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REVIEW ON PREPARATION, EVALUATION AND APPLICATION OF GOLD NANOPARTICLES

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ABSTRACT

AuNPs (Gold Nanoparticles) are used in resonance scattering dark-field microscopy for the detection of microbial cells and their metabolites the bio-imaging of tumor cells and for the detection of receptors on their surface and for the study of endocytosis. They are small gold particles with a diameter of 1 to 100 nm which, once dispersed in water, are also known as colloidal gold. Spherical AuNPs possess useful attributes such as size- and shape-related optoelectronic properties, large surface-to-volume ratio, excellent biocompatibility, and low toxicity. These properties make AuNPs an important tool in bionanotechnology.

Keywords: Bionanotechnology, Gold Nanoparticles, Endocytosis

INTRODUCTION

Because of their unique characteristics and diverse surface activities, gold nanoparticles (AuNPs) have been widely used in bionanotechnology. The ease with which AuNP can be functionalized makes it a useful platform for nanobiological assemblies containing oligonucleotides, antibodies, and proteins. AuNP bioconjugates have also emerged as interesting possibilities for the development

of novel biomaterials for the study of biological systems. AuNPs' flexibility has made them valuable in a variety of biomedical applications. The binding of analytes to AuNPs can change the physicochemical features of AuNPs, such as surface plasmon resonance, conductivity, and redox activity, resulting in observable signals in diagnostics. AuNPs can also be used as therapeutic platforms because of

their large surface area, which allows for a dense presentation of multifunctional moieties (e.g., drugs and targeting agents). In this study, we give a quick

summary of spherical AuNPs' synthesis, characteristics, and conjugation techniques, as well as a few of their recent applications in bionanotechnology [1].

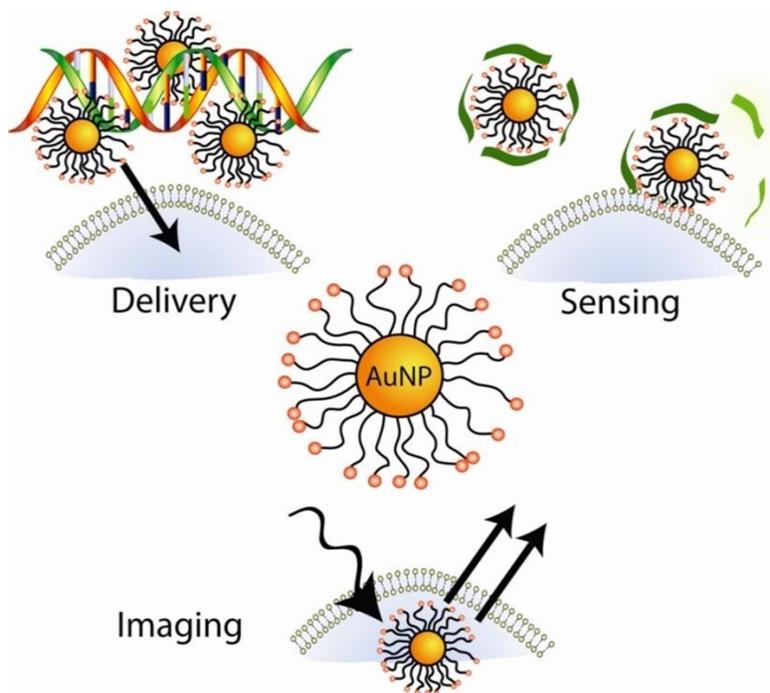


Figure 1: Concept of Gold Nanoparticles

Properties of Gold Nanoparticles:

1. Physical Properties:

Localized surface plasmon resonance (LSPR), radioactivity, and a high X-ray absorption coefficient are among the physical features of AuNPs that are commonly exploited in the diagnosis and treatment of cancers. Surface-enhanced Raman spectroscopy (SERS), surface enhanced fluorescence (SEF), photothermal conversion, photochemical conversion, and colorimetric responses are all possible with AuNPs' LSPR. These outstanding characteristics have been widely used in non-invasive detection in vivo and in situ,

imaging, PTT, PDT, and in vitro diagnostics (IVD). AuNPs can be utilised for radiotherapy and radionuclide imaging because of their radioactivity (RNI). The radiation sensitivities of AuNPs with a high atomic number have been investigated [2].

