REVIEW

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# A REVIEW ON NANOPARTICLES

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**ABSTRACT:**

Nanoparticles are spherical, polymeric particles composed of natural or artificial polymers. A nanoparticle is the most fundamental component in the fabrication of a nanostructure. Their size is ranges between 1 and 500 nm. As these particles have spherical shape and high surface area to volume ratio, so these particles are used in a wide range and have potential application. Inn this review, we have endeavoured to briefly explain the nanomaterials, their properties, different method of their preparation and hoe they are used as a potent delivery of drugs or therapeutic molecules.

**KEY WORDS:** Nanoparticles, Polymers, Targated Drug Delivery, Organic nanoparticles, Carbon nano tubes.

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## 1. INTRODUCTION

Nanotechnology is the science that deals with matter at the scale of 1 billionth of a meter (i.e., $10^{-9}$ m = 1 nm), and is also the study of manipulating matter at the atomic and molecular scale. A nanoparticle is the most fundamental component in the fabrication of a nanostructure, and is far smaller than the world of everyday objects. (1) The word "nano" is derived from a greek word "nanos" which means very small or dwarf. The particles with 1 and 100 nm size are termed as nanoparticles. Nanoclusters have at least one dimension between 1 and 10 nanometres and a narrow size distribution. (2) As the nanoparticles have greater surface area, the properties of conventional products will change when they come from nanoparticles.

Nanoparticles may not exhibit size related properties but they differ from the fine particles or bulk materials. Nanoparticles are usually distinguished from microparticles (1-1000 µm), "fine particles" (sized between 100 and 2500 nm), and "coarse particles" (ranging from 2500 to 10,000 nm), because their smaller size drives very different physical or chemical properties, like colloidal properties and optical or electric properties. Being more subject to the Brownian (3) motion, they usually do not sediment, like colloidal particles that conversely are usually understood to range from 1 to 1000 nm. Being much smaller than the wavelengths of visible light (400-700 nm), nanoparticles cannot be seen with ordinary optical microscopes, requiring the use of electron microscopes or microscopes with laser. Nanoparticles also easily pass-through common filters, such as common ceramic candles, (4) so that separation from liquids requires special nanofiltration techniques.

The properties of nanoparticles often differ markedly from those of larger particles of the same substance. Since the typical diameter of an atom is between 0.15 and 0.6 nm, a large fraction of the nanoparticle's material lies within a few atomic diameters from its surface. Therefore, the properties of that surface layer may dominate over those of the bulk material. This effect is particularly strong for nanoparticles dispersed in a medium of different composition since the interactions between the two materials at their interface also becomes significant. (5)

Nanotechnology is currently employed as a tool to explore the darkest avenues of medical sciences in several ways like imaging, sensing, (7) targeted drug deliverygene delivery (8) systems, and artificial implants. (9) The new age drugs are nanoparticles of polymers, metals, or ceramics, which can combat conditions like cancerand fight human pathogens like bacteria.Applying nanotechnology in treatment, diagnosis, monitoring, and control of diseases has been referred to as "nanomedicine." Although the application of nanotechnology in medicine appears to be a relatively recent trend, the basic nanotechnology approaches for medical application date back to several decades. (6). In this article we discussed bout the history synthesis and application of the nano particles.

## 2. HISTORY OF NANOPARTICLES

History of Nanoparticles dates back to 9$^{th}$ century in Mesapotamia. Artisans used these to generate a glittering effect on the surface of pots (10,11) This glitter over pottery is due to a metallic film that was applied to the transparent surface of a glazing.

The optical property is one of the fundamental attractions and a characteristic of a nanoparticle. For example, a 20-nm gold nanoparticle has a characteristic wine-redcolour. A silver nanoparticle is yellowish grey. Platinum and palladium nanoparticles are black. Not surprisingly, the optical characteristics of nanoparticles have been used from time immemorial in sculptures and paintings even before the 4th century AD. The most famous example is the Lycurgus cup (fourth century AD)(12).

