ABSTRACT

Nanotechnology is the science and engineering of creating structures in the nanometer scale which have been applied in the field of drug delivery, catalysis, optical devices and nanoelectronics. Although nanomaterials may be synthesized using chemical approaches it is now possible to use biological materials for the same. Biological systems, masters of ambient condition chemistry, synthesize inorganic materials that are hierarchically organized from the nano to the macroscale. Recent studies on the use of microorganisms in the synthesis of nanoparticles are a relatively new and exciting area of research with considerable potential for development. In this review, we critically assess the role of biological entities such as plants and microorganisms in the synthesis of gold and silver nanoparticles and their advanced applications in the field of medicine and catalysis.

KEYWORDS : Nanotechnology, Microorganisms, Catalysis

I. INTRODUCTION

Synthesis of noble metal nanoparticles using biological entities has great interest due to their physico-chemical properties which are not observed either in individual molecules or in bulk metals. Nature has devised various processes for the synthesis of nano and micro scaled inorganic materials which have contributed to the development of relatively new and largely unexplored area of research based on biosynthesis of nanomaterials[1]. Gold and silver nanoparticles exhibit strong absorption of electromagnetic waves in the visible range due to Surface Plasmon Resonance (SPR) which is highly influenced by shape and size of the nanoparticles. Various synthesis procedures for gold and silver nanoparticles have been explained by many scientists around the globe. The special interest on noble metal has been taken since they don’t undergo corrosion or oxidation easily.

II. PLANT EXTRACTS IN THE SYNTHESIS OF GOLD AND SILVER NANOPARTICLES

Gold nanoparticles were synthesized using various plant extracts, leaves and their biomasses. The size of the nanoparticles obtained from each plant was different from others. Gold nanotriangles formed were of 50 nm size from Aloe vera[2]. The pH dependent binding trend of Au(111) ions to Avena sativa[3] biomass and subsequent formation of Au nanoparticles of variable size were common during all pH level. Gold nanoparticles were 50-100 nm which were synthesized using Azadirachta indica[4]. Extracellular synthesis of gold nanoparticles occurred while using Emblica Officinalis[5] fruit extract as reducing agent. Similarly, the size of gold nanoparticles formed were 50 nm of Pelargonium graveolens [6], 55nm of Cinnamomum camphora [7], 100 nm while using Lemon grass [8] and 20-40 nm of Tamarind [9] leaf extract. The surface plasmon resonance of gold nanoparticles will correspond to 520 nm and 420 nm for silver nanoparticles in a UV-visible spectral study also the wavelength may differ from +20 nm based on the size and shape of the nanoparticles formed. Silver nanoparticles are also synthesized using Aloe vera [2], Azadirachta indica [4], Cinnamomum camphora [7] and Pelargonium graveolens [10]. The main difference in controlling the size and shape of gold and silver nanoparticles was due to protective biomolecules and reductive biomolecules. The stabilization and reduction of nanoparticles were mainly due to water-soluble heterocyclic components and polyphenolic components. Gold nanoparticles are also synthesized extracellularly using marine alga Sargassum Wightii[24] Greville. Different scale of monodisperse TEM images of gold nanoparticles synthesized using this alga are presented in Fig1.

III. BACTERIA IN THE SYNTHESIS OF AU AND AG NANOPARTICLES

Pseudomonas stutzeri AG259 isolated from silver mines has shown to produce silver nanoparticles [11]. Nair and Pradeep reported that common Lactobacillus [12] strains found in buttermilk assisted the growth of gold and silver crystalline nanoparticles of well-defined morphology. Recently, bacterial cell supernatant of Pseudomonas aeruginosa was used for the reduction of gold ions resulting in the extracellular biosynthesis of gold nanoparticles[13]. This will help us to understand the biochemical and molecular mechanism of nanoparticles synthesis. Morphological control over the shape of gold nanoparticles has been achieved by using Plectonema boryanum[14] UTEX485 a filamentaceous cyanobacterium. When it is reacted with aqueous Au(S2O3)2 3- and AuCl4 - solutions at 25-100 o C for upto one month resulted in the precipitation of cubic gold nanoparticles and octahedral gold platelets.
IV. ROLE OF FUNGI