2. Chemical Properties:

Easy to Couple:

AuNPs have the ability to make stable chemical connections with S- and N-containing groups, which gives them an advantage over many other nanoparticles. AuNPs can bind to a wide range of organic ligands or polymers with specific functions as a result of this. AuNPs have excellent

biocompatibility, targeting, and drug delivery properties as a result of these surface changes [3].

Biocompatibility

The biocompatibility of AuNPs is through their natural destiny in vivo, which can be assessed by pharmacokinetics, tissue appropriation, harmfulness and freedom. Biocompatibility is the fundamental condition for all utilization of AuNPs in vivo, which can be improved by surface adjustment, a large portion of which depends on the development of Au-S securities. Measures to improve the pharmacokinetics of AuNPs are to build the dissemination half-life through lessening the freedom by the mononuclear phagocyte framework (MPS) or advancing the actual size. Polyethylene glycol (Stake) has been broadly applied to diminish phagocytosis of AuNPs by MPS, and the dissemination half-life increments as the length of the Stake chains increments. Contrasted with 100 nm AuNPs, 15 nm AuNPs can course in vivo for a more extended time frame. Be that as it may, more modest AuNPs (under 6 nm) will be quickly sifted through and cleared by the kidneys. AuNPs utilized for growth finding and treatment need to expand their maintenance in cancer tissues and decrease their gathering in different tissues. AuNPs enter the blood dissemination and can arrive at opsonization in practically no time, which

prompts the development of a protein crown on the AuNP surface to work with the acknowledgment by phagocytic cells in the MPS. The MPS includes the liver, spleen and bone marrow. The leeway of AuNPs from the body rely upon the renal and biliary freedom, in light of the fact that AuNPs can't be processed by compounds inside the body. Little AuNPs (under 10 nm) are more effectively taken out than enormous ones. Little AuNPs can be eliminated from the body by renal freedom, up to 70% of it inside 72 h . Regardless of whether the itemized system is hazy, the investigations have shown that little AuNPs can be taken out from the body through bile. Intrigued perusers can acquire additional data from different surveys [4].

Targeting:

The focusing of AuNPs can be presented from two viewpoints: latent focusing on (improved porousness and maintenance (EPR) impact and MPS break) and dynamic focusing on (cancer cell focusing on and boosts reaction). Because of the fast development of the cancer, the inside veins are imperfect and the lymphatic vessels are immature. This permits AuNPs of a specific size to go through growth vessels effectively and gather in cancer locales, which has been applied for growth imaging and treatment. The MPS departure of AuNPs can be executed through coatings of hydrophilic polymers, shaping the particles

from stretched or with hydrophilic and hydrophobic spaces. The growth cell focusing of AuNPs chiefly depends on the ligand and can be perceived by destructive cells, for example, Lam 67R and GRP human prostate cancers, and CCR5 and HER2 for bosom growths. The improvements reaction incorporates exogenous boosts, for example, NIR, attractive, ultrasound and endogenous upgrades, for example, Ph and redox [5].

Delivery:

AuNPs can be combined with chemotherapy drugs, proteins or nucleic acids via electrostatic adsorption or covalent bonds. This belongings, collectively with its superior biocompatibility and targeting, makes it the most promising transport for tumor targeting. For chemotherapy, AuNPs can carry mitoxantrone (MTX), phthalocyanine4 (Pc4), doxorubicin (Dox) and photosensitizer to improve their tumor focused on and enhance its therapeutic effect. For immunotherapy, AuNPs may be loaded with immune target antibodies and stimulate the activation of immune cells. These antibodies encompass polyclonal anti-carcino-embryonic antigen (CEA), monoclonal anti-HER2 and so on. Dumani *et al.* Designed AuNPs lined with glycol-chitosan that can be taken up via immune cells and ultimately transported to the sentinel lymph node to stumble on

metastases. AuNPs can changed with nucleotide collection for detecting, imaging and therapy [6].

