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A REVIEW ON NANOPARTICLES: SYNTHESIS, CHARACTERIZATION AND APPLICATION

Kavali Bhavana*[1], Gottemukkula Lakshmi Devi[1], Kavali Pavan Yadav[1], Akkala Govardhan[1], Kasula Arun Goud[1]

[1*]Department of Pharmaceutics, Vijaya Nagar, Ranga Reddy, Telangana, India.

ABSTRACT

Nanoparticle is any material having at least one of its dimensions in range 1-100nm [nano] word derived from Greek words nanos meaning dwarf [or] small a nanometer is one billionth of meter [10-9] nanoparticle is the medicine is to deliver drug around to body drug deliver to inside of cell smaller nanoparticles are subjected to extravasations and renal clearance larger nanoparticle quickly opsonized and removed from blood stream via macrophages of the reticuloendothelial system these are categorized into different groups such as organic inorganic and carbon based NPs on the basis of their origin properties shape and size for commercial uses which are classified into three types - chemical physical and mechanical processes this paper is to present a review on nanoparticle their types characterization synthesis methods and applications in fields of environment.

KEYWORDS

Nanoparticle types synthesis characteristics and Applications.

Author for Correspondence:

Kavali Bhavana,

Department of Pharmaceutics,

Vijaya Nagar, Ranga Reddy, Telangana, India.

Email: bhavanayadav799@gmail.com

INTRODUCTION

Thousand years ago Chinese used gold nanoparticle as in organic dye introduce red colour in ceramic porcelain in 1857 faraday prepared gold colloids and destroyed during world war-2 Bhasma nanomedicine of ancient time the nano comes Greek words meaning dwarf [or] tiny with convention of international system of units it indicate a reduction factor of 109 times Nobel laureate Richard p Feynman first presented nanotechnology during his well known 1959 lecture there plenty of room at the bottom nanoparticle are fundamental components of nanotechnology nanoparticles are the particulate matter with at least

one dimensions less than 100nm they can be made up of carbon metal oxides [or] organic matter the nanoparticles in medicine creating fluorescent biological label and in research and diagnosis of diseases drug delivery system -gene delivery system in gene therapy for biological detection of disease causing organisms detection of proteins isolation and purification of biological molecules and cells in research probing of DNA structure genetic and tissue engineering nanoparticles are being increasingly used in drug delivery system they size and surface characteristics of nanoparticles can be easily manipulated this could be used for both passive and active drug targeting nanoparticle can be made to control and sustain release of the drug during the transportation as well as the location of the release since distribution and subsequent clearance of the drug from the body can be altered an increases in drug therapeutic efficacy and reduction in side effect can be achieved targeted drugs may be developed various routes of administration including oral nasal injection intraocular [within the eyes etc nanoscale dimensions the no of dimensions of a material which are outside the nanoscale less than100nm range accordingly in zero dimensional [od] nanomaterial all the dimensions are measured within the nanoscale [no dimensions are larger than 100nm] most commonly od nanomaterial are nanoparticle in two dimensional nanomaterial-two dimensions are outside the nanoscale this class exhibits plate like shapes includes graphene nanofilms nanolayers and the nanocoatings three dimensional nanomaterial are the material that are not confined to nanoscale in any dimension this class can contain bulk powder dispersions of nanoparticle bundles of nanowires and nanotubes as well as it multi it nanolayer.

CLASSIFICATION OF NANOPARTICLE

Properties based on physical and chemical characteristics, some of the well-known classes of NPs are given as below.

