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Characterization of Nanoparticle Drug Delivery Systems and their Properties

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Commentary

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ABOUT THE STUDY

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 recently gained attention due to their potential application in effective medicine delivery.

Nanomaterials have distinct chemical and physical properties, as well as 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 tenability and ability to interact with biomolecules to enhance absorption through the cell membrane are all significant advantages of nanoparticles. For targeting and regulated release, the high interfacial area has a high affinity for medicines and tiny molecules such as ligands or antibodies.

Nanoparticles are broad category of organic and inorganic compounds. Each material has uniquely adjustable qualities and may thus be tailored to specific purposes. Despite the numerous benefits of nanoparticles, there are various challenges, such as nanotoxicity, biodistribution and accumulation, and nanoparticle elimination by the human body. The National Institute of Biomedical Imaging and Bioengineering has proposed the following directions for further research in nanoparticle medication delivery systems.

Crossing the blood-brain barrier (BBB) in brain diseases and disorders and improving targeted intracellular delivery to assure therapies for reaching the particular structures inside the brain.

It takes around seven years to finish fundamental research and development before moving on to preclinical animal trials for new medication systems.

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 altered. 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.

Polymeric nanoparticles, inorganic nanoparticles, viral nanoparticles, lipid-based nanoparticles and nanoparticle albumin-bound (nab) technologies are the current categories for nanoparticle drug delivery systems. Each family has its own distinct qualities.

Polymeric nanoparticles are polymers that range in size from 10 to 100 nm. Polyacrylamide, polyacrylate and chitosan are examples of common synthesised polymeric nanoparticles. Drug molecules can be added before or after polymerization. The medication can be covalently bonded, enclosed in a hydrophobic core or conjugated electrostatically depending on the polymerization chemistry. Microfluidic techniques, electrodropping, high pressure homogenization and emulsion-based interfacial polymerization are all common synthetic procedures for polymeric nanoparticles. When selecting the proper nanoparticle chemistry, polymer biodegradability is a crucial factor to consider. In the body, biodegradable polymer nanocarriers hydrolyze and produce biocompatible tiny molecules such as lactic acid and glycolic acid.

Polymeric nanoparticles can be generated through self-assembly or other ways such as particle replication in non-wetting templates, which allows for modification of the nanoparticle's composition, size, and shape using microscopic moulds.

Because of their well-defined and highly controllable 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 varying from imaging and diagnosis to medication delivery. Inorganic nanoparticles are typically formed of inert metals such as gold and titanium that form nanospheres, but iron oxide nanoparticles have also emerged as a viable choice.