Catalytic Activity and Applications:

The POD-mimic interest of AuNPs became first observed via catalyzing the oxidation of the peroxidase substrate 3, three, five, 5-tetramethylbenzidine (TMB) via H_2O_2 to develop a blue shade in an aqueous answer. This has been used to catalyze H_2O_2 located in tumor cells to generate $\cdot OH$ underneath an acidic pH for intracellular oxidative harm of gastric tumors or to discover the attention of GSH for cancer prognosis. The GO-mimic activity of AuNPs became first tested thru the cardio oxidation of glucose to gluconate and H_2O_2 , which is regarded as a version response. The manufacturing of H_2O_2 in situ can result in AuNP increase that could come across most cancers biomarkers on the picomolar tiers. The H_2O_2 also may be used as a substrate that is catalyzed by using POD to disencumber high-poisonous hydroxyl radicals for inducing tumor-cellular death [7].

Preparation method:

1. Physical Method

The γ -irradiation method is one technique for the synthesis of Au/NPs with uniform length from the variety five-40 nm and high purity, using polysaccharide alginate as stabilizer . The technique of microwave irradiation became used to put together

Au/NPs by way of lowering dealers including citric acid and a binding agent such as cetyltrimethylammonium bromide (CTAB). Furthermore, Au/NPs are prepared with the aid of the use of warmth or photochemical discount, and discount of HAuCl_4 by way of citrate, tartrate, and malate. A not unusual method of photochemical discount has been recorded for the synthesis of gold- polyethylene glycol nanoparticles by way of polymerization reactions with size 10-50 nm. Furthermore, in this method, gold salt is decreased by radical formation covered with polyethylene glycol diacrylate by way of UV-response. One of any other method, synthesis porous Au/NPs from alloys of gold is by using HAuCl_4 and AgNO_3 as precursors, then discount with the aid of NaBH_4 as a decreasing agent. After that, de-alloying can be completed by means of nitric acid [8].

Chemical method:

Chemical method became cautioned by Gimenez et al. To put together Au/NPs with the aid of the reduction procedure of the HAuCl_4 through a solution of thiolated chitosan. The approach of thermal citrate reduction used inside the coaching of Au/NPs through Raman spectroscopy (SERS) by means of the use of inositol hexakisphosphate (IP6) to lessen HAuCl_4 . It is also prepared by trisodium citrate, and hydrogen tetrachlorocuprate (III)

tetrahydrate (chloroauric acid). Encapsulated Au/NPs can be produced in polyethylene glycol dendrimers and reduced by formaldehyde in the near infrared. The peptide-biphenyl method is used to make gold nanoparticles. hybrids (PBHs) as a gold stabiliser, and the size range in this method The wavelength range was reported to be 1.8 to 3.7 nm. Dendrimers/Au nanoparticles have the ability to be made from a HAuCl_4 solution that has been reduced as well as sodium Boronhydride Au/NPs with a size of less than 10 nm can be synthesised. Ethylene glycol and dodecanethiol were the two thiols involved [9].

Advantages:

1. Gold nanoparticles is simple for diagnosis.
2. It is less invasive.
3. It provides increased contrast for diagnosis of oral cancer.
4. It is nontoxic to human being
5. It does not photo bleaching or blinking which is inherent to many other fluorophores.

Disadvantage:

1. Optical signals of AuNPs may not be as strong as quantum dot.
2. It exhibits difficulties like biocompatibility, in vivo kinetics, and tumour target efficiency.
3. It leads to acute or chronic toxicity.

