Review Article
CODEN (USA): IJPLCP

ISSN: 0976-7126
Gawai *et al.*, 11(4):6540-6548, 2020

International Journal of Pharmacy & Life Sciences
Open Access to Researcher

A Review on nanoparticles, their preparation and applications

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Article info

Received: 30/01/2020

Revised: 28/02/2020

Accepted: 13/04/2020

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Abstract

The aim of pharmaceutical nanotechnology is to deliver the drug in the form of nanoparticles by enhancing their therapeutic potential. Nanoparticles are solid colloidal particles ranging size 10 to 1000 nanometer, nanoparticle possess a matrix structure which incorporate pharmacological active substances & facilitate control release of active agent. While the nano capsule contains an oily core incorporating drug surrounded by membrane structure. Nanoparticals use to successfully deliver the verity of drug protein, peptide & genes to cell both as non-targeted & targeted form. Drug can coupled in monomers that are specific for cell & organs. This strategies use to concentrate drug in selected targeted tissues thus minimizing side effect & toxicity.

Nanoparticles are prepared from either synthetic or natural macro molecules using two distinct techniques that is bottom up& top down technology. The bottom up technology adopts method to aggregate molecule into particle of nano range, while top-down adapt to breaking down macro molecules into nano range. Nano-tubes are used to deliver drug into targeted tissue cell & organs meanly use Carbon nanotube membrane. DNA nanotube, pharmaceutical nanoparticle are those where the drug is dissolved entrapped encapsulated or adsorbed on surface.

Keywords: Nanoparticles, Encapsulated, Nanopolymers

Introduction

Nanoparticle is a small object that behaves as a whole unit in terms of its transport & properties, size of nanoparticle is 1 to 100 nanometer, nanocluster have at least one dimension between 1 & 10 nanometer & narrow size distribution, nanopowder on the other hand are agglomerates of ultrafine particles of nanoparticle or nanocluster. Nanoparticle size crystals are called nanocrystals.[1-4]The size and surface characteristics of nano particles can be easily manipulated and this could be use for both passive & active targeting. Nanoparticles can be made to control & sustained release of the drug during the transportation as well as the location of the release. Since distribution & clearance of the drug from the body can be altered & increase in drug therapeutic efficacy &reduction in side effect can be achieved by various routs of administration including oral, nasal, injection and intraocular use. Copper nanoparticles smaller than 50 nanometer are consider super hard material that do not exhibit the same malleability & ductility as bulk copper. Ferroelectric nano particle are smaller than10 nanometer. Suspension of nanoparticle are possible because the interaction of particle surface with the solvent is strong enough to overcome differences in density which usually result in material either sinking or plotting liquid.

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Gold nanoparticle appears deep red to black in solution size 1 to 10 nanoparticle. They have very high surface area to volume ratio. The coarse particle are in the range 10000 to 2500 nanometer, then fine partical are in the range 2500 to 100 nanometer &nano particle are in the range 100 to 1 nanometer.[5-7]

Classes of Nanoparticle

The nanoparticles can be of Polysaccharide, powders & granules, protein & antibodies, soil & sediments, surface &interfaces, suspension slurries & pastes, viruses & vaccines.[8]

Use of nanoparticle in biology & medicine[9]

1) Creating Fluorescent biological labels for important biological markers & molecule in research & diagnosis of disease.
2) Gene delivery system in gene therapy
3) For biological detection of disease causing organisms & diagnosis
4) Detection of proteins
5) Isolation & purification of biological molecules & cell in research
6) Probing of DNA structure
7) Genetic and tissue engineering
8) Destruction of tumors with drugs
9) In MRI studies
10) In pharmacokinetic study

Types of Nanoparticles use in Pharmacy

1) Magnetic Nanoparticles

These are the class of Nanoparticles which can be manipulated using magnetic field which commonly consist of magnetic elements such as iron, nickel, cobalt etc. While magnetic nanoparticles smaller than 1 micrometer in diameter i.e., (5-500nm) have been focus of much research because they possess attractive properties.[10]

2) Iron Oxide nanoparticle

With diameter between 1 to 100 nm, the two main forms of iron oxide nanoparticles i.e., magnetic and magnetite have attracted extensive interest due to their super paramagnetic properties and potential application in Pharmaceuticals use in catalysis, sensor, medical diagnosis and therapeutics.[11]

