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CURRENT REVIEW ON NANOPARTICLES: PROPERTIES, APPLICATION AND TOXICITY

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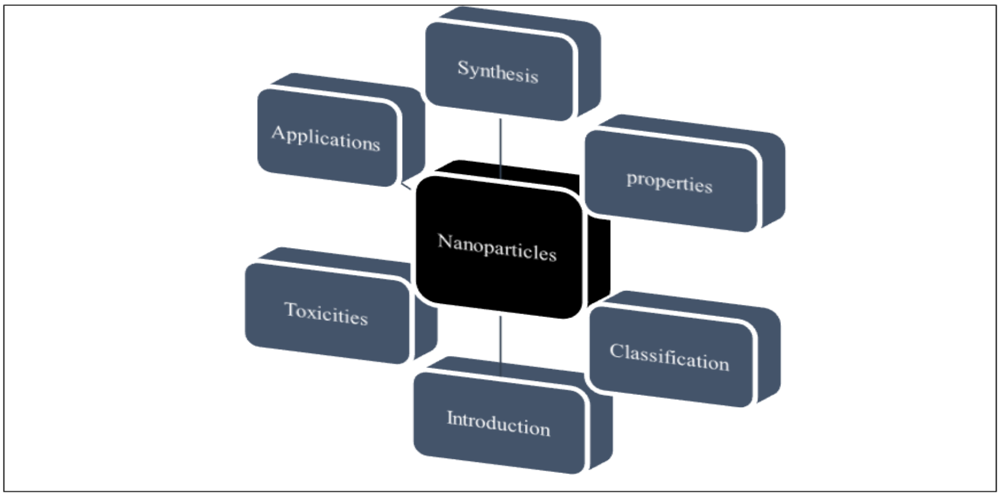
ABSTRACT

This review is provided a detailed overview of the synthesis, properties, Characterization and applications of nanoparticles. (NPs) are tiny material having size range from 1 to100 mm. Nano medicine is a relatively new field of science and technology. Nanoparticle are classified according to its properties, size and shape. The different groups include, metal NPs, ceramic NPs, and polymeric NPs, carbon NPs. The synthesis of nanoparticle are by Top-down synthesis and Bottom up methods are given. The characterization method of nanoparticle is given and different Applications of nano particles in drug delivery, Applications in energy, Applications in agriculture and environmental application and toxicity of NPs.

Graphical abstract



KEYWORDS: Nanoparticles, Carbon nanotube, nanoparticle synthesis, Toxicities.

1. INTRODUCTION

Nanotechnology (or"nanotech") is management of material on an nuclear, molecular, and supramolecular scale. The most primitive, extensive description of nanotechnology.[1][2] Mentioned to the particular technological goal of exactly manipulating atoms and molecules for manufacture of macroscale products, similarly now mentioned to as molecular nanotechnology. A more widespread description of nanotechnology was afterward recognized by the National Nanotechnology Initiative, which describes nanotechnology as the management of matter with at least one measurement sized from 1 to 100 nanometres. This meaning reflects the fact that important mechanical belongings are significant at this quantum-realm scale, and so the meaning shifted from a particular technological goal to a research category inclusive of all types of research and technologies that deal with the special properties of matter which occur below the given size threshold. It is therefore common to see the plural form "nanotechnologies" as well as "nanoscale technologies" to refer to the broad range of research and applications whose common trait is size. Nanotechnology as defined by size is naturally very broad, including fields of science as diverse as surface science, organic chemistry, molecular biology, energy storage,[3][4] microfabrication,[5] molecular engineering, etc.[6] The associated research and applications are equally diverse, ranging from extensions of conventional device physics to completely new approaches based upon molecular self-assembly,[7] from developing new materials with dimensions on the nanoscale to direct control of matter on the atomic scale. Scientists currently debate the future implications of nanotechnology. Nanotechnology may be able to create many new materials and devices with a vast range of applications, such as in nanomedicine, nanoelectronics, biomaterials energy production, and consumer products. On the other hand, nanotechnology raises many of the same issues as any new technology, including concerns about the toxicity and environmental impact of nanomaterials,[8] and their potential effects on global economics, as well as speculation about various doomsday scenarios. These concerns have led to a debate among advocacy groups and governments on whether special regulation of nanotechnology is warranted. In this review article we provide general overview on different type synthesis methods, characterization, properties and applications of Nanoparticle.

2. Classification of nanoparticle

2.1 Carbon-based nanoparticle

Carbon nanotubes (CNTs) are tubes made of carbon with diameters typically measured in nanometres. Carbon nanotubes often refer to single-wall carbon nanotubes (SWCNTs) with diameters in the range of a nanometre. They were revealed individualistically by Iijima and Ichihashi[9] and Bethune et al.[10] in carbon arc chambers like to those used to produce fullerenes. Single-wall carbon nanotubes are one of the allotropes of carbon, intermediate among fullerene cages and flat graphene. Though not complete this way, single-wall carbon nanotubes can be supposed of as cut-outs from a two-dimensional hexagonal lattice of carbon particles moved up along one of the Bravais lattice vectors of the hexagonal lattice to form a hollow cylinder. In this creation, periodic boundary conditions are executed over the length of this roll up vector to yield a lattice with helical symmetry of seamlessly bonded carbon atoms on the cylinder surface.[11] Carbon nanotubes also often mention to multi-wall carbon nanotubes (MWCNTs) covering of nested single-wall carbon nanotubes.[11] If not identical, these tubes are very like to Oberlin, Endo and Koyama's long straight and parallel carbon layers cylindrically trolled around a hollow tube.[12] Multi-wall carbon nanotubes are also occasionally used to mention to double- and triple-wall carbon nanotubes. Carbon nanotubes can also mention to tubes with an undetermined carbon-wall construction and diameters less than 100 nanometres. Such tubes were discovered by Radushkevich and Lukyanov ich. While nanotubes of other compositions exist, most research has been focused on the carbon ones. Therefore, the "carbon" qualifier is often left implicit in the acronyms, and the names are abbreviated NT, SWNT, and MWNT. Carbon nanotubes can exhibit remarkable electrical conductivity. They also have exceptional tensile strength[13] and thermal conductivity,[14] [15] because of their nanostructure and strength of the bonds between carbon atoms. In addition, they can be chemically modified.[16] These properties are expected to be valuable in many areas of technology, such as electronics, optics, composite materials (replacing or complementing carbon fibres), nanotechnology, and other applications of materials science.

