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Review on Gold Nanoparticles with Mediated Drug Delivery

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Abstract – This paper focuses on therapeutic gold nanoparticles & selective distribution of medicines. In this region nanotechnology has been one of the most exciting & innovative research fields. Gold nanoparticles have specific benefits in this field because of their unique properties, small size & strong area-to - volume ratio among nanoparticles. These particles were commonly utilized in different biomedical applications & drug delivery systems because of their inert existence, mobility, strong dispersion, non-cytototoxicity & biocompatibility.

Key Words – Gold Nanoparticles, Biomedical Applications, Targeted Drug Delivery, Nanotechnology.

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INTRODUCTION

It is a well-known truth that all the matter in the universe consists of atoms which are called the building blocks. Depending on the structure and composition of the atoms, small scattered matter (i.e. particles) is known as coarse particles (10,000-2,500 nm), fine particles (2,500-100 nm) & ultrafine particles (1-100 nm) (Figure 1), & smallest of these types, ultrafine particles, are often generally recognised as nanoparticles (Figure 2). The science division concerned with nanoparticles, identified as 'nanotechnology,' has arisen as a region of intensive scientific study & has uses in the fields of medicine, electronics, biomaterials, development of energy storage. This is apparent from the rapid development (Figure 3) of nanotechnology study papers during the last decade. Nanoparticles' tremendous ability is attributed to the special properties of elements as their scale is limited to the amount of nano-metres. In general, the characteristics of particles over the nano-meter scale are not substantially different from their equivalents in volume.

Similarly, their physical & chemical properties (example, melting point, fluorescence, electrical properties, magnetic permeability, & chemical reactivity) will dramatically alter if particles are minimized to their nano-levels. The differences in these products are heavily affected by their Environmental scale, shape &design.

Recently, colloidal gold nanoparticles known to mankind for their bright colours because the Roman times have gained substantial interest owing to their ability for a extensive variety of biological applications in which optical properties of AuNPs are precisely balanced by varying morphological & reaction characteristics to produce AuNPs of desirable form & scale. This study relies on several of the essential aspects of AuNPs highlighting their past and life since ancient times, the properties of AuNPs, numerous synthetic routes accessible & finally a summary of different AuNPs utilized either intact or combined with various functional moieties as an efficient antibacterial agent together with their modes of action as figured out from various populations.

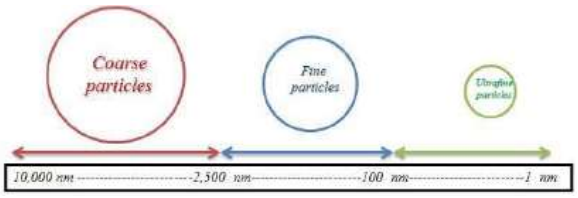

Figure 1. Classification of particles within nanometer scale range based on their size distribution.

Figure 2. A conceptual representation of each of the scale examples & their differing scale degree contrast. (Credit: Central Coordination Office for Nanotechnologies).

GOLD NANOPARTICLES

Gold nanoparticles' properties differ from their bulk form because bulk gold is yellow solid & inert in nature whereas gold nanoparticles are red wine solution & reported to be antioxidant. Inter-particle interactions & alignment of networks of gold nanoparticles play a key role in determining the properties of those nanoparticles. Gold nanoparticles are of similar sizes varying from 1 nm to 8 μm and have diverse types like circular, suboctahedral, octahedral, decahedral, icosahedral multiple twined, multiple twined, triangular type, tetrahedral, nanotriangle, nanoprism, hexagonal platelets & nanorods (Figure 3).

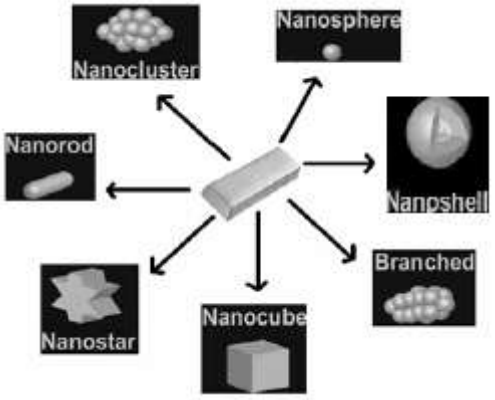

Figure 3: Various shapes of gold nanoparticles

Triangular formed nanoparticles exhibit appealing optical properties in contrast to the spherical shaped nanoparticles in both these types. The use of single active material from plant extract in the synthesis of gold NP is an imperative technique in bio-synthesis for purifying gold nanoparticles & researching their medical uses. Gold nanoparticles were commonly utilised as a radiation enhancer in the area of nuclear medicine & can offer a clinical aid in radiation therapy owing to the effective and controlled delivery of medications to the tumour site. Gold nanoparticles have multiple features as platform nanomaterials for ultrasensitive biomolecular detection, cancer cells are killed through hyperthermal treatment, cell & protein labelling, & therapeutic agents are delivered within cells.