Carbon-Based NPs

Fullerenes and carbon based np fullerenes contain nanomaterial that are made of globular hollow cage such as allotropic forms of carbon they have created noteworthy commercial interest due to their electrical conductivity high strength structure electron affinity and versatility these material possess arranged pentagonal and hexagonal carbon units CNT are elongated tubular structure 1=2nm in diameter these can be predicted as metallic or semi conducting reliant on their diameter telicity these are structurally resembling to graphite sheet can be single – walled double walled or multi – walled carbon nanotubes respectively they are widely synthesized by deposition of carbon precursors especially the atomic carbons vaporized from graphite by laser or by electric are on metal particle lately they are synthesized via chemical vapour deposition due to their chemical and mechanical characteristics these materials are not only used in pristine form but also in nanocomposites for many commercial applications etc.

Metal Nanoparticle

Metal nanoparticle are purely made of the metals precursors due to well known localised surface plasmon resonance characteristics these np possess unique optoelectrial properties NP of the alkali and noble metals i.e cu ag and au have abroad absorption band visible zone of the electromagnetic solar spectrum the facet size and shape controlled synthesis of metal NP is important in present day cutting edges material due to their advanced optical properties.

Ceramics Nanoparticle

Ceramics np are inorganic nonmetallic solids synthesized via heat and succesive cooling they can be found in amorphous poiycrystalline dense porous or hollow forms therefore NP getting great attention of researchers due to their uses in application such as catalysis photocatalysis photodegradation of dynes and imaging applications.

Semiconductor Nanoparticle

Semiconductor material possess properties between metals and nonmetal and therefore they found various appication in the literature due this property

semiconductor possess wide bandgaps and therefore showed significant alteration in their properties with bandgap tuning therefore they are very important material in photocatalysis photo optics and electronic devices as an examples variety of semi conductor np are found exceptionally efficient in water splitting applicationn due their suitable bandgap and bandedge positions.

Polymeric Nanoparticle

These are normally organic based NP and in the literature a special term polymer nanopartcle collective used for it they are mostly nanosphere or nanocapsular shaped the former are matrix particle whose overall mass is generally solid and other molecules are adsorbed at the outer molecules are adsorbed at the outer boundary of the spherical surface in the latte case the solid mass is encapsulated within the particle completely the pnp are readily functionalize and thus find bundles of application in the literatures.

Lipid-Based Nanoparticle

These NPs contain lipid moieties and effectively using in many biomedical applications generally a lipid NP is characteristically spherical with diameter ranging from 10 to 1000nm like polymeric NPs possess a solids core made of lipid and a matrix contain soluble lipophilic molecules surfactants or emulsifiers stabilized the external core of NPs lipid nanotechnology is a special fields which focus the designing and synthesis of lipid NPs for various application such as drug carriers and delivery and RNA release in cancer therapy.

SYNTHESIS OF NANOPARTICLES

Various method can be employed for the synthesis of NP but these methods are broadly divided into two main classes i.e[1] bottom up approach[2] top-down approach these approaches further divide into various subclasses based on operations reaction conditions.

Top-down Syntheses

In this method destructive approach is employed starting from larger molecule which decomposed into smaller units and then these units are converted into suitable NPs examples of this method are grinding/milimg CVD physical vapour deposition PVD and other decomposition techniques this approach is used to synthesized coconut shell CS powder were finely milled for different interval of times with the help of ceramic balls and well known planetary mills they showed the effect of milling time on overall size of the NPs crystallite size decreases as calculated by Scherer equation they also realized that with each hour increment the brownish colour faded away due to size decrease of the NPs the SEM results were also in an agreement with x-ray pattern which also indicated the particle size decreases with time simple top down route was employed to synthesize colloidal carbon spherical particle with control size the synthesis technique was based on the continuous chemical absorption of polyoxometalates [pom] on the carbon interfacial surface adsorption made the carbon black aggregates into relatively smaller spherical particles with high dispersion capacity and narrow size distribution.

