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Review Article

Nanotechnology- based target drug delivery system

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ABSTRACT

A nanotechnology can be described as the process of manipulating, studying, and manufacturing objects with a nanometer dimension. Through site-specific, targeted delivery of medicines, nanotechnology can benefit the treatment of chronic diseases in humans. Recent nanomedicine discoveries have led to the development of numerous outstanding drugs e.g., chemotherapeutics, biologics, immunotherapeutic, etc. The purpose of this chapter is to describe various nanocarriers that can be used to deliver therapeutic molecules.

1. Introduction

The nanoparticles used for drug delivery are typically over 100 nm in at least one dimension and can be composed of polymers, lipids, metals, or natural polymers. It is possible to integrate drugs into particle matrixes or attach them to particle surfaces for therapeutic purposes. The fate of a drug entering the biological environment should be controlled by a drug targeting system. Several types of nanosystems have been investigated for their potential use in drug delivery and gene delivery.[1–5] In order to achieve efficient drug delivery, nanosystems must be developed based on an understanding of their interaction with the biological environment, cell population, and cell receptors.[6] The effectiveness of drugs can be compromised by a variety of factors, including drug instability in the cell, unavailability due to multiple targeting mechanisms, genetic changes in cell receptors, or overexpression of efflux pumps.[7] Different types of nanocarriers are used for delivery as shown in Figure 1. The purpose of this review is to discuss the application of nanomedicine to drug delivery.

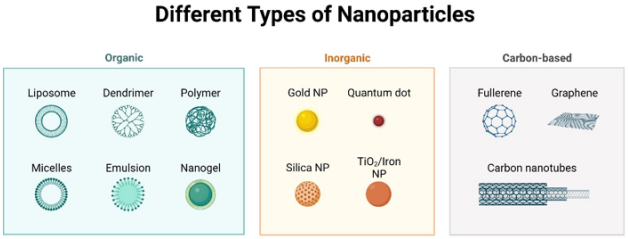

Fig. 1: Types of nanocarriers for drug delivery

1.1. Solid lipid nanoparticles

The 50–1000 nm range is covered by the colloidal active ingredient system SLN, which was developed in the early 1990s. They contain emulsifiers that aid in stabilizing the water in the molten solid lipid dispersions.[8] The two processes that are most frequently utilized to create SLNs are micro emulsification and high-pressure homogenization (HPH). Delivery of drugs to certain tissues and cells is made possible by SLN's lipophilic lipid matrix, drug dispersion, and encapsulating drug compounds such as medicines, proteins, antigens and nucleotides. One of

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SLN's special qualities is its capacity to lessen adverse effects while increasing medication in vivo and in vitro stability. The primary distinguishing feature between SLNs and nanoemulsions is that SLNs employ both solid and liquid lipids in their formulations, on the other hand nanoemulsions exclusively use liquid lipids. The puerarin-loaded SLN is the most widely utilized SLN in rats. Rapid absorption in target organs including the brain and heart, improved bioavailability, and elevated drug levels are its distinguishing features. Another research found that "triptolide-loaded SLN" significantly reduced the activity of glutathione (GSH) and myeloperoxidase (MPO). Enhancing solubility and toxicity, glutathione functions as an antioxidant and anti-inflammatory product. It also lessens skin irritation. Avoiding gastrointestinal (GIT) and regionally high drug levels and releasing the medication gradually.[9]

1.2. Non structured lipid carriers

They are created from SLNs with different lipid matrix defects and are known as "second generation lipid nanoparticles" since they are composed of a combination of solid and liquid lipids. It makes extensive use of both liquid and solid lipids, including mustard oil, olive oil, castor oil and cod liver oil. Solid lipids used include solidified palm oil, stearic acid, glyceryl monostearate and cetyl alcohol. Thimerosal served as a stabilizer in this system. NLC outperforms SLN in terms of stability, controlled drug release, better drug loading capacity, and little drug loss in encapsulation. Numerous researches have concentrated on drug delivery mechanisms, co-delivery, drug control of release, changes in water solubility, and uptake of bioactive chemicals in NLC by improving gastrointestinal absorption. Due to the incorporation of several organic and synthetic bioactive compounds, NLC carriers have become viable options for oral medication administration. Triptolides, triptolides, and curcumin-loaded NLCs, for instance, shown increased absorption. The lipid concentration, tiny particle size, and surface area may be to blame for this. A prominent example of therapeutic application to treat various liver problems was silymarin-loaded NLC. Additionally, Cardamom Essential Oil (CEO) NLC has been created effectively utilizing food grade lipids, such as olive oil and cocoa butter, and has a reduced size and better loading capacity (> 25%), both physically and chemically stable.[10]