3) Platinum Nanoparticle

Usually in the form of suspension or collides of sub micrometer size particle of platinum in a fluid. Platinum nanoparticles can be made with size between 2 to 20 nm. Platinum nanoparticle suspended in the brownish red or black color in colloidal solution.[12]

4) Gold Nanoparticles

Gold nanoparticles are used in immunochemical studies for identification of protein interaction. They are used as a Lab tracer to detect presence of DNA in a sample. Gold is even use in some medicines for targeted drug delivery system. The gold nanoparticleis more beneficial as it really small with diameter of 5 nm or less.[13]

5) Silver Nanoparticle

Silver nanoparticles are used to kill bacteria because of good electrical & thermal conductivity. It contains large number of silver ions & its surface use in antimicrobial agent.[14-15]

General Method of synthesis of nanoparticle

The process of condensation leads to fine powder with irregular particle sizes and shapes intypical powder. These may lead to non-uniformity of structure in the package nanoparticle that may lead in packaging density variation in the compact powder. In addition un controlled agglomeration of powder due to attractive Vander walls forces may also results in non-homogenous formation nano-clusters & nano particles packages. There are variations in stresses that can result in non-uniform drying shrinkage & this is directly proportional to the rate at which the solvent can be removing. Porosity & its distribution these determines the process to a large extent, such stresses have been associated with a plastic to brittle transitionin consolidated bodies & lead to propagation of cracks. Homogeneity may further be compromised where there are fluctuations in packing density in the compact as it is prepared for during the sintering process. Some pores & other structural defects associated with density variations have been shown to play a detrimental role in the sintering process. Finally produce nano material of uniform size & shape most important the distribution of components and porosity.[16]

Uniformity of Nanoparticles

In the synthesis of nanoparticle, high purity and uniformity of structure is necessary for putting this particle to use. There must be high purity ceramic polymers, glass ceramic & material

composites in creation of this particle. Nanoparticle is generally classified based on their dimensionality, morphology, composition, agglomeration and uniformity.[17]

Nanoparticle can improve medical diagnostic

Early detection of disease remains a primary goal of the medical community. Nanoparticle holds great promise to achievement of this goal. Nanoparticle in particular have exhibited tremendous potential for detecting fragment of viruses, pre-cancerous cells, disease markers & indicators of radiation damage. Gold coating has made it possible to use toxic cobalt nanoparticles for biomedical application. Gold coated ferromagnetic nanoparticle tagged with HIV antibodies may be able to detect virus particles left after completion of conventional drug therapy.[18]

Nanoparticle can improve targeted drug delivery method

Targeted drug delivery system can convey drugs more effectively and more conveniently that increases patient's compliance, extent the product life cycle, provide product differentiation & reduce health care cost. Targeted drug delivery rely on nanoparticles compounds characterized by low oral bioavailability due to poor water solubility, permeability, instability and provide for longer sustained & controlled release profile.[19]

Characterization of Nanoparticles[20]

1) Particle diameter < 100 nm
2) Electrical charged- ζ potential
3) Pharmaceutical stability
4) Physical stability in drug (no aggregation)
5) Nontoxic, biodegradable & biocompatible
6) Scalable & cost effective MFG process
7) Amenable to small molecules, peptides, protein or nucleic acid
8) Possible modulation of drug release profile

Nanocapsules

Nanocapsule is spherical structure which is form by an envelope of polymer film surrounding a liquid central cavity. The technique for preparation of (PIBCA)Polymeric isobutylcyanoacrylate nanocapsule are by injecting organic phase consisting of oil with dissolved drug, isobutylcyanoacrylate &ethanol into the aqueous phase containing pluronic f68under magnetic stirring. The colloidal suspension obtained was concentrated by evaporation under vacuum & filter to obtain nanocapsule. The nano capsule possess cell like structure with a wall thickness of 3nm around nanocapsule& pH range is 4 to 10.Similar to prepared (PIHCA) polyisohexylacynoacrylate involving treatment of monomer with sulphur dioxide & dissolved in a solution containing miglyol810 in ethanol, this solution was added slowly in 1:2 ratio into aqueous phase containing solution of 0.5% poloxamer 407 & 10mm phosphate buffer under stirring were purified centrifugation & washing with distilled water. The presence of non-ionic surfactant allowed polymerization of ethyl cyanoacrylate at O/W interface. Thus encapsulating miglyol812 droplets the immediate polymerization triggered formation of drug loaded nanocapsule. The suspension were concentrated under vacuum to remove acetone to produce smaller size nanocapsule.[21,22]

Nanotubes[23]

Nanotubes are generally used to deliver drug into targeted cell, tissue & organs they are mainly classified into four types.

