



Gold Nanoparticles Use In Cancer Treatment

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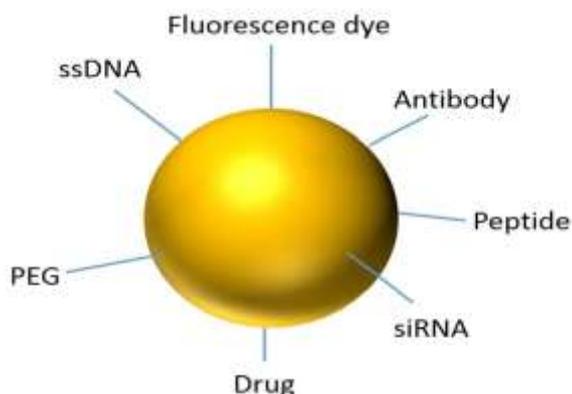
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1.ABSTRACT: Gold nanoparticles (AuNPs) are important components for biomedical applications. AuNPs have been widely employed for diagnostics, and have seen increasing use in the area of therapeutics. The review provides an overview of nanoparticles, including their types, properties, synthesis methods, and various application. Nanotechnology is an emerging field of science. The base of nanotechnology is nanoparticles. The size of nanoparticles ranges from 1 to 100 nm. The nanoparticles are synthesized by using two approaches like top-down approach and bottom-up approach. In this review chemical, physical and green synthesis of nanoparticles is reported. Gold nanoparticles (GNPs) were prepared using four different plant extracts as reducing and stabilizing agents. they can be used for imaging and drug-delivery applications in the human body. There are various therapeutic approaches like photothermal-therapy, cell-therapy, gene therapy which can treat the cancer.

Keywords: Nanoparticles, Types of Nanoparticles, Gold Nanoparticles, Therapies of Cancer, synthesis of nanoparticles, application, advantages, disadvantages, green synthesis, nanotechnology

2.INTRODUCTION: In recent cancer is leading to death. It is observed in growing number of people suffering from cancer. There are many therapies related to cancer like surgery, radiotherapy, chemotherapy, photothermal therapy and some are in research. Some people can also suffer from reoccurrence of cancer after surgery. Among all these therapies, chemotherapeutic drugs can reach on all body via bloodstream but it affect or damage the normal tissue. So there is a need of effective therapy or treatment of cancer for cure, diagnosis and detection of cancer. Various drug delivery has been developed but this are not accurate or effective. Nanotechnology has been one of the challenging therapy for cancer in recent. Gold nanoparticles has been drawn more attention in biomedical application or cancer therapy. Gold Nanoparticles are effective radiosensitizer in biomedical applications. Mostly, it is applicable in cancer therapy. With advancement in this gold nanoparticles variables in size shape, and composition it can be easy to controlled the drug delivery. The size of the nanoparticles are generally below 100nm. Many therapeutic approaches has been reported of gold nanoparticles like anti cancer drug delivery, gene delivery, diagnosis of disease, detection of pathogens, photothermal therapy and detection of images, etc. Gold Nanoparticles has been developed as an ideal nano object such as biosensors, imaging treatment. Gold Nanoparticles can be directly conjugate with proteins, peptides, antibodies, ligands and other molecules, this can improve their biological activity and increase the potency of as an anticancer agent.



3. NANOPARTICLES

These are the small (tiny), solid colloidal particles having size below 100nm, composed of medicament called as Nanoparticles can act on living cells which can give biologically active response. It can be made up of carbon, metal or organic material. It can exist in various size, length and shape including spiral, tubular, circular, oval, flat, hollow, etc. NPs[1]. It having distinct physical and chemical properties and these properties make them applicable in biomedicines, environment, imaging, diagnosing and detection of various cells in human body. NPs composed of 3 layers:

1. A surface layer that have different small molecules, metal ions, surfactants, or polymers
2. The shell layer is chemically distinct from the core.
3. The fundamental components; the heart of NPs[2]

TYPES OF NANOPARTICLES

1. Micelle
2. Liposomes
3. Dendrimers
4. Carbon Nanotubes
5. Metallic Nanoparticles
6. Nanohydrogels
7. Solid lipid Nanoparticles

1. Micelle:- Micelles are amphiphilic surfactant molecules that consist of lipids and amphiphilic molecules. Micelles spontaneously aggregate and self-assemble into spherical vesicles under aqueous conditions with a hydrophilic outer monolayer and a hydrophobic core, and thus can be used to incorporate hydrophobic therapeutic agents. The unique properties of micelles allow for the enhancement of the solubility of hydrophobic drugs, thus improving bioavailability. The diameter of micelles ranges from 10-100 nm. Micelles have various applications, such as drug delivery agents.[4]

2. Liposomes:- Liposomes are spherical vesicles with particle sizes ranging from 30 nm to several microns, that consist of lipid bilayers. Liposomes can be used to incorporate hydrophilic therapeutic agents inside the aqueous phase and hydrophobic agents in the liposomal membrane layer. Liposomes are versatile; their surface characteristics can be modified with polymers, antibodies and/or proteins, enabling macromolecular drugs, including nucleic acids and crystalline metals, to be integrated into liposomes. Polyethylene glycol (PEG) liposomal doxorubicin is the first FDA-approved nanomedicine, which has been used for treatment of breast cancer, and it enhances the effective drug concentration in malignant effusions without the need to increase the overall dose[3, 4].

