A Review on Gold Nanoparticle: An Emerging Trend in Nanomedicine and Biomedical Application

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ABSTRACT

Nanotechnology has become a recent trend and one of the most interesting and advanced areas of research. The advantage of using nanoparticles include improved bioavailability, targeting the drug to a specific location in the body, and to provide a controlled release therapy. Among nanoparticles, gold nanoparticles contribute to advances due to their unique properties. These particles are widely used in various biomedical applications & as a drug delivery system due to their inert nature, high dispersity, and biocompatibility. This review describes the preparation, evaluations, and applications of gold nanoparticles in biomedical fields and targeted drug delivery.
INTRODUCTION:

The term “nano” is derived from the Greek word “Nanos” which means small. Nanoparticles are of size 1 – 100 nm. These particles have special and enhanced physical as well as chemical properties, compared to their bulk materials due to their large reactive and exposed surface area and quantum size effect. These particles are widely used in various fields such as electronics, photochemical, biomedicine, and chemistry. Inorganic nanoparticle possesses certain physical, chemical, optical, and electrical properties which make them different and more applicable than large size materials \[1\].

Nanoparticle provides a multi-functional platform because it can be used for imaging, therapeutic and diagnostic purposes. Among this, inorganic platforms are most important for diagnosis and simultaneous therapy due to their easy modification, stability, and high drug loading capacity \[5\]. Recently, they had possessed a wide range of applications in the biomedical field such as to deliver pharmaceutics, due to the small-sized particles they can be used for targeted drug delivery \[3\]. They enhance the selectivity and efficiency of the drug delivery system because they act as mediators for drug release. They are having an extremely small size and high surface area due to which their surfaces have been available for modification with hydrophobic, hydrophilic, cationic, anionic or any neutral moieties to the surrounding environment therefore they have many applications in biological sciences \[6\]. Drug delivery systems based on nanoparticles have been a great route for targeting malignant brain tumors where conventional therapy is not as effective \[10\]. Enhanced permeability and retention (EPR) are another unique property of nanoparticles which helps to accumulate and interact with the tumor cells. The interaction of nanoparticles and the vascular pathway plays an essential part in the management and prevention of cardiovascular disease \[7\].

FIG -1: Nanoparticle
Among nanoparticle, metallic nanoparticles especially the gold nanoparticles proved to be the safest and much fewer toxic agents for drug delivery and hypothermic agents for the cancer treatment. These have abundant use in the field of biotechnology and biomedicine because they have large surface bioconjugation with molecular probes $^{[4]}$. The main properties of nanoparticles that are made effective for the delivery of drugs include monodispersed, lack of cytotoxicity, and a simple mechanism of interaction with desired ligands. Based on these characteristics they have been synthesized and used in cancer treatment, drug delivery systems, and imaging such as dendrites, quantum dots, polymer gels, gold nanoparticles $^{[15]}$.

**GOLD NANOPARTICLES:**

Gold is inert and is generally regarded as a biocompatible. The properties of gold nanoparticles are different from their bulk form $^{[12]}$. The bulk gold is a yellow solid which is inert while gold nanoparticles are wine red solution and are reported to be anti-oxidant. Gold nanoparticles exhibit various sizes ranging from 1 nm to 8 μg and exhibit different shapes such as spherical, sub-octahedral, octahedral, decahedral, multiple twined, multiple twined, irregular shape, tetrahedral, nano triangles, nano prisms, hexagonal platelets, and nanorods $^{[13]}$. Use of a single active substance from plant extract during the synthesis of gold nanoparticles is an important biosynthesis technique, to purify gold nanoparticles and to determine their medical uses $^{[9]}$. 

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**Figure No. 2: Drug delivery using nanoparticle**

Gold nanoparticles have been widely used in the field of radiation medicine as radiation enhancers due to the efficient and targeted drug delivery to the tumor site. They have various applications in biomolecular ultra-sensitive detection, killing cancer cells by hypothermal treatment, labeling for cells and proteins, and delivery of therapeutic agents within cells. Fluorescent nanoparticles or nanoprobes-based gold nanoparticles have good biocompatibility for molecular imaging which is necessary for cellular functions in cancer [2]. Gold nanoparticles are recently used in biomedical science including tissue or tumor imaging, drug delivery, photothermal therapy, and immune chromatographic identification of pathogens in clinical specimens due to the surface Plasmon resonance (SPR) [25]. The second major advantage of using gold nanoparticles is that they are non-cytotoxic, so they can bind with organic molecules easily and can be used as therapeutic agents or as vaccine carriers to specific cells thereby increases the efficiency of drugs and destroy pathogens. Another benefit is regarding their surfaces, they have a large surface area and are readily available for modification with targeting molecules or specific biomarkers and applicable in biomedical purposes [2].