1) **Carbon nanotubes:**S pinning carbon nanotubes are allotropes of carbon with a cylindrical nano structure. Nanotubes have been constructed with length to diameter ratio of up to 132,000,000: 1 significantly larger than for any other material. These cylindrical carbon moleculesare valuable for science & technology to their extraordinary thermal conductivity & electrical properties.
2) **Inorganic Nanotubes:** Is a cylindrical metal composing of metal oxide. They occurred in some mineral deposits.
3) **Membrane Nanotube:** Also called cytaneme are long & thin formed from the plasma membrane that connect different animal cells over long distance & could sometimes extend for over 100 micrometer between T cells. Two types of nanotubes have been observed. The first is less than 0.7 micrometer in diameter contain actin & carry portion of plasma membrane between cell in both direction and second type is larger than 0.7 micrometer contains both actin and

microtubules can carry components of cytoplasm between cells such as vesicles & organelles. This structure may be involving in cell to cell communication transfer of nucleic acid between cell in a tissue and spread of pathogens or toxins.

Application of Nanotubes[24]

1) Nanotubes bounds to an antibody that destroy breast cancer tumors. The antibodies carrying nano tubes are attracted towards proteins produces by a one type of breast cancer cell. Then nanotubes absorbed light from an infrared laser incinerating the nanotubes & the tumors.
2) Carbon nanotubes have developed to detect protein indicative of oral cancer providing results in less than hour.
3) Medical implants made of porous plastic coated with Carbon nanotubes, therapeutic drug are attached to nanotubes can be release into blood stream this developing in plant called biocapsule.

Types of preparation of nanoparticle :

1) Polymeric nanoparticle
2) Solid lipid nanoparticle
3) Hydro gel nanoparticle
4) Peptide nanoparticle
5) Nanocrystals &nanosuspension

Preparation of polymeric nanoparticle

A) By Polymerization process[25,26]

1) **Dispersion polymerization:** The Monomer has solvent hence newly form polymer has insoluble, polymer forms in continuous phase & precipitation as particles. The nucleation of aq. monomer solution when this chain exceeds a critical chain length, small particle is formed by aggregation of growing polymer chain & precipitation form continuous phase. Stable colloidal particles are formed by coalescence & with aggregates. In this technique the monomer is dispersed or dissolved in aq. medium form polymer precipitation out. Initiation of monomer of polymerization which may generate ion or radicals to start polymerization process. Nucleation of polymer is called ionic polymerization. Ionic polymerization may be anionic or cationic.
2) **Emulsion polymerization:** The monomer is emulsified in non-solvent containing surfactant which leads to formation of monomer swollen micelles & stabilized droplets. Polymerization required initiator which generates radicals/ions defending upon the type of initiator a nucleate, the monomeric unit and start polymerization process. The particle obtained in emulsion polymerization is small (100-300nm.)
3) **In an organic continuous phase:** In this process, the water soluble monomers are polymerized e.g. acrylamide & cross linker N,N'-bisacrylamide were prototype monomers to be polymerized using chemical initiator such as N, N, N' N'–tetra methyl ethylene diamine and potassiumperoxidesulphate or light irradiation and ultraviolet (U.V) radiations. High toxicity of monomer required high amount of organic solvent & surfactant for this technique. Polyalkyalcyanoacrylate (PACA) is prepared by this method. Nanocapsulesare also formed during polymerization by this method.
   a) **In an aq. continuous phase:** This technique required wide variety of monomer includes alkylcyanoacrylates. It requires low amount of surfactant & stabilized newly form polymer particle. In aq. media containing dextran,hydroxylpropyl, polyethylcyanoacrylate andpolyisobutylcyanoacrylates (PIBCA) nanosphere containing metaclopramide have been prepared by this technique. The technique result in only 9.2 to 14.8 % drug loading, respectively due to lose of water soluble drug in aq. Polymerization media. The cyanoacrylate monomer is initiated by OH^- ions & the polymerization was performed by low pH to control reaction, rapid polymerization resulting in precipitation of large polymer aggregates. The stabilizer influence on size of formed polymer particle. High concentration of poloxamer reduce particle size of PIBCA Nanoparticle from

around 200nm without emulsifier down to about 31-56nm.

