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REVIEW ON NANO PARTICLE DRUG DELIVERY SYSTEM

Sherkar Ashwini Sopan[1]

[1]Institute/Organization: Shri Swami Samarth institute of pharmacy Malwadi, Bota

ABSTRACT

Targeted medicine delivery has drawn more interest recently due to a number of benefits. Numerous avenues were investigated for targeted drug delivery. Particulate dispersions or solid particles with sizes between 10 and 1000 nm are called nanoparticles. The medication is attached to a matrix of nanoparticles, dissolved, entrapped, or encapsulated. Nanoparticles, nanospheres, or nanocapsules can be produced based on the preparation technique. In order to obtain site-specific action of the drug at the therapeutically optimal rate and dose regimen, the main objectives of designing nanoparticles as a delivery system are to control particle size, surface characteristics, and release of pharmacologically active substances. The methods of manufacture, characterization, and use of several Nano particulate drug delivery systems are revealed in this review. At the molecular and sub molecular level, nanotechnology investigates structural behaviour in addition to electrical, optical, and magnetic activity. It has the ability to completely transform a number of biotechnology and medical instruments and processes, making them more affordable, portable, safe, and simple to use. Nanoparticles are used for a wide range of applications, including medical treatments, the production of solar and oxide fuel batteries for energy storage, and their widespread integration into a variety of everyday materials like clothing, cosmetics, optical devices, catalytic, bactericidal, electronic, sensor technology, biological labeling, and the treatment of certain cancers.

Keywords- Nano-pharmaceuticals, Nanotechnology, Nanoparticles, types, application, method.

1. INTRODUCTION

The study of manipulating matter at the atomic and molecular scales, as well as dealing with matter at a scale of one billionth of a meter, is known as nanotechnology. The most basic building block for creating a nanostructure is a nanoparticle, which is larger than an atom or a simple molecule, which are subject to quantum mechanics, but much smaller than the world of common things, which are characterized by Newton's laws of motion. The National Nanotechnology Initiative (NNI) was established by the United States in 2000, and in 2001, numerous nanotechnology initiatives were launched by almost all of the country's departments and agencies.[1] The Nationa1 Science Foundation (NSF), an organization that reports only to the President of the United States and is tasked with supporting the greatest basic science and technology initiatives, later provided funding for about 20 Research Centres. The pharmaceutical industry will be heavily impacted by the market for nanotechnology and medication delivery systems built on this technology.

The number of products and patents in this industry has grown dramatically in recent years. Nano particulate drug delivery systems have been referred to by a number of different names. Drug carriers are typically either polymers or lipids, and the particle sizes in delivery systems range from a few Nano meters to a few hundred nanometres. Nano medicine is a broad field that includes nanoparticles that mimic biological processes (e.g., functionalized carbon nanotubes), "nanomachics" (e.g., made from DNA scaffolds and interchangeable DNA parts, such as stick cubes and octahedrons), nanofibers and polymeric Nano constructs as biomaterials (e.g., molecular self-assembly and nano-fibers of peptides and peptide amphiphiles for tissue engineering), shape memory polymers as molecular switches, Nano porous membranes, microfabrication-based devices (e.g. silicon microchips for drug release and micro machined hollow needles and two-dimensional Needles assay from single crystal silicon), sensors, and laboratory diagnostics. [2, 3] By using nanostructures and Nano phases in a variety of scientific fields, nanotechnology has been demonstrated to overcome the divide between the biological and physical sciences [4].Such particles are particularly important in Nano medicine and nano-based drug delivery systems [5, 6]. Nanomaterials, which range in size from 1 to 100 nm, are materials that impact the boundaries of Nano medicine, ranging from Hence tissue engineering to drug delivery, biosensors, microfluidics, and microarray testing [7– 8]. To create Nano medicines, nanotechnology uses therapeutic molecules at the nanoscale level. Nanoparticles have fuelled the biomedical fields of tissue engineering, drug delivery, biosensors, and Nano biotechnology [9]. Since compounds made of nanoparticles They are typically tiny nanospheres at the atomic or molecular level [10].

