Review Article

Nanoparticles in Drug Delivery

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Received: 18-01-2023; **Revised:** 20-03-2023; **Accepted:** 26-03-2023; **Published on:** 15-04-2023.

ABSTRACT

Systems for targeted administration and controlled release of medicinal drugs using nanoparticles are known as nanoparticle drug delivery systems. A modern drug delivery system should lower dosage and frequency while minimising negative effects. The nanoparticles can be built into smart systems, encasing medicinal and imaging chemicals as well as bearing stealth property, by manipulating their size, surface properties, and material composition. These devices can also give controlled release therapy and drug delivery to particular tissues.

Keywords: Nanoparticle, drug delivery, nano diodes, nano transistors, nano tubes.

QUICK RESPONSE CODE →

DOI:
10.47583/ijpsrr.2023.v79i02.009

DOI link: http://dx.doi.org/10.47583/ijpsrr.2023.v79i02.009

INTRODUCTION

A particle of matter with a diameter of one to one hundred nanometers (nm) is commonly referred to as a nanoparticle or ultrafine particle[1]. When referring to fibres and tubes that are smaller than 100 nm in only two orientations or larger particles up to 500 nm, the phrase is occasionally used[2]. Because of their smaller size, nanoparticles are typically distinguished from microparticles (1-1000 m), "fine particles" (sized between 100 and 2500 nm), and "coarse particles" (ranging from 2500 to 10,000 nm)[3]. These properties, such as colloidal properties, ultrafast optical effects, or electric properties, are driven by their smaller size[4].

Nanoparticles are significantly smaller than the visible light spectrum (400–700 nm), making it impossible to observe them with standard optical microscopes. Instead, they must be viewed with electron microscopes or laser microscopes[5]. For the same reason, nanoparticle suspensions in transparent media may be transparent, in contrast to suspensions of bigger particles, which often scatter some or all incident visible light[6]. Nanoparticle separation from liquids necessitates unique nanofiltration techniques since nanoparticles readily pass through ordinary filters, such as everyday ceramic candles.

When compared to bigger particles of the same chemical, the characteristics of nanoparticles frequently differ significantly. A significant portion of the nanoparticle's substance is located within a few atomic diameters of its surface because an atom's usual diameter ranges from 0.15 to 0.6 nm. Thus, the surface layer's characteristics may predominate over those of the bulk material. Because of the increased significance of the interactions between the two materials at their interface, this effect is particularly potent for nanoparticles distributed in media with differing compositions[7].

Although nanoparticles tend to sustain a variety of dislocations that may be seen with high-resolution electron microscopes, they often have fewer point defects than their bulk counterparts[8]. However, the mechanical properties of nanoparticles differ from those of the bulk material due to their distinct surface structures and differing dislocation mechanics[9].

Non-spherical nanoparticles, such prisms, cubes, and rods, have chemical and physical properties that rely on their form and size (anisotropy). Due to their intriguing optical properties, non-spherical nanoparticles of gold (Au), silver (Ag), and platinum (Pt) are finding use in a variety of fields. Nanoprisms' non-spherical geometries result in colloidal solutions with high effective cross-sections and richer hues[10]. Utilizing them for molecular labelling, biomolecular assays, trace metal detection, or nanotechnical applications is made possible by the ability to change the resonance frequencies by adjusting the particle geometry. Under unpolarized light, anisotropic nanoparticles exhibit a particular absorption behaviour and stochastic particle orientation, revealing a unique resonance mode for each excitable axis.

Advantages

The benefits of employing nanoparticles for medicine delivery come from their two primary fundamental characteristics. First, nanoparticles. Due to their tiny size, nanoparticles are able to pass through smaller capillaries and are ingested by cells, allowing for effective drug accumulation at the target areas. Second, prolonged drug

release within the target site over the course of days or even weeks is made possible by the use of biodegradable components in nanoparticle formation[11]. Nanoparticles are crucial, but not just for pharmaceuticals. Many electronic processes, applications, and products could actually undergo a revolution thanks to nanotechnology. When it comes to electronic devices, fields that profit from the continuous development of nanotechnology include nano diodes, nano transistors, OLED, plasma displays, quantum computers, and many more.

With the help of this technology, products like batteries, fuel cells, and solar cells may be made smaller while also being more efficient. Another The manufacturing sector, which will require materials like aerogels, nanotubes, nanoparticles, and other similar goods to make their products, can profit from nanotechnology. These materials frequently outperform non-nanotechnology generated materials in terms of strength, durability, and weight[12]. Additional benefits of nanoparticles over their manufacture and medication delivery method exist.

Nanoparticles are employed in drugs to target specific areas since they are relatively simple to create. The efficient drug accumulation at the body's target areas is made possible by nanoparticles' ability to enter narrow capillaries and be absorbed by cells. When drugs are delivered by nanoparticles, the drug's encapsulation is well protected and its size can be controlled. Longer clearance times are associated with drug retention at the active site.