3. Dendrimers:- Dendrimers are macromolecules with branched repeating units expanding from a central core and consists of exterior functional groups[3, 5]. These functional groups can be anionic, neutral or cationic terminals, and they can be used to modify the entire structure, and/or the chemical and physical properties. Therapeutic agents can be encapsulated within the interior space of dendrimers, or attached to the surface groups, making dendrimers highly bioavailable and biodegradable[6].

4. Carbon Nanotubes:- Carbon nanotubes are cylindrical molecules that consist of rolled-up sheets of a single-layer of carbon atoms (graphene). They can be single-walled or multi-walled, or composed of several concentrically interlinked nanotubes[7]. Due to their high external surface area, carbon nanotubes can achieve considerably high loading capacities as drug carriers. Additionally, their unique optical, mechanical and electronic properties have made carbon tubes appealing as imaging contrast agents and biological sensors[8, 9, 10].

5. Metallic Nanoparticles:- Metallic nanoparticles include iron oxide and gold nanoparticles. Iron oxide nanoparticles consist of a magnetic core (4-5 nm) and hydrophilic polymers, such as dextran or PEG[7, 10]. Conversely, gold nanoparticles are composed of a gold atom core surrounded by negative reactive groups on the surface that can be functionalized by adding a monolayer of surface moieties as ligands for active targeting. Metallic nanoparticles have been used as imaging contrast agents[11], in laser-based treatment as optical biosensors[5] and drug delivery vehicles[12].

6. Nanohydrogel: Nanohydrogels are 3D networks of cross-linked hydrophilic polymers with high water content and with a size usually of <200 nm. They combine the advantages of hydrogels and nanoparticles for drug formulation and delivery. The cross-linking of nanohydrogels is either through physical interaction such as hydrophilic-hydrophobic interactions, electrostatic interactions or hydrogen bonding, or through chemical interaction with covalent bond. The swelling of nanohydrogels in the aqueous environment is determined by type of polymers, degree of cross-linking and external environment. Nanohydrogels are promising in the delivery of therapeutic agents for multimodality treatment,

especially for hydrophilic biomolecules such as peptides, proteins and oligonucleotides. They show high biocompatibility due to their high water content. The positively charged surface could then load negatively charged proteins for co-delivery. The nanogels showed efficient cell uptake. The gels used to co-deliver paclitaxel and doxorubicin showed significant prolongation of the survival rate in B16-F10 tumor-bearing mice.

7.Solid lipid nanoparticles:-These are having an average dia.of 10–1,000 nm, formed with lipids that remain in a solid state at room temperature and body temperature. They combine the advantages of liposomes and polymeric nanoparticles, and show high stability in the physiological environment. Their preparation processes usually do not need to induce toxic organic solvents. They can load both hydrophilic and hydrophobic agents, especially showing advantages in protein or peptide delivery. They also show good potential for large-scale production. The CI value of PQSLN/Bcl-2 siRNA was smaller than 0.5. It also showed that the platform synergistically promoted the apoptotic death of cancer cells by activating caspase-mediated pathways. Cell viability studies in MIA PaCa-2 and Panc-1 cells demonstrated that the combination of low doses of the drugs significantly reduced cell viability by 43.6 and 48.49%, respectively, which showed the superiority of the multimodality treatment to the individual treatment.

4.Gold Nanoparticles

These are small gold particles having diameter range 1 to 400 nm.Gold is inert and recognized as biocompatible.AuNPs are made up in various according to their biological activity.The transport mechanism of AuNPs are passive diffusion.

AuNPs are used widely in biomedical application because of following properties:-

Biocompatibility: AuNPs are less toxic than other nanoparticles, such as cadmium and silver.

Optical properties: AuNPs have strong optical properties due to localized surface plasmon resonance (LSPR).