B) Nanoparticle Prepared from performed polymer

1) **A. Solvent evaporation method[27]:** In this method, the polymer solution is prepared in organic solvent such as chloroform, ethyl acetate or dichloromethane. The drug to be encapsulated is dissolved in polymer solution. The organic phase emulsified with aq. Phase containing surfactant to abstained oil/water emulsion, the organic solvent is then evaporated at elevated temp or reduced pressure. The size of resulting nanoparticle greatly depends on size of emulsion droplets formed prior to solvent evaporation. The size can be controlled by number of factor such as stirring rate, type and amount of dispersant, viscosity of organic and aq. phases and temp. etc. The surfactant use in emulsion formation includespoloxamers, polysorbates 80polyvinyl alcohol.Higher PVA concentration in PLGA nanoparticles leads to decrease in nanoparticle size.

   B. Emulsification solvent diffusion method[28]

   The technique employs use of water miscible solvents such as acetone or methanol along with nonpolar solvent which were used as organic phase. Due to solubility of polar organic solvent in water they spontaneously diffuse into aq. phase and interfacial turbulence is created between two phases leading to precipitation of droplets as small as polymeric nanoparticle. As organic solvent utilized hazardous to environment various other technique such as
   a) Salting out technique
   b) Emulsion diffusion technique.

2) **Super critical fluid technology[30]**

   Hydrophobic drug have problem of low solubility, poor bioavailability and irregular absorption after oral administration. Nanoparticle can be prepared by size distribution, wet melting & high pressure homogenization. But contamination of product at degradation due to high temp. Generated during processing. The most popular method for preparation of nanoparticle is supercritical fluid technology (SCF). SCF technology facilitates rapid precipitation and form of dry nanoparticle. They can use environment friendly solvent such as CO_2, nitrogen, particle form with high purity and low traces of organic solvent. SCF techniques mainly divided into two major types.

   a) Rapid expansion of supercritical solution for drug soluble in SCF (RESS).
   b) Supercritical anti-solvent process for drug insoluble in fluid (SAS).

   In RESS the solute is solubilized in SCF and solution is expanded through a nozzle causing sudden decrease in solubility followed by particle ppt^n. The solvent power of SCF eventually decrease result in precipitation of solute, in this technique each particle is surrounded by same kind of particle in expansion zone & often result in larger particle due to aggregation(29). In SAS the solute is dissolved in organic solvent and solution is charged into SCF in precipitation vessel, at high pressure anti -solvent enter into liquid phase & result solvent power will be lower & solute precipitate out after precipitation, when final operation pressure is reached, the anti-solvent flows through the vessel so as to strip the residual solvent. The solvent content reduced to desired level the vessel is depressurized & solid product is collected.

Evaluation of polymeric nanoparticle[31-33]

Particle size: The methods of size analysis are photon correlation spectroscopy (PCS) and laser diffractometry. PCS determines hydrodynamic diameter of the nanoparticle via Brownian motion, the electron microscopy determine exact particle size but required coating of conductive material such as gold. The gold coating usually results as size more than normal & also procedure is limited to dry sample. Another one is transmission electron microscopy (TEM), with or without staining is a relatively easier method of particle size determination, not been stained, not electron dense or melted when irradiated by electron beam of microscope cannot be visualized by this method. Such nanoparticles are visualized by

TEM after freeze substitution. Investigation of nanoparticle surfaces recently new types of high resolution microscopes such as atomic force microscope, lesser force microscope and scanning & tunneling microscope are developed.

Molecular weight: Dissolution of particles in appropriate solvent and its analysis results obtained only if polymer standards have similar structure & similar properties as test material.

Density: Perform by helium compression pycnometry& by density gradient centrifugation.

Structure & Crystallinity: Can be determined by x-ray diffraction thermo analytical method.

Hydrophobicity: Two major methods such as contact angle measurement & hydrophobic interaction chromatography can be performed onlya flat surface where in differentiation between nanoparticle with different surface property can be obtained by loading particles & columns with alkyl sepharose& eluting then with a triton x-100 gradient.

