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Review Article on Applications and Classification of Gold Nanoparticles

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Abstract

The Nanoparticles have several industrial and biomedical based applications in the diagnosis of different disease, drug delivery and targeted chemotherapy. The major character of nanoparticle is multifunctionality and micro-size. Nanoparticles can be linked with different ligands, therapeutic agents, imaging labels, and other functionalities. In the review paper we are deliberating the application, types and characteristics of gold nanoparticles which are commonly considered among all the metallo-nanoparticles. Many anticancer medications are present but this causes the necrosis of cancerous cell and as compared the gold nanoparticles cause necrosis of the cancer cells. These are the selected drug delivery schemes which are lesser than the human cells so it can easily enter into the tumors and terminate the cancerous cell. Several anticancer based drugs interconnected with gold nanoparticles and it increased the efficiency of the various anticancer drugs. Gold nanoparticles are valuable for the chemotherapy and also in the diagnosis of cancer due to having high photo and optical property. It is also possible to functionalize with peptides, protein and many nucleic acid units. So the gold NPs have application in bio sensing, gene, protein and drug delivery.

Keywords: *Gold Nanoparticles, Properties, Classifications, Cancer, Application, Sensors*

1. Introduction

The Au nanoparticles have more advantages than other metals like Ag, Cu, and Sn nanoparticles due to the presence of non-cytotoxicity and biocompatibility properties. Generally the nanoparticles are many times smaller than human different cells. They contain range in 1-100nm. The gold is very common in human use due to having excellent chemical inertness. The gold nanoparticles size can be measured through their synthesis and functionalization. These types of nanoparticles accumulate in the cells like tumors cells and show their optical scattering behavior. Therefore, they are acting as probe for studying the different nature of cancer cells and it also helpful in chemotherapy and vital role in identification of the cancer cell [1]. Gold nanoparticles have wide applications in the protein delivery, bio sensing, gene and their drugs [2]. Gold

nanoparticles arise in different sizes ranges between 2 -100 nm; but in between 20- 50 nm particles size show significant cellular uptake. Particularly, the cell toxicity is presented by 40 - 50 nm particles size. These particles size is diffuse into the tumors cells and soon simply recover it. The large size particles are unable to diffuse the tumors cell and live near blood vessels [3]. The surface plasmon band is based on their size. The surface plasmon resonances exist at 520 nm. The conjugated based Au nanoparticles mostly depend upon the thiol or gold ratio [4]. So if the thiol (SH) quantity is more than the size of particles will be less. The Crystal of thiol single layer safe the gold nanoparticles which contains the gold (102 atoms) and units of 44 p-mercaptobenzoic acid [5]. Multi-functionalization is major property of gold nanoparticles. The nanoparticles can be united with imaging labels, ligands, therapeutic agents and much other functionality for drug delivery and naturally cellular uptake. A drug named; Doxorubicin is anticancer drug can be able to conjugate with pure gold nanoparticles [6]. So the potency of the doxorubicin can be increase after conjugation. The nanoparticles of gold can convert the poor active different drugs to highly active drugs. Therefore the gold different nature of nanoparticles have great role in diagnosis, treatment of cancer cell and HIV treatment [7].A Coumarin is a fluorescent dye after linked with polyethylene glycol from one end and attached with gold nanoparticles on other side, then the Coumarin-PGE-thiol effect is increased and the fluorescent effect of nanoparticles decreased due to the conjugation of PEG [8]. Therefore, the PEG spacer and gold nanoparticles can be linked with different biologically ligands such as antibiotics, fluorescent dye etc.

2. Properties

The Gold nanoparticles general properties are **[**9- 11]

i. The photo-physical properties are helpful for the drug release at distant place.
ii. It gives opportunity of microscopic probes for the investigational study of the cancer cell.
iii. Chemically inertness
iv. Optical properties such as plasmon resonance are present.
v. High stability due to the presence of gold-sulphur conjugation.
vi. Biological compatibility is found

The some physical properties [12] of Gold nanoparticles are also in Table No.1

Sr. No.	**Properties of Gold**	
1.	Melting Point	1064.23°C
2.	Boiling Point	3239 K
3.	Density	19.33 g/cm^3

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4.	Molar heat capacity	25.419 J/(mol·K)
5.	Heat of vaporization	342 kJ/mol

3. Classification

The gold nanoparticles are classified into the following category

1. Nano rods
2. Nano sphere
3. Nano cages
4. Nano Particles

Nano Rods: The Gold nanorodes are synthesized by using template method as shown in figure 1. These are produced by the electrochemical deposition of gold. The Au nanorodes diameter is similar to the pore diameter of template membrane [13].

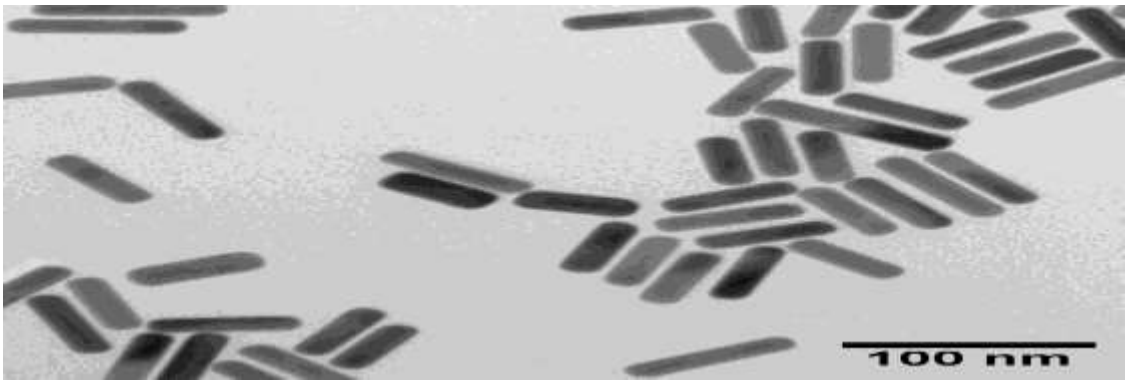

Figure 1; Gold Nanorodes with 100nm in size [12]

Nano Sphere: The nano spheres are prepared by using the reduction of an aqueous medium $HAuCl_4$ with citrate as serving reducing agent. The citrates can control the size of nanosphere and it shown in figure 2.