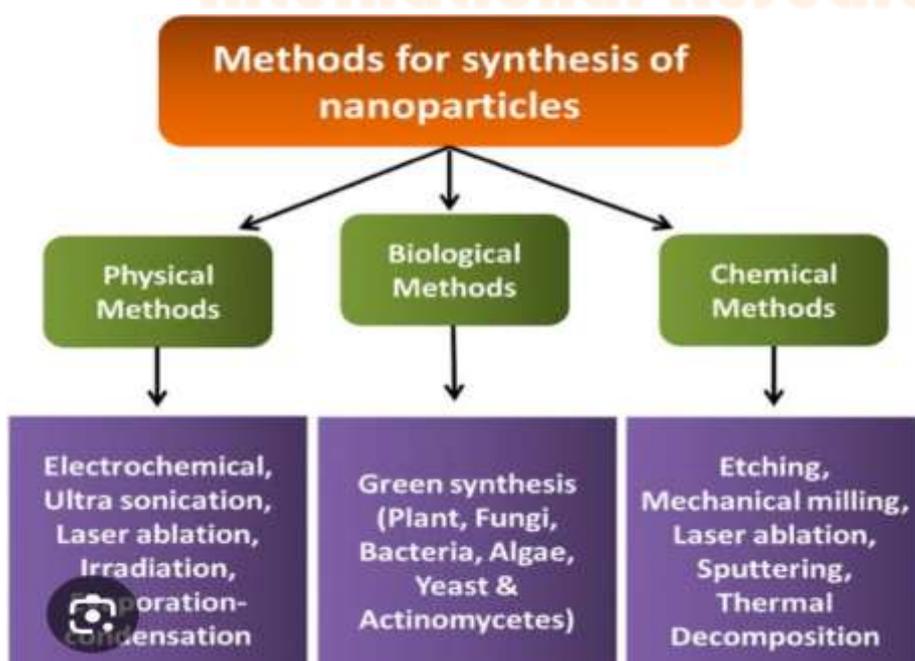
Controllable surface chemistry: The surface chemistry of AuNP can be easily controlled, allowing for the addition of surface functional groups.

Particle size and shape control: AuNPs can be synthesized in a variety of shapes and sizes.

Photothermal therapy: AuNPs can absorb near-infrared light and emit thermal energy, which can destroy tumor cells

Imaging: AuNPs can be used as contrast agents in imaging modalities, such as CT scans. They can also be conjugated to antibodies that target tumor expressing specific proteins.

5.Different Methods of Synthesis of Gold Nanoparticles: The nanoparticles are synthesized by using two approaches like top-down approach and bottom-up approach. In this review chemical, physical and green synthesis of nanoparticles is reported.A variety of technique of preparation of gold nanoparticles is as follows



1. Bottom-up Method

A. Sol-gel method

The sol is a colloidal suspension of solid particles in liquid. The gel is a mixture of solid macromolecules and a solvent. A chemical solution that serves as a precursor for an integrated system of discrete particles is used in this wet chemical process. In the sol-gel process, metal oxide and chlorides are frequently used as precursors. After the precursor is mixed with the host liquid using shaking, stirring, or sonication, a liquid and solid phase are produced [13].

B. Chemical vapour deposition (CVD)

A solid is deposited on a heated surface using the well-known CVD process, which involves a chemical reaction between the gaseous and vapor phases. In thermal CVD, a high temperature greater than 900 °C activates the reaction. By using CVD, nano-composite powder has been created. At 1400 degrees Celsius, SiC/Si₃N composite powder was created using SiH₄, CH₄, WF₆, and H₂ as gas sources [14].

C. Pyrolysis

By typically dissolving the metal salt of the product in the solvent, a starting solution is created in order to prepare fine particles by spray pyrolysis. The droplets are introduced to the furnace after being atomized from a starting solution. To create the finished product, processes such as solvent evaporation, solute diffusion drying, precipitation, reaction between the precursor and the surrounding gas, pyrolysis, or sintering may take place inside the furnace [15].

D. Spinning

The forced convection that the spinning procedure creates in the vapour above the substrate is constant. In spin coating, the evaporation rate is typically quite uniform. An essential step in the fabrication of semiconductors is the spin-coating of very thin, uniform photoresist films [15]. As a result, the synthesis of NPs processed by an SDR and a rotating disc inside of it aids in the control of physical parameters like temperature. In order to prevent chemical reactions inside the reactor, inert gases or nitrogen are typically filled with it. Precursor and water were pumped into the SDR, which rotated at various speeds. The result of the spinning is that the atoms fuse and precipitate, collect, and dry. Liquid flow rate, disc rotation speed, liquid precursor ratio, feed location, and disc surface are all factors in the synthesis of NPs [16].

2. Top-down Method

a. Thermal decomposition method

It is an endothermic process in which heat drives chemical breakdown. This heat damages a compound's chemical bond. The temperature at which an element begins to chemically decompose is known as the decomposition temperature [17].

b. Lithography

Top-down lithographic methods alone or in combination with other fabrication techniques, such as reactive ion etching (RIE), can be used to create size- and shape-controlled nanoparticles. The conventional semiconductor industry and other fields requiring micro and nano patterns have made extensive use of photolithography, one of all top-down approaches, which has been well developed. Ion beam and e-beam lithography have the ability to directly write ultra-small structural units with extremely fine patterns as well as create masks or molds for use with other lithography techniques. However, the throughput and cost of these techniques are incredibly low. Nanoimprint lithography (NIL), which duplicates nano-patterns through a nanostructured master mold in an easy, parallel, and affordable manner, can resolve the aforementioned problem of top-down fabrication technique [19].