Application of polymeric nanoparticles in drug delivery

a) **Opthalmic delivery of nanoparticles**[34]**:**Oral &i.v.administration of drug for treatment of ocular diseases is very little due to poor concentration attained in retina. Delivery of drug to macula was partly successful by injection through various routs such as subconjunctival, juxtascleral or direct intraquitreal injection. However this mode of therapy apart from rapid onset of action, also results in rapid clearance of drug & demands multiple doses at frequent intervals which is not always advisable. Polymeric system such as nanoparticle solves this problem due to their ease of administration &injectability. E.g. budenoside was successfully delivered through nanoparticles into subconjunctival space to suppress vascular endothelial growth factor expression. Second e.g. is intravitreal administration of dye (Rh-6G [Rh])or nile red (NR) loaded PLA nanoparticles result in their immediate appearance in vitreal space.

b) **Brain delivery of polymeric nanoparticle**[35]:Blood brain barrier (BBB) is a tight endothelial junction prevent transport of molecule into brain requiring of carrier for transportation. Nanoparticles are most logical approach for transportation,success of transportation depends upon smaller size (< 100 nm) prolong circulationtransport by transcytosis. E.g. polysorbate 80 coated PBCA Nano particle where shown to successfully delivery associated with hesapeptidedalarginto the brain as determine by its therapeutic effect. Coating modified tissue distribution & decrease the distribution of nano particle to organs of reticulo endothelial system significantly coated nanoparticles are higher concentration around brain. Increase retention & absorption of nanoparticle in brain capillary. Opening of tight junction to allow penetration of drug. Inhibition of p-glycoprotein associated with efflux process.

c) **Delivery of nano particle to cancer cell**[36-37]**:** some drugs gets poorly incorporated into cancer cell by substrate to p-gp& multidrug resistance associated protein (MRP) efflux pumps e.g. doxorubicin. To overcome this problem such drug are incorporated into nanoparticles.Doxorubicin conjugated with PLGA nanoparticle show greater antitumor activity after single dose injection in subcutaneously. PEGylated gelatin nanoparticle show enhances blood circulation time & uptake into lewis lunges carcinoma grown as solid tumor. Smaller size chitosan nanoparticle (64nm) found to possess antitumor activity when tested in MGC803 human gastric carcinoma cells. The PIHCA nanoparticles improved antitumor activity of Doxorubicin in vivo in hepatocellular carcinoma bearing transgenic mice over expressing mdr-1 & mdr-3 gene.

d) **Delivery of nanoparticle to macrophages**[38]:The Nanoparticles are extensively taken up by endocytosis through macrophages phagocytic receptors such as mannose receptors, D-galactose receptors&scanvenger receptors. mannose receptors bound nanoparticle are injested by the macrophages at a faster rate. Surface charge & chemistry of nanoparticles also

important to for macrophages uptake. E.g. amphotericin for leishmaniainfection.

Pharmaceutical Application of nanoparticles[39-41]

1) A method to deliver a chemotherapeutic drug called paclitaxel to bladder cancer cell uses nanoparticles called micelles to carry the drug.
2) Polymer nanoparticles are being developed to carry the chemotherapy drug called docetaxel directly to cancer tumor nanoparticle are attracted towards a protein a many types of cancer tumor resulting in high delivery of drug to tumor. The company developing this targeted chemotherapy methods called bind biosciences.
3) Gold nanoparticle uses to fight skin cancer to which RNA molecules attached.
4) A method is developed in fight aging uses mesoporous nanoparticle with a coating that releases the content is of the nanoparticle when an enzyme found in aging cell is present.
5) Aluminosilicate nanoparticles can reduces bleeding in trauma patients with external wounds by activating blood clotting mechanism.
6) Polymer nanoparticle act as synthetic platelets injection of this platelets significantly reduces blood losses.
7) Nanoparticle composed of polyethylene glycon-hydrophilic carbon cluster have been shown to absorbed free radicals at much higher rate than protein out body uses for this function this ability to absorbed free radicals may reduce the harm that is cause by the release of free radical after a brain injury.
8) Ironoxide nanoparticles can use to improved MRI images of cancer tumor.
9) Nanoparticles coated with protein that attach to damage portions of arteries. This could allow delivery of the to the damage regions of arteries to fight cardiovascular disease.
10) Quantum dot nanoparticle that identify the location of cancer cell in body
11) Iron nanoparticle use to clean up carbon tetrachloride pollution in ground water.
12) Silver nanoparticle in fabric that kills bacteria making clothing odor resistant.
13) Porous silica nanoparticles use to delivery up chemotherapeutic drug to cancer cell.
14) Nano particles when activated by x-rays that generate electron that cause the destruction of cancer cell to which they have attach themselves this is to be use in place radiation therapy with much less damage to healthy tissue.
15) A nanopartical cream that releases nitric oxide gas to fight stop infection.

