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GOLDEN PROGRESS: ADVANCEMENTS IN GOLD NANOPARTICLE STUDY

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ABSTRACT
Gold nanoparticles are attractive materials in many applications because of their special optical and physical characteristics, like surface plasmon oscillations for identifying, seeing, and feeling. Biomedical applications have advanced significantly recently, offering improved biocompatibility for disease diagnosis and treatment. Numerous functionalizing agents, including polymers, surfactants, ligands, dendrimers, medications, DNA, RNA, proteins, peptides, and oligonucleotides, can be produced and coupled with Au-NPs. In order to broaden and improve gold nanoparticles in targeting pharmaceuticals for photothermal therapy with reduced cytotoxic effects in various malignancies, gene therapy, and many other diseases, this review addressed the usage of gold nanoparticles and the surface functionalization with a wide range of molecules. All things considered, Au-NPs would be a promising drug delivery and therapeutic vehicle.

Keywords: Gold nanoparticle, Gene Therapy, Drug Delivery, Biomedical, Malignancies.

INTRODUCTION

The Greek word "nanos" which meaning little, is the source of the term "nano" which is used as the prefix for one billionth part. The American Society for Testing and Materials (ASTM International, 2006) defines nanoparticles as particles with two or more dimensions that fall between one and one hundred nanometers in size. Due to their enormous reactive and exposed surface area and the quantum size effect caused by certain electronic structures, these particles exhibit unique and enhanced physical and chemical capabilities relative to their bulk materials. In numerous disciplines, including chemistry, photochemistry, biology, and electronics, these particles have found extensive application. The physical, chemical, and optical properties of inorganic nanoparticles and hybrids created by combining inorganic nanoparticles with organic components are distinct. They are distinct from large-size materials and have more applications because to their optical and electrical qualities. Because they can be applied to a wide range of imaging and therapeutic applications, nanoparticles have proven to be a potential multifunctional platform. These platforms can be created by combining various organic, inorganic, or hybrid materials; however, because of their high drug loading capacity, stability, and ease of modification, inorganic platforms are the most crucial for diagnosis and concurrent therapy [1,2].

Gold Nanoparticles

The bulk form of gold is a yellow solid that is inert in nature, however the properties of gold nanoparticles are different. Wine-red solution nanoparticles are said to have antioxidant properties. The formation of gold nanoparticle networks and inter-particle interactions are important factors in determining the characteristics of these nanoparticles. A range of sizes and shapes are exhibited by gold nanoparticles, from 1 nm to 8 µm. These include spherical, sub-octahedral, octahedral, decahedral, icosahedral multiple twined, irregular shape, tetrahedral, nanotriangles, nanoprisms, hexagonal platelets, and nanorods. When compared to spherical-shaped nanoparticles, triangular-shaped nanoparticles exhibit more appealing optical characteristics [3,4].

Application of Gold Nanoparticles

Due to their distinct size and form, gold nanoparticles exhibit special electric and magnetic properties and have attracted a lot of interest in The fields of biological tagging, chemical and biological sensing, optoelectronics, photo thermal therapy, biomedical imaging, DNA labelling, microscopy and photoacoustic imaging, surface-enhanced Raman spectroscopy, tracking and drug delivery, catalysis, and cancer therapy are among the research areas that are particularly relevant. Sensors based on gold nanoparticles may identify different metal ions by utilizing the principle of color change brought about by the aggregation of gold nanoparticles. These kinds of sensors are frequently used to find arsenic, copper, mercury, and lead in water [5-7].

Other application of gold nanoparticle

- Gold Nanoparticles for Protein, Peptide, and Nucleic Acid Delivery
- Imaging in medicine
- The identification of a biomolecule or biomolecules specific to a particular illness type and stage can be used to diagnose diseases.
- Tumor detection involves functionalizing a nanoparticle with an antibody that recognizes specific antigens in the tumor, followed by spectroscopic analysis of the nanoparticle.
- Specific Photo thermal Therapy for Cancer

Advancement of Gold Nanoparticles

Gold nanoparticles (GNPs) are tiny, stable, non-cytotoxic, and have a high surface area, which makes them useful for a variety of imaging, diagnostic, and drug delivery applications. Experiments both in vitro and in vivo have demonstrated that GNPs can be modified to carry chemical medications straight to tumors. For instance, Maryland University researchers delivered TNF to mice's solid tumors using a colloidal gold vector. The highest tumor-specific TNF activity was indicated by the intense red/purple color of the tumor after the GNPs accumulated in the tumor cells [8].