Bottom-up Synthese

This approach is employed in reverse as NPs are formed from relatively simpler substance therefore this approach is also called building up approach examples of this case are sedimentation and reduction technique it includes sol green synthesis spinning and biochemical synthesis they used alizarin and titanium isopropoxide precursors to synthesize the photoactive composite for photocatalytic degradation of methylene blue alizarin was selected as it offer strong binding capacity with Tio2 through their axial hydroxyl terminal groups green and biogenic bottom up synthesis attracting many researchers due to feasibility and less toxic nature of processes these processes are cost effective and environmental friendly where synthesis of NPs is accomplished via biological system such as using plants extract bacterial yeast fungi aloevera tamarind and even human cells are used for synthesis of NPs Au NPs have been synthesis from the biomass of wheat and oat and using the microorganisms and plants extract as reducing agent.

PROPERTIES OF NANOPARTICLE

The properties of nanoparticle are generally categorized into physical and chemical the properties of few common nanoparticle they are nanoparticles properties reference.

Carbon-based nanoparticles

Fullerenes – safe and inert semiconductor and superconductor transmits light based on intensity

Graphene – extreme strength thermal electrical conductivity light absorption

Carbon Nanotubes [CNT] - high electrical and thermal conductivity tensile strength flexible and elastic

Carbon Black – high strength and electrical conductivity surface are resistant to uv degradation

Metal-based nanoparticle

Aluminium – high reactivity sensitive to moisture heat and sunlight large surface area

Iron – reactive and unstable sensitive to air and water

Silver – absorbs and scatters light stable antibacterial disinfectant

Gold – interactive with visible light reactive

Cadmium – semiconductor of electricity insoluble

Lead – high toxicity reactive highly stable

Copper – ductile very high thermal and electrical conductivity highly flammable solids

Zinc – antibacterial anti corrosive antifungal UV filtering

Metal-oxide based nanoparticle

Titanium oxide – high surface area magnetic inhibits bacterial growth

Iron oxide - reactive and unstable

Magnetite – magnetic highly reactive

Silicon dioxide -stable less toxic able to be functionalize many molecules

Cerium oxide – antioxidant low reduction potential

Aluminium oxide – increased reactivity sensitive to moisture heat and sunlight large surface area

Physical

The physical properties include optical such as the colour of the nanoparticle its light penetration absorption and reflection capabilities and UV absorption and reflection abilities in a solution or when coated on a surface it also include the mechanical properties such as elastic ductile tensile strengths and flexibility that plays a significant factor in their application other properties like hydrophobicity suspension diffusion and setting characteristics has found its ways many modern everyday things magnetic and electrical properties such as conductivity semi conductivity and resistivity has led a path for the nanoparticle to be used in modern electronics thermal conductivity in renewable energy applications.

Chemical

The chemical properties such as the reactivity of the nanoparticles with target and stability and sensitivity to factors such as moisture atmosphere heat and light determine its application the antibacterial antifungal disinfection and toxicity properties of the nanoparticle are ideal for biomedical and environmental application corrosive anti corrosive oxidation reduction and flammability characteristics of the nanoparticle determine their respective usage.

CHARACTERISATION

The unique characteristics determines the potential and application of a nanoparticle the nanoparticle characterisation is carried out by various measurement technique they are.

Various characterisation method for nanoparticle in solid, liquid and gaseous phase

Soild

Size- electron microscope and laser diffraction for bulk samples

Surface area – BET isotherm

Composition – XPS and chemical digestion followed by wet chemical analysis for bulk samples

Surface charge – image analysis of electron micrographs

Surface charge – zeta potential

Crystallography - powder X-ray or neutron diffraction

Liquid

Size – photon correlation spectroscopy and centrifungal

Surface Area – simple fitration and NMR experiments

Composition – chemical digestion for mass spectrometry atomic emission spectroscopy and ion chromatography
Surface morphology – deposition onto a surface for electron microscopy
Surface charge – zeta potential

Gaseous

Size – SMPS and optical particle counter
Surface area – SMPS DMA
Composition – particle are collected for analysis by spectrometric or wet chemical techniques
Surface morphology – capture particle electrostatically or by filtration for imaging using electron microscopy
Surface charge -DMA
Concentration – CPC

APPLICATIONS

Cosmetic and sunscreens

The conventional ultraviolet [UV] protection sunscreen lacks iong term stability during usage the sunscreen including nanoparticles such as titanium dioxide provides numerous advantages the UV protection property of titanium oxide and zinc oxides nanoparticle as they are transparent to visible light as well as absorbs and reflect UV rays found their way to be used in some sunscreen some lipsticks use iron oxide nanoparticle as a pigment.