c. Laser ablation

Pulsed lasers are used to remove molecules from a substrate's surface in order to create microstructures, and they are widely used in the manufacturing of metals, ceramics, polymers, and glasses. By concentrating a laser beam, which absorbs energy to cause melting, evaporation, or vaporization, a substance is removed from a surface. The process that deals with both vaporization and melt ejection is known as laser ablation, and it is constant throughout the entire laser machining application [18].

d. Sputtering

By bombarding the target surface with highly energetic ions of an inert gas (argon), which results in the ejection of atoms and clusters, materials from the target's surface (a solid) can be vaporized. A controlled inert gas is first introduced into the vacuum chamber as part of the sputtering method, and then the cathode is electrically energized to produce self-sustaining plasma. The materials that sputtered together make up a vapour steam. In order to hit and stick to the substrate in order to form a thin film or surface coating, this vapour steam travels through the chamber [19].

e. Mechanical milling method

In mechanical milling, a suitable powder charge and an appropriate milling medium are placed in a high energy mill. Reducing particle size and blending particles into new phases are the goals of milling. The balls may drop freely and strike the powder and balls below them or they may roll down the surface of the chamber in a series of parallel layers. The energy transferred from the balls to the powder during mechanical milling or alloying depends on the kinetics of the process. The industries of powder metallurgy, processing minerals, and ceramics all heavily rely on milling of materials. The high energy ball mills, such as tumbler ball mills, vibratory mills, and planetary ball mills, have typically been used for these purposes[20].

3. Green Synthesis/Biological Method

The biological synthesis of nanoparticles is a safe, dynamic, and energy efficient method of producing nanoparticles. This approach comprises a range of biological resources ranging from prokaryotes to eukaryotes to synthesize NPs *in vivo*. Metabolites (proteins, fatty acids, sugars, enzymes, and phenolic compounds) found in these sources play a significant role in both the bioreduction of metallic ions to NPs and their stability. AuNPs generated biologically are more stable than those generated using other methods. AuNPs can efficiently manufacture from chemical routes, but the main risk is the generation of by-products (secondary product) that are hazardous to human health and the environment. New routes for the production of safe nanoproducts are therefore being intensively explored by many biological systems, such as plants, bacteria, yeasts, and fungi, for the manufacture of AuNPs[23].

a. Green synthesis of AuNP by plant extract

Nature is rich with a wellspring of plants which has the advantage of a low cost, high reproducibility, eco-friendly and precise purification process compared to other environmental friendly biological methods. The green pathways with the use of plant extracts as reducing agents and stabilizer for the preparation of various types of nanoparticles are critical for the preservation of long-term growth. Because of the scalability and cost-effectiveness of fungal growth on an industrial scale, extracellular or intracellular extracts of fungi are suitable materials for the synthesis of metal nanoparticles. Fungi can produce gold nanoparticles in one of three ways: extracellular, fungal autolysate, or intracellular. The size and distribution of the fungi differ depending on the strain and the experimental conditions (Molnár et al., 2018). Fungi have an advantage over other microorganisms in that they can produce a large number of extracellular enzymes capable of reducing metal salts to nanoparticles. Fungi can also be easily prepared in the laboratory as well as on a large scale, as mycelia can withstand harsh conditions in bioreactors. Marine endophytic fungi have been found coexisting with marine algae. Several scholars have been able to synthesize antioxidant gold nanoparticles from *Penicillium citrinum*, an endophytic fungus isolated from the seaweed *Sargassum wightii*, in recent years (M et al., 2017). The advantage of using *M. phaseolina* to create gold nanoparticles is that its oxidoreductase activity is higher than that of other fungal species, which is economically useful since less enzyme is needed for the generation of gold nanoparticles and stabilizers for the preparation of gold nanoparticles has increased interest in not long past due to their several[24]

b. Green synthesis of AuNPs by cultivating plant cells

This is one of the methods for developing plant cells indefinitely. Hypocotyl regions from one-week-old seedlings germinated on water agar medium and inoculated on MS medium³⁸, pH 5.7, supplemented with 30% sucrose, 0.8% agar, 0.2 mg/L IAA, and 0.2 mg/L BA. After couple of weeks, the callus mass was transferred to the same composition liquid medium. Callus clumps in conical flasks containing medium in an orbital shaker with 100 rpm at 27 °C for 48 h for cell suspension. A microscopic examination confirms the culture's single-cell existence[26]. For AuNP Synthesis, cell culture was supplemented with KAuCl_4 at a rate of 10–200 ppm and incubated on a shaker for 24 h in the dark. Pipetting the culture (1 ml) into the Eppendorf tubes, centrifugation for 2 min (14,000 rpm), and removal of the medium. Several times, nanopore water was used to fully extract traces of medium and unreacted gold. The cells were resuspended in 100L of water before being lysed with a sonicator for 2 min. The formation of gold nanoparticles was discovered by studying the reaction of the color medium, which shifted from yellow to red. Following that, the resulting colloidal solution of gold nanoparticles was subjected to various characterization processes[24, 26].