References

1. MohanrajV.J.,Chen Y. (2006). Nanoparticle a review.*Tro J PharmRes*, 5:1:561-573.
2. Langer R. (2000). Biomaterials in drug delivery and tissue engineering: one laboratory experience. *AccChem Res*.33:94-101.
3. Bhadra D,Bhadra S,Jain P, Jain NK.(2002).Pegnology: a review of PEG-ylated systems.*Pharmazie*, 57:5-29.
4. Kommareddy S, Tiwari S.B.,Amiji M. M.(2005). Long Circulating polymeric nanovectors for tumor selective gene delivery. *Technol Cancer Res Treat*, 4:6:15-25.
5. Tipnis and Bajaj. (2010).Textbook of vesicular particulate drug delivery systems.edited by R.S.R Murthy. 1st ed. Career Publication;p. 231-76.
6. Hans M.L., Lowman A.M. (2002). Biodegradable Nanoparticles for drug delivery and Targeting. *CurrOpin Solid Staste Mater Sci*,6: 319-327.
7. Sopimath K.S., Amminabhavi T.M., Kulkarni A.R., Rudzinski W.E.(2001). Biodegradable Polymeric Nanoparticles as Drug Delivery Devices. *J ContRel*, 70: 1-20.
8. Singletary Michael.(2001). Application of Nanotechnology:Nanobodies. Abstracts for a Presentation given at the 6th foresight *Conference on molecular Nanotechnology*. Dec.12.
9. Equsquiaquree S.P., Igartua M, Hernande Z.M. (2014).Nanoparticle delivery systems for cancer therapy: advances in clinical and preclinical research. *CliTranslOncol*.4; 14:2:83-93.