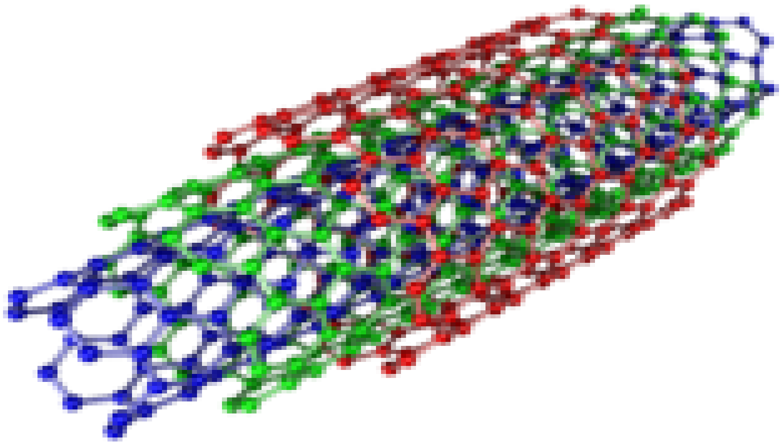


Fig. 1: Triple-walled armchair carbon nanotube.

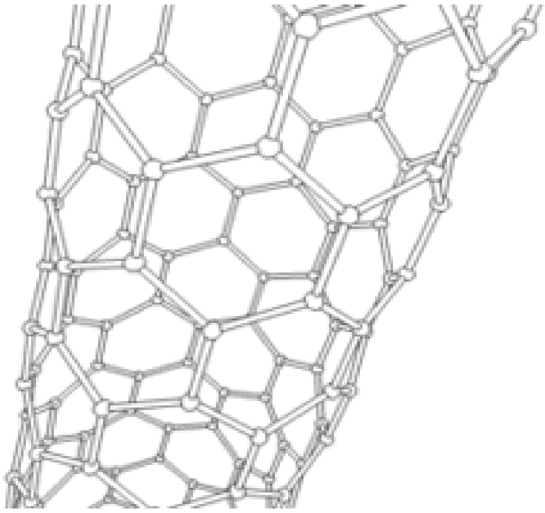


Fig. 2: Rotating single-walled zigzag carbon nanotube.

2.2 Ceramic nanoparticles

Ceramic nanoparticle is a type of nanoparticle that is composed of ceramics, which are generally classified as inorganic, heat-resistant. Non-metallic solids that can be made of both metallic and non-metallic compounds. The material offers unique properties. Macroscale ceramics are brittle and rigid and break upon impact. However, Ceramic nanoparticles take on a larger variety of functions[17] including dielectric, ferroelectric, piezoelectric, pyroelectric, ferromagnetic, magnetoresistive, superconductive and electro-optical. Ceramic nanoparticle was discovered in the early 1980s. They were formed using a process called sol-gel which mixes nanoparticles within a solution and gel to form the nanoparticle. Later methods involved sintering (pressure and heat). The material is so small that it has basically no flaws. Larger scale materials have flaws that render them brittle. In 2014 researchers announced a lasering process involving polymers and ceramic particles to form a nanotruss. This structure was able to recover its original form after repeated crushing. Ceramic nanoparticles have been used as drug delivery mechanism in several diseases including bacterial infections, glaucoma, and most commonly, chemotherapy deliver in cancer.[18]

2.3 Polymeric nanoparticles

Polymeric nanoparticles are synthetic polymers with a size ranging from 10 to 100 nm. Common synthetic polymeric nanoparticles include polyacrylamide,[19] polyacrylate,[20] and chitosan.[21] Drug molecules can be incorporated either during or after polymerization. Depending on the polymerization chemistry, the drug can be covalently bonded, encapsulated in a hydrophobic core, or conjugated electrostatically.[20][22] Common synthetic strategies for polymeric nanoparticles include microfluidic approaches,[23] electro dropping,[24] high pressure homogenization, and emulsion-based interfacial polymerization.[25] Polymer biodegradability is an important aspect to consider when choosing the appropriate nanoparticle chemistry. Nanocarriers composed of biodegradable polymers undergo hydrolysis in the body, producing biocompatible small molecules such as lactic acid and glycolic acid.[26] Polymeric nanoparticles can be created via self-assembly or other methods such as particle replication in nonwetting templates (PRINT) which allows customization of composition, size, and shape of the nanoparticle using tiny molds.[27]

2.4 Lipid-based nanoparticles

Solid pid nanoparticles (SLNs) are a new pharmaceutical delivery system or pharmaceutical formulation.[28][29] The conventional approaches such as use of permeation enhancers, surface modification, prodrug synthesis, complex formation and colloidal lipid carrier-based strategies have been developed for the delivery of drugs to intestinal lymphatics. In addition, polymeric nanoparticles, self-emulsifying delivery systems, liposomes, microemulsions, micellar solutions and recently solid lipid nanoparticles (SLN) have been exploited as probable possibilities as carriers for oral intestinal lymphatic delivery.[30] A solid lipid nanoparticle is typically spherical with an average diameter between 10 and 1000 nanometres. Solid lipid nanoparticles possess a solid lipid core matrix that can solubilize lipophilic molecules. The lipid core is stabilized by surfactants (emulsifiers). The emulsifier used depends on administration routes and is more limited for parenteral administrations.[31] The term lipid is used here in a broader sense and includes triglycerides (e.g. tristearin), diglycerides (e.g.glycerolbehenate), monoglycerides (e.g. glycer ol monostearate), fatty acids (e.g. stearic acid), steroids (e.g. cholesterol), and waxes (e.g. Cetyl palmitate). All classes of emulsifiers (with respect to charge and molecular weight) have been used to stabilize the lipid dispersion. It has been found that the combination of emulsifiers might prevent particle agglomeration more efficiently. Development of solid lipid nanoparticles is one of the emerging fields of lipid nanotechnology with several potential applications in drug delivery, clinical medicine and research, as well as in other discipline. Due to their unique size-dependent properties, lipid nanoparticles offer the possibility to develop new therapeutics. The ability to incorporate drugs into nanocarriers offers a new prototype in drug delivery that could hold great promise for attaining the bioavailability enhancement along with controlled and site-specific drug delivery. SLN's are also considered too well tolerated in general, due to their composition from physiologically similar lipids.