Gold nanoparticles dependent on fluorescent nanoparticles or nanoprobes provide strong biocompatibility

For molecular diagnostics of many of the enzymes & metabolites required for cellular cancer functions. Owing to their peculiar optical & chemical properties and thus utilized for biological applications, gold nanorods has gained significant interest in recent years. Gold nanorods have unique anisotropic geometry that allows them to obtain tunable absorption in both visible & near infrared (NIR) regions and create them appropriate for probable applications in biosensing, gene delivery & phototherapy. Gold nanoparticles have significant benefits over traditional iodine-based agents as gold has a higher absorption coefficient than iodine owing to its elevated atomic number & electron density, thereby improving the CT contrast more than iodine such that they have been utilized as molecular probes in X-ray CT imaging.

The second major benefit of gold NP is that they could be non-cytotoxic & third major benefit of gold NP is their surfaces since they have a wide surface area which allows their surfaces easily accessible for variation with targeting molecules or unique biomarkers & appropriate for biomedical applications. The role of gold NP in the biological

sciences is essential due to the stability, the combination of these particles with the biomolecules & their flexible optical properties due to the shape, size & surface area of the gold NP. Because of the small size & broad base, form & crystallinity, nanoparticles are known to be outstanding therapeutic agents, since they can fly asily into the target cells & carry high drug load. Gold nanoparticles are commonly utilized in biomedical sciences, such as tissue or tumour analysis, medication distribution, phototherapy & pathogen immunochromatography.

Clinical Plasmon Resonance Surface Measurements (SPR). Nanoparticles have specific physiochemical properties with surface area, amphilicity, form, biocompatibility and surface carrier capabilities that render them ideal for gene transmission, as role of conjugated gold NP describe by different factors like protein structure, particle morphology, & conjugated strategy. Owing to the plasmon resonance absorption & light scattering in the near infrared region, gold nanorods have numerous prospects in the areas of in vivo photography. Owing to their simple preparation through chemical processes, colloidal gold NP have attracted a lot of popularity and can effectively be incorporated into the tissues and cells owing to their very small size which is equivalent to biological molecules such as DNA & proteins.

Gold nanoparticles could bind to a broad variety of organic molecules so they have low toxicity & flexible physical & chemical properties such that has utilized as medicinal agents or vaccine carriers of individual cells such that they can improve the medication efficacy & kill pathogens. NPs has widely utilizedfor epidermal delivery of DNA vaccines with the usage of gene gun gold and this approach is one of the safest ways to distribute DNA vaccines. Coated walls of gold nanocages were utilized as drug carrier with temperature-sensitive polymer that releasing their effectors with the interaction of near-infrared irradiations. Gold nanoparticles, tiny in size and around 1 nm in diameter, will cross the cell membrane & nuclei to bind with DNA on the opposite 18 nm gold nanoparticles show outstanding cell penetration but cytotoxicity has not been detected.

Gold nanoparticles has good alkyne sensitivity relative to other transition metal catalysts, however homogeneous structures are not economically & ecologically desirable due to the gradual reduction of active gold complexes in inert metallic gold during C-H alkyne activation. Because of the special optical & electronic properties of the nanoparticles they generate

The colour identifying samples were commonly utilized in the creation of analytical techniques utilized for the sensing of different analytes. The remarkable durability and special properties including strong biocompatibility, that is important to maintain the native structure & enzymatic action of the attached proteins or enzymes, gold colloids could used in surface alteration of ideal electrodes. The incorporation of gold NP into smart polymer such as polymer (N-isopropylacrylamine) is an efficient method for improving polymer's different properties, like the reversibility of collapse swell in caused by temperature stimuli.

DIFFERENT TYPES OF NANOPARTICLES

Nanoparticles could be grouped into numerous categories by scale, shape, physical & chemical properties. There are carbon-containing NP, ceramic NP, metal NP, nanoparticles with semiconductors, polymeric nanoparticles, & nanoparticles centred on lipids.

Carbon Nanoparticles: Nanoparticles dependent on carbon contain two primary materials: carbon nanotubes (CNTs) & fullerenes. CNTs are nothing but sheets of graphene folded up into a tunnel. These products are primarily utilized to strengthen the frame, as they are 100 times stronger than steel. CNTs may be categorised into single-walled nanotubes of carbon (SWCNT) & multi-walled nanotubes of carbon (MWCNT). CNTs are peculiar in that they are thermally conductive throughout the length of the conduit & non-conductive across it.