Electronics

The higher necessity for larger size and high brightness displays in recent days that are used in the computer monitors and television is encouraging the use of nanoparticles in the display technology for examples nanocrystalline lead telluride cadmium sulphide zinc selenide and sulphide are used in the lights emitting diodes [LED] of modern displays the development in portable consumer electronics such as mobile phones and laptop computer led to the enormous demands for a compact lightweight and high capacity batteries a considerable more energy can be stored compared to traditional batteries due to their foam like [aerogel] structure batteries made from nanocrystalline nickel and metal hydrides due to their large surface area requires less recharging and last longer the increases in electrical conductivity of nanoparticle are used to detect gases like nitrogen this is due to increases in the pores of nanoparticles due to charge transfer firm nanoparticles to nitrogen as the gas molecules bind them together making them a better gas sensors.

Catalysis

Nanoparticle contain high surface area that offers higher catalytic activity due to their extremely large surface to volume ratio the nanoparticles functions as efficient catalyst in the production of chemicals one of the important applications is the use of platinum nanoparticles in the automotive catalytic converters as thy reduces the amount of platinum required due to very high surface area of the nanoparticles this reducing the cost significantly and improving performance some chemical reactions for examples reductions of nickel oxide to metal nickel [Ni] is performed using nanoparticles.

Medicine

Nanotechnology has improved the medical field by use of nanoparticle in drug delivery the drug can be delivered to specific cells using nanoparticles the total drug consumption and side effect are significantly lowered by placing the drug in the required area in required dosages this methods reduces the cost and side effects the reproduction and repair of damage tissue [tissue engineering] can be carried out with help nanotechnology the traditional treatments such as artificial implants and organ transplants can be replaced by tissue engineering one such example is the growth of bones carbon nanotube scaffolds the use ofgold in medicine is not new in ayurveda an Indian medical system gold is used in several practices one common prescription is the use of gold for memory enhancement to enhance the mental fitness of a baby gold is included in certain medical preparations.

Food

The improvement in production processing protection and packaging of food is achieved by incorporating nanotechnology for examples a nanocomposite coating in a food packaging process can directly introduce the anti -microbial substances

on the coated film surface one of the example is the canola oil production industry includes nanodrops an additive designed to transfer the vitamins and minerals in the food.