Evaluation methods:

1. Characterization of GNPs:

A laser diffraction particle-size analyzer (Sald 2101, Shimadzu, Japan) equipped with Wing software was used to determine the mean particle-size values of GNPs (version 1.20). Transmission electron microscopy (TEM) was used to examine the nanoparticles' morphology (LEO906, Germany). On a Formvar-coated copper grid, drops of the gold suspension (formulation F6) were deposited and dried. A spectrophotometer (Shimadzu, Japan) was used to record the UV-visible absorption spectra of one of the produced colloidal solutions from 400 to 900 nm [10].

2. Gel fabrication:

Water (89 percent of total mass), acrylamide (3 percent), N,N-methylene-bisacrylamide (3 percent), and gelatin make up the gel solution (5 percent). In a 500 ml beaker, the gel components were mixed together at 35-40 °C. As an anti-oxidant, Tetrakis (hydroxyl methyl) phosphonium chloride (THPC) was added at a concentration of 10 mM to the gel mixture. To build gel with GNPs batch, nano gold (formulation F3) was used as a portion of water in gel preparation. In the gel, the GNPs were found to mix uniformly. As a control, a batch of gel lacking GNPs was used. After that, the gel was swiftly poured into each tubes [11].

3. Irradiation:

After being placed in a head and neck phantom, the tubes from both groups were irradiated with a CT scanner. Radiation dosages of 40, 80, and 120 Gy were applied to the gel samples. The gel samples were irradiated with the following parameters at the Day CT scanning centre: slice thickness=1 cm, t=0.8 s/turn, mA=200, kVp=140. [12].

4. Magnetic Resonance Imaging (MRI):

A 1.5 T MRI scanner (GE Sigma, Milwaukee, USA) was used to scan irradiated and non- irradiated gel samples in order to quantify the spin-spin relaxation time of the free protons using a head coil. The following settings were employed in the fast-spin echo sequence: field of view =105 120 mm², slice thickness = 5 mm (kV X-ray beams), effective echo time TE = 22 ms, turbo factor = 14, repetition time (TR) = 5,710 ms, field of view = 128 matrix, total imaging duration = 20 minutes. Prior to imaging, at least 24 hours had passed after the irradiation to allow for polymerization. At room temperature, all of the samples are scanned. [13].

5. Data analysis:

The image was analysed using the MATLAB software (version 3.5.7). (The Math Works Inc, Natick, Massachusetts, USA). Before examining the data to find the region of interest, the programme evaluated it. On a pixel-by-pixel basis, T2 values were calculated and T2 maps were

created. The R2 (1/T2) was used to compare the levels of polymerization of the irradiation gels with and without GNPs. [14].

6. Anti-bacterial test:

Antibacterial action was considered by the agar-well-dispersion strategy, wherein 100 ml bacterial suspension was added to 20-mL clean supplement Mueller Hinton agar at 45 °C and the combination was hardened on a Petri dish. After the medium had hardened, 7-mm-width wells were made in the agar (three wells for every dish) that were equidistant from each other and from the dish edge. The wells got 150 mL of various convergence of GNPs from detailing F2 (400 ppm, 200 ppm, 100 ppm). The Petri dishes were brooded in an indoor

regulator at 37 °C for 24 h. After brooding, the distance across of the zone of bacterial-development hindrance was estimated. All investigations were accomplished for five clinical strains of E. coli and rehashed threefold [15].

Factors affecting:

Several factors (**Figure 2**) are important in predicting the toxicity of AuNPs in vitro, in vivo, and most specifically in vivo. Numerous studies have indicated that toxicity is quite depending on the physicochemical properties of nanoparticles, despite the fact that lots of these precise properties cause them to appealing to nanomedicine and biological applications [16].