Cancer Vaccine

One of the leading causes of death globally, cancer can strike individuals of any age, including young children and fetuses, with the risk often rising with advancing years. Because current treatments are not very specific for tumors, they can have unfavorable side effects.

HIV vaccine

A recent review by multiple authors examined the application of gold nanoparticles in the development of HIV vaccines. There is currently no effective vaccine for HIV, even after more than 30 years after the virus was discovered in 1983. As demonstrated in, certain histocompatibility complex molecules expressed on the surface of HIV may be targets for antibodies that neutralize them [9].

HEPATITIS Vaccine

Inflammation of the liver, hepatitis can cause a yellowing of the skin and eyes, as well as abdominal pain. Viruses, alcohol misuse, and certain drugs can also cause this illness. Viral hepatitis comes in numerous forms: types A, B, C, D, and E. While hepatitis B is primarily transmitted through sexual contact, it can also be transferred from mother to child during pregnancy, and hepatitis A, E, and T are frequently shared by tainted food and water.

Advancement of Gold Nanoparticles in Cancer Management

Because of their special optical qualities and capacity to conjugate with a wide range of molecules, gold nanoparticles (GNPs) are being investigated as a potential cancer therapeutic agent.

GNPs may be utilized in the treatment of cancer for:

- Medication administration GNPs may gather in tumor locations as a result of the EPR effect. They can also be made to penetrate deeply into biological tissues by activating them with near-infrared (NIR) laser light.

- Thermal phototherapy (PTT) GNPs have the potential to minimize non-specific distribution by being delivered directly into the local tumor region.
- Contrast agents GNPs are applicable to computed tomography (CT) imaging of X-rays.
- Sensitizers to radioactivity GNPs have the potential to decrease the spread of micro metastases when employed in conjunction with chemotherapy, or chemo radiation [10,11].

Types of gold nanoparticles

It is possible to classify gold nanoparticles (GNPs) based on their size, shape, and physical characteristics. Several typical GNP setups consist of:

- Gold nanospheres, often referred to as gold colloids, can be produced by carefully reducing an aqueous solution of HAuCl.
- Gold nanorods: The template method, which includes electrochemically depositing gold into the pores of nonporous polycarbonate or alumina template membranes, can be used to produce them.
- Gold Nano shells: These are made of dielectric silica gels covered in a thin, hollow gold shell on the outside.
- Nano cubes: A typical GNP arrangement.
- Nano branches: A typical GNP arrangement.
- Nano rings: A typical GNP arrangement.

Gold Nanoparticles in Diagnostics

Visualization and bio imaging: Chemical and biological agent identification has been actively using gold nanoparticles. Because of the high electron density of colloidal gold particles, electron microscopy (particularly transmission electron microscopy, or TEM) has historically remained the method of choice for detecting biospecific interactions [12].

Immune chromatography: A number of international businesses introduced immune- chromatographic test systems for instrument-free diagnostics about ten years ago. Owing to the immunoassay's excellent sensitivity and specificity, these tests have been widely used to identify poisons, narcotic drugs, early pregnancy diagnosis, and screening for potentially fatal urogenital infections.

Gold Nanoparticles in Therapy

Photo thermal therapy using gold nanoparticles. With intense development, photo thermal cell injury is a viable avenue for both tumor therapy and the treatment of infectious disorders. This method's main components are as follows: Gold nanoparticles heat up when exposed to light at the wavelength at which they absorb the most light, which is in the visible or near infrared range [10].

Photo dynamic therapy using gold nanoparticles: The photodynamic approach, which uses dyes and other light-sensitive substances called photosensitizers—as well as visible light of a certain wavelength—is used to treat several infectious and dermatological conditions as well as cancerous disorders. Usually, the organism is exposed to the sensitizers intravenously, however they can also be used topically or orally. Photodynamic treatment (PDT) chemicals have the ability to aggregate specifically in target tissues, such as tumors, or in cells.