Gold colloids have been used in the surface modification of ideal electrodes due to their stability, high biocompatibility which is necessary to retain the native structure and enzymatic activity of the attached proteins or enzymes [11]. Gold nanorods can be used in biological applications due to their specific optical, chemical property, compatibility, conjugation of these particles to the biomolecules [18]. These are suitable for potential applications in the fields of biosensing, gene delivery, and photothermal therapy and also in vivo imaging due to the plasmon resonance absorption and scattering of light in the near-infrared region [31]. Colloidal gold nanoparticles have also gained attention, due to their easy preparation through chemical methods and can be easily imported to the tissues and cells because of their very small size which is equal to the biological molecules like DNA and proteins [29].
Gold nanoparticles have a strong affinity for alkynes as compared to other transition metal catalysts but the homogeneous systems are not favorable economically and environmentally due to the rapid reduction of active gold complexes into inert metallic gold \(^{[30]}\). Combination of gold nanoparticles into smart polymer like poly (N-isopropyl acrylamide) is an effective process to enhance the various properties of the polymer such as showing the swell of collapse reversibility in response to the temperature stimuli \(^{[14]}\).

![Figure No. 4: Different shapes of gold nanoparticle](image)

**PROPERTIES OF NANOPARTICLES:**

1. **PHYSICAL PROPERTIES OF NANOPARTICLES:**

Physical properties of nanoparticles include: Size and Shape, Specific surface area, Agglomeration/aggregation, State of size distribution, Surface morphology/topography, and Structure including Crystallinity, Solubility \(^{[25]}\).

- **SIZE AND SHAPE:**

Nanoparticles below 20–30 nm in size are characterized by an excess of energy at the surface and are thermodynamically unstable due to the interfacial tension, which acts as a driving force, which leads to a spontaneous reduction of the surface area \(^{[8]}\). When the size decreases, the molecules present at the particle’s surface increases. Various shapes of nanoparticles such as spheres, rods, tubes, fibers, and disks, and more extraordinary geometries such as worms, squares, urchins, and ellipsoids. The optical properties of nanoparticles depend on their size and shape.
SURFACE AND SIZE DISTRIBUTION:

Dynamic light scattering (DLS) enables evaluation of the size distribution of nanoparticles, and Zetentaler can be used to determine the surface charge of nanoparticles. Compared to nanoparticles having a neutral or negative charge, positively charged ones are taken up at a faster rate. The dispersion status of nanoparticles in aqueous media depends on the surface charge and the effect of different parameters such as dispersion, surface properties, and agglomeration and de-agglomeration can be controlled using Ultrasonication, ionic strength and pH of aqueous solutions, physiological buffers, and cell culture media using a Scanning electron microscope (SEM) respectively.[12]

STRUCTURAL AND SPECIES SPECIFIES 0F NANOPARTICLES

X-ray diffraction (XRD) is an essential tool to characterize crystal structures. They provide information about the given material’s space group and structural parameters etc.[15].

2. CHEMICAL PROPERTIES OF NANOPARTICLES:

Chemical properties include the elemental composition of nanomaterial and its surface chemistry such as Zeta potential and Photocatalytic properties. The chemical properties are determined by the type of motion of its electrons.[16].

CHARACTERISATION OF GOLD NANOPARTICLES:

1. UV- VISIBLE SPECTROSCOPY:

An ultraviolet-visible spectrophotometer with a diffuse reflectance sphere for solid-phase samples was to determine the surface Plasmon resonance (SPR) for metallic gold. About 10 mg of the sample was mixed with potassium bromide (to reduce the concentration of sample) placed in a cell holder. The absorbance was recorded in the range of 200-800 nm.

2. XRD SPECTROSCOPY:

An X-ray diffractometer was used to investigate the crystal structure of No and Au/No. The sample was grounded and pressed into the sample holder to get a smooth plane surface, and the diffraction pattern was recorded over a 2θ range of 30° -120°. The diffractogram obtained was compared to the standard database of the International center of diffraction data (ICCD) [17].
3. TEM SPECTROSCOPY:

TEM images were obtained with a Phillip CM12 microscope at 80 kV. The sample was suspended in ethanol and homogenized for 15 min using a solicitor. One drop of the unsettled suspension was placed on a copper grid and the solvent was allowed to dry at room temperature. The average diameter of particles was calculated by measuring 100-300 individual particles with SIS Soft Imaging GmbH image analysis software.