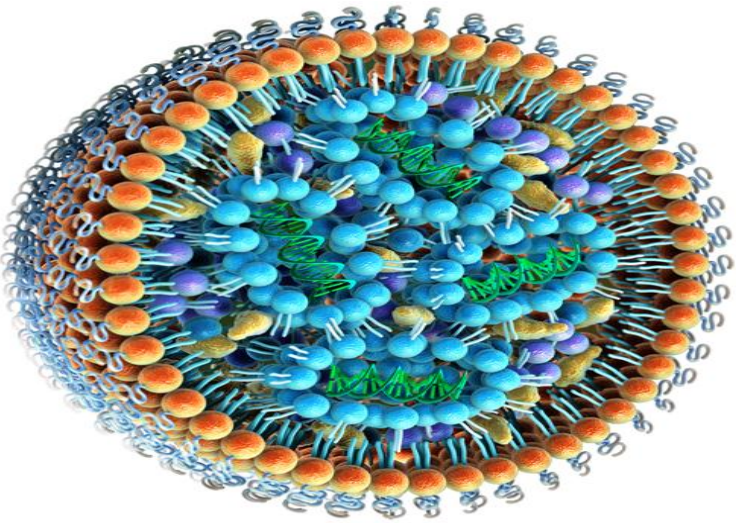


Fig. 3: Lipid nanoparticles.

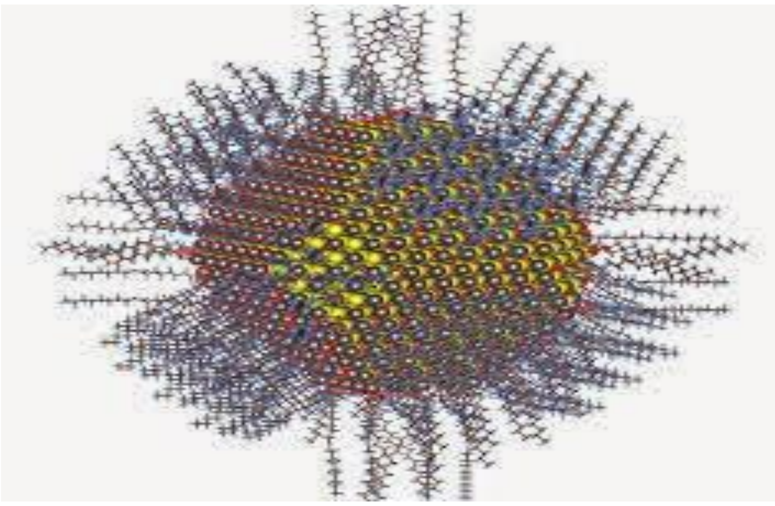


Fig.4: Semiconductor nanoparticles.

2.5 Metal nanoparticles

Metal nanoparticles are prepared from metal precursors. These nanoparticles can be synthesized by chemical, electrochemical, or photochemical methods. In chemical methods, the metal nanoparticles are obtained by reducing the metal-ion precursors in solution by chemical reducing agents. These have the ability to adsorb small molecules and have high surface energy. These nanoparticles have applications in research areas, detection and imaging of biomolecules and in environmental and bioanalytical applications. For example, gold nanoparticles are used to coat the sample before analysing in SEM. This is usually done to enhance the electronic stream, which helps us to get high quality SEM images.

2.6 Semiconductor nanoparticles

Semiconductor nanoparticles have properties like those of metals and non-metals. They are found in the periodic table in groups II-VI, III-V or IV-VI. These particles have wide bandgaps, which on tuning shows different properties. They are used in photocatalysis, electronics devices, photo-optics and water splitting applications. Some examples of semiconductor nanoparticles are GaN, GaP, InP, InAs from group III-V, ZnO, ZnS, CdS, CdSe, CdTe are II-VI semiconductors and silicon and germanium are from group IV.

3. Properties of nanomaterials

3.1 large area/volume ratio

A bulk material should have constant physical properties (such as thermal and electrical conductivity, stiffness, density, and viscosity) regardless of its size. However, in a nanoparticle, the volume of the surface layer (the material that is within a few atomic diameters of the surface) becomes a significant fraction of the particle's volume; whereas that fraction is insignificant for particles with diameter of one micrometre or more.

3.2 Interfacial layer

For nanoparticles dispersed in a medium of different composition, the interfacial layer — formed by ions and molecules from the medium that are within a few atomic diameters of the surface of each particle — can mask or change its chemical and physical properties. Indeed, that layer can be considered an integral part of each nanoparticle.[32]

3.3 Solvent affinity

Suspensions of nanoparticles are possible since the interaction of the particle surface with the solvent is strong enough to overcome density differences, which otherwise usually result in a material either sinking or floating in a liquid.

3.4 Coatings

Nanoparticles often develop or receive coatings of other substances, distinct from both the particle's material and of the surrounding medium. Even when only a single molecule thick, these coatings can radically change the particles' properties, such as and chemical reactivity, catalytic activity, and stability in suspension.

3.5 Diffusion across the surface

The high surface area of a material in nanoparticle form allows heat, molecules, and ions to diffuse into or out of the particles at very large rates. The small particle diameter, on the other hand, allows the whole material to reach homogeneous equilibrium with respect to diffusion in a very short time. Thus many processes that depend on diffusion, such as sintering can take place at lower temperatures and over shorter time scales.