In 1990, the scientists analysed the cup using a transmission electron microscopy (TEM) to explain the phenomenon of dichroism (13). The observed dichroism (two colours) is due to the presence of nanoparticles. X-ray analysis showed that these nanoparticles are silver-gold Ag-Au alloycontaining in addition about 10% copper (Cu) dispersed in a glass matrix (14,15). The Au nanoparticles produce a red colour as result of light absorption. The red-purple colour is due to the absorption by the bigger particles while the green colour is due to the Ag nanoparticles. The Lycurgus cup is recognized as one of the oldest synthetic nanomaterials (16).

During the 9th–17th centuries, glowing, glittering "luster" ceramic glazes used in the Islamic world, and later in Europe contained Ag or copper (Cu) or other nanoparticles (18). The Italians also employed nanoparticles in creating Renaissance pottery during 16th century (19)). These colours and material properties were produced intentionally for hundreds of years. Medieval artists and forgers, however, did not know the cause of these surprising effects.

In 1857, Michael Faraday studied the preparation and properties of colloidal suspensions of "Ruby" gold. Their unique optical and electronic properties make them some of the most interesting nanoparticles. Faraday demonstrated how gold nanoparticles produce different-coloured solutions under certain lighting conditions (21). Industrial production of nanomaterials saw its origins in the twentieth century. For example, nanoparticles of carbon black have been used in the fab-rication of rubber tires. Pigments such as $SiO_2$ and $TiO_2$ have been prepared by a high-temperature com-bastion method. Since the 1970s, the innovative development of nanoparticles is due to a combination of theory and experiments in the fields of physics, chemistry, materials science, and biosciences. Applications of nanoparticles in various fields require an inexpensive and simple process of synthesizing high quality shaped-nanoparticles. In this regard, recent years have witnessed significant research being done in the use of microwave radiation in nanoparticle synthesis. (22).

In only a few decades, nanotechnology and nanoscience have become of fundamental importance to industrial applications and medical devices, such as diagnostic biosensors, drug delivery systems, and imaging probes. (24)

## 3. CLASSIFICATION OF NANOPARTICLES

The nanoparticles are generally classified into the organic, inorganic and carbon based. Fig.1