4. SEM SPECTROSCOPY:

The morphological features of the particles were studied with a scanning electron microscope (SEM) with a FESEM 50VP, Leo SUPRA instrument. A minimal amount of sample was placed on carbon tape for SEM analysis. An energy-dispersive X-ray detection instrument (EDX) was used to examine the elemental composition of the sample.

5. ATOMIC ABSORPTION SPECTROSCOPY:

The sample was digested with aqua regia and diluted with distilled deionized water. Aqua regia was prepared by mixing 1-part concentrated HNO3 with 4 parts concentrated HCl to dissolve the gold. Elemental analysis of the amount of gold in the sample was done using an atomic spectrometer at a wavelength of 243 nm\textsuperscript{17,30}.

SYNTHESIS TERMINOLOGY AND CONCEPTS:

a) Nucleation - Nucleation is the first step in the formation of either a new thermodynamic phase or a new structure via self-assembly or self-organization. Nucleation is typically defined to be the process that determines how long an observer has to wait before the new phase or self-organized structure appears. It is the arrangement of a small number of molecules in a pattern.

b) Growth - Crystal growth is a major stage of a crystallization process and consists of the addition of new atoms, ions, or polymer strings into the characteristic arrangement of a crystalline Bravais lattice.

c) Aggregation - The growth of branched clusters and networks may proceed through the formation of reversible (physical) or irreversible (chemical) bonds.

d) Agglomeration - According to the IUPAC definition, flocculation is "a process of contact and adhesion whereby the particles of a dispersion form larger-size clusters." Flocculation is
synonymous with agglomeration and coagulation/coalescence. Molecules are joined loosely in solid-state but can be broken down.

e) Supersaturation - There is a point when a solution contains more solute than the solvent can dissolve. This solution is known as a supersaturated solution.

f) Precursor - A precursor is a compound that participates in a chemical reaction that produces another compound.

g) Electrostatic Stabilization - Electrostatic stabilization of Colloids is the mechanism in which the attraction van der Waals forces are counterbalanced by the repulsive Coulomb forces acting between the negatively charged colloidal particles.

h) Stabilizing agent - It refers to a chemical that inhibits separation of suspensions, emulsions, and foams. It prevents the aggregation of particles.

i) Capping agent- It is used to aid the stabilization of nanoparticles. A capping agent is used to protect the surface of materials. It prevents degradation and can help preserve different properties of the material [33].

Figure No. 5: Different phases of reaction and different color of solutions for different size of gold nanoparticles

PREPARATIONS OF GOLD NANOPARTICLE:

1) SYNTHETIC METHOD:

Techniques for making different gold nanoparticles can be categorized into two principles, the “bottom-up” method or “top-down” methods. These methods generate gold nanoparticles with the desired size and shape [11].
Some of the more commonly used techniques involving the “bottom-up” method for making gold nanoparticles are discussed below.

- **TURKEVICH METHOD:**

   The Tonkovich method was commonly used for the synthesis of spherical gold nanoparticles in the size range of 10 nm-20 nm. The principle of this method involves the reduction of gold ions to gold atoms in the presence of reducing agents like citrate, amino acids, ascorbic acid, or UV light. Size is further stabilized using various capping/stabilizing agents. The major limitation of this method is the low yield and the restriction of using water as the solvent.[21]

- **BRUST METHOD:**

   This method is a two-phase process to generate 1.5 nm -5.2. nm gold nanoparticle using organic solvents and by varying the ratio of thiol to gold[9]. The Brust method was inspired by Faraday’s two-phase system. The method involves the transfer of gold salt from an aqueous solution to an organic solvent (e.g. toluene) using a phase transfer agent (e.g., tetraethylammonium bromide (TOAB). The gold is then reduced using sodium borohydride in presence of an alkanethiol. The alkanethiols stabilize, resulting in a color change of the reaction from orange to brown[17].
MISCELLANEOUS METHOD:

Digestive ripening has proven to be a convenient method to generate monodisperse gold nanoparticles from polydisperse nanoparticles by using excessive ligands (digestive ripening agents). The process involves heating a colloidal suspension at high temperatures (~138 °C) for 2 minutes followed by 110 °C for 5 hours in presence of alkanethiols. Temperature plays an important role in controlling the size distribution of the gold colloids produced. Various ligands that are used for the digestive ripening process include thiols, amines, silanes, phosphines. Also, other utilized methods involving ultrasonic waves, microwaves, laser ablation, solvothermal method, electrochemical and photochemical reduction, etc.[26].