1.3. Nanocrystals

These pure solid drug molecules vary in size from 100 nm to 1000 nm and are made largely of the medication ingredient itself, stabilized with stabilizers or detergents. The dispersion medium has been employed with water, oil, liquid polyethylene glycol (600), and other "aqueous or non-aqueous" substances. We were able to get around issues with "dissolution rate, saturation solubility, surface area, and cell membrane thickness" because to the great features of nanocrystals. For the preparation of nanocrystals, bottom-up and top-down approaches have both been established. Sedimentation, high gravity driven precipitation techniques, ultrasonic crystallization, limited collision liquid jet precipitation techniques, and multi-inlet vortex mixing techniques are all examples of top-down procedures. This procedure costs a lot since it eliminates materials using organic solvents. High pressure homogenization is utilized in the grinding process in the bottom-up strategy, however. The most widely applied production methods were milling, precipitation, and high-pressure homogenization. The drug's methods for absorption in nanocrystals include enhanced solubility, suspension rate, and gut wall retention. These have significant advantages such better safe dose forms, solubility, disintegration, dissolution, and bioavailability, and their molecular size and surface structure offer a greater level of safety. We have created a procedure for adding "Sinasigate nanocrystals" to microparticles made of chitosan that are used to deliver hydrophobic medications to the lungs. The ability of the polymer to swell and adhere to the mucous membranes allows for sustained release of the drug, improving its inhalation effect in medical conditions.[11]

1.4. Liposomes

In 1960, Alec Bangham invented liposomes. These spherical, polar lipid nanoparticles have a size range of 50 to 450 nanometers. They are able to easily diffuse into the "aqueous core" while encasing it in "single or multiple lipid bilayers of natural or synthetic origin." They have a membrane structure like a cell. As a result of the materials used to make liposomes having both lipophilic and hydrophilic groups, both classes of pharmacological molecules can be enclosed in the same framework. Liposomes display drug delivery, drug solubility, bioavailability of trapped medicines, absorption of medications into cells, and both in vivo and *in vitro* as a result of their special trait of containing a phospholipid bilayer.[12] Drugs can be distributed more widely throughout the body. For the purpose of creating vaccines, nutritional supplements, and cosmetics, the ADME profile of pharmaceuticals such as herbs, proteins and enzymes can be altered as necessary. Additionally, the development of vaccines has benefited from a number of unique properties, including environmental protection of drug molecules trapped in charged bioactive agents, primary destruction of charged bioactive agents, cost effectiveness, and quick recovery with little systemic morbidity. Additionally, biomedical formulations employ some unique properties, such as: environmental protection for medication molecules that have been captured, quick

and inexpensive therapy, and minimal systemic prevalence exaggerated. Liposome based drug delivery is shown in Figure 2.

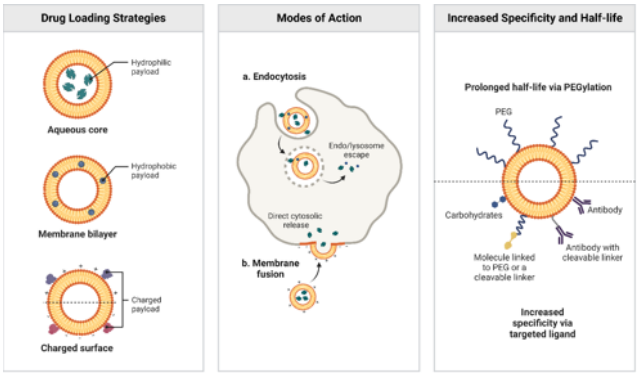

Fig. 2: Liposome based drug delivery

1.5. Phytosomes

Pharmacological, bioactive, and water-soluble phytochemicals are enclosed in phospholipid-compatible molecular complexes called phytosomes for improved absorption and bioavailability. Due to their high molecular size, hydrophilic phytochemicals like polyphenols and flavonoids are difficult for the body to absorb through biological membranes. Phytosomes helped to circumvent these restrictions. The creation of molecular complexes and chemical bonding between plant material and phosphatidylcholine in a 1: 1 or 1: 2 ratio is one of their connected peculiarities. Phytosomes and liposomes are structurally related, with the exception of substance encapsulation. In phytosomes, the medicine is an integral component of the membrane, as opposed to liposomes, where the drug dissolves in the medium present in the membrane layer. Enterocytes' cell membranes are changed by phytosomes from water-soluble to lipophilic, which allows them to penetrate cells, enter the circulation, and shield Chinese herbs from stomach acid and gut microbes. To ascertain its effectiveness and quality in comparison to other conventional distribution methods, extensive study has been conducted. Several flavonoids, including quercetin, kaempferol, and apigenin, have recently been combined into a phytosomes termed a flavonoid, which has been found to be a strong antioxidant, liver protector, and heat supplement. Bioactive, pharmacological and water-soluble phytochemicals are enclosed in phospholipid-compatible bound phytosomes for improved bioavailability and absorption. Hydrophilic phytochemicals such as flavonoids and polyphenols are difficult for the body to absorb due to their large molecular size, and are difficult to absorb through biological membranes. These limitations were overcome by phytosomes. Their associated uniqueness includes the formation of molecular complexes and chemical bonds in a 1: 1 or 1: 2 ratios between plant material and phosphatidylcholine. Structurally, except for material encapsulation, phytosomes bear resemblance to liposomes.[13]