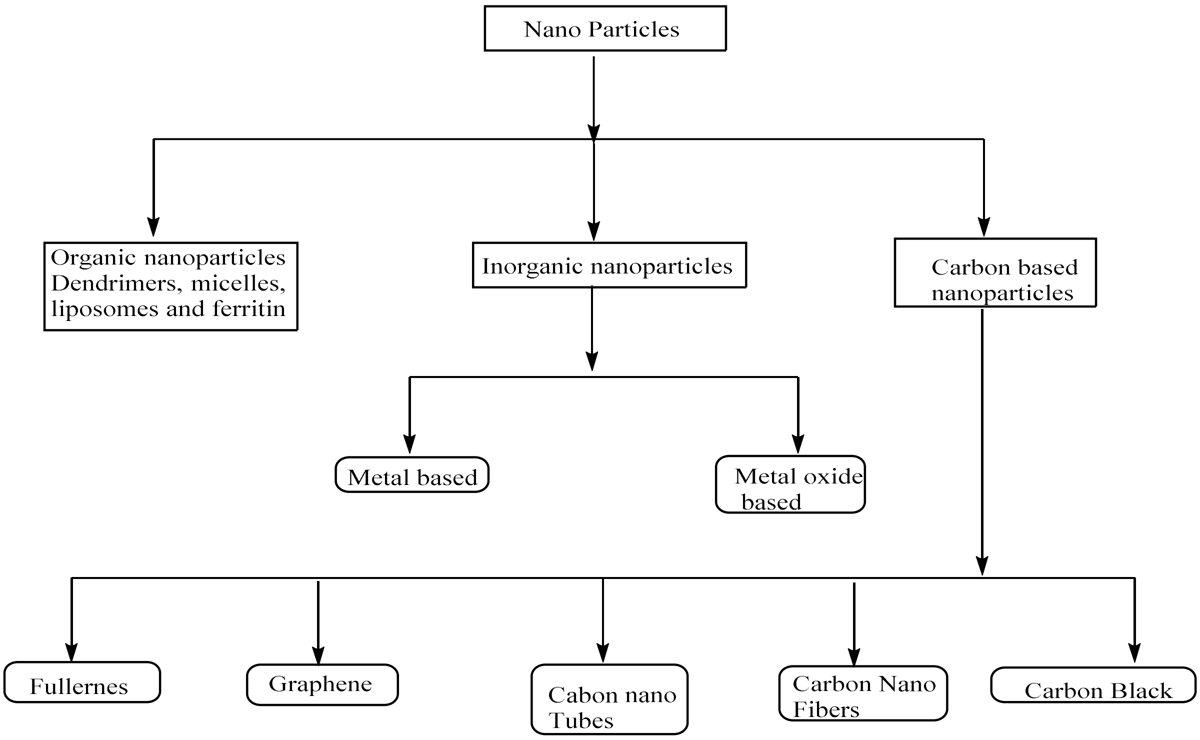


**Fig. No: 1:Classification of Nanoparticles**

### 3.1 Organic nanoparticles

Dendrimers, micelles, liposomes and ferritin, etc. are commonly knows the organic nanoparticles or polymers. These nanoparticles are biodegradable, non-toxic but some are such as micelles and liposomes has a hollow core Fig.2, also known as nano capsules and are sensitive to thermal and electromagnetic radiation such as heat and light. These unique characteristics makes them an ideal choice for drug delivery. (25)

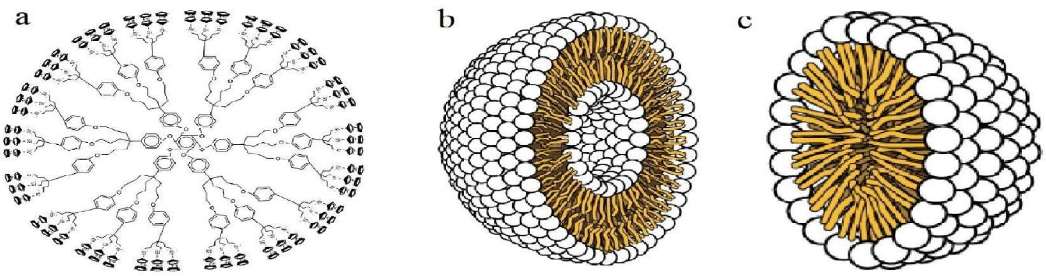


**Fig. No. 2: Organic nanoparticles: a – Dendrimers, b – Liposomes and c – micelles.**

**3.2 Inorganic nanoparticles**

Inorganic nanoparticles are particles that are not made up of carbon. Metal and metal oxide-basednanoparticles are generally categorised as inorganic nanoparticles. These are of 2 types.

**3.2.1. Metal based.**

Nanoparticles that are synthesised from metals bydestructive or constructive methods. Almost all the metals can besynthesised into their nanoparticles (26). The nanoparticles have distinctive properties like sizes as low as 10 to 100nm, high surface area to volume ratio, pore size, surface charge and surface chargedensity, crystalline and amorphous structures, shapes like spherical and cylindrical and colour,reactivity and sensitivity to environmental factors

**3.2.2. Metal oxides based**.

The metal oxide-based nanoparticles are synthesised to modify theproperties of their respective metal-based nanoparticles, for example nanoparticles of iron (Fe)instantly oxidises to iron oxide ($Fe_2O_3$) in the presence of oxygen at room temperature that increasesits reactivity compared to iron nanoparticles. (27).