2) BIOSYNTHESIS OF GOLDS NANOPARTICLES:

The major drawback of synthetic methods is the requirement for, and generation of, toxic byproducts that may prove to have environmental consequences during large scale production. The use of toxic chemicals and solvents in these methods may prove to be problematic for downstream biological applications of gold nanoparticles [18]. The development of non-toxic methods has embraced the principles of green chemistry, such as the use of rapidly biodegradable reagents, limiting waste products, synthesis at ambient temperature and pressure, and low toxicity of chemical products.

Biological synthesis of gold nanoparticles using components like carbohydrates, lipids, nucleic acids, or proteins produced in nature, is a fast-growing area of research to synthesis in a clean, eco-friendly, non-toxic method. Also, this method is having additional advantages such as wide availability, low cost of production, ease of synthesis, and environmentally safe [7].

EVALUATION OF GOLD NANOPARTICLES:

a) SIZE EVALUATION:

The evaluation of the average size of gold nanoparticles based on the fitting of their UV is spectra by the Mie model for spheres [25]. It has been successfully applied to free and functionalized gold nanoparticles in various solvents with diameters in the 4–25 nm range. Despite the differences among samples, an accuracy of about 6% on the nanoparticle's average size concerning sizes measured by transmission electron microscopy (TEM). Moreover, the fitting model provides other information not available from TEM like the
concentration of gold nanoparticle in the sample and the fraction of non-spherical nanoparticles, which is particularly useful for measuring aggregation processes [28].

b) TOXICITY EVALUATION OF GOLD NANOPARTICLE:

The progressive increase in the usage of gold nanoparticles in industrial and commercial products leads to the potential release of nanoparticles into the environment, which could cause adverse effects on living systems. In the present work, the size- and dose-dependent cytogenetic effects of gold nanoparticles towards a plant system were evaluated by a simple and cost-effective bioassay.

Citrate-capped gold nanoparticles of three different sizes, 15 (Au15), 30 (Au30), and 40 (Au40) nm, were synthesized by a citrate reduction method. The mean hydrodynamic diameter and morphology of as-synthesized gold NPs were characterized by dynamic light scattering and transmission electron microscopy analyses [14].

c) STRUCTURAL AND FUNCTIONAL EVALUATION:

The bactericidal efficacy of gold nanoparticles conjugated with the antibiotics was evaluated. The conjugation of nanoparticles was confirmed by dynamic light scattering (DLS) and electron microscopic (EM) studies. Such gold nanoparticles conjugated antibiotics showed greater bactericidal activity in standard agar well diffusion assay [16,30].

Due to its small size, high surface area ratio, and being chemically inert gold act as an active vehicle that binds specifically to the tumor. The gold nanoparticle produces a covalent bond with the cytotoxic drug and doesn’t react with any other molecules. Infra-red light is used to oscillate the gold nanoparticle attached with the cancer cell and energy formed due to oscillation as heat and at sudden temperature increase kills the cancer cells [27].

ADVANTAGES OF GOLD NANOPARTICLES:

- Gold nanoparticles mediated drug delivery systems have many advantages over other nanocarriers as well as to conventional drugs.
- They have been widely used as a cancer antigen and in tumor therapies.
- Gold nanoparticles have unique optical, physical, and chemical properties due to their size and shape.
They have a high surface area that provides dense drug loading.

These particles are biocompatible and are readily available for conjugation with small biomolecules such as proteins, enzymes, carboxylic acid, DNA, and amino acids.

They have controlled dispersity.

Due to small size and uniform dispersion they can easily reach to the targeted site.

They are non-cytotoxic to the normal cells.

They can be easily synthesized by various methods\(^{[10]}\).

**DISADVANTAGES OF GOLD NANOPARTICLES:**

- Drug resistance.

- Lack of selectivity and drug solubility.

- Dynamic change and only a small amount of drug reach to cancer cells.

- Serious side effects of chemotherapy.

- Poor targeting of heterogenic tumors.

- Inability of the drug to enter the core of tumors, resulting in impaired treatment with reduced dose and low survival rate\(^{[10]}\).

**APPLICATIONS:**

The range of applications in the areas of medicine, biology, and electronics has attracted a lot of attention over the last decade.
Gold nanoparticles are good candidates for labeling applications because of their ability to interact strongly with visible light. In labeling applications, they are targeted and accumulated at the desired site. They can be detected in the following ways: phase-contrast optical microscopy, darkfield microscopy, photothermal imaging, and photo imaging. Also, owing to its high atomic weight.