The use of fungi is potentially exciting since they secrete large amount of enzymes. Nanoparticles with well defined dimensions and good monodispersity can be obtained using fungi. Bioreduction of aqueous AuCl₄⁻ ions was carried out using fungus Verticillium[15] sp led to the formation of nanoparticles with fairly well defined dimensions. In this reaction it was concluded that surface trapping of chloroaurate ions occur in fungal cells by electrostatic interaction with positively charged groups in enzymes that are present in the mycelia cell wall. Fungi are known to secrete higher amounts of proteins thus might have significantly higher productivity of nanoparticles in biosynthetic approach using Fusarium oxysporum[16]. The fungus Aspergillus flavus[17] also resulted in the accumulation of silver nanoparticles on the surface of its cell wall when incubated with silver nitrate solution. Endophytic fungus Colletotrichum[6]sp. grows in the leaves of geranium has been used for the synthesis of stable and various shaped gold nanoparticles. When gold ions were incubated with Trichothecium[18] sp biomass under stationary led to the formation of extracellular nanoparticles. During shaking conditions the same resulted in intracellular synthesis, since enzyme and proteins could be responsible for the synthesis. Aspergillus fumigatus[19] fungus resulted in the rapid synthesis of silver nanoparticles and the particles formed were monodisperse which can be used in bacterial applications.

V. APPLICATION OF NANOPARTICLES

Development of nano-devices using biological materials and their use in wide array of applications on living organisms has recently attracted the attention of biologists towards nanobiotechnology. Here we have mentioned few applications based on biological concepts as foremost focus on living organisms. Gold nanoparticles based probes have been used in the identification of pathogenic bacteria in DNA-microarray technology. Silver nanoparticles have antibacterial effects, it has been reported that extracellularly synthesized silver nanoparticles using Fusarium oxysporum can be incorporated in several kinds of dressing materials. These clothes with silver nanoparticles are sterile and can be useful in hospitals to minimize infection with pathogenic bacteria such as Staphylococcus aureus [20]. Silver nanoparticles have applications in spectrally selective coatings and for biolabelling techniques. Currently, positive results have been achieved to control HIV-1 virus via preferential binding to the gp120 glycoprotein knobs. Due to this interaction, silver nanoparticles inhibit the virus from binding to host cells[21]. Gold nanoparticles have a good tunable shape and size dependent optical property which has been exploited in various surface coatings and biomedical applications. They are biocompatible, non toxic, bind readily to a large range of biomolecules such as amino acids, proteins/enzymes and DNA and expose large surface areas for the immobilization of such biomolecules. The ability to modulate the surface chemistry of gold nanoparticles by binding suitable ligands has important applications in many areas such as novel organic reactions, sensors (both inorganic and biological entities), drug/ DNA delivery and imaging.

Branched polyethyleneimine covalently attached to gold nanoparticles has been investigated for the delivery of plasmid. The antitumor drug cisplatin was adsorbed on Au-Au2S nanoparticles via 11-mercaptopundecanoic acid (MUA) layers. Gu et al., have shown that gold nanoparticles in toluene react with bis(vancomycine) cystamide in water under vigorous stirring conditions to form vancomycin-capped gold nanoparticles; the antibiotic-capped gold nanoparticles showed enhanced antibacterial activity against E. coli strains. Analytical detection and biological assay of antileukemic drug 5-fluourouracil[22] using gold nanoparticles as probe. Gold nanoparticles could serve as excellent carriers for insulin in the treatment of diabetes mellitus[23]. Proteins are the important part of cell’s structure and machinery, understanding their functionalities is extremely important for further progress in human’s welfare. Gold nanoparticles are also widely used in immunohistochemistry to identify protein-protein interaction.

VI. CONCLUSION AND FUTURE EXPLORATION

Biological resources are gaining importance in the synthesis and applications of the nanomaterials. Nanobiotechnology is at its infancy but the examples of the synthesis methods and their applications explained in the above article will magnetize the attention of people to proceed their research towards the endless biotechnology. In future the main focus is to elucidate the mechanism of the biomolecules which are exactly responsible for reduction and to find more applications in the area of drug delivery to support the medicine field to find solutions for the unanswered questions.
Fig.1 (a-d). The various TEM images of gold nanoparticles synthesized using Sargassum wightii Greville ranging from (a) 20 nm, (b)10 nm, (c)10 nm to (d)5 nm.

REFERENCES


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