c. Green synthesis of AuNPs by bacteria

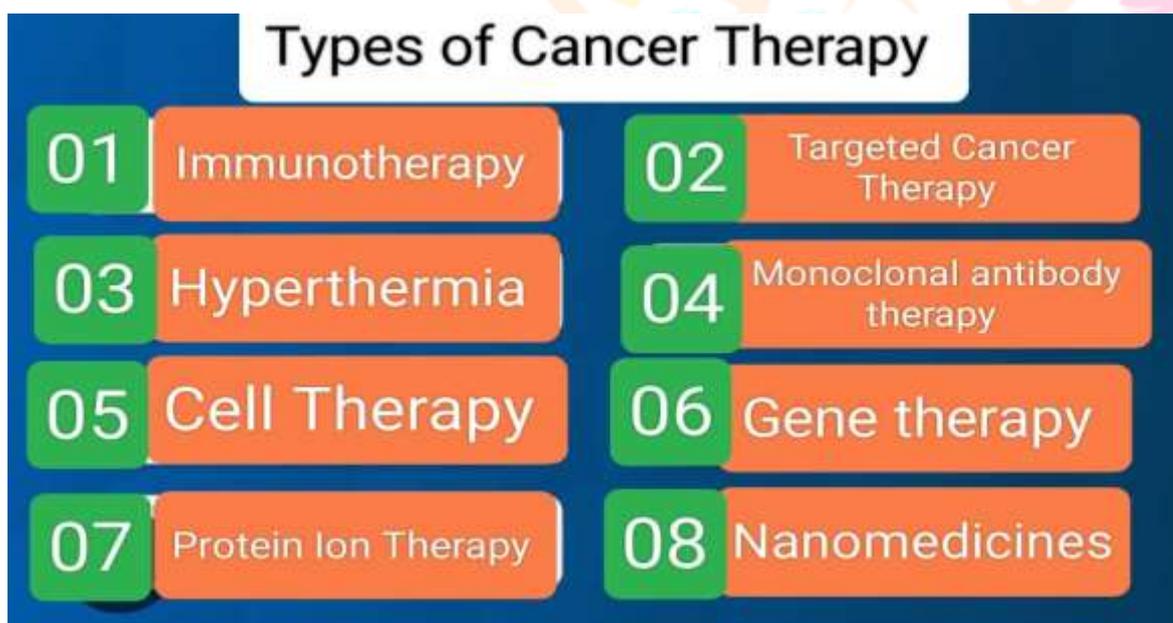
Beveridge and Murray conducted their first research on the biosynthesis of gold nanoparticles (GNPs) using the bacteria *Bacillus subtilis* in 1980. Since then, a variety of microorganisms have been used to synthesize a variety of metals, nonmetals, metal oxides, and bimetallic nanoparticles, with more applications being considered. The use of marine bacteria to synthesize gold and silver nanoparticles has been active in recent years, as has the novel bacterial strain *Marinobacter algicola*, which was isolated from marine waters in the Indian Sector's Southern Ocean. Furthermore, several bacteria, including strains of *Bacillus*, *Cupriavidus*, and *Shewanella*, were discovered to be capable of reducing Au(III) to Au NPs[27]

d.Green synthesis of AuNPs by fungi

Another way, green synthetic approaches for the preparation of various types of nanoparticles are critical for the preservation of long-term growth. Because of the scalability and cost-effectiveness of fungal growth on an industrial scale, extracellular or intracellular extracts of fungi are suitable materials for the synthesis of metal nanoparticles. Fungi can produce gold nanoparticles in one of three ways: extracellular, fungal autolysate, or intracellular. The size and distribution of the fungi differ depending on the strain and the experimental conditions[28]. Fungi have an advantage over other microorganisms in that they can produce a large number of extracellular enzymes capable of reducing metal salts to nanoparticles. Fungi can also be easily prepared in the laboratory as well as on a large scale, as mycelia can withstand harsh conditions in bioreactors. Marine endophytic fungi have been found coexisting with marine algae. Several Scholars have been able to synthesize antioxidant gold nanoparticles from *Penicillium citrinum*, an endophytic fungus isolated from the seaweed *Sargassum wightii*, in recent years[29]. The advantage of using *M. phaseolina* to create gold nanoparticles is that its oxidoreductase activity is higher than that of other fungal species, which is economically useful since less enzyme is needed for the generation of gold nanoparticles[30].

6.THERAPY IN CANCER

Cancer becomes greatest critical soundness problems, the most reason of death in the globe (Dykman, 2019). Significant developments in nanomedicine have given rise to cancer detection and treatment. Due to low toxicity of metal nanoparticles, it showed a predominant preference in medical applications, especially due to low toxicity. Gold nanoparticles also shown outstanding diagnostic and therapeutic uses, including biosensors, targeted distribution of anticancer medications, and enzyme-linked immunosorbent assays. Gold nanoparticles (AuNPs) with increased absorption and scattering properties, optical tenability, and specific tumor targeting competence (Anticancer Activity) for cancer care. Through the advent of chemical synthesis technologies, AuNPs of diverse shapes and sizes with desired properties that can obtain multimodal cancer therapy with extended anti-tumor activity can be synthesizes.