Compared to larger materials, they have greater mobility throughout the human body. Particles at the nanoscale have special mechanical, chemical, electrical, magnetic, biological, and structural characteristics. Because nanostructures can be used as delivery agents to encapsulate pharmaceuticals or attach therapeutic substances and transport them to target tissues more accurately with a controlled release, Nano medicines have gained popularity recently [13,14].Nanoparticles are

available in a The fundamental units of nanotechnology are nanoparticles. Nanoparticles can be composed of carbon, metal, metal oxide, or organic substance, and their sizes range from 1 to 100 nm. Nanoparticles differ in size, shape, and dimension in addition to their composition. There are many different types of nanoparticles, such as one-dimensional graphemes, which can only have one parameter, two-dimensional carbon nanotubes, which have both length and breadth, three-dimensional gold nanoparticles, which have all three dimensions, and zero- dimensional nan dots, which have their length, width, and height fixed at a single point.

The range of shapes, sizes, and configurations, such as conical, hollow core, spiral, flat, spherical, cylindrical, tubular, and so forth1. Nanotechnology involves designing, producing, and using materials at the atomic, molecular, and macromolecular scales to develop new Nano sized materials. Pharmaceutical nanoparticles are solid drug carriers that are submicron in size (less than 100 nm in diameter) and either biodegradable or not.

The structure of Nanoparticles is intricate. They have two or three Layers each.

1. A surface layer that has been Functionalized by different small molecules, metal Ions, surfactants, or polymers. 2. The shell layer is Chemically distinct from the core and can be Intentionally added.

3. The fundamental Components; the heart of NPs4. Chemical or Biological processes can be used to create Nanoparticles. Due to the presence of some toxic Chemicals, chemical synthesis has been linked to Numerous negative effects, and physical synthesis Is the biological way of producing Nanoparticles.

Advantage of Nanoparticles : Following are a few benefits of nanoparticles:[15- 20]

1. Ease of modifying nanoparticle surface Properties and particle size to target drugs Both passively and actively after parenteral Administration .

2. Using Nano sized quantum dots based on Immunofluorescence to label particular Bacteria, which makes it easier to identify and Get rid of them.

3. Nanotechnology is a growing field in many Industries, including aquaculture, and it has Numerous applications in areas like nutrition.

4. Reproduction, water purification, fishing, and Disease control as well as the reduction of Toxicity and negative effects.

5. The preparation of nanoparticles using Biodegradable materials enables sustained Drug release at the target site over the course Of days or even weeks.

6. Because nanoparticles are so small, they Easily pass through tiny capillaries and are Absorbed by cells, enabling effective drug Accumulation at the body's target sites

7. Nanotechnology can make fabrics more Durable because NPs have a high surface Energy and a large surface area to volume Ratio

8. Nano supplements can be easily added using The encapsulation technique for effective drug And nutritional delivery.

9. Nanobarcodes are used to label food products For safety and to track their distribution.

10. Nanoparticles overcome the resistance offered by The physiological barriers in the body because Efficient delivery of drug to various parts of the Body is directly affected by particle size.

11. Nanoparticles aid in efficient drug delivery to Improve aqueous solubility of poorly soluble drugs That enhance Bioavailability for timed release of Drug molecules, and precise drug targeting.

12. The surface properties of nanoparticles can be Modified for targeted drug delivery for e.g. small Molecules, proteins, peptides, and nucleic acids Loaded nanoparticles are not recognized by immune System and efficiently targeted to particular tissue Types.

13. Targeted nano drug carriers reduce drug toxicity and Provide more efficient drug distribution.Nanocarriers holds promise to deliver biotech drugs Over various anatomic extremities of body such as Blood brain barrier.[22]

Disadvantage of Nanoparticles : [19,20]

1. Because of their small size and high surface Area, nanoparticles are highly reactive in the Cellular environment.

2. When used for drug delivery, non-Biodegradable particles may accumulate at the Site of the drug delivery, causing a chronic Inflammatory response.