Bioavailability and therapeutic effectiveness were both improved by nanoparticles. They lessened the variance of fed/fasted, which improved medication stability[13]. Stable dose forms for medications whose non-nanoparticulate dosage forms are either unstable or have an unacceptable low bioavailability.Nanoparticles used for drug delivery have no biotoxicity to the carrier. Nanoparticles only prevent using organic solvents during large-scale manufacture and sterilisation,

Disadvantages

The following are some of the unfavourable aspects of nanotechnology that should be mentioned when discussing its benefits and drawbacks: The potential loss of jobs in the conventional farming and manufacturing sectors is one of the drawbacks of this research and its advancement. Atomic weapons can now be made more powerful and devastating, as well as more easily accessible. The risk to human health from nanotechnology has increased as well. Just inhaling for 60 seconds in air containing nanoparticles can easily damage lungs and create inhalation problems or many other fatal diseases. Nanotechnology is currently exceedingly expensive, and creating it can be very expensive. Products developed with nanotechnology are likely more expensive because they are more expensive to produce. While improving living conditions, nanotechnology has also led to a rise in pollutants, including air and water contamination. Nano pollution is the term for contamination brought on by nanotechnology. For living things, this form of pollution is extremely harmful. The drawbacks of nanoparticles are not well understood. Therefore, based on drug delivery, there are only a handful more of them. The extensive use of polyvinyl alcohol as a detergent in the production of nanoparticles for medication delivery raises concerns about toxicity. Because of the restricted targeting capabilities of nanoparticles, therapy cannot be stopped.

Nanoparticle drug delivery exhibits cytotoxicity and alveolar inflammation. Nanoparticles' disruption of autonomic imbalance has a direct impact on cardiac and vascular function. Particle growth, irregular gelation tendencies, surprising dynamics of polymeric transmissions, and occasionally burst release are all characteristics of nanoparticles.

Method of Preparation

*1. **Physical Methods***

1. Mechanical Method
2. Pulse Laser Ablation
3. Pulsed Wire Discharge Method
4. Chemical Vapor Deposition
5. Laser Pyrolysis
6. Ionized Cluster Beam Deposition

*2. **Chemical Methods***

1.Solgel method
2.Sonochemical method
3.Co-precipitation method
4.Inert gas condensation method
5.Hydrothermal synthesis

*3. **Biological Methods***

1. Synthesis Using Microorganisms
2. Synthesis Using Plant Extracts
3. Synthesis Using Algae

PHYSICAL METHODS

Mechanical Method

Ball milling

Innovative methods for producing nanoparticles. Planetary, vibratory, rod, and tumbler mill types are commonly employed. The container contains steel or carbide-based hard balls. crystalline nanoco, This process is used to synthesis Cr, W, and Ag-Fe. Balls to materials are arranged in a 2:1 ratio. Inert gas or air is placed inside the container, which is then rapidly rotated around its axis. Between the container's walls and the balls, the materials are compressed. The creation of nanoparticles with the ideal size depends significantly on the rate and length of milling[14,15].

Melt mixing

Turbulence and molten metal streams are combined to create nanoparticles. In a glass, nanoparticles are detained. Glass is a material that lacks symmetry atoms or molecules and is amorphous. Metals can produce amorphous solids and metallic glasses when they are cooled rapidly. Ex: A Cu stream that has melted[16,17].

Pulse laser ablation

A vacuum chamber is filled with the desired sample. Plasma, which had previously been a colloidal solution of nanoparticles, is created when the high-pulsed laser beam is focused on the sample. In the creation of nanoparticles, the second-harmonic group type lasr is widely employed. Elements that have an impact on the creation are the type of laser ,some pulse ,type of solvent , pulsing time[18,19].

Pulsed wire discharged method

The method used in physical preparation of nanoparticles. The most used technique for creating metal nanoparticles. A pulsating current causes a metal wire to evaporate, producing a vapour that is then cooled by ambient gas to produce nanoparticles. This plan may have a quick fabrication time and great energy output[20,21]

Chemical vapor deposition

At between 300 and 1200 °C, a thin coating of a gaseous reactant is applied to the substrate. A thin film of product is produced on the surface of the substrate as a result of a chemical interaction between the heated substrate and the combining gas. The applied pressure fluctuates between 100 and 105 Pa. There are numerous CVD variations, including Plasma Enhanced CVD, Atomic Layer Epitaxy, Vapor Phase Epitaxy, and Metallo Organic CVD. The manufacturing of stiff, homogeneous, strong, and extremely pure nanoparticles is a benefit of this method. In order to remove the by-products from the substrate, they must be transported back to the gaseous phase. Substrates are heated using two different techniques: cold wall and hot wall. Deposition may happen in the hot wall configuration. The cold wall method avoids this. The growth rate and quality of film are ultimately influenced by gas pressure and substrate temperature[23].

Laser pyrolysis

Laser pyrolysis is the term for the laser-assisted production of nanoparticles. In order to break down the combination of reactant gases in the presence of some inert gas, such as helium or argon, a powerful laser beam is concentrated. The distribution and size of the particles are significantly influenced by the gas pressure[24].