Ethosomes

Water, phospholipids like phosphatidylcholine, phosphatidylserine, phosphatidylethanolamine and phosphatidylglycerol, and around 30–45 percent isopropyl alcohol and ethanol make up ethosomes, which are soft, non-invasive elastic media based on lipids. Topical medication delivery, transdermal transport efficiency, and drug capture efficiency of both hydrophilic and lipophilic medicines are all improved by Ethomen's ratio composition. They guarantee that ingredients reach deeper tissues and blood vessels. Due to the flexible lecithin bilayer, ethosomes are physically more stable than liposomes. Ethosomes, on the other hand, are subject to a number of limitations, such as decreased stability brought on by evaporation of alcohol and the gradual leaking of trapped material, as well as nanoscale to micrometer magnification. This weakness can be alleviated by mixing alcohol with propylene glycol and trehalose. PEGylated and standard liposomes and ethosomes encapsulated with curcumin were created and put to the test in a rat model to see if they could transfer trapped molecules to the skin. In order to more effectively control foot edema in rat models, PEGylated liposomes have emerged as the most efficient ex vivo transdermal drug delivery method.[14,15]

1.6. Niosomes

These are vesicles made of nanospheres with dimensions ranging from 100 nm to 2 m. In the lamellar phase, they are nonionic and have an aqueous core around by nonionic amphipathic lipids. Sonication, microfuidization, thin film hydration, multimembrane extrusion, remote loading, reverse phase evaporation techniques, and bubble procedures are a few examples of preparation processes. Similar in structure to liposomes, niosomes demonstrated greater stability, osmotic capability, favorable effectiveness, and less toxicity.[16] Niosomes' key benefits are flexibility, affordability, increased solubility of drug, and sustained release of bioactive pharmaceuticals that have been encapsulated which serve as a target for tumors and absorb the medication percutaneously. Delivery is made possible by this efficient peptide and haemoglobin carrier molecule. However, niosomes exhibited sustained drug release, skin retention and penetration, and extended drug circulation at the target region. Particularly for topical applications in the treatment of skin disorders like skin cancer, these nanocarriers are more stable than supposedly non-toxic liposomes.

1.7. Cubosomess

These are viscous, isotropic vesicles mostly composed of thermodynamically stable surfactants such poloxamers and amphipathic lipids (unsaturated monoglycerides). Due to its characteristics, such as its 3D structure with hydrophobic and hydrophilic domains, it has a large inner surface area per unit volume (about 400 m^2/g) and readily accommodates not just amphipathic chemicals but also water-soluble and insoluble compounds. For the prolonged release of trapped drug particles, whose lipid ingredients are bioadhesive, digestible and biodegradable, its broad surface offers a variety of diffusion pathways. The cubic gel phase is frequently dispersed or broken up in the liquid phase to produce them. A top-down technique and a bottom-up approach have both been devised for the manufacture of cubosomes. Insulin, rifampicin, somatostatin, indomethacin, and other drugs are well-encapsulated in cubosomes. Additionally, just a few cases of cubic combs are being examined, and the administration of peptides, anti-muscarinic medications, enzymes, antibiotics, and analgesics is a minor pharmacological usage. Cubosomes can easily release trapped bioactive chemicals into the epidermis and have a stratum corneum resembling structure. Additionally, cubosomes' permeability and adhesiveness imply that they might be useful in treating skin cancer (melanoma). The development of polymer-free cubosomes for photodynamic skin treatment has recently been studied, and biological imaging of malignant skin tumors with very low cytotoxicity to the skin system has been performed.

2. Conclusion

As part of the ongoing effort to improve the delivery of drugs and the effectiveness of treatments, nanotechnology has emerged over the last 25 years. Infectious diseases, however, account for only a small proportion of the most successful nanoformulations. A quantum leap for controlling pandemics requires integrating key enabling technologies, including nanotechnology. This article highlights various nanocarriers for delivering to the targeted site. Moreover, nanosystems may require dosage recalibration due to their increased efficiency of drug delivery. There is still a lot to look forward to in the future.

3. Source of Funding

None.

4. Conflict of Interest

None.

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