersion is the best example for bottom up method.

Biomedical Applications of Biosynthesized Metal Nanoparticles

Biosynthesized MNPs may have different characteristics than MNPs made via physicochemical methods. The biosynthesis process may give MNPs special characteristics that are difficult to obtain using conventional methods. Biosynthesized MNPs are used in a variety of biological and environmental applications, including antibacterial activity, medication delivery, and disease detection (catalytic water treatment and sensors). Antimicrobial activity, drug transport, diagnostics, therapeutics, and other uses of MNPs in the biomedical sector have seen fast and continuing development.

Antimicrobial Applications

The widespread use and abuse of traditional antimicrobial medications has become routine, leading in the emergence of antimicrobial resistance, which has become a major issue. This has prompted the creation of novel microbial disease control methods. Nanomedicines have emerged as novel antibacterial medications among them. MNPs, in particular, have been shown to be effective in vitro and in vivo against a variety of microbial illnesses, including antibiotic-resistant infections.

AgNPs, for example, have been utilized in wound dressings, trauma implants, tumor prosthesis, and bone cements because of their antibacterial activity. Silver, gold, copper, magnesium, and titanium are examples of MNPs with antiviral, antibacterial, and antifungal properties.

Antiparasitic Activity

Biosynthesized MNPs are being investigated as an antiparasitic agent for a variety of illnesses. Ponarulselvum et al. discovered that Catharanthus roseus leaf extract mediated AgNPs had antiplasmodial action. They used aqueous leaf extracts to make AgNPs that are 35-55 nm in size and have been shown to be effective against the malaria parasite Plasmodium falciparum. Govindasamy et al. reported antiplasmodial activity of Eclipta prostrata extract produced palladium nanoparticles against Plasmodium berghei in Swiss albino mice in a separate study.

Vectoricidal Activity

Metal nanoparticles made from biosynthesis are effective against a variety of disease-causing insects. Rajkumar et al. examined the antilarval activity of AgNPs produced from E. prostrata extract.

The adulticidal effects of C. roseus leaf extract produced titanium oxide nanoparticle for the hematophagous fly leach, Hippobosca maculata, and sheep-biting louse, Bovicola ovis, were investigated in another study.

Anticancer Property

Biosynthesized MNPs have been studied for their anticancer properties against several cancer cell lines. In one study, grape (V. vinefera) phytochemicals were utilized to make AuNP, which exhibited substantial cytotoxicity against HBL-100 (human breast cancer cells). Raghunandan and silver nanoparticles were tested on four cancer cell lines, including HT-29, HEK293, K-562, and HeLa. Several research groups have looked at the anticancer properties of biogenic AgNPs. The use of Origanum vulgare extract in the biosynthesis of AgNPs resulted in a dose-dependent response against the human lung cancer A549 cell line. Jacob et al. investigated the anti-tumor efficacy of AgNPs mediated by P. longum leaf extract, which caused substantial cell death in Hep-2 cancer cell lines. At 500 g/ml of AgNP treatment, significant cytotoxicity (94.02 percent) was detected, while 51 percent of cell death was seen at 31.25 g/ml. AgNPs generated from Citrullus colocynthis callus extract were tested against Hep-2 cell lines in a similar research.

Drug Delivery

The main problems to consider while designing and developing a new drug delivery system are safe and accurate delivery to the target at the appropriate moment, regulated drug release, and maximal therapeutic efficacy. MNPs' functional characteristics make them an ideal prospective vehicle for drug delivery; their tiny size allows drug carriers to bypass the blood-brain barrier, which delays medication delivery to the intended target location. Second, MNPs have superior pharmacokinetics and biodistribution due to their large surface area to volume ratio.

Pandey et al. described the anticancer drug delivery efficacy of Trapa bispinosa peel extract mediated AuNPs. Various statistical models were employed to determine the best medication release profile, with Higuchi coming out on top. HeLa cells expressing folic acid were shown to be resistant to AuNP-FA-BHC complexes.

Sensors

Because of their unique electrical and optical characteristics, MNPs may be utilized in biosensor applications. To immobilize glucose oxidase for glucose biosensing, AuNPs with a diameter of 25 7 nm were produced via eggshell membrane. B. subtilis produced spherical monoclinic SeNPs that can be converted into a one-dimensional trigonal structure and used as augmenting and settled materials for H2O2 biosensors, according to Wang et al. The H2O2 biosensor was reported as having a high sensitivity and affinity for H2O2, with a detection limit of 8 10-8 M for H2O2. Bindhu and Umadevi recently reported monodispersed and spherical AgNPs produced from aqueous fruit extract of Ananas comosus. They produced AgNPs with a diameter of 10 nm and discovered that the antibacterial activity of the obtained nanoparticles were size-dependent, with smaller nanoparticles having a greater bactericidal impact. At room temperature, the potential use of AgNPs as a sensor for detecting Zn2+ and Cu2+ was explored utilizing a surface plasmon resonance (SPR) based optical sensor.

Conclusion

Because of its applicability in a variety of areas, research in the subject of nanoscience and nanotechnology has received a lot of attention recently. As a result, physical, chemical, biological, and engineering disciplines were brought together to create novel methods for moving and controlling matter at the atomic level. In spite of the fact that nanotechnology is frequently discussed, there is little agreement on where the domain starts. A billionth of a meter is one nanometer (nm). It's also crucial to realize that nanoscale materials exist in nature. Deoxyribonucleic acid (DNA), the genetic material present within cells, has a diameter of 2.5 nm. Although biological processes are cost-effective, sustainable, and environmentally friendly, they do have certain drawbacks, such as poor monodispersity, high purity, undesired aggregation, sluggish rate of production, and scaling up. As a result, effective techniques for controlling the dispersity, size, and shape of nanoparticles for different purposes are required.

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