3. Because nanoparticles have limited targeting Capabilities, it is not possible to stop the Therapy.

4. Nanotechnology is very expensive, and it can Be even more expensive to develop.

5. Atomic weapons are now easier to obtain, More potent, and more destructive to use.

6. Toxicity : Nanoparticles can be toxic and can damage cells and biomolecules, which can affect organ function. For

example, nanoparticles can cause lung inflammation and liver toxicity.

7. Drug resistance : Tumor cells can adapt and become resistant to chemotherapy drugs carried by nanoparticles.

8. Biodistribution : The biodistribution of drug molecules can change when delivered via a nanoparticle, which can lead to local overexposure in certain organs.

9. Brain toxicity : Nanoparticles can cross the blood-brain barrier, which can make them toxic to the brain.

10. Difficult to distinguish toxicity :It can be difficult to distinguish the toxicity of the drug from that of the nanoparticle.

11. Working with nanotechnology can prove to be very Risky too. The investment needed to start up a Project involving this science can be huge without Any guarantee of success and this can lead to huge Losses. At the same time, the technology poses risks To health as well.

12. It is true that nanotechnology has raised our standard Of living but it has also led to an increase in the Levels of pollution. The pollution caused due to Nanotechnology is known as Nano pollution and this Can be very dangerous for living organisms.

13. Another major disadvantage of nanotechnology is The possible mass poisoning of material which is Processed at a Nano scale. This can leave a negative Impact on the health and industry and can happen if The coatings on the products produced by

this Technology include some of the poisonous micro Particles which can penetrate into our brains.[21].

Nanoparticles preparation is most frequently by three Methods :

Solvent evaporation method : One of the most popular techniques for creating nanoparticles is the solvent evaporation approach. This method consists of two steps: first, the polymer solution is emulsified into an aqueous phase; second, the polymer solvent evaporates, causing the polymer to precipitate as nanospheres. This technique relies on the solubility of the hydrophobic medication and the polymer because both are dissolved in an organic solvent (ethyl acetate, chloroform, or dichloromethane), which is also employed as the solvent for dissolving the hydrophobic drug. After that, the mixture made from the medication and polymer solution is emulsified in an aqueous solution. To create an oil in water (o/w) emulsion, this aqueous solution comprises an emulsifying agent or surfactant. Either constant stirring or lowering the pressure is used to evaporate the organic solvent after the stable emulsion has formed. It was discovered that the stabilizer type and concentration, the concentration of the polymer, and the speed of the homogenizer all affected the size range of the nanoparticles. High-speed homogenization or ultra sonication are frequently used to create particles with a small size.[23, 24, 25].

Polymerization method : This process creates nanoparticles in an aqueous solution by polymerizing monomers. After polymerization is finished, the drug is integrated either by adsorption onto the nanoparticles or by dissolution in the polymerization media. By ultracentrifugation and re-suspension of the particles in an isotonic surfactant-free medium, the nanoparticle suspension is then filtered to exclude different stabilizers and surfactants used for polymerization. Polybutyl cyanoacrylate or poly (alkyl cyanoacrylate) nanoparticles have been reported to be produced using this method.[26].

Coacervation or ionic gelation method : The goal of recent research on biodegradable polymers like sodium alginate and gelatin is to produce biodegradable nanoparticles with characteristics like low toxicity and biocompatibility. Hydrophilic polymer-based nanoparticles can be prepared using techniques like ionic gelation. Calvo and colleagues created an ionic gelation method for creating chitosan-based nanoparticles. The polymer [chitosan, a di-block co-polymer ethylene oxide or propylene oxide (PEO-PPO)] and the poly anion sodium

triphosphate are synthesized in two distinct aqueous phases using this approach. This technique creates coacervates with a size in the range of nanometers by utilizing the strong electrostatic contact between the negatively charged tri polyphosphate and the positively charged amino group of chitosan. Strong electrostatic forces are present. Coacervates are created when two aqueous phases interact with one another. Ionic gelation, on the other hand, is the process by which a substance changes from a liquid to a gel at room temperature as a result of ionic interaction circumstances.[27].