Fullerenes are the carbon allotropes which have a hollow cage consisting of 60 or more carbon atoms. Buckminsterfullerene is considered the C-60 form, which appears like a hollow football. The carbon units in such systems are organised pentagonally & hexagonally. Because of their electrical conductivity, composition, strong strength & electron sensitivity these have industrial applications.

Nanoparticles in Ceramic: Ceramic nanoparticles are inorganic acid, carbide, carbonate, & phosphate solids. These nanoparticles are extremely immune to heat & have chemical inertness. They have uses in the areas of photocatalysis, colour loss, medication distribution, & photography.

They serve as a good drug delivery agent by regulating some of the characteristics of ceramic nanoparticles, such as scale, surface region, porosity, surface-to - volume ratio respectively. These nanoparticles were successfully utilized as a drug delivery device for a variety of diseases like bacterial infections, glaucoma, aids, and so on.

Metal Nanoparticles: Nanoparticles formed from metal are formed from precursors. This nanoparticles may be synthesised utilising techniques such as nuclear, electrochemical or photochemical. The metal nanoparticles are produced in chemical methods by growing the

metal-ion precursors in solvent by chemical reduction agents. They are capable of swallowing tiny molecules, and have large surface energy.

This nanoparticles have uses in the fields of science, biomolecular identification & analysis, and in environmental & bioanalytical uses. For example, before analysing in SEM, gold nanoparticles are utilized to coat the sample. Typically this is achieved to boost the electronic medium, which lets us get good quality SEM pictures.

Nanoparticles Semi-Conductor: Semiconductor nanoparticles has identical properties to metals & non-metals. They are contained in sections II-VI, III-V or IV-VI, in the periodic table. These particles have large bandgaps that display different properties at tuning. They are utilized in applications for photocatalysis, sensors, photo-optics & water splitting. Several instances of semiconductor NP are GaN, GaP, InP, InAs group III-V, ZnO, ZnS, CdS, CdSe, CdTe, II-VI semiconductors, & silicon and germanium group IV.

Polymers Nanoparticles: Polymeric nanoparticles are nanoparticles of an biological nature. These are frameworks formed like nanocapsular or nanospheres, based on preparation process. A particle in the nanosphere has a matrix-like composition while the shape of the nanocapsular material is core-shell. The active compounds & polymer are evenly distributed in the former whilst the active compounds are contained in the latter & enclosed by a polymer layer.

Any of the benefits of polymeric nanoparticles are controlled release, drug molecules defence, the potential to integrate therapy and imaging, precise targeting & much more. They have medical and medication distribution software. The medication supplies are extremely biodegradable & biocompatible with polymeric nanoparticles.

Lipid Nanoparticles: In general, lipid nanoparticles are spherical in size with a diameter varying from 10 to 100 nm. It consists of a solid centre consisting of lipid & matrix of lipophilic soluble molecules. These nanoparticles' exterior heart is stabilised by surfactants & emulsifiers. Ses nanoparticles are utilized in the biomedical field as a medication carrier, & cancer therapy transmission and release of RNA. The area of nanotechnology is thus far from being saturated and, as the statistics suggest, it sits on the staircase of an exponential trend of development. It is essentially at the same level as IT was in the 1960s, & biotechnology in the 1980s. And it can be accurately expected that this area will undergo the same accelerated development as historically experienced by the other two technical areas.

COMMON DRUGS FOR CANCER THERAPY

Constructive processes are limited for the clinical cancer therapy. Such common techniques utilized for cancer treatment include surgical restraint, chemotherapy & irradiation but these methods are not only harmful, non-specific and could cause multiple side effects. Cancer patients receiving radio & chemotherapy experience medication resistance like cisplatin, cancer induced exhaustion (CRF) & other cardio-vascular symptoms including cardiomyopathy, ischemia, arrhythmias, asthma, thromboembolism, pericardial disorders or cardiac failure as they kill the cancer cells along with the death of healthy cells.