3.6 Ferromagnetic and ferroelectric effects

The small size of nanoparticles affects their magnetic and electric properties. For example, while particles of ferromagnetic materials in the micrometre range are widely used in magnetic recording media, for the stability of their magnetization state, those smaller than 10 nm can change their state as the result of thermal energy at ordinary temperatures, thus making them unsuitable for that application.[33]

3.7 Melting point depression

A material may have lower melting point in nanoparticle form than in the bulk form. For example, 2.5 nm gold nanoparticles melt at about 300 °C, whereas bulk gold melts at 1064 °C.[34]

3.8 Quantum mechanics effects

Quantum mechanics effects become noticeable for nanoscale objects.[35] They include quantum confinement in semiconductor particles, localized surface plasmons[35] in some metal particles, and superparamagnetic in magnetic materials. Quantum dots are nanoparticles of semiconducting material that are small enough (typically sub 10 nm or less) to have quantized electronic levels. Quantum effects are responsible for the deep-red to black colour of gold or silicon nano powders and nanoparticle suspensions.[36] Absorption of solar radiation is much higher in materials composed of nanoparticles than in thin films of continuous sheets of material. In both solar PV and solar thermal applications, by controlling the size, shape, and material of the particles, it is possible to control solar absorption.[37][38][39][40] Core-shell nanoparticles can support simultaneously both electric and magnetic resonances, demonstrating entirely new properties when compared with bare metallic nanoparticles if the resonances are properly engineered.[41][42][43] The formation of the core-shell structure from two different metals enables an energy exchange between the core and the shell, typically found in upconverting nanoparticles and down converting nanoparticles, and causes a shift in the emission wavelength spectrum.[44] By introducing a dielectric layer, plasmonic core (metal)-shell (dielectric) nanoparticles enhance light absorption by increasing scattering. Recently, the metal core-dielectric shell nanoparticle has demonstrated a zero backward scattering with enhanced forward scattering on a silicon substrate when surface plasmon is located in front of a solar cell.[45]

3.9 Regular packing

Nanoparticles of sufficiently uniform size may spontaneously settle into regular arrangements, forming a colloidal crystal. These arrangements may exhibit original physical properties, such as observed in photonic crystals [46][47]

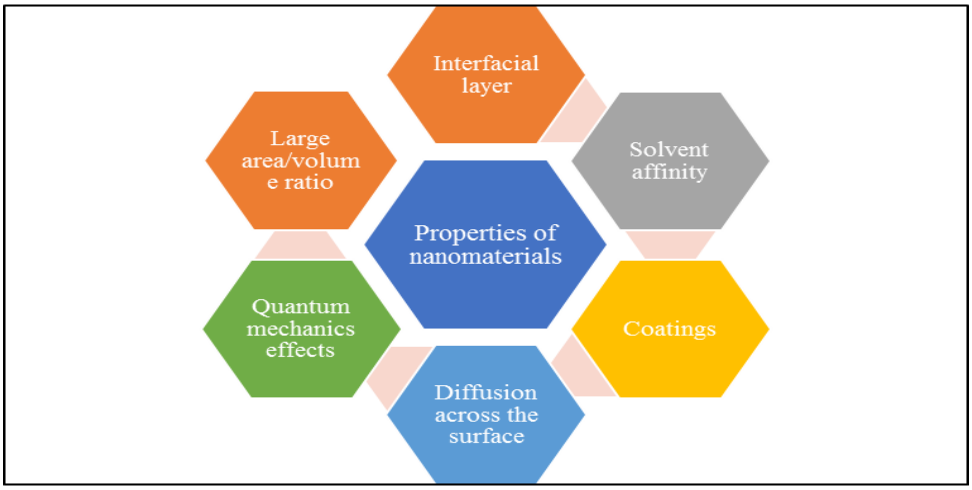


Fig. 5: Properties of nanomaterials.

4. Synthesis of nanoparticles

The goal of any synthetic method for nanomaterials is to yield a material that exhibits properties that are a result of their characteristic length scale being in the nanometre range (1

– 100 nm). Accordingly, the synthetic method should exhibit control of size in this range so that one property or another can be attained. Often the methods are divided into two main types, "bottom up" and "top down".

4.1. Top-down synthesis

Top-down routes are included in the typical solid –state processing of the materials. This route is based with the bulk material and makes it smaller, thus breaking up larger particles by the use of physical processes like crushing, milling or grinding. Usually this route is not suitable for preparing uniformly shaped materials, and it is very difficult to realize very small particles even with high energy consumption. The biggest problem with top-down approach is the imperfection of the surface structure. Such imperfection would have a significant impact on physical properties and surface chemistry of nanostructures and nanomaterials. It is well known that the conventional top-down technique can cause significant crystallographic damage to the processed patterns. Top down methods adopt some 'force' (e. g. mechanical force, laser) to break bulk materials into nanoparticles. A popular method involves mechanical break apart bulk materials into nanomaterials is 'ball milling'. Besides, nanoparticles can also be made by laser ablation which apply short pulse lasers (e. g. femtosecond laser) to ablate a target (solid).[48]

4.2 Bottom up methods

Bottom up methods involve the assembly of atoms or molecules into nanostructured arrays. In these methods the raw material sources can be in the form of gases, liquids or solids. The latter require some sort of disassembly prior to their incorporation onto a nanostructure. Bottom up methods generally fall into two categories: chaotic and controlled. Chaotic processes involve elevating the constituent atoms or molecules to a chaotic state and then suddenly changing the conditions so as to make that state unstable. Through the clever manipulation of any number of parameters, products form largely as a result of the insuring kinetics. The collapse from the chaotic state can be difficult or impossible to control and so ensemble statistics often govern the resulting size distribution and average size. Accordingly, nanoparticle formation is controlled through manipulation of the end state of the products. Examples of chaotic processes are laser ablation,[49] exploding wire, arc, flame pyrolysis, combustion, and precipitation synthesis techniques. Controlled processes involve the controlled delivery of the constituent atoms or molecules to the site(s) of nanoparticle formation such that the nanoparticle can grow to a prescribed size in a controlled manner.