Immunologic Properties of Gold Nanoparticles

Researchers have been particularly interested in the immunological characteristics of colloidal metals-gold, in particular since the 1920s. This has mostly been linked to J. Bordet's physicochemical (non-specific) immunity theory, which holds that the compounds' physicochemical characteristics and, above all, their colloidal state are the primary determinants of immunogenicity and antigenic specificity. In his attempts to extract agglutinating sera from colloidal gold, L.A. Zilber was successful [12]. Additionally, it was shown that the production of antibodies can be triggered by specific haptenes adsorbed on colloidal particles. A wealth of information about the impact of colloidal gold on nonspecific immunological reactions was included in one of the best early assessments. Specifically, it was observed that the leukocyte content in 1 ml of blood increases significantly two hours after 5 ml of colloidal gold is injected intravenously into rabbit bits. This is in contrast to a negligible decrease in mononuclear forms and a significant increase in polynuclear forms. It should be mentioned that other colloidal metals have not been reported to have similar effects. Regretfully, as immunology has advanced and many of Bordet's theory's postulates have been proven false, interest in the Returning to colloidal immunological properties.

Synthesis of Gold Nanoparticles

Numerous physiochemical techniques have been used to create nanoparticles, and each one has put a heavy burden on the environment. Due to their extensive history of therapeutic applications, gold nanoparticles are the most significant of the metal nanoparticles discussed above. Gold nanoparticles are the form that has been reported on the most in the literature. Roughly 87,000 publications have been published since 1996. Given their extensive documentation, copper, silver, iron, and titanium nanoparticles ought to be investigated independently (Daruich De Souza et al., 2019). Numerous distinct biological, physical, and chemical synthesis methods have been established for the production of gold nanoparticles [13].

Biological method: - An energy-efficient, dynamic, and safe way to create nanoparticles is by biological synthesis. In order to create NPs in vivo, this method uses a variety of biological resources, including prokaryotes and eukaryotes. These sources contain metabolites (proteins, fatty acids, carbohydrates, enzymes, and phenolic compounds) that are important for the bio reduction of metallic ions to nanoparticles (NPs) as well as their stability.

Chemical processes: There have also been reports of the creation of gold nanoparticles using the seeded growth approach. Using formaldehyde as a reducing agent, gold nanoparticles encased in polyethylene glycol were produced to produce gold nanoparticles, which exhibit a high near infrared absorption. Gold nanoparticles of size range 1.8-3.7 nm have been synthesized by using peptide-biphenyl hybrids (PBHs) which are good stabilizer for gold as capping agents via single-phase system.

Physical method: For the manufacture of highly pure and controllable-sized gold nanoparticles, the y-radiation approach proved to be the most effective. The y- radiation process is used to create 5–40 mm-sized gold nanoparticles. This approach used a natural polysaccharide solution as a stabilizer. Bovine serum albumin protein has been used as a stabilizer in a single-step y-radiation method to create gold nanoparticles with sizes ranging from 2 to 7 am. Using the photochemical synthesis technique, HAuQ, aqueous glycine solution was subjected to UV irradiation to produce gold nanoparticles [14,15].

CONCLUSION

The current review discusses cancer therapy options, nanoparticles, and other types of medicines. PDT and PTT are the two main therapeutic modalities that can be combined with GNPs; PDT needs oxygen to have a therapeutic impact, whilst PTT does not need oxygen to do so in a cell. Low wavelength light, which has less negative effects, can be used in PTT. Contemporary researchers now have access to a wide range of particles with varying sizes, forms, architectures, and optical properties, owing to the swift advancement in technologies for the chemical synthesis of GNP during the last ten years. Furthermore, the issue of simulating nanoparticles with the appropriate physical (thermal, optical, etc.) characteristics is now being considered, along with the creation of the methods for creating the simulated structures. Gold nanoparticles (GNP) are emerging as promising agents for cancer therapy and are being investigated as drug carriers, photo thermal agents, contrast agents and several biomedical applications and radiosensitisers. Due to its small size, high surface area ratio and being chemically inert gold acts as an active vehicle which binds specifically to the tumor cell. The main advantage of GNPs is that they minimize the toxicity of the anti-cancer drugs.

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