Immunotherapy

The concept of Immunotherapy in medicine incorporates the use of components of the immune system, including antibodies (Abs), cytokines, and dendritic cells, to treat various illnesses, such as cancer, allergies, and autoimmune and infectious diseases. Immunotherapy also includes the use of vaccines for the prevention of allergies and tumors. Immunotherapy adds new dimensions to clinical practice, offering much more specificity, higher efficacy, directed therapy, less toxicity, lower secondary effects and better tolerance. Although immunotherapy can be used for several illnesses (macular degeneration, autoimmune diseases, etc.), in the case of cancer, the aim of immunotherapy is to kill tumor cells (either directly or indirectly) or to help patients' immune systems destroy tumors. Of all the types of anti-tumoral immunotherapy, this review will focus on the use of antibodies, their history, problems and current applications[34].

Targeted Cancer Therapies

Nanoparticles are engineered to achieve cell targeting by using selective moieties (e.g., antibodies and their fragments, carbohydrates, peptides, nucleic acids), which binds to its corresponding antigen, cell surface carbohydrate or over-expressed receptor in tumor cells. The rapid cellular proliferation of these cells is also exploited by coupling the nanoparticles with different biological agents, such as folic acid. The rationale for coupling these carriers with folic acid is

that the folate receptor is over-expressed in a broad range of tumor cell types, including solid and hematological malignancies [35]. Once it has reached the target, the cargo is released into the interior of the cell, and ideally, a signaling marker attached to the vector will aid the physician in visualizing the tumor. Such a vector may also be grafted with a moiety (usually PEG), which retards recognition by the reticulo-endothelial system (RES) to increase nanoparticle systemic circulation

Hyperthermia

Hyperthermia, as an anticancer therapy, consists of heating a tumor to inhibit proliferation of cancer cells with the aim of destroying or rendering them more sensitive to the effects of conventional protocols of radiation and chemotherapy. In fact, hyperthermia is currently used as an adjunct therapy to radiotherapy and/or chemotherapy. When cells are heated beyond their normal temperature they can become sensitized to conventional therapeutic agents such as radiation and chemotherapy. When high temperatures are used, typically above 43 °C, the heat causes irreparable damage and results in tumor cell death in a process known as thermal ablation. The success of local thermal ablation consists of destroying the entire tumor mass without damaging adjacent vital structures. This requirement is particularly important for patient with limited reserves of tissue function[34].

Monoclonal antibody therapy

Monoclonal antibodies (mAbs) are produced by B cells and specifically target antigens. There are five isotypes of mAbs: IgG, IgA, IgM, IgD, and IgE. Because of its extended half-life and high affinity, IgG, —particularly IgG1 and IgG4, isotypes are frequently used in the development of monoclonal antibodies. Since the introduction of the first monoclonal antibody drug, Rituximab, in 1997, immunoglobulins have been potent drugs for cancer treatment in recent decades[31]. By 2023, the US FDA has approved 79 therapeutic monoclonal antibodies, of which at least 48 are used for cancer treatment[32]. These monoclonal antibodies are a class of proteins that target specific antigens to exert single or multiple effects for eliminating cancers.

Cell therapy

Cell therapy, also known as cellular therapy, is a cutting-edge approach in medicine that utilizes living cells to against cancers. Ongoing research and advancements in cell therapy continue to pave the way for revolutionary breakthroughs in healthcare, providing hope for patients in need of novel and effective treatment options. Currently, popular tumor cell therapies include Chimeric Antigen Receptor T-Cell Therapy (CAR-T), T-Cell Receptor Modified T cells (TCR-T), Tumor-Infiltrating Lymphocytes (TIL), Chimeric Antigen Receptor-Modified Natural Killer (CAR-NK) cells, T-Cell Receptor Modified T-Cells (TCR-T) and Chimeric Antigen Receptor-Modified Macrophages (CAR-M)[33].

Gene Therapy

gene therapy is described as “the introduction, removal, or modification of a person’s genetic code to treat or cure a disease.” This therapeutic approach involves directly introducing genetic material (usually DNA or RNA) into cells to alter genetic information and biological functions. Although it has shown promise in preclinical research and early-phase clinical trials, it still faces many challenges, including ensuring the safety of the treatment, improving the efficiency of gene delivery, and avoiding immune responses mRNA therapy is an emerging medical technology that uses mRNA-based molecules to treat or prevent diseases. Compared to other therapies, mRNA technology has numerous advantages. It can produce a variety of vaccines and therapeutic drugs in a shorter time frame. The production cycle for mRNA, from In Vitro Transcription (IVT) to the preparation of mRNA-LNP complexes, takes approximately 10 days. Upon administration into the organism, mRNA does not integrate into the host genome, therefore, the risk of mutations can be avoided. It degrades in the body after a brief period of action, resulting in no long-term toxicity. Moreover, mRNA therapy does not require a viral vector, which also reduces the risk of infection[33].

