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# Gold Nanoparticles: Overview

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**ABSTRACT**: Nanotechnology is a rapidly developing field nowadays. Gold nanoparticlesare one of thequintessential nanoparticles in the field of nanotechnology. This article provides an overview of gold nanoparticles and their significance. It begins with a brief introduction of nanotechnology and nanoparticles, then goes on to the size, shape and colour of gold nanoparticles. Furthermore, it explains the various approaches for the synthesis of the gold nanoparticle. And finally, it focuses on the properties and the applications of the gold nanoparticles in pharmaceutical and medical field.
**KEYWORDS:**Gold nanoparticles, Nanotechnology, Synthesis, Cancer therapy.

## I. INTRODUCTION

Norio Taniguchi was a professor of Tokyo University of Sciences. He coined the term "Nanotechnology" in 1974.Nano-technology' mainly consists of the processing of separation, consolidation, and deformation of materials by one atom or one molecule[1]. "Nano"- this word is derived from a Greek word "Nanos" which means small. It is used as the prefix for one billionth parts.According to the American society for testing and materials (ASTM international 2006), nanoparticles are those particles which have two or more than two dimensions in the size range of 1-100 nm [2].Nanomedicine is defined as the area using the concepts of nanotechnology for the benefit of human's health and well-being [3]. Nanomedicine is rapidly developing field nowadays. It brings a new platform for delivering drugs to precise targets.

Gold Nanoparticles are one of the prime candidates in the targeted drug delivery system. Gold nanoparticles have unique properties like robust and simple production processes, surface functionalization, distinctive optical and photo thermal capabilities. This set apart gold nanoparticlesfrom the other traditional nanoparticles and conventional drugs.

## II. SIZE, SHAPE

Gold nanoparticles exhibit various sizes ranging from 1 nm to 8 µm and they also exhibit different shapes such as spherical, sub-octahedral, octahedral, decahedral, icosahedral multiple twined, multiple twined, irregular shape, tetrahedral, nanotriangles, nanoprisms, hexagonal platelets and nanorods [2]

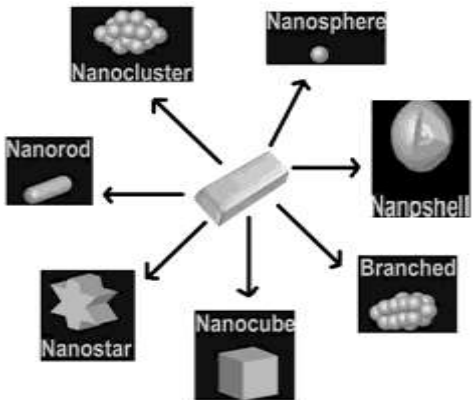


Figure 1: Various shapes of gold nanoparticles [2]

Different shapes of the gold nanoparticles show different properties. Their characteristics also depend upon their shapes for example:

- Gold Nanosphere: Nanospheres consist of a gold coating over a silica core.[4]. It is also one of the most often employed gold nanostructures in drug-delivery applications [5].
- Gold Nanorods: These solid cylinders of gold have a diameter as small as 10 nm [4].It is extensively employed in photo thermal and near infra-red (NIR) applications [5].
- Gold Nanotriangles: It show attractive optical properties as compared to the spherical shaped nanoparticles [2].

Gold nanoparticles are relatively tiny in comparison to light wavelengths, absorbing light in the blue-green section of the spectrum (450nm) and reflecting red light (700nm), giving gold nanoparticles a deep red colour (ruby gold) [6].

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## III. SYNTHESIS

There are physical, chemical and Microbial approaches for thepreparation of gold nanoparticle.

Physical approach consists destruction of the crystal lattice of the material and to convert it into the nanoparticles. It consists methods such as laser ablation, cathode sputtering and electric arc dispersion. Top-down strategy mostly falls under the physical approach of nanoparticle synthesis.Top-down strategy rely on size reduction of bigger particles utilising equipment designed for material removal from bulk to build nano-sized ring structures [7]. The top-down technique is a subtractive procedure that begins with bulk material slicing and ends with self-assembled nanoscale objects [8]

Disadvantages of Physical approach [8] =

- Manufacturing nanoparticles of uniform size is difficult
- limitations in controlling the surface and structure of gold nanoparticles
- Uncontrolled size distribution
- High energy consumption
- Very unprofitable
- Low purity
- It is highly reactive or toxic in nature for human consumption or to the environment [9]

Chemical approach is based upon the chemical reactions. It consists procedures such as reduction in solution, followed by the nanoparticle precipitation, formation and stabilization. Bottom-up strategy mostly falls under the chemical approach of synthesis. The bottom-up strategy involves a gradual build-up of nanoparticles from individual atom or molecules [7].

Advantages of Chemical approach =

- more convenient, efficient, and customizable than physical approach [8]
- large-scale manufacturing [8]
- preparation of smaller nanoparticles with superior control over the size [7]
- Most widely used

Disadvantage of Chemical approach=

- It is highly reactive or toxic in nature for human consumption or to the environment [9]
- Expensive

Microbial approach comprises a range of biological resources ranging from prokaryotes to eukaryotes to synthesize nanoparticles[6] It uses microorganisms as reducing agents, such as fungus, bacteria, algae, viruses, and plants, among which algae is known as the "bio-nano factories"[9].