Classification of nanoparticles: The three types of nanoparticles—organic, Inorganic, and carbon-based—are used to Categorize them:

1. Organic nanoparticles: This class of organic nanoparticles is made up of molecules that are at least 100 Nm22 in size. Organic-based NPs, sometimes referred to as nanocapsules, are safe for the environment and non-toxic. Ferritin, liposomes, micelles, and dendrimers are all highly sensitive organic nanoparticles or polymers that are subjected to heat or light.

Dendrimers : The dendrimer is a novel family of controlled-structure polymers with nanometric dimensions. Dendrimers used in imaging and drug administration often include several functional groups on their surface and are between 10 and 100 nm in size. In the pharmaceutical industry, dendrimers have been employed as pro-drugs, antimicrobials, anticancer agents, non-steroidal anti-inflammatory medicines, and screening agents for high-throughput drug development.

Liposomes : Liposomes' straightforward functionalization, efficient drug encapsulation, biocompatible qualities**,** and size control make them an ideal DDS for chemotherapy. Spherical vesicles with one or more phospho-lipid bilayers are called liposomes. A major disadvantage to their clinical application is their short circulation half-life, despite the fact that surface modification can be beneficial.[28–30]

2. Inorganic nanoparticles : They are composed of non-carbon materials such as metals, metal salts, and metal oxides. They can assume a number of shapes, such as spheres, cylinders, oblates, ellipsoids, cubes, and stars, depending on how the atoms are packed, while yet retaining the crystallinity of metal-based compounds.

Metal based nanoparticles : The process for synthesizing metal-based Nanoparticles to nanometric size can be destructive Or constructive.

Gold nanoparticles : Gold nanoparticles are on the nanoscale scale in size. Their unique physical and chemical characteristics allow them to both absorb and scatter visible and near-infrared light. Gold nanoparticles are excellent study materials because they are among the most stable, non-toxic, and easily synthesized NPs. They also exhibit a number of intriguing properties, such as the ability to assemble into various forms and the quantum size effect.[31–33]

3. Carbon-based nanoparticles : They are made up of Sp2 Bonded carbon atoms. They include grapheme, fullerenes, single and multiwalled carbon nanotubes, carbon nanofibres, nano-diamonds, nano-horns, nano-onions, and nano-graphite. The three synthesis methods for carbon-based materials are chemical vapour deposition, laser ablation, and arch discharge.

Carbon-nanotubes : The large specific surface area and oleophilic properties of CNTs greatly aid in the construction of an oil-removing membrane with a high penetration flux [30]. Multi-walled carbon nanotubes range in size from 2 to 100 nm, whereas single-walled carbon nanotubes have a diameter of 0.4 to 2 nm. Enrolled graphite sheets are the building blocks of carbon nanotubes.

Graphene: A two-dimensional (2D) grapheme is a single sheet of carbon atoms that are organized hexagonally in a crystalline lattic that resembles a honeycomb and reaches even micro and millimeter in both lateral sizes. This material has minimal toxicity, high intrinsic strength, thermal conductivity, and biocompatibility. Greatest benefits for biosensing applications.[34–36].

Nanotechnology in Medicine Application :

Cell Repair[37] : In fact, Nano robots might be trained to fix particular damaged cells, acting similarly to antibodies in our body's natural healing processes. Read this article to learn about the design study of one such cell repair Nano robot.