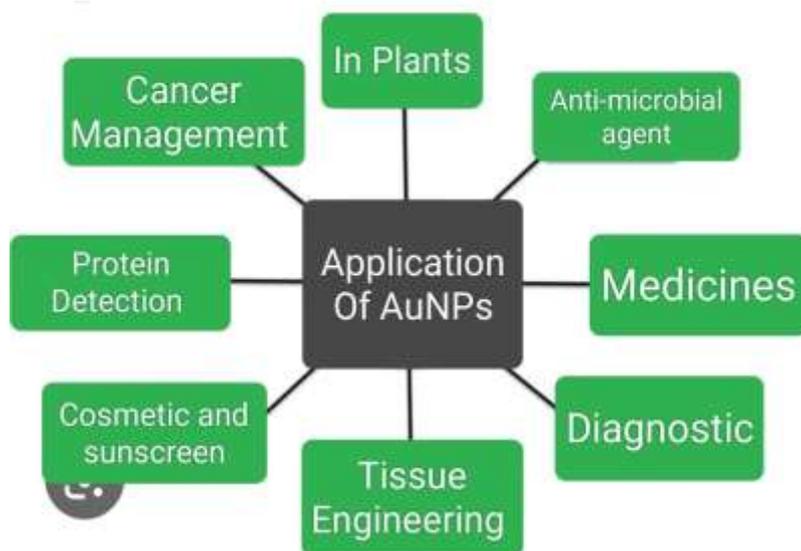
Proton therapy and carbon ion therapy

Proton therapy and carbon ion therapy are types of charged particle radiotherapy proton and carbon ion therapy deliver a lower radiation dose to surrounding tissues and reduce adverse effects[34, 35, 36]. In 1990, the first hospital dedicated to proton therapy opened in Loma Linda[37], and the technology has since matured for cancer treatment. Due to higher costs and the technical demands of heavy ion accelerators, carbon ion therapy is less commonly applied in clinical practice, despite its potential advantages over proton therapy[38].

Nanomedicine

Nanomedicines are an emerging drug delivery system that leverages nanotechnology to enhance the bioavailability, stability, targeting, and therapeutic efficiency of drugs. These medicines typically refer to drug carriers or drug molecules at the nanoscale (1 to 100 nanometers), which can include traditional small-molecule drugs, peptides, proteins, nucleic acids, or other bioactive molecules.

7. Application of AuNPs



In plants

AuNPs have been recommended for use in a variety of agricultural crops, as well as in the germination of seeds from endangered plant species[36,37]. The effect of AuNPs synthesized utilizing Terminalia arjuna fruit extract on the germination of *Gloriosa superba* seeds and the growth of the plant's leaves has been investigated. AuNPs were found to have a beneficial effect on seed germination, node elongation, and vegetative growth of plants. *Gloriosa superba* seed germination and vegetative growth were shown to be strongly correlated with the concentration of AuNPs in the environment. Moreover, it has been observed that spraying AuNPs at concentrations of 10 and 25 mg/L on *Brassica juncea* plants can increase the quantity of chlorophyll[38]. Finally, we can conclude that AuNPs have favorable impacts on plant growth and development.

Antimicrobial agents

It is possible that the use of gold nanoparticles as new antibacterial agents may provide a viable alternative to the current methods of limiting or inhibiting the growth of many pathogenic species. The gold nanoparticles synthesized with the help of *Solanum nigrum* leaf extract were expected to have free radical scavenging action as well as antibacterial static agents, which they achieved[39].

Medicine

Clinical medicine has benefited greatly from nanoparticles' contributions to drug and gene delivery as well as medical imaging. In biomedical applications, iron oxide particles like magnetite (Fe_3O_4) or its oxidized form, hematite (Fe_2O_3), are most frequently used. Because of their antimicrobial activity, Ag NPs are being used more and more in household products, wound dressings, and catheters. As drug carriers, photothermal agents, and contrast agents, gold nanoparticles are showing great promise in the treatment of cancer. The development of biodegradable nanoparticles as efficient drug delivery vehicles has attracted a lot of attention over the past few decades. Drug delivery research has made use of a variety of polymers because they can efficiently transport medications to their intended location, increasing therapeutic benefits while lowering side effects[40].

Diagnostics

NPs can assist in the visualization of particular body parts when used as imaging agents. For instance, iron oxide nanoparticles, or Fe_3O_4 NPs, have been used as MRI contrast agents to improve the visibility of organs and tissues. Because Au NPs can accumulate in some cancerous tumors, they have unique optical, electrical, and catalytic properties and are being investigated for use in diagnostics.

Tissue engineering

NPs have the ability to promote tissue and organ growth and repair. For instance, because titanium dioxide nanoparticles (TiO_2) can promote bone cell growth, they have been investigated for use in tissue engineering

Cosmetic and sunscreens

The traditional UV sunscreen doesn't use drugs that are stable over time. Sunscreen containing nanoparticles, like titanium dioxide, has many benefits. Due to their ability to both absorb and reflect UV rays while remaining transparent to visible light, titanium oxide and zinc oxide nanoparticles have found application in sunscreens. Iron oxide nanoparticles are used as a pigment in some lipsticks[41].