**3.3. Carbon based**

The nanoparticles made completely of carbon are knows as carbon based (8). They can be classifiedinto fullerenes, graphene, carbon nano tubes (CNT), carbon nanofibers and carbon black andsometimes activated carbon in nano size

**3.3.1. Fullerenes.**

Fullerenes (C60) is a carbon molecule that is spherical in shape and made up ofcarbon atoms held together by sp2 hybridization. About 28 to 1500 carbon atoms forms the sphericalstructure with diameters up to 8.2 nm for a single layer and 4 to 36 nm for multi-layered fullerenes.

**3.2.2 Graphene**

Graphene is an allotrope, hexagonal network of honeycomb lattice made up of carbon atoms in a two-dimensional planar surface. Generally, the thickness of thegraphene sheet is around 1 nm.

**3.3.3. Carbon Nano Tubes (CNT).**

Carbon Nano Tubes (CNT), a graphene nano foil with a honeycomblattice of carbon atoms is wound into hollow cylinders to form nanotubes of diameters as low as 0.7nm for a single layered and 100 nm for multi-layered CNT and length.

**3.3.4. Carbon Nanofiber.**

The same graphene nano foils are used to produce carbon nanofiber as CNTbut wound into a cone or cup shape instead of a regular cylindrical tube.

**3.3.5. Carbon black.**

An amorphous material made up of carbon, generally spherical in shape withdiameters from 20 to 70 nm. The interaction between the particles are so high that they bound in aggregates and around 500 nm agglomerates are formed.

**4. SYNTHESIS OF NANOPARTICLES**

**4.1 Bottom-up method-**Bottom-up or constructive method is the build-up of material from atom to clusters to nanoparticles. Fig. 3.

**4.1.1. Sol-gel. The sol Method-**A colloidal solution of solids suspended in a liquid phase. The gel – a solid macromolecule submerged in a solvent. It is the most preferred bottom-up method due to its simplicity and as most of the nanoparticles can be synthesized from this method. (28).

**4.1.2. Spinning Method -** The synthesis of nanoparticles by spinning is carried out by a spinning disc reactor (SDR). It contains a rotating disc inside a chamber/reactor. The disc is rotated at different speed the liquid i.e. precursor and water is pumped in. The spinning causes the atoms or molecules to fuse together and is precipitated, collected and dried (30).

**4.1.3. Chemical Vapour Deposition (CVD)-**

CVDis the deposition of a thin film of gaseous reactants onto a substrate. The deposition is carried out in a reaction chamber by combining gas molecule. (31).

**4.1.4. Pyrolysis-** Itis the most commonly used process in industries for largescale production of nanoparticle. It involves burning a precursor with flame. The precursor is either liquid or vapour that is fed into the furnace at high pressure through a small hole where it burns (32).

**4.1.5. Biosynthesis-** Biosynthesis uses bacteria, plant extracts, fungi, etc. along with the precursors to produce nanoparticle. (34).

**4.2. Top-down method**

Top-down or destructive method is the reduction of a bulk material to nanometric scale particles.

**4.2.1. Mechanical milling.**

The mechanical milling is the most extensively used to produce various nanoparticles. (35). The influencing factors in mechanical milling is plastic deformation that leads to particle shape, fracture leads to decrease in particle size and cold-welding leads to increase in particle size.