Generally, the state of the constituent atoms or molecules are never far from that needed for nanoparticle formation. Accordingly, nanoparticle formation is controlled through the control of the state of the reactants. Examples of controlled processes are self-limiting growth solution, self-limited chemical vapor deposition, shaped pulse femtosecond laser techniques, and molecular beam epitaxy.

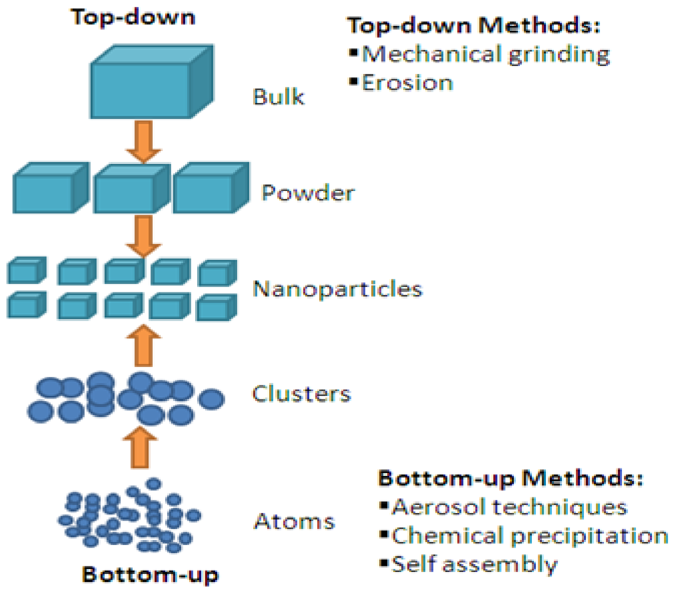


Fig. 6: Synthesis of nanoparticles.

5. Charecterization of nanoparticles

Nanoparticles have other physical properties that must be measured for a complete description, such as size, shape, surface properties, crystallinity, and dispersion state. The characterization of nanoparticles is a branch of nanometrology that deals with the characterization, or measurement, of the physical and chemical properties of nanoparticles. Nanoparticles measure less than 100 nanometres in at least one of their external dimensions, and are often engineered for their unique properties. Nanoparticles are unlike conventional chemicals in that their chemical composition and concentration are not sufficient metrics for a complete description, because they vary in other physical properties such as size, shape, surface properties, crystallinity, and dispersion state. Nanoparticles are characterized for various purposes, including nanotoxicology studies and exposure assessment in workplaces to assess their health and safety hazards, as well as manufacturing process control. There is a wide range of instrumentation to measure these properties, including microscopy and spectroscopy methods as well as particle counters.

Metrology standards and reference materials for nanotechnology, while still a new discipline, are available from many organizations.

5.1 Morphological characterization

Morphology refers to the physical shape of a particle, as well as its surface topography, for example, the presence of cracks, ridges, or pores. Morphology influences dispersion, functionality, and toxicity, and has similar considerations as size measurements. Evaluation of morphology requires direct visualization of the particles through techniques like scanning electron microscopy, transmission electron microscopy, and atomic force microscopy.[50] Several metrics can be used, such as sphericity or circularity, aspect ratio, elongation, convexity, and fractal dimension.[51] Because microscopy involves measurements of single particles, a large sample size is necessary to ensure a representative sample, and orientation and sample preparation effects must be accounted for.[52]

Scanning electron microscope (SEM): Is a type of electron microscope that produces images of a sample by scanning the surface with a focused beam of electrons. The electrons interact with atoms in the sample, producing various signals that contain information about the surface topography and composition of the sample. The electron beam is scanned in a raster scan pattern, and the position of the beam is combined with the intensity of the detected signal to produce an image. In the most common SEM mode, secondary electrons emitted by atoms excited by the electron beam are detected using a secondary electron detector (Everhart-Thornley detector). The number of secondary electrons that can be detected, and thus the signal intensity, depends, among other things, on specimen topography. SEM can achieve resolution better than 1 nanometre. Specimens are observed in high vacuum in conventional SEM, or in low vacuum or wet conditions in variable pressure or environmental SEM, and at a wide range of cryogenic or elevated temperatures with specialized instruments.

Transmission electron microscopy (TEM): is a microscopy technique in which a beam of electrons is transmitted through a specimen to form an image. The specimen is most often an ultrathin section less than 100 nm thick or a suspension on a grid. An image is formed from the interaction of the electrons with the sample as the beam is transmitted through the specimen. The image is then magnified and focused onto an imaging device, such as a fluorescent screen, a layer of photographic film, or a sensor such as a scintillator attached to a charge-coupled device. Transmission electron microscopes are capable of imaging at a significantly higher resolution than light microscopes, owing to the smaller de Broglie wavelength of electrons. This enables the instrument to capture fine detail—even as small as a single column of atoms, which is thousands of times smaller than a resolvable object seen in a light microscope. Transmission electron microscopy is a major analytical method in the physical, chemical and biological sciences. TEMs find application in cancer research, virology, and materials science as well as pollution, nanotechnology and semiconductor research, but also in other fields such as palaeontology and palynology's instruments boast an enormous array of operating modes including conventional imaging, scanning TEM imaging (STEM), diffraction, spectroscopy, and combinations of these. Even within conventional imaging, there are many fundamentally different ways that contrast is produced, called "image contrast mechanisms." Contrast can arise from position-to-position differences in the thickness or density ("mass-thickness contrast"), atomic number ("Z contrast," referring to the common abbreviation Z for atomic number), crystal structure or orientation ("crystallographic contrast" or "diffraction contrast"), the slight quantum-mechanical phase shifts that individual atoms produce in electrons that pass through them ("phase contrast"), the energy lost by electrons on passing through the sample ("spectrum imaging") and more. Each mechanism tells the user a different kind of information, depending not only on the contrast mechanism but on how the microscope is used—the settings of lenses, apertures, and detectors. What this means is that a TEM is capable of returning an extraordinary variety of nanometre- and atomic-resolution information, in ideal cases revealing not only where all the atoms are but what kinds of atoms they are and how they are bonded to each other. For this reason, TEM is regarded as an essential tool for nanoscience in both biological and materials fields.