Protein detection

Understanding the functions of proteins, which are an essential component of the language, machinery, and structure of cells, is crucial for the continued development of human cells. In immunohistochemistry, gold nanoparticles are frequently utilized to detect protein-protein interactions. The technique of Raman scattering spectroscopy is widely recognized for its ability to identify and detect individual dye molecules. The multiplexing power of protein probes can be significantly increased by integrating both techniques into a single NPs probe. Hydrophilic oligonucleotides with a Raman dye at one end and a small molecules recognition element terminally capped are used to coat the NPs.

Biological application

Copper has shown promise in the fight against cancer, and nanoparticles have been shown to trigger both intrinsic and extrinsic apoptotic pathways for the death of cancerous cells. Hela cells, Md A-MB-231 human breast cancer cell lines, Caco-2 human colon cancer cells, HepG2 human liver cancer cells, and McF-7 human breast cancer cells are all susceptible to the anticancer effects of copper and copper oxide nanoparticles. In rats given CFA (Complete Freund's adjuvant, which simulates the course of human arthritis), copper nanoparticles enhanced antioxidant enzymes and decreased pro-inflammatory markers, demonstrating their anti-inflammatory and anti-arthritic properties. CuNPs' ability to heal wounds was demonstrated in an in vivo study on mice, where there was a notable increase in the concentration of fibrocytes that eventually formed collagen for wound contraction and repair[42].

In cancer management

AuNPs as sensors for probing and imaging tumor cells. AuNPs are good candidates for labelling applications because of their ability to interact strongly with visible light. Upon exposure to light, free electrons in gold atoms are excited to a state of collective oscillation known as surface plasmon resonance (SPR), conferring gold the ability to absorb and scatter visible light[32]. In labelling applications, AuNPs are targeted and accumulated at the site of interest and based on their optical scattering properties, they enable visualization of the region under study.

8.ADVANTAGES OF GOLD NANOPARTICLES

1. The advantages of using nanoparticles for the drug delivery result from their two main basic properties. First nanoparticles, because of their small size, nanoparticles can penetrate through smaller capillaries and are taken up by cells, which allow efficient drug accumulation at the target sites. Second, the use of biodegradable materials for nanoparticle preparation allows sustained drug release within the target site over the period of days or even weeks.
2. Nanoparticles are fairly easy to prepare that's why they are used in drug after targeting the area.
3. Due to their small size Nanoparticles penetrate small capillary and are taken up by the cell which allows for efficient drug accumulation at the target sites in the body.
4. Nanoparticles increased the therapeutic efficiency as well as bioavailability.
5. Nanoparticles do not show any problem in large scale production and sterilization but they only avoid organic solvent .
6. Nanotechnology is a growing field in many industries, including aquaculture, and it has numerous applications
7. Nanotechnology can make fabrics more durable because NPs have a high surface energy and a large surface area to volume ratio
8. Nano supplements can be easily added using the encapsulation technique for effective drug and nutritional deliver
9. Nanobarcodes are used to label food products for safety and to track their distribution.
10. Ease of modifying nanoparticles surface properties and particle size to target drugs both passively and actively after parenteral administration.

9.DISADVANTAGES OF GOLD NANOPARTICLES

1. Nanotechnology has increased risk to the health also, nanoparticles due to their small size can cause inhalation problem and many other fatal diseases by just inhaling for 60 seconds in the air contain nanoparticles can damage lungs easily.
2. Presently, nanotechnology is very expensive and developing it can cost you a lot of money. Nanotechnology has raised the standard of living but at the same time, it has increased the

3. pollution, which includes water pollution, air pollution. The pollution caused by nanotechnology is known as nanopollution. This kind of pollution is very dangerous for living organisms.
4. The disadvantages of nanoparticles are very poorly explored. So there are only a few more of them based on drug delivery
5. Producing Nanoparticles for drug delivering extensive use of polyvinyl alcohol as a detergent that create an issue on toxicity. Drug delivery with Nanoparticles shows cytotoxicity, alveolar inflammation. The disturbance of autonomic imbalance by nanoparticles having direct effect on heart and vascular function.
6. When used for drug delivery, non-biodegradable particles may accumulate at the site of the drug delivery, causing a chronic inflammatory response.
7. Because nanoparticles have limited targeting capabilities, it is not possible to stop the therapy.
8. Nanotechnology is very expensive, and it can be even more expensive to develop.

10. CONCLUSION:

In this review we had tried to describe the aim of gold nanoparticles. The main role of gold nanoparticles is imaging, scanning, diagnosis, treatment and drug delivery. These types of nanoparticles become an effective therapy of cancer which detect the tumor cells in early stage. The nanoparticles are very challenging in the future because of the high surface area of loading of drug which shows long-term effect.

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