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Synoptic Note on Principles and Platforms of Nanoparticle Drug Delivery System

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Perspective

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DESCRIPTION

Nanoparticle drug delivery systems are designed technologies that use nanoparticles to deliver therapeutic drugs in a targeted and regulated manner. A modern medicine delivery system should reduce both dosage and dosage frequency while minimising negative effects. Nanoparticles have increasingly achieved attention due to their potential application in effective medicine delivery. Nanomaterials have distinct chemical and physical properties, and also biological consequences, than their larger-scale equivalents, which can be advantageous for drug delivery systems. The high surface-area-to-volume ratio, chemical and geometric tunability, and ability to interact with biomolecules to enhance absorption through the cell membrane are all significant advantages of nanoparticles. The enormous surface area also has a high affinity for medicines and tiny molecules, such as ligands or antibodies, allowing targeted and controlled release.

The goal of nanoparticle medication delivery is to maximise pharmacological efficacy while reducing cytotoxicity. The following issues must be addressed while fine-tuning nanoparticle characteristics for optimal medication delivery. To allow for increased ligand binding to the surface, the surface-area-to-volume ratio of nanoparticles can be changed. Increasing ligand binding efficiency can reduce dosage while also reducing nanoparticle toxicity. Minimizing dosage or frequency reduces the mass of nanoparticles per mass of medication, resulting in improved efficiency. Metal nanoparticles, such as gold nanoparticles, offer optical properties that enable for less invasive imaging techniques

(also detailed in nanomaterials). In addition, the photothermal response of nanoparticles to optical stimulation can be used directly for tumour therapy.

Platforms

Current nanoparticle drug delivery systems can be cataloged based on their platform composition into several groups: polymeric nanoparticles, inorganic nanoparticles, viral nanoparticles, lipid-based nanoparticles, and nanoparticle albumin-bound (nab) technology. Each family has its unique characteristics.

Polymeric nanoparticles: Polymeric nanoparticles are synthetic polymers ranging in size from 10 to 100 nm. Polyacrylamide, polyacrylate, and chitosan are examples of commonly used synthetic polymeric nanoparticles. Drug molecules might be added before or after the polymerization process. The medication can be covalently bonded, enclosed in a hydrophobic core, or conjugated electrostatically, depending on the polymerization chemistry. Microfluidic methods, electro dropping, high pressure homogenization, and emulsion-based interfacial polymerization are examples of common synthetic processes for polymeric nanoparticles.

Dendrimers: Dendrimers are one-of-a-kind hyper-branched synthetic polymers with a monodispersed size, well-defined structure, and a highly functionalized terminal surface. They are normally made up of amino acids, nucleic acids, and carbohydrates, whether synthetic or natural. Therapeutics can be easily loaded into the inside of dendrimers or the terminal surface of branches *via* electrostatic contact, hydrophobic interactions, hydrogen bonds, chemical connections, or covalent conjugation. Drug-dendrimer conjugation can extend drug half-life.

Inorganic nanoparticles and nanocrystals: Due to their well-defined and highly adjustable features such as size, shape, and surface functionalization, inorganic nanoparticles have emerged as very desirable functional building blocks for drug delivery systems. Inorganic nanoparticles have found widespread application in biological and medical applications spanning from imaging and diagnostics to medication delivery. Inorganic nanoparticles are typically formed of inert metals such as gold and titanium that form nanospheres; however, iron oxide nanoparticles have emerged as a viable alternative.

Organic nanocrystals: Organic nanocrystals are made up of pure pharmaceuticals as well as surface active substances that aid in stabilization. They are classified as carrier-free submicron colloidal drug delivery systems containing nanometer-sized particles. The fundamental benefit of medication formulation into nanocrystals is increased particle surface area in contact with the dissolution medium, which increases bioavailability. There are several medication products on the market that were created in this manner.

Lipid-based nanoparticles: Liposomes are spherical vesicles made up of synthetic or natural phospholipids that self-assemble in aqueous solution and range in size from tens of nanometers to micrometers. For therapeutic applications, the resulting vesicle, which has an aqueous core surrounded by a hydrophobic membrane, can be loaded with a wide range of hydrophobic or hydrophilic compounds.

Viral nanoparticles: Viruses can be used to deliver genes for genetic engineering or gene therapy. Adenoviruses, retroviruses, and different bacteriophages are all normally employed viruses. To improve targeting, the surface of the viral particle can be changed with ligands. While viral vectors can be employed effectively, one issue is that they may generate off-target effects because to their innate tropism. This usually entails replacing the proteins that cause virus-cell interactions with chimeric proteins. In addition to viruses, medicinal molecules can be contained in protein particles produced from viral capsids or virus-like particles.

Nanoparticle albumin-bound (Nab) technology: Through noncovalent binding, nanoparticle albumin-bound technology uses the protein albumin as a carrier for hydrophobic chemotherapeutic medicines. Because albumin is already a natural carrier of hydrophobic particles and has the ability to transcytose molecules bonded to itself, albumin-based nanoparticles have proven to be a useful technique in clinical research for the treatment of a variety of disorders.