5.2 Structural characterization

Structural characterization provides information about bulk properties of materials. XRD IR, Raman, BET, Zeta size analyser are common technique for structural characterization.

X-ray scattering techniques are a family of non-destructive analytical techniques which reveal information about the crystal structure, chemical composition, and physical properties of materials and thin films. These techniques are based on observing the scattered intensity of an X-ray beam hitting a sample as a function of incident and scattered angle, polarization, and wavelength or energy. XRD is one of the most important technique. When X-ray light reflects on any crystal, it leads to the formation of many diffraction patterns, and the patterns reflect the physico-chemical characteristics of the crystal structures. In a powder specimen, diffracted beams typically come from the sample and reflect its structural physico-chemical features. Thus, XRD can analyse the structural features of a wide range of materials, such as inorganic catalysts, superconductors, biomolecules, glasses, polymers, and so on.

5.3 Particle Size and Surface area characterization

Particle size is the external dimensions of a particle, and dispersity is a measure of the range of particle sizes in a sample. If the particle is elongated or irregularly shaped, the size will differ between dimensions, although many measurement techniques yield an equivalent spherical diameter based on the surrogate property being measured. Size can be calculated from physical properties such as settling velocity, diffusion rate or coefficient, and electrical mobility. Size can also be calculated from microscope images using measured parameters such as Ferret diameter, Martin diameter and projected area diameters; electron microscopy is often used for this purpose for nanoparticles. Size measurements may differ between methods because they measure different aspects of particle dimensions, they average distributions over an ensemble differently, or the preparation for or operation of the method may change the effective particle size.[53] For airborne nanoparticles, techniques for measuring size include cascade impactors, electrical low-pressure impactors, mobility analysers, and time-of-flight mass spectrometers. For nanoparticles in suspension, techniques include dynamic light scattering, laser diffraction, field flow fractionation, particle tracking analysis, size exclusion chromatography, centrifugal sedimentation, and atomic force microscopy. For dry materials, techniques for measuring size include electron microscopy, atomic force microscopy, and X-ray diffraction. Back-calculation from surface area measurements are commonly employed, but these are subject to error for porous materials.[53] Additional methods include hydrodynamic chromatography, static light scattering, multiangle light scattering, nephelometry, laser-induced breakdown detection, and ultraviolet–visible spectroscopy;[54] as well as near-field scanning optical microscopy, confocal laser scanning microscopy, capillary electrophoresis, ultracentrifugation, cross-flow filtration, small-angle X-ray scattering, and differential mobility analysis.[55] Use of an environmental scanning electron microscope avoids morphological changes caused by the vacuum required for standard scanning electron microscopy, at the cost of resolution.[54][55] Surface area is an important metric for engineered nanoparticles because it influences reactivity and surface interactions with ligands. Specific surface area refers to the surface area of a powder normalized to mass or volume. Different methods measure different aspects of surface area.[53] Direct measurement of nanoparticle surface area utilizes adsorption of an inert gas such as nitrogen or krypton under varying conditions of pressure to form a monolayer of gas coverage. The number of gas molecules needed to form a monolayer and the cross-sectional area of the adsorbate gas molecule are related to the "total surface area" of the particle, including internal pores and crevices, using the Brunauer–Emmett–Teller equation.[53] Organic molecules can be used in place of gasses, such as ethylene glycol monoethyl ether.[54] There are several indirect measurement techniques for airborne nanoparticles, which do not account for porosity and other surface irregularities and therefore may be inaccurate. Real-time diffusion chargers measure the "active surface area", the area of the particle that interacts with the surrounding gas or ions and is accessible only from the outside. Electrical mobility analysers calculate the spherical equivalent diameter, which can be converted using geometric relationships. These methods cannot discriminate a nanoparticle of interest from incidental nanoparticles that may occur in complex environments such as workplace atmospheres. Nanoparticles can be collected onto a substrate and their external dimensions can be measured using electron microscopy, then converted to surface area using geometric relations.[53]

6. Applications of nanoparticles

Nanoparticle can be used in variety of particle some of these are following.

6.1 *Application in drugs and medications*

Nano medicine is a relatively new field of science and technology. By interacting with biological molecules at nano scale, nanotechnology broadens the field of research and application. Interactions of nano devices with bio molecules can be understood both in the extracellular medium and inside the human cells. Operation at nano scale allows exploitation of physical properties different from those observed at micro scale such as the volume/surface ratio Nanotechnology in medicine involves applications of nanoparticles currently under development, as well as longer range research that involves the use of manufactured nano-robots to make repairs at the cellular level (sometimes referred to as *nanomedicine*). Whatever you call it, the use of nanotechnology in the field of medicine could revolutionize the way we detect and treat damage to the human body and disease in the future, and many techniques only imagined a few years ago are making remarkable progress towards becoming realities. One application of nanotechnology in medicine currently being developed involves employing nanoparticles to deliver drugs, heat, light or other substances to specific types of cells (such as cancer cells). nanotechnology in cancer carbon nanotubes, liposomes, polymeric nanoparticle liposomes are potential carrier in drug delivery because it prevents the degradation of drug target to the site of action by reducing nanotoxicity. NP are help to increase the rateability of drugs or problems and possess convenient controlled drug release properties.[56]