10. Fan T.X., Chow S.K.,Zhang D. (2009). Biomorphic Mineralization: from Biology to materials.*ProgInMaterials Sci*. 54:5:542-659.
11. Saba Hasan. (2015). A review on nanoparticle:Their Synthesis and Types.*Res J Rec Sci*. 4:1-3.
12. Baban D,Seymou L.W. (1998). Control of tumour vascular permeability. *Adv Drug Deliv Rev*. 34:109-119.
13. AvnikaTomar, Garima Garg. (2013). Short Review on application of Gold Nanoparticles. *Global JPharm*.3;7:1:34-38.
14. Mahendra R, AlkaY,Aniket G. (2009).Silver nanoparticles as a new generation of antimicrobials. *Biotech Adv*.27:1:76-83.
15. Lateef A, Adelere I.A., Gueguim E.B. (2015).Green synthesis of silver nanoparticles using keratinase obtained from a strain of Bacilllussafensis LAU 13. *Int Nano Lett*. 5:29-35.
16. Smith R.H.,(2001). Social, Ethical & Legal Implication of Nanotechnology. *Societal Implications of Nanoscience Foundation*.16 Dec: Sec.6.5: 203-205.
17. Vyas S.P.,Khar R.K., (2004). Targeted & Controlled Drug Delivery. CBS Publisher & Distributor. 368-380.
18. Erik F, Mahajan R. (2003).Contradictory Intent? US federal legislation on integrating societal concerns into nanotechnology research and development. *Sci Pub Policy*. 33:1:5-16.
19. Mary C, Michele M. Simkin& Stephen Maebius. (2005). A Success Story about the 1st Nanoparticulate Drugs Approved by the FDA. United States: Nanotech meets the FDA,27.
20. Gupta R.B., Kompella U.B. (2006).Nanoparticle technology for Drug Delivery. Published by Tailor &Fransis group,New York. 131-135.
21. Magenheim B, Benita S. (1991). Nanoparticle Characterisation: A comprehensive physicochemical approach.*STP Pharm Sci*.1-21.
22. Damge C, Michael C, Aprahamian M, Couvreur P, Devissaguet JP. (1990).Nanocapsules as carrier for oral peptide delivery. *J Control Release*. 3:233.
23. Vandooren J, Berghmans N, Dillen C. (2013). Intradermal Kim air pouch leukocytosis as an in vivo test for nanoparticles. *Int J Nanomed.* 8: 4745-4756.
24. Kam N.W., Connell O.M., Wisdom I.A. (2005). Carbon Nanotubes as multifunctional biological transports and near infrared agents for cell cancer destruction.*Proc Natl Acad Sci*. USA 10211600.
25. Kompella U.B., Bandi N,Ayalasomayajula S.P.,(2001). Poly(Lactic Acid) nanoparticles for sustain release of budenosoide.*Drug DelivTechnol*.1:1-7.
26. Li Y.P., Pie Y.Y., Zhou Z.H.(2001). PEGylated polycyanoacrylate nanoparticles as a tumor necrosis factor-[alpha] carriers.*J Control Release*. 71:287-296.
27. Narayanan K.B., Sakhthikel N.(2010). Biological Synthesis if nanoparticles by microbes.*Advcoll Inter Sci.* 156:1-13.
28. Shiv S.S., Akhilesh R, Absar A, Murli S.(2004).Rapid synthesis of Au, Ag and bimetallic Au core-Ag shell nanoparticles using Neem (Azadirachtaindica) leaf broth. *J Colloid Int Sci*. 275:2:496-502.
29. Jung J, Perrut M, Pathak M. (2001). Particle design using supercritical fluid: Literature and patent survey. J Supercritical fluids. 20:179-219.
30. Thote A.J., Gupta R.B.(2005). Formation of nanoparticles of a hydrophilic drug using supercritical carbon dioxide and microencapsulation for sustain release Nano medicine.*Nanotech Bio Med*. 1:58-90.
31. Kestens V, Roebben G. (2016). Challenges in the size analysis of silica nanoparticles mixture as candidate certified references.*J Nanopart Res*. 18:171-179.
32. Silkora A, Shard A.G., Mineli C. (2016).Size and potential measurement of silica nanoparticles in serum using

tunable resistive pulse sensing.*Langmuir*. 32:2216-2224.
33. Filipe V, Hawe A, Jiskoot W.(2010). Critical evaluation of nanoparticle tracking analysis (NTA) by nanosight for the measurement f nanoparticles and protein aggregates. *Pharm Res*. 27:796-810.
34. Samaligly E, Rohdewald P, Mohmoud H.A. (1986).PolyalkylcyanoacrylateNanocapsules. *J PharmPharmacol*.38:216.
35. Chen Y, Dalwadi G, Benson H. (2004). Drug Delivery across the blood brain barrier. *Current Drug Deli*. 1:361-376.
36. Verdun C, Brasseur F, Vranckk H.(1990). Tissue distribution of doxorubicin associated with polyhexylcyanoacrylate nanoparticle. *Cancer ChemotherPharmacol*. 26:13-18.
37. Couvreur P, Kante B. (1980). Tissue Distribution of antitumor drugs associated with polyalkylcyanoacrylate nanoparticles. *J Pharmacol Sci*.69:199-202.
38. Moshfeghi A.A.,Peyman G.A. (2005). Micro &Nanoparticulate. *Adv Drug delivery Rev*. 57: 2047-2052.
39. Alexis F, Pridgen E, Molnar LK.(2008). Factors affecting the clearance and biodistribution of polymeric nanoparticles.*Mol Pharm*. 5:505-515.
40. Ali A, Zafar H, Zia M, UlHaq. (2016).Synthesis, Characterization, applications, and challenges of iron oxide nanoparticle. *NanotechnolSci Appl.* 9: 49-67.
41. Loureiro A, Gomes N.G., CavocaP.A. (2016). Albumin Based nanodevives as drug carriers. Curr Pharm Des.22:1371-1390.

Cite this article as:
Gawai A.A., Sarode R.J. and Biyani K.R. (2020). A Review on nanoparticles, their preparation and applications, *Int. J. of Pharm. & Life Sci.*, 11(4): 6540-6548.
Source of Support: Nil
Conflict of Interest: Not declared
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