In comparison to other traditional therapies, chemotherapy is the key cancer cure, however owing to numerous unfavorable effects induce by undefined delivery of drugs throughout the body attributable to multiple chemotherapeutic agents such as cytotoxic drugs it is not more recover. Paclitaxel (PTX) exhibits cytotoxicity toward multiple cancer forms because it is deemed an important chemotherapeutic medication with minimal clinical results owing to to toxicity induced by low water solubility & selectivity. Efficient methods should be rejected regardless of these limitations. Chemotherapeutic agents induce numerous adverse effects in cancer patients like nephrotoxicity, dehydration, myelosuppression, extreme nausea, ototoxicity, & neurotoxicity attributable to CDDP (cisplatin) administration, while stomach disturbances, intense nausea , fatigue, stomatitis, alopecia baldness, nervous dysfunction, bone marrow, aplasia, chronic heart toxicity, & bone marrow depressanium. Methotrexate, irinotecan, & cisplatin patients can endure from fluoropyrimidines (5FU) Diarrhea & constipation. Hyperglycemia, stomatitis, hypophosphatemia, interstitial lung disease & pneumonia have been identified in patients with advanced renal cell carcinoma while administered with temsirolimus as a single drug anaemia. Every year cancer causes significant numbers of deaths due to lack of selectivity, drug targeting capacity, inadequate metastatic tumour therapy & drug-resistant tumour cells (Table 1). For this cause, innovative chemotherapy therapies were essential to destroy cancer cells. Currently, experimental fuscous side effects are transferred to natural goods that also need to show their efficacy in order to prevent them.

Table 1: Conventional intravenously administered drugs and their side effects

Chemotherapeutic agent	Cancer type	Possible short-term side effect
Carboplatin (Paraplatin)	Cancers of the ovary, head and neck, and lungs	Decrease in blood cell counts, hair loss (reversible), confusion, nausea, vomiting, and/or diarrhea
Cisplatin (Platinol, Platinol-AQ)	Cancers of the bladder, ovary, and testicles	Decrease in blood cell counts, allergic reaction, including a rash and/or labored breathing, nausea and vomiting that usually occurs for 24 hours or longer, ringing in ears and hearing loss, fluctuations in blood electrolytes, and kidney damage
Doxorubicin (Adriamycin)	Breast cancer, lymphoma, and multiple myeloma	Decrease in blood cell counts, mouth ulcers, hair loss (reversible), nausea and vomiting, and heart damage
Paclitaxel (Taxol)	Cancers of the breast, ovary, and lung	Decrease in blood cell counts, allergic reaction, nausea and vomiting, loss of appetite, change in taste, thin or brittle hair, joint pain (short term), and numbness or tingling in fingers or toes
Fluorouracil (5-FU)	Cancers of the colon, breast, stomach, and head and neck	Decrease in blood cell counts, diarrhea, mouth ulcers, photosensitivity, and dry skin

GOLD NANOPARTICLE-MEDIATED DRUG DELIVERY

Targeted drug delivery is better than conventional drug therapy even though targeted drug delivery targets the main area of drug delivery & delivers drug locally so that it minimises the side effects of conventional drugs. The primary objective of developing anticancer agents is to minimise the various side effects that are affected by conventional drugs & improve drug selectivity and efficacy. Recently, targeted drug delivery was the main area of interest for scientists & much work was done on synthesised systems for targeted drug delivery like nanoparticles, quantum dots, polymer gels, Fe_3O_4, & ZnO ..

Gold nanoparticles get the ability for therapy to bio-image the cancer cells which have been affected. For an effective drug delivery system or drug therapy, it is crucial to analyze the biological properties of nanofluids as gold nanoparticles has unique physical & chemical properties & strong binding attraction for thiols, proteins, carboxylic acid aptamers & disulfides, so that has extensively utilized in the field of biosciences, particularly in the delivery of cancer drugs. Gold nanoparticles have followed three main cellular uptake pathways that include receptor-mediated endocytosis, phagocytosis, & endocytosis of the fluid phase.

The toxicity of nanoparticles in gold depends on their size, shape, method of synthesis, surface charge, surface covering & functional molecules and whilst overall gold nanoparticles cytotoxicity nanoparticles acceptable as gold are regarded non-toxic agents. There are two factors, namely the release & transport of drugs, that are very necessary for the correct delivery of drugs configuration. Drugs are equipped into nanocarriers either through non - covalent contact through covalent conjugation with the aid of pro-drug, that the cell handles. Thanks to their monolayers, gold NP provide flexibility to use an effective solution.

CONCLUSION

Gold nanoparticles have revolutionised the medicine market in several respects due to its wide-spread applications in controlled drug delivery, visualisation, diagnosis. Functionalized gold nanoparticles has utilized in cancer therapy for different biomolecules such as proteins, DNA, amino acids & carboxylic acids and have an outstanding drug delivery method. Targeted delivery & programmed release of therapeutic drugs to the specific site is accomplished by the utilize of gold nanoparticles, since they can hold heavy drug loads and transfer them to the specific site different routes of administration, which may communicate with cancer cells. Conventional Side effects conjugation with gold nanoparticles has reduced medications & improved the efficiency patient Life.

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