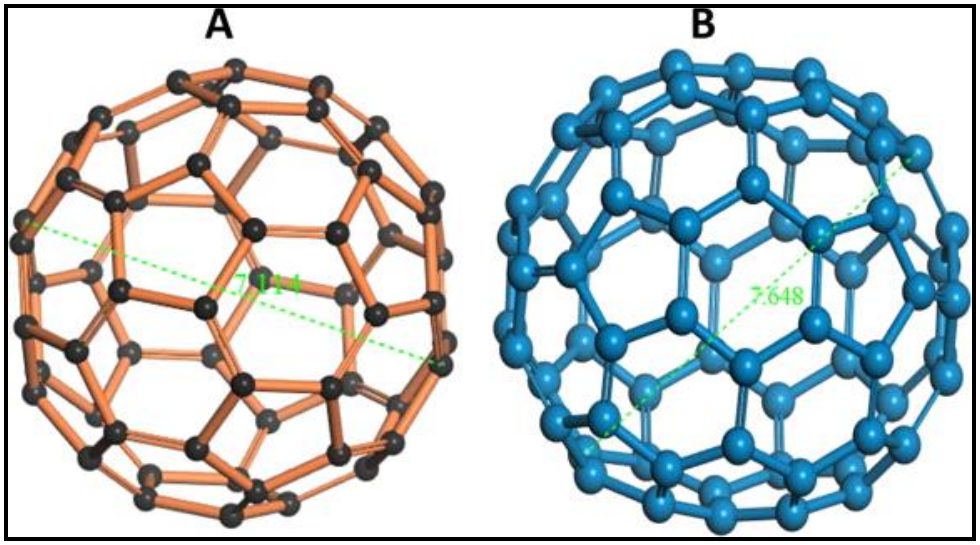
Construction

Nanotechnology has improved the construction processes by making them quicker inexpensive and safer for examples when nanosilica is mixed with normal concrete the nanoparticle can improve its mechanical properties and also improvement in durability the addition of haematite nanoparticles increases the strength of the concrete steel is the most widely available and used material in the construction industry the properties of steel can be improved by using nanotechnology in steel for examples in bridge construction the use of nano size steel offer stronger steel cables the other important construction material is glass extensive research is being performed on the application of nanotechnology in construction glass since titanium dioxide nanoparticles has sterilizing and anti-fouling properties and catalyse powerful chemical reactions that breakdown volatile organic compounds [VOV] and organic pollutants it is used to coat glazing the use of nanotechnology provides a better blocking of light and heat penetrating through the windows the paints with self-healing abilities and corrosions resistance and insulation are obtained by adding nanoparticles to the paints the hydrophobic property of these paints repels water and hence can be used to coat metal pipes to offer protections from salt water attack the addition of nanoparticles in paints also improves its performance by making them lighter with ehanced properties so when used for examples on aircraft it might reduce their overall weight and the amount of paint required which is favourable to the environmental as well the company to improves cost saving.

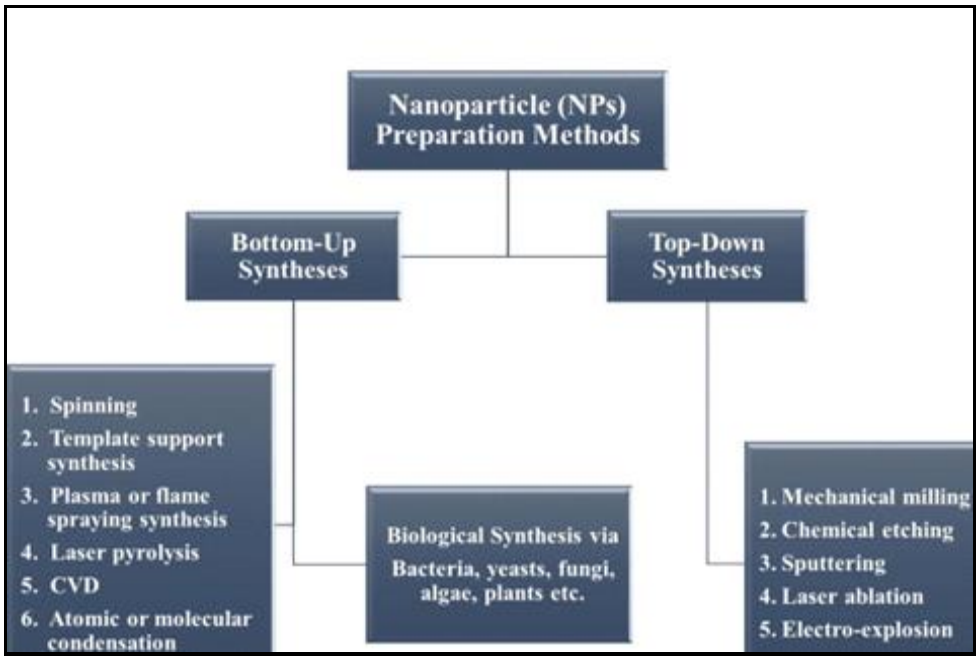
Renewable energy and environmental remediation