Figure 2; Nanosphere

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Gold Nano cage: The gold nano cages are produced with the help of galvanic reaction between silver nanocubes and aqueous medium $HAuCl_4$. The nanocage morphology is shown in figure 3.

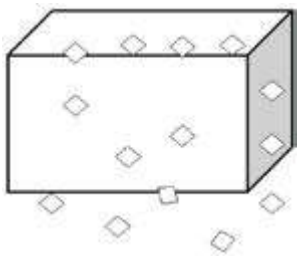

Figure 3; Nanocage [12]

Gold Nanoparticle: The gold nanoparticles are form in a liquid form by reducing the chloroauric acid. After mixing the acid then solution is mixed with a reducing compound. This method then causes the Au^{3+} ions to be condensed to neutral form of gold atoms. As more gold atoms are produced, the mixture becomes supersaturated. The gold begins to form precipitate in the nanometer particles. If the mixture is mixed then the particles is in uniform size shown in figure 4. Sometime it necessary to added stabilizing agent to protect the particles from the aggregating factors.

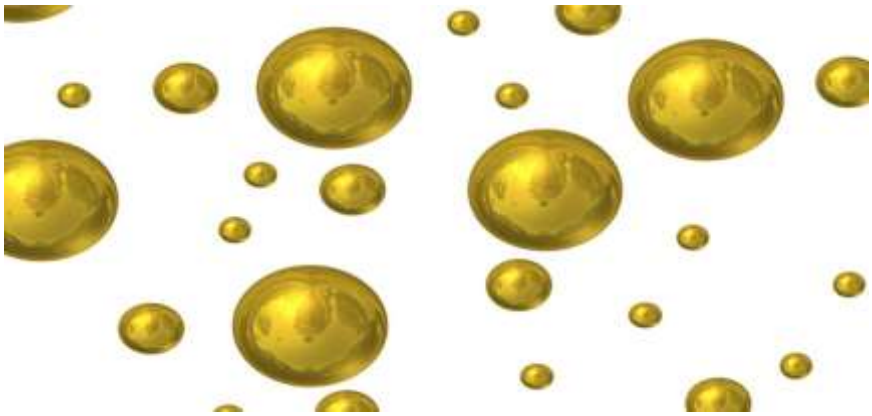

Figure 4; Gold Nanoparticles [12]

4. Application

1. **Delivery of Peptides Nucleic Acid and Protein;** The gold nanoparticles serve as a carrier for peptides, nucleic acid and proteins i.e. DNA due to their effective size [14].The nanoparticles of gold's are functionalized directly with ammonium group that can interact with DNA plasmid through the electrostatic interactions and it protects DNA from the enzymatic digestion. These nanoparticles can be as

carrier for the peptides and proteins, have stated that the tetra alkyl ammonium functionalized nanoparticles identify the cell surface based receptor [15]. The Gold nanoparticles are also work for insulin delivery. Chitosan covered gold nanoparticles certainly adsorb the insulin on their external surface and enhanced the delivery system of insulin [16].

2. **Sensor;** This type of nanoparticles also used in colorimetric probes system. Usually, the nanoparticle of gold can act as bio sensing that is depend upon the interface of the cross-linker with casual receptor type molecule on the nanoparticles or the interaction among all nanoparticles having receptors when the ligand significantly added in. Especially, the Au nanoparticles secure by the bovine serum base albumin have been presented as the fluorescent probe for the in *vivo* detection. This approach can also be applicable for the identification of proteins, different pollutants, and free molecules [17].
3. **Catalysis**; Gold nanoparticles are generally used as effective catalysts in chemical reactions [18]. The surface nanoparticle can be helpful for selective oxidation or in some cases the surface of nanoparticle can slow the reaction. Gold nanoparticles are produced for the fuel cell and its different applications. These technologies can be valuable in the other automotive fields and display industry.
4. **Electronics**; The Gold nanoparticles are very remarkable applications in electronic industries. It can be act as conductors from the printable inks to effective electronic chips [19]. In modern period electronics industries, make smaller electronics stuff and it playing vital role in chip design. It can be used to conductors, connect resistors and electronic chip.
5. **Probes**; It can produced emerging colors in the presence of dark field microscopy [20]. The different scattered colors of these nanoparticles have wide application [21] in the biological imaging field. The Au nanoparticles are dense and it makes them useful for TEM (Transmission electron microscopy)
6. **Diagnostics;** Gold nanoparticles are very significant in the diagnostic procedure of different disease like heart, cancers and other infectious agents. E.g. computer tomography is diagnostic imaging technique for gold particles in vivo detection, which is helpful to identify the tissue density, it also show better intensity signal and stability on spectrum [22]. The Au gold is commonly used for flow assays and due to their optical properties of nanoparticles, naked eyes detection can achievable.

5. Conclusion

The remarkable and significant gold nanoparticles arise as capable carriers of the biomolecules such as insulin, protein, nucleic acid and peptides. Their low toxicity, some multifunctionality characters, larger

surface area, improved photo physical and some active optical properties report unique aspects that have role in many applications such as chemotherapy, drug delivery and cancer diagnosis etc.

Conflicts of Interest: The authors declare no conflict of interest.

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