6.2 Application in environment

Environmental application of NPs are in green nanotechnology which has two goals producing nanomaterials and products without harming the environment or human health, and producing nano-products that provide solutions to environmental problems. It uses existing principles of green chemistry and green engineering to make nanomaterials and nano-products without toxic ingredients, at low temperatures using less energy and renewable inputs wherever possible, and using lifecycle thinking in all design and engineering stages. In addition to making nanomaterials and products with less impact to the environment, green nanotechnology also means using nanotechnology to make current manufacturing processes for non-nano materials and products more environmentally friendly. For example, nanoscale membranes can help separate desired chemical reaction products from waste materials. Nanoscale catalysts can make chemical reactions more efficient and less wasteful. Sensors at the nanoscale can form a part of process control systems, working with nano-enabled information systems. Using alternative energy systems, made possible by nanotechnology, is another way to "green" manufacturing processes. The second goal of green nanotechnology involves developing products that benefit the environment either directly or indirectly. Nanomaterials or products directly can clean hazardous waste sites, desalinate water, treat pollutants, or sense and monitor environmental pollutants. Indirectly, lightweight nanocomposites for automobiles and other means of transportation could save fuel and reduce materials used for production; nanotechnology-enabled fuel cells and light-emitting diodes (LEDs) could reduce pollution from energy generation and help conserve fossil fuels; self-cleaning nanoscale surface coatings could reduce or eliminate many cleaning chemicals used in regular maintenance routines; and enhanced battery life could lead to less material use and less waste. Green Nanotechnology takes a broad system view of nanomaterials and products, ensuring that unforeseen consequences are minimized and that impacts are anticipated throughout the full life cycle.

6.3 Application in energy

As the world's energy demand continues to grow, the development of more efficient and sustainable technologies for generating and storing energy is becoming increasingly important. Nanotechnology a relatively new field of science and engineering, has shown promise to have a significant impact on the energy industry. Nanotechnology is defined as any technology that contains particles with one dimension under 100 nanometres in length. For scale, a single virus particle is about 100 nanometres wide. Commonly used nanomaterials in energy.

Graphene - Based materials: Graphene is recently emerged as a promising material for energy storage because of several properties, such as low weight, chemical inertness and low price. Graphene is an allotrope of carbon that exists as a two-dimensional sheet of carbon atoms organized in a hexagonal lattice. A family of graphene-related materials, called "graphene's" by the research community, consists of structural or chemical derivatives of graphene.[57] The most important chemically derived graphene is graphene oxide (defined as single layer of graphite oxide,[58] Graphite oxide can be obtained by reacting graphite with strong oxidizers, for example, a mixture of sulfuric acid, sodium nitrate, and potassium permanganate[59]) which is usually prepared from graphite by oxidization to graphite oxide and consequent exfoliation. The properties of graphene depend greatly on the method of fabrication.

Nanocellulose-based materials: Cellulose is the most abundant natural polymer on earth. Currently, nanocellulose-based mesoporous structures, flexible thin films, fibres, and networks are developed and used in photovoltaic (PV) devices, energy storage systems, mechanical energy harvesters, and catalysts components. Inclusion of nanocellulose in those energy-related devices largely raises the portion of eco-friendly materials and is very promising in addressing the relevant environmental concerns. Furthermore, cellulose manifests itself in the low cost and large-scale promises.[60] The example of nanotechnology in energy are Lithium-sulphur Based High-performance Batteries,_Nanomaterials in Solar Cells,_Nanoparticle Fuel Additives.

6.4 Application in agriculture

Nano-fertilizers Nanotechnology has played a role in the field of agriculture One area of active research in this field is the use of Nano fertilizers. Because of the aforementioned special properties of nanoparticles, Nano fertilizers can be tuned to have specialized delivery to plants. Conventional fertilizers can be dangerous to the environment because of the sheer amount of runoff that stems from their use.[61] in most cases, greater than 50% of the amount of fertilizer applied to soil is lost to the environment, in some cases up to 90%. As mentioned before, this poses extremely negative environmental implications, while also demonstrating the high waste associated with conventional fertilizers. On the other hand, Nano fertilizers are able to amend this issue because of their high absorption efficiency into the targeted plant- which is owed to their remarkably high surface area to volume ratios. In a study done on the use of phosphorus nano-fertilizers, absorption efficiencies of up to 90.6% were achieved, making them a highly desirable fertilizer material. Another beneficial aspect of using Nano fertilizers is the ability to provide slow release of nutrients into the plant over a 40-50-day time period, rather than the 4-10-day period of conventional fertilizers. This again proves to be beneficial economically, requiring less resources to be devoted to fertilizer transport, and less amount of total fertilizer needed. Also, Nanotechnology in plant transformation is important application of nanotechnology by using genetic engineering.

6.5 Diagnostic application of nanoparticle

Nanoparticles are now employed in various diagnostic modalities because of certain advantages including higher sensitivity of detection methods. The various possible nanoparticles employed in nano diagnosis are Gold nanoparticles, Quantum dots, nano barcodes, nanoparticles with magnetic properties.

Gold nanoparticle for diagnostics

Gold nanoparticles have been studied for nano diagnosis. A large number of techniques are available which can help in tracing of gold nanoparticles like fluorescence, optical absorption, electrical conductivity, atomic and magnetic force. Hence, Gold nanoparticles form excellent label for sensors gold nanoparticle in to detect millions of different DNA sequence However, small pieces of DNA can be attached to gold nanoparticle no longer than 13mm in diameter. The gold nanoparticle assembles onto the sensor surface only in the presence of complementary Target the technique can detect different DNA sequences.[62]

Quantum dots

Quantum dots are highly fluorescent nanoparticles. They are composed of solid semiconductor particles which can absorb light of varying wavelength but re-emit it in a single wavelength which depends upon the size of the particle. The dots usually have a polymer coating with multivalent bio-conjugate attached, or are embedded into microbeads. They have high sensitivity, broad excitation spectra, stable fluorescence with simple excitation, and no need for lasers. Their red/infrared colours enable whole blood assays. QDs have a wide range of applications for molecular diagnostics and genotyping. QDs also enable multiplexed diagnostics and integration of diagnostics with therapeutics. QDs can be used in multicolour optical coding for biological assays. The most important potential applications of QDs are for cancer diagnosis.[63]