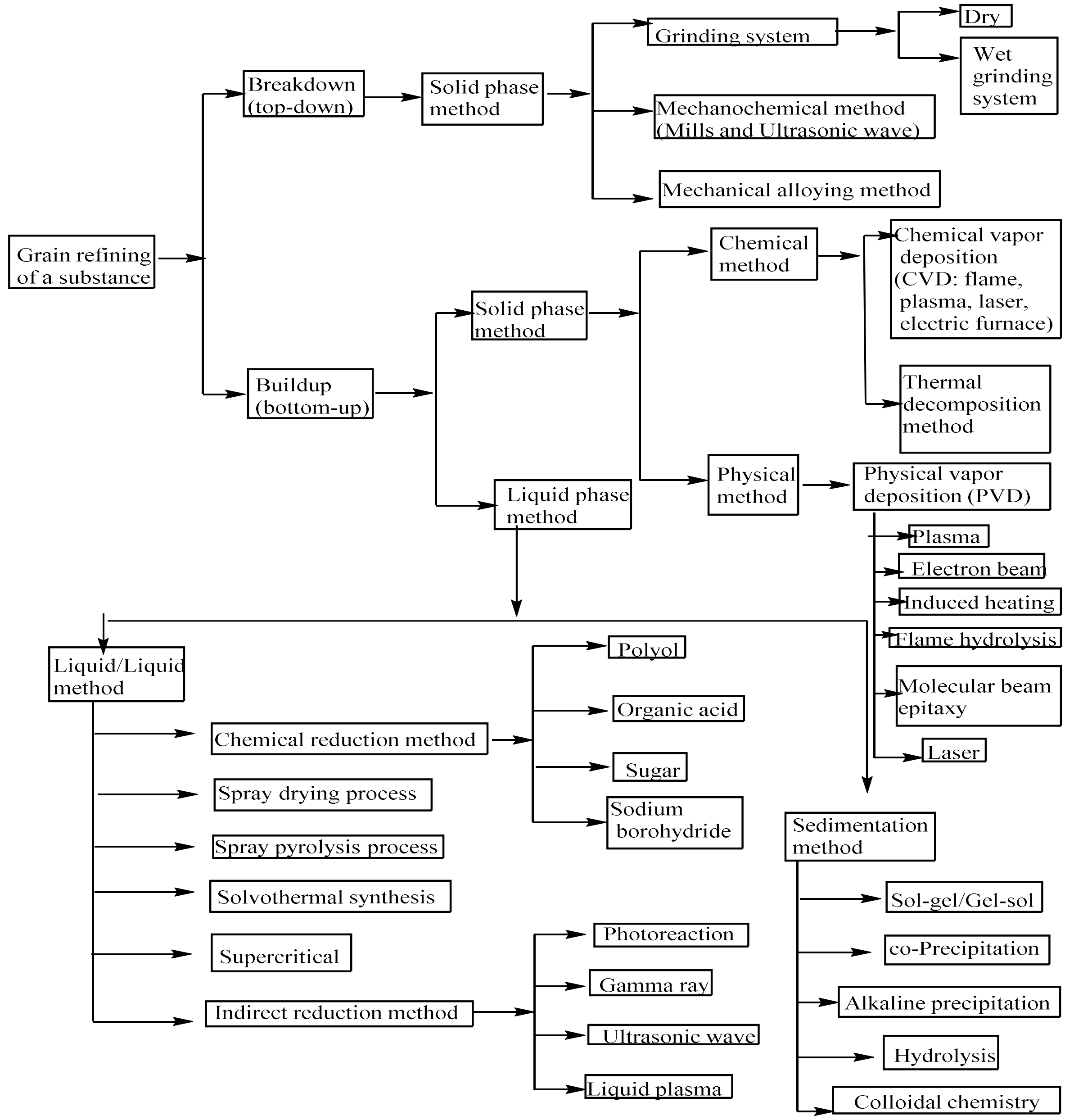


**Fig. No. 3: Typical synthetic methods for nanoparticles for the top-down and bottom-up approaches.**

**4.2.2. Nanolithography.**

Lithography is the process of printing a required shape or structure on a light sensitive material that selectively removes a portion of material to create the desired shape and structure. (36).

**4.2.3. Laser ablation.**

Laser Ablation Synthesis in Solution (LASiS) is a common method for nanoparticle production from various solvents. The irradiation of a metal submerged in a liquid solution by a laser beam condenses a plasma plume that produces nanoparticles (37).

#### 4.2.4. Sputtering.

Sputtering is the deposition of nanoparticles on a surface by ejecting particles from it by colliding with ions (38).