The bacteria Rhodopseudomonascapsulata was screened and found to successfully produce gold nanoparticles of different sizes and shapes. The important parameter, which controls the size and shape of gold nanoparticles, was pH value [10]

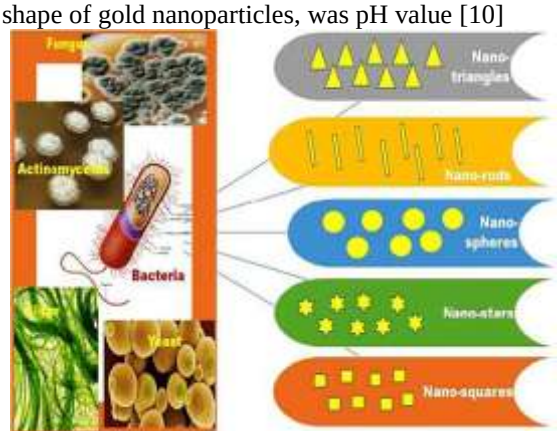


Fig. 2. The gold nanoparticle with different shapes produced from various microbial sources [9].

Advantages of Microbial approach [9] =

- Healthy and environment-friendly methods
- Don't require the exploitation of the toxic chemicals
- Environmentally effective
- Affordable
- Uniquely structured, macroscopic
- Have a high capability of metal uptake

## IV. PROPERTIES

Firstly, Gold nanoparticles are considered to be relatively biologically non-reactive as compared to the very toxic cadmium and silver nanoparticles. Secondly, it's easy to control AuNP shape and size during synthesis. Thirdly, AuNP surface chemistry is easily controllable thus we can attach variety of ligands to it [11]. These surface modifications give AuNPs an outstanding biocompatibility, targeting and drug delivery capabilities [12].

AuNP is also advantageous due to its strong optical properties like localized surface plasmon resonance (LSPR) [11].LSPR, radioactivity and high X-ray absorption coefficient of gold nanoparticles are widely used in the diagnosis and treatment of tumours [12].Because of all these unique properties gold nanoparticle has become the first choice for researchers, particularly in the pharmaceutical field.

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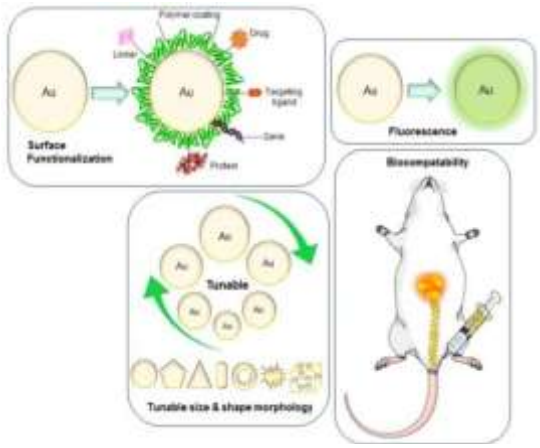


Figure 3. Important properties of gold nanoparticles [13].

## V. APPLICATIONS

One of the most important applications of gold nanoparticles in medicine is photothermal treatment. Gold nanoparticles' capacity to absorb light and convert it to heat which is used to destroy cancer cells, germs, and viruses [14]. This property of AuNP enables effective laser therapy with minimal "collateral damage" to the surrounding healthy tissue. The mechanism by which AuNPs exert their photothermal effect is through SPR [11].

AuNPs are multivalent. We can attach variety of functional groups and antibodies to them. AuNPs use as vehicles for delivery of drug molecules and antibodies into cells. Therefore, they are described as "promising nanocarriers for therapeutics [11].

Radiation therapy is one of the most commonly used treatments for cancer. The dose of delivered ionizing radiation can be amplified by the presence of gold nanoparticles because of its high photoelectric effect [14]

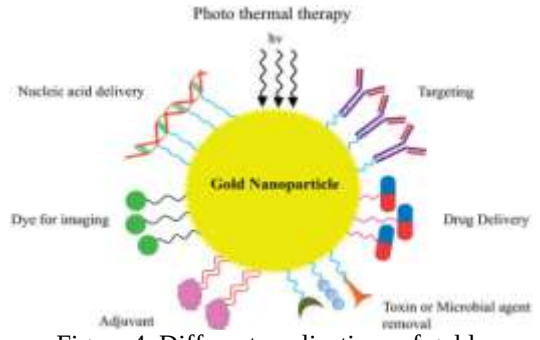


Figure 4. Different applications of gold nanoparticles in the diagnosis and therapy of cancer [17]

Apart from the being useful in the various cancer treatments AuNPs have many different applications in other areas of life too. For example, in the over-the-counter First Response® pregnancy test (Carter–Wallace), intense optical properties of gold nanoparticles are used as a chemically-stable, highly visible optical indicator [15]. In First Response® pregnancy test gold nanoparticles are deposited at 2 locations on a pregnancy test strip, forming the "control line" and the "testline."These AuNPs may appear as off-white/slightly grey lines on the test strip – before or after use. If hCG is present in the urine, both the test line and control line will appear pink. Two pink lines indicate a positive result. If no hCG is detected in your urine, only the control line will appear pink coloured [16].

## VI. CONCLUSION

Gold Nanoparticles are the potential candidate in the Novel drug delivery system.They show wide range of unique properties such as high bioavailability and safety, surface functionalization, tunability, ease of production and strong optical properties. Therefore, Gold nanoparticles are considered as multifunctional and plays an important role in the diagnosis and treatment of the many types of cancer. However, gold nanoparticle's research is still at its infancy. There is still a requirement for more cost-effective gold nanoparticle-based innovations. Advancement in the research of gold nanoparticles can minimize a suffering of the cancer patients by mitigating the side effects of current cancer therapy.

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