The unique physical and chemical properties of nanoparticles has made them an ideal choice to be used nowadays in environmental remediation to enhancing the performance in renewable energy sector. Nanoparticles occur in nature themselves and some of them are found to cure the environment. Environmental remediation using nanoparticles or nanoremediation is successfully being used to treat or decontaminate the air, water and soil for over a decade Nanoremediation is one of the effective solutions as it offers in situ treatment eliminating the necessity of pumping the ground water out for treatment and the need for excavation to reach the target destination. The nanoparticles are injected into the desired location and gets carried along the groundwater flow and decontaminates the water by immobilising the contaminants. The general mechanism involving in decontamination is the redox reactions. The nanoparticles are used to treat the surface water by disinfection, purification and desalination. Some of the contaminants are most likely to be heavy metals, pathogens and organic contaminants. It has proven to be efficient and eliminating the need for chemicals that may sometime produce secondary reaction products. Oil spill is one of the major problem worldwide as it may spread over very long distances. Cleaning them by conventional methods is difficult and time consuming that makes the situation worse as it may spread more. The nanoparticles are also used to clean-up oil spills and has also established to be effective method. The major use of nanoparticles are to treat municipal and industrial wastewater as well as the sludge produced. The replacement of nanoparticles for conventional chemicals is due to less cost, higher efficiency and lower quantity required for treatment. Nanofiltration is a recent membrane filtration system for water purification widely used in food and dairy industries. Soil contamination is also an increasing concern. Contaminated soil is cleaned or treated using nanoparticles by injecting the nanoparticles into specific target locations for heavy metal contamination, toxic industrial waste, etc. The higher surface area of certain nanoparticles has been used as a nanocatalyst in gaseous reactions. The most widely used area is in industrial stacks to reduce the contaminant level to prescribed limits or to remove completely that reduces the air

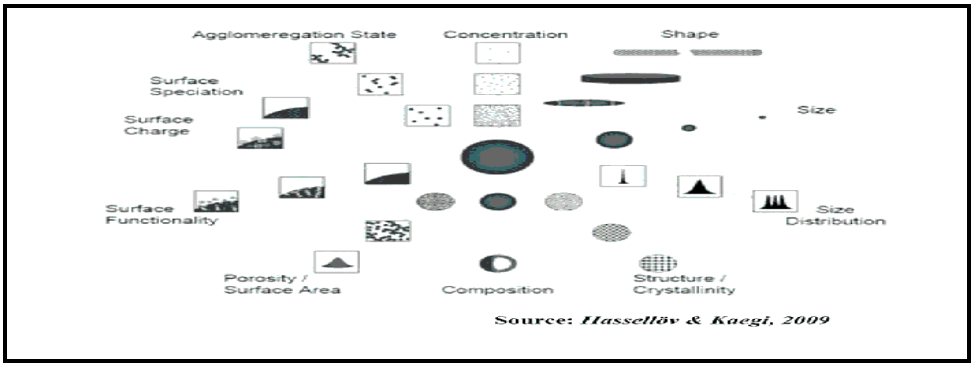
pollution. Extensive research is being carried out in the use of nanoparticles for renewable energy. Higher light and UV absorption with a very low reflection coatings in solar cells has improved their efficiency by considerable extent. The hydrophobic property of some nanoparticles has led to self-cleaning solar cells. High thermal conductivity and heat absorption capacity of certain nanoparticles are used to coat boilers and solar concentrators to improve their thermal efficiency.



Carbon-Based NPs



Various subclasses based on operations reaction conditions



Various measurement techniques

CONCLUSION

In this review article we have given brief overview of nanoparticle their structure classifications method of synthesis and application in various fields and properties of nanoparticles and characterisations of nanoparticle Nanoparticles have gained prominence in medicine environmental remediation and renewable energy constructions, food and many other areas.

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CONFLICT OF INTEREST

We declare that we have no conflict of interest.

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