Ionized cluster beam deposition

The process was created in 1985. The primary goal of this technique is to produce excellent single-crystalline thin films. A source of evaporation, a nozzle through which material can expand into the chamber, an arrangement to accelerate the clusters, an electron beam to ionise the clusters, and a substrate on which a nanoparticle layer can be formed are all included in the arrangement. Collections become ionised following contact with an electron beam. The clusters are concentrated close to the substrate because of the hastening voltage utilised. By keeping an eye on the accelerating voltage, it is probable to be able to regulate the energy with which the clusters impact the substrate. Since stable clusters of some materials would require a lot of energy to break their bonds, they would prefer to stay that way[25].

CHEMICAL METHODS

Sol gel method

Metal alkoxides or metal precursors in solution are condensed, hydrolyzed, and thermally decomposed. A reliable answer is known as the sol, formed. The gel's viscosity increases as a result of hydrolysis or condensation. By adjusting the precursor concentration, temperature, and pH levels, the particle size can be observed. In order to facilitate the growth of solid mass, a mature stage is necessary. The solvent elimination, Ostwald ripening, and phase transformation could all take a few days. Nanoparticles are created by detaching the unstable chemicals[26].

Sono chemical synthesis

In the presence of palladium and water, sonochemical fusion with copper salt has successfully created Pd-CuO nanohybrids. Switch metal salts could be converted into their oxides in the presence of palladium and water by using ultrasonic waves. The palladium supply is either the palladium salts or pure metallic palladium Pd(0)[27,28].

Co precipitation method

It is a solvent displacement method and is a wet chemical procedure. Ethanol, acetone, hexane, and nonsolvent polymer are examples of polymer solvents. Polymer phases can be either synthetic or natural. By mixing the polymer solution last, fast diffusion of the polymer-solvent into the nonsolvent phase of the polymer results. Interfacial stress at two phases results in the formation of nanoparticles[29,30].

Inert gas condensation method

Metal nanoparticles are produced using this method in large quantities. It had been popular to make fine nanoparticles using the inactive gas compression approach, which creates nanoparticles by causing a metallic source to vanish in an inert gas. At a temperature that is attainable, metals evaporate at a tolerable pace.

Copper metal nanoparticles are created by vaporising copper metal inside a container containing argon, helium, or neon. By cooling the vaporised atom with an inert gas after it boils out, the atom quickly loses its energy. Liquid nitrogen is used to cool the gases, forming nanoparticles in a range of 2-100 nm[31].

Hydrothermal synthesis

It is one of the techniques for making nanoparticles that is most frequently employed. It is primarily based on chemical reactions. For the synthesis of nanoparticles, hydrothermal synthesis uses a wide temperature range from ambient temperature to extremely high temperatures. Comparing this strategy to physical and biological ones has a number of benefits. Higher temperature ranges may make the hydrothermal synthesis-produced nanomaterials unstable[32].

BIOLOGICAL METHODS

Synthesis using micro-organism

In recent years, microbes have been used to create nanoparticles. have drawn increased attention because they are economical and environmentally friendly. There are two methods for generating nanoparticles: One is extracellular biosynthesis, while the other is intracellular biosynthesis, both of which can be produced by a bacterium. Metal ions can be separated by some microorganisms. Pseudomonas stuzeri Ag295 can accumulate silver within or outside of cell walls, making it common in silver mines. Microorganisms have a variety of reductase enzymes that can store and detoxify heavy metals. CdS nanoparticles can be created using Klebsiella pneumonia[34,35].

Synthesis using plant extracts

The production of nanoparticles demonstrates the critical role played by plant extracts. This method of producing nanoparticles is also known as green synthesis or a green technique. The geranium plant (Pelargonium graveolens) has leaves that have been utilised to make gold nanoparticles. To create silver nanoparticles, 1 ml of a 1 mmol aqueous silver nitrate solution is added to 5 ml of the plant extract. The same process is used to create compounds from alcoholic extract, The plant extract and silver nitrate are shaken in the dark at 150 rpm[35,36].

Synthesis using algae

Preparation of algal extract in an organic or aqueous solvent through heating or boiling for a set amount of time. preparation of an ionic metallic complex molar solution. Algae solution and molar solution of ionic metallic complexes are incubated under regulated conditions with either continuous stirring or without stirring for a set amount of time. The method of creating nanoparticles is dose-dependent and depends on the kind of algae employed. Peptides, pigments, and polysaccharides are biomolecules that are responsible for the reduction of metals. Algae may produce nanoparticles more quickly than other types of living organisms. Sargassumwightii and Fucusvesiculosus are two seaweeds that can be utilised to create AgNPs of different sizes and forms[37].

CONCLUSION

Drug delivery systems using nanocarriers are intended to enhance the therapeutic and pharmacological qualities of traditional medications. Including medicinal molecules in nanocarriers can help a drug fend off threats. Offers opportunities for targeting and controlled release in addition to deterioration. Nanocarriers are able to pass through the blood-brain barrier (BBB) and function at the cellular level because of their small dimensions. Nanocarrier-drug conjugates are more effective and selective than conventional drug forms. By building up the medications in the target areas, they can lessen the toxicity and other negative side effects in healthy tissues.

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Source of Support: The author(s) received no financial support for the research, authorship, and/or publication of this article.

Conflict of Interest: The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.