Nano barcodes

Nano barcodes are useful in SNP mapping, Coding in multiplexed assays for proteomics, population diagnostics and in point-of-care handheld devices. Proteins detection by either mass spectrometry or fluorescence measure (after proteins immobilization on a metal surface).[63]

Nano biosensors

Biosensors are chemical sensors, in which recognition processes rely on biochemical mechanisms utilisation. They consist of a biological element (responsible for sampling), and a physical element (often called transducer, transmitting sampling results for further processing) Nanomaterials are sensitive to chemical and biological sensors. Ability to identify a particular type of cells or areas in a body makes the nano biosensors to find its place in medical diagnostics. Based on the differences in volume, concentration, displacement and velocity, gravitational, electrical, and magnetic forces, pressure, or temperature of cells in a body, nano sensors may be able to distinguish between and recognize certain cells, most notably those of cancer, at the molecular level in order to deliver medicine or monitor development to specific places in the body. In addition, they may be able to detect macroscopic variations from outside the body and communicate these changes to other nanoproducts working within the body.

Nanoparticles for discovery of biomarkers

Nanotechnology has refined the detection of biomarkers. Some biomarkers also form the basis of innovative molecular diagnostic tests. The physicochemical characteristics and high surface areas of nanoparticles make them ideal candidates for developing biomarker-harvesting platforms. The variety of nanoparticle technologies that are available, it is feasible to tailor nanoparticle surfaces to selectively bind a subset of biomarkers and sequester them for later study using high-sensitivity proteomic tests. Biomarker harvesting is an application of nanoparticle technology and is likely to undergo substantial growth.[64]

The other diagnostic application of NPs is in diagnosis of infectious disease, molecule identification, Protein Microarrays/Chips.

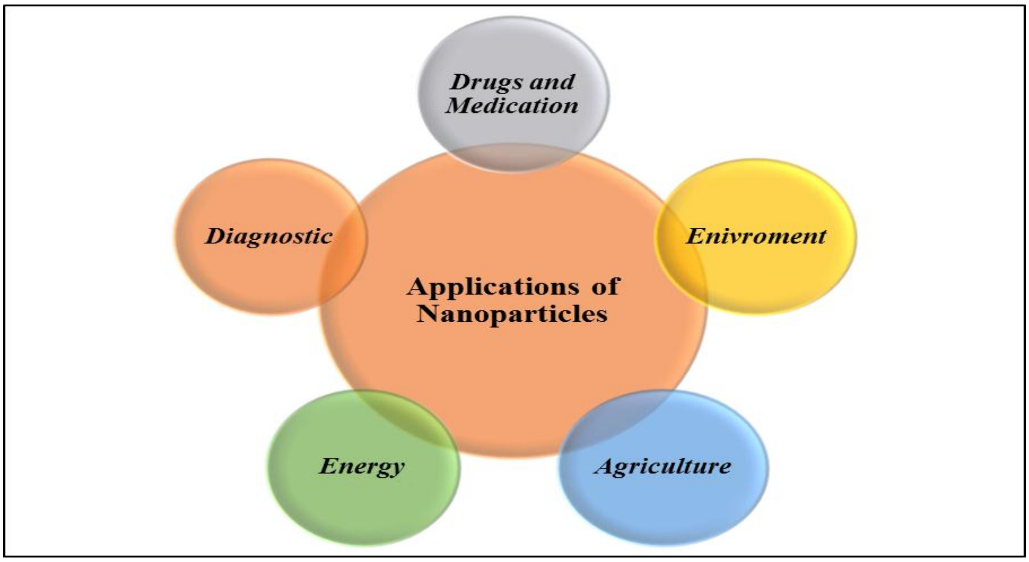


Fig.7: Applications of nanoparticles.

7. Toxicity of nanoparticles

Nanoparticle have many medical and industrial application but they also have toxicity i.e. nanotoxicity.[65] NPs enter the environment through water, soil, and air during various human activities. However, the application of NPs for environmental treatment dumps engineered NPs into the soil or aquatic systems. This has resultantly attracted increasing concern from all stakeholders. The advantages of magnetic NPs such as their small size, high reactivity and great capacity, could become potential lethal factors by inducing adverse cellular toxic and harmful effects, unusual in micron-sized counter parts. Some studies addressed NPs enter organisms during ingestion or inhalation and translocate within the body to various organs and tissues where the NPs have possibility to produce toxicological effect. Although some studies have also illustrated that toxicological effects of NPs on animal cells and plant cells the toxicological studies with magnetic NPs on plants. the use of Ag nanoparticle in different consumer product lead them release to the aquatics environment and thus exerts toxic effect to the aquatic organism such as algae fishes, bacteria etc.[66] The NPs enter into the respiratory tract by inhalation which produce toxicity by receive cardiac output and effect on lungs.[67] NPs properties also effect on the toxicity Size is a key factor in determining the potential toxicity of a particle. However, it is not the only important factor. Other properties of nanomaterials that influence toxicity include: chemical composition, shape, surface structure, surface charge, aggregation and solubility,[68] and the presence or absence of functional groups of other chemicals. The large number of variables influencing toxicity means that it is difficult to generalise about health risks associated with exposure to nanomaterials. One of the NPs toxicity is the ability to organize around the protein concentration that depends on particles size, shape and surface characteristics charge, functionalized groups, and free energy. Due to this binding, some particles generate adverse biological outcomes through protein unfolding, fibrillation, and due to this loss of enzymatic activity. Another paradigm is the release of toxic ions when the thermodynamic properties of materials favour particles dissolution in a suspending medium or biological environment.[69]

8. CONCLUSION

In this overview we present nanoparticle types, properties different characterization method of nanoparticle by using SEM, TEM, XRD. The morphological, structural characterization of nanoparticles are studied. The synthesis of nanoparticle. The various application of nanoparticle in different field and also the toxicity of nanoparticle toxicity on respiratory tract Ag nanoparticle toxicity on aquatic animals and toxicity due to the nanoparticle properties.

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