Nanoparticles for drug delivery into the brain[38] : The most significant factor preventing the development of novel medications for the central nervous system is the blood-brain barrier (BBB). Tight junctions, enzymatic activity, and active efflux transport systems are characteristics of relatively impermeable endothelial cells that make up the blood-brain barrier. Through the action of enzymes or efflux pumps, it successfully blocks the entry of water-soluble molecules from the blood circulation into the central nervous system (CNS) and can also lower the concentration of lipid-

soluble molecules in the brain. Therefore, only chemicals that are necessary for brain function can be transported selectively across the blood-brain barrier. Targeting nanoparticles to the brain depends on their interaction with certain receptor-mediated transport systems in the blood-brain barrier. For instance, it has been demonstrated that polysorbate 80/LDL, lactoferrin, cell penetrating peptides, transferrin receptor binding antibodies (like OX26), and melanotransferrin can deliver a self- nontransportable drug into the brain through a chimeric construct that can undergo receptor-mediated transcytosis.

Cancer therapy : The cytotoxic atomic oxygen generated by lasers, which kills cancer cells, is the cornerstone of photodynamic cancer therapy. Cancer cells absorb more of a certain dye that is used to create atomic oxygen than healthy tissue does. So, the only radiation that comes from cancer cells Unfortunately, the remaining dye molecules migrate to the patient's skin and eyes, making them particularly sensitive to daylight exposure. It could take up to six weeks for this effect to go away. To avoid this negative effect, porous nanoparticles were used to enclose the hydrophobic colour molecules. The dye stayed confined within the Cromosil NPs43 and did not spread to other parts of the body.

Protein detection : The continued development of human cells depends on an understanding of the roles played by proteins, which are a fundamental part of the language, machinery, and structure of cells. Gold nanoparticles are widely used in immunohistochemistry to identify protein-protein interactions. Surface enhancement The capacity of Raman scattering spectroscopy to identify and detect individual dye molecules is generally acknowledged. By combining both methods into a single NPs probe, the multiplexing power of protein probes can be greatly enhanced. The NPs are coated with hydrophilic oligonucleotides that have a small molecules recognition element terminally capped and a Raman dye at one end.

Nanoparticles for Gene delivery : In order to trigger an immune response, polynucleotide vaccines transfer genes encoding pertinent antigens to host cells where they are produced. This results in the production of the antigenic protein close to expert antigen-presenting cells. Because intracellular protein synthesis, rather than extracellular deposition, stimulates both arms of the immune system, such vaccines result in both humoral and cell-mediated protection.

Anti-Microbial Techniques : Using nanocrystalline silver as an antibacterial agent to treat wounds was one of the first uses of Nano medicine. A lotion containing nanoparticles has been demonstrated to combat staph infections. Nitric oxide gas, which is known to destroy germs, is present in the nanoparticles. According to research on mice, applying the cream nanoparticle to staph abscess sites to release nitric oxide gas greatly decreased infection. A burn dressing that has been covered in antibiotic nanocapsules. In the event of an infection, the antibiotics are released when the nanocapsules rupture due to the presence of harmful bacteria in the lesion. This makes it possible to treat an infection much more quickly and minimizes the frequency of dressing changes. Eliminating bacterial infections in a patient in a matter of minutes rather than administering antibiotic treatment over several weeks is a welcome concept in the early stages of research.

2 . CONCLUSION

A promising method of controlled and targeted drug delivery is represented by nanoparticles. The development of nanotechnology is probably going to have a big effect on the drug delivery industry, influencing almost all administration routes, from injectable to oral. Cheaper drug toxicity, cheaper treatment costs, increased bioavailability, and a longer economic life for patented medications should also be benefits for physicians and patients. The aforementioned demonstrates the immense potential of nanoparticle systems, which can transform biologically active substances that are poorly soluble, poorly absorbed, and labile into viable deliverable medications. This system's core can include a wide range of medications, enzymes, and genes. It is distinguished by a hydrophilic shell that inhibits the reticular-endothelial system from recognizing it. Particle engineering and a deeper comprehension of the various biological interaction pathways are still needed to optimize this medication delivery technology. To make the idea of nanoparticle technology a viable, real-world use as the next generation of medicine delivery systems, more development is required. This would enhance the efficacy of medication therapies and lessen adverse effects by enabling earlier and more individualized diagnosis and therapy. Furthermore, a viable platform technology for the manufacture of contrast agents specific to molecules is nanoparticles.

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