#### 4.2.5. Thermal decomposition.

Thermal decomposition is an endothermic chemical decomposition produced by heat that breaks the chemical bonds in the compound (41).

## 5. PROPERTIES OF NANOPARTICLES

The properties of nanoparticles are generally categorised into physical and chemical. The properties of few common nanoparticles are given in Table 1

**Table 1: Physical and chemical properties of different nanoparticles**

| Nanoparticles | Properties | Reference |
|---|---|---|
| **Carbon based nanoparticles** | | |
| Fullerenes | Safe and inert, semiconductor, conductorand superconductor, transmits light based on intensity | 41 |
| Graphene | Extreme strength, thermal, electrical conductivity, light absorption | 42 |
| Carbon NanoTubes | High electrical and thermal conductivity, tensile strength, flexibleand elastic | 43 |
| Carbon Nanofiber | High thermal, electrical, frequency shielding, and mechanicalproperties | 44 |
| Carbon Black | High strength and electrical conductivity, surface area; resistant to UV degradation | 45 |
| **Metal based nanoparticles** | | |
| Aluminium | High reactivity, sensitive to moisture, heat, and sunlight, largesurface area | 46 |
| Iron | Reactive and unstable, sensitive to air (oxygen) and water | 47 |
| Silver | Absorbs and scatters light, stable, anti-bacterial, disinfectant | 48 |
| Gold | Interactive with visible light, reactive | 48 |
| Cobalt | Unstable, magnetic, toxic, absorbs microwaves, magnetic | 49 |
| Cadmium | Semiconductor of electricity, insoluble | 50 |
| Lead | High toxicity, reactive, highly stable | 51 |
| Copper | Ductile, very high thermal and electrical conductivity, highly flammable solids | 52 |
| Zinc | Antibacterial, anti-corrosive, antifungal, UV filtering | 53 |
| **Metal oxide-based nanoparticles** | | |
| Titanium oxide | High surface area, magnetic, inhibits bacterial growth | 53 |
| Iron oxide | Reactive and unstable [53] | 54 |
| Magnetite | Magnetic highly reactive | 55 |
| Silicon dioxide | Stable, less toxic, able to be functionalize many molecules | 56 |
| Zinc oxide | Antibacterial, anti-corrosive, antifungal and UV filtering | 57 |
| Cerium oxide | Antioxidant, low reduction potential | 57 |

## 6. APPLICATIONS

### 6.1. Cosmetics and Sunscreens

Thesunscreen including nanoparticles such as titanium dioxide provides numerous advantages. Somelipsticks use iron oxide nanoparticles as a pigment (59).

### 6.2. Electronics

The higher necessity for large size and high brightness displays in recent days that are used in thecomputer monitors and television is encouraging the use of nanoparticles in the display technology.For example, nanocrystalline lead telluride, cadmium sulphide, zinc selenide and sulphideare used inthe light emitting diodes (LED) of modern displays (60).

### 6.3. Catalysis

Due to their extremelylarge surface to volume ratio the nanoparticles function as efficient catalyst in the production ofchemicals (61).

**6.4. Medicine**

Nanotechnology has improved the medical field by use of nanoparticles in drug delivery. The drug canbe delivered to specific cells using nanoparticles (62).

**6.5. Food**

The improvement in production, processing, protection and packaging of food is achieved by incorporating nanotechnology. (65).

**6.6. Construction**

Nanotechnology has improved the construction processes by making them quicker, inexpensive andsafer (66).

## 7. CONCLUSION

Due to their incredible properties, nanoparticles have become significant in many fields in recent years such as energy, healthcare, environment, agriculture etc. Nanotechnologyhas great potential being able to convert poorly soluble, poorly absorbed and labile biologically active substanceinto promising deliverable substances.

In this review we discuss research previously published by scientist and academicians rather than reporting novel research results in this review articles we try to summary of current state of understanding on nano particles and nanotechnology. This review covered various types, uses, size, shape and different synthesis of nanoparticles etc.

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