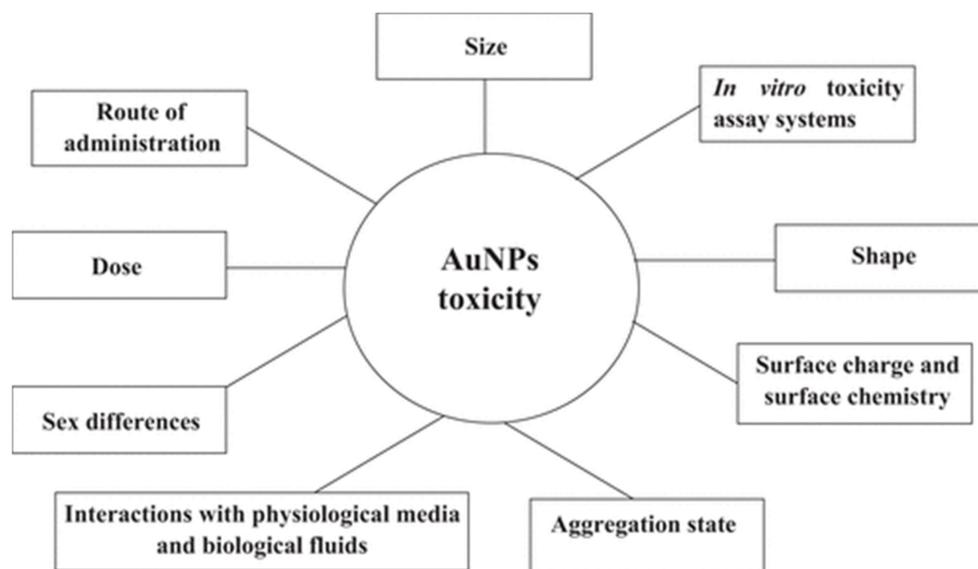


Figure 2: Gold Nanoparticles and Toxicity

Applications:

The range of packages for gold nanoparticles is growing hastily and

consists of:

1. Electronics:

Gold nanoparticles are designed to be used

as conductors from printable inks to digital chips. As the sector of electronics end up smaller, nanoparticles are essential additives in chip layout. Nanoscale gold nanoparticles are getting used to attach resistors, conductors, and different elements of an electronic chip [17].

2. Photodynamic Therapy:

Near-IR soaking up gold nanoparticles (inclusive of gold nanoshells and nanorods) produce warmth while excited by means of mild at wavelengths from seven hundred to 800 nm. This permits these nanoparticles to remove centered tumors. When mild is implemented to a tumor containing gold nanoparticles, the particles unexpectedly warmth up, killing tumor cells in a treatment additionally referred to as hyperthermia therapy [18].

3. Therapeutic Agent Delivery:

Therapeutic retailers can also be covered onto the floor of gold nanoparticles. The large surface place-to-quantity ratio of gold nanoparticles allows their floor to be lined with loads of molecules (including therapeutics, focused on sellers, and anti-fouling polymers) [19].

4. Sensors:

Gold nanoparticles are used in a diffusion of sensors. For example, a colorimetric sensor based totally on gold nanoparticles can pick out if foods are appropriate for intake. Other methods, consisting of surface more advantageous Raman spectroscopy,

exploit gold nanoparticles as substrates to enable the measurement of vibrational energies of chemical bonds. This method may also be used for the detection of proteins, pollution, and different molecules label-unfastened [20].

5. Probes:

Gold nanoparticles also scatter mild and may produce an array of thrilling shades underneath dark-discipline microscopy. The scattered colorations of gold nanoparticles are currently used for biological imaging packages. Also, gold nanoparticles are tremendously dense, making them beneficial as probes for transmission electron microscope [21].

6. Diagnostics:

Gold nanoparticles are also used to hit upon biomarkers in the diagnosis of coronary heart diseases, cancers, and infectious sellers [22].

7. Catalysis:

Gold nanoparticles are used as catalysts in a number of chemical reactions. The floor of a gold nanoparticle can be used for selective oxidation or in certain cases the floor can reduce a reaction (nitrogen oxides). Gold nanoparticles are being developed for fuel cellular packages. These technologies could be useful inside the automotive and show industry [23].

CONCLUSION

Gold nanoparticles are being developed for various purposes. These technologies could

find suitable applications in industry.

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