Gold nanoparticles have unique electric and magnetic properties due to their shape and size so they have been received great attention in research areas especially in the field of biological tagging, chemical and biological sensing, optoelectronics, photothermal therapy, biomedical imaging, DNA labeling, microscopy, and photoimaging, surface-enhanced Raman spectroscopy, tracking and drug delivery, catalysis and cancer therapy.

Table No. 1: Application Based On Various Shapes

<table>
<thead>
<tr>
<th>SHAPE</th>
<th>SIZE</th>
<th>APPLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nanorod</td>
<td>2-5nm</td>
<td>Drug delivery&amp; photothermal therapy</td>
</tr>
<tr>
<td>Hollow Particle</td>
<td>25nm</td>
<td>Photoelectronic, catalysis and cancer therapy</td>
</tr>
<tr>
<td>Triangular Particle</td>
<td>3.85-7.13nm</td>
<td>Highly effective against <em>E.coli</em> and <em>K.pneumonia</em></td>
</tr>
<tr>
<td>Faceted Particle</td>
<td>50-100nm</td>
<td>Effective, reproducible, and stable large-area substrates for NIR SERS</td>
</tr>
<tr>
<td>Nanocube</td>
<td>50nm</td>
<td>Refractive index sensing</td>
</tr>
<tr>
<td>Nanobelt</td>
<td>50nm</td>
<td>Strain sensor</td>
</tr>
<tr>
<td>Branched Particle</td>
<td>90nm</td>
<td>Substrate for SERS based imaging of kidney cells</td>
</tr>
</tbody>
</table>
Gold nanoparticles-based sensors can be used to detect various metal ions by working on the principle of color change due to the aggregation of gold nanoparticles. These types of sensors have been used for the detection of copper, mercury, lead, and arsenic in water. Noble metals such as gold nanoparticles play a key role in the synthesis of biosensors due to large surface area, small size, good biocompatibility, conductivity, and excellent catalytic properties.[25]

Another important application of gold nanoparticles is in memory devices. Gold nanoparticles coated with suitable insulators exhibit excellent stability for memory devices and this insulation helps in the prevention of accumulation of charges when the applied field has been removed.[17]

BIOMEDICAL APPLICATION OF GOLD NANOPARTICLE:

Biomedical applications of gold nanoparticles include diagnostics, genomics, biosensors, phototherapy of cancer cells or tumors, targeted delivery of drugs, bioimaging, etc.

CANCER / TUMOR TREATMENT:

Conventional strategies for cancer treatment include surgery, chemotherapy, and radiation therapy. Most studies of gold nanoparticle-based cancer therapy have used photothermal therapy for the destruction of cancer cells or tumor tissue, which may be potentially useful in the clinical setting. When irradiated with focused laser pulses of suitable wavelength, targeted gold nanospheres, nanorods, nanoshells, and nanocages can kill bacteria and cancer cells.[30]

Treatment of Cancer, generally, is extremely challenging. Even when severe cancers get treated, some residual tumor cells get left behind, if untreated, eventually reintroduce cancer. Several methods were introduced to detect and eliminate these residual cancer cells. One such innovative method describes the engulfing of numerous nanoparticles by cancer cells, which eventually helps to destroy these residual cancer cells, without causing significant harm to the cells of the organs the tumors bind with. This method uses the concept of Plasmonic Nano Bubble nanosurgery often known as PNB to detect and eliminate these residual cancer cells. Studies show that this surgical method prevented the reintroduction of cancer and came across 100% tumor-free survival.[34]

Cancer nanotechnology is an interdisciplinary area with broad potential applications in fighting cancer, including molecular imaging, molecular diagnosis, targeted therapy, and
bioinformatics. The continued development of cancer nanotechnology holds the promise for personalized oncology in which genetic and protein biomarkers can be used to diagnose and treat cancer based on the molecular profile of each patient. Gold nanoparticles have been investigating in diverse areas such as in vitro assays, in vitro and in vivo imaging, cancer therapy, and drug delivery.[28]

**BIONANOMEDICINE:**

Gold nanoparticles have truly revolutionized the field of bio nanomedicine which is evident from its numerous existing applications. The applications of gold nanoparticles skyrocketed due to the advancement of nanoscale analytical tools. The use of toxic chemicals and solvents had sown the seed for developing biological methods which can be more eco-friendly and bio-friendly, utilizing the combined reduction and capping the ability of various biological sources such as plants, microorganisms, and biomolecules for making gold nanoparticles.[22] Green chemistry synthesis routes are environment friendly and non-toxic. The biosynthesis method for the preparation of gold nanoparticles was reported by using the natural biomaterial eggshell membrane (ESM) and also by using edible mushroom via sunlight exposure. Gold nanoparticles were successfully synthesized by adopting the sunlight irradiation method and were modified with folate acid and capped by 6-mercaptopurine.[32,33]

**GOLD NANOPARTICLE-MEDIATED DRUG DELIVERY:**

![Gold nanoparticle-mediated drug delivery](image)

**Figure No. 8: Gold nanoparticle-mediated drug delivery**

Targeted drug delivery is better than conventional drug therapy as they target the drug to be delivered at the main affected area, locally so it minimizes the side effects caused by conventional drugs.[34] Targeted drug delivery is an interesting area for scientists recently and
works have been done to synthesized systems for targeted drug delivery such as nanoparticles, quantum dots, polymer gels, Fe3O4, and ZnO [18]. Gold nanoparticles have the ability of bio-imaging of the affected cancerous cells for therapy. For an effective drug delivery system or drug therapy, it is important to investigate about the biological effects of the nanoparticles gold nanoparticles have unique physical and chemical properties and have a strong binding attraction for thiols, proteins, carboxylic acid, aptamers, and disulfides so they have been extensively used in the field of biosciences especially in drug delivery for cancer therapy. Gold nanoparticles are followed three main pathways for the cellular uptake which include receptor-mediated endocytosis, phagocytosis, and fluid-phase endocytosis [31]. There are two factors, i.e. drug release and transport, which are very important for the efficient drug delivery system. Drugs are loaded on nanocarriers by noncovalent interaction or through covalent conjugation with the help of pro-drug, which is treated by the cell. Gold nanoparticles have functional flexibility due to their monolayers so they provide an efficient system [32]. Gold nanoparticles work as a non-toxic carrier of drugs. Gold nanoparticles can deliver large biomolecules, without themselves having to act as carriers for just small molecular drugs [34].

FUTURE SCOPE OF GOLD NANOPARTICLES:

The field of nanotechnology is a highly developing field because of its wide applications in science and technology. Outlining and advancement of novel and affordable techniques for scale-up production of nano-materials have not only given a fascinating area of study but in near future will also address the growing human necessities including health safety and environmental issues etc. In the industries, the application of nano-particles is increasing extensively by the day, and they will soon in the future be able to replace the toxic chemicals currently used as antimicrobial agents. Another development, being worked on is that of, the building of computer memory using. Gold nanoparticle integrated into a water purification device can adequately catch and remove halocarbon-based pesticides from drinking. In cancer treatment, gold nano-particles is emerging as a recent trend, where cancer cells are destroyed by zapping nano-bubbles method, future work is in progress. Potential applications for this technology are also being developed in the flexible electronics area, where research is going on in producing less harmful electrode brain-implants using gold nanoparticles for treating Parkinson's, epilepsy, and other diseases. Future work is still undergoing gold nanoparticle applications, as this might turn out to be very useful in a lot of industries including biomedical engineering, nanobiotechnology, and also electronic engineering. They
can be applied to many different applications across the field of biology and medicine, environment, and technology\textsuperscript{[32,34]}.

**CONCLUSION:**

Gold nanoparticles have, in some ways, revolutionized the field of medicine because of its widespread applications in targeted drug delivery, imaging, diagnosis, and therapeutics due to their extremely small size, high surface area, stability, non-cytotoxicity, and tunable optical, physical, and chemical properties. Functionalized gold nanoparticles with various biomolecules such as proteins, DNA, amino acids, and carboxylic acids have been used in cancer therapy and provide an excellent drug delivery system. Gold nanoparticles have truly revolutionized the field of bio nanomedicine. Targeted delivery and programmed release of therapeutic drugs to the specific site is achieved by using gold nanoparticles because they can bear high drug load and release it to the specific site through various administration routes and can interact with the cancerous cell. Side effects of conventional drugs have been minimized by conjugation with gold nanoparticles and they increase the quality life of patients\textsuperscript{[31,34]}.

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**REFERENCES:**

6. Chithrani BD, Ghazani AA, Chan WC. Determining the size and shape dependence of gold nanoparticle uptake into mammalian cell.2006
30. www.wikipedia.com