Research and Reviews: Drug Delivery

Role of Nanoparticles in the Drug Delivery Systems

Robert Ting CAI*

Department of Medicine, Cairo University, Giza, Egypt

Editorial

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***For Correspondence :** Robert Ting CAI, Department of Medicine, Cairo University, Giza, Egypt;

Email: roberttingcai@gmail.com

EDITORIAL

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 minimizing negative effects. Nanoparticles have received interest recently because of their potential role in efficient medication delivery. Compared to their larger scale counterparts, differ chemically and physically or in their biological consequences, 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 some significant advantages of nanoparticles. For targeting and controlled release applications, the vast surface area also offers a high affinity for medications and tiny molecules, such as ligands or antibodies.

An extensive family of organic and inorganic materials is referred to as nanoparticles. Each material can be specifically developed for particular uses because each one has individually customizable qualities. Nanoparticles have many benefits, but there are also many disadvantages, such as nanotoxicity, bio distribution and accumulation, and human body clearance of nanoparticles.

The following are prospective directions for study into nanoparticle drug delivery systems, according to the national institute of biomedical imaging and bioengineering: Improving targeted intracellular delivery to make sure the therapies reach the right structures inside cells; bridging the Blood Brain Barrier (BBB) in brain diseases and disorders. Integrating the two aspects of treatment.

It takes roughly seven years to finish fundamental research and development before moving on to preclinical animal trials, which adds time to the process of developing novel medication systems.

The goals of nanoparticle drug delivery are to increase drug efficacy and reduce cytotoxicity. The following parameters need to be taken into consideration while fine tuning nanoparticle characteristics for efficient medication delivery. To promote greater ligand binding to the surface, nanoparticles surface area to volume ratio can be changed. Minimizing nanoparticle toxicity and dose can both be accomplished by improving ligand binding effectiveness. Reduced dosage or dosage frequency also results in a decrease in the mass of nanoparticles per mass of medication, increasing efficiency.

Another crucial component of design is surface functionalization of nanoparticles, which is frequently achieved through bio conjugation or passive adsorption of molecules onto the nanoparticle surface. Greater efficacy and less toxicity are obtained by functionalizing the surfaces of nanoparticles with ligands that improve drug binding, inhibit immune response, or enable targeting/controlled release. More medicine is delivered to the target site, increasing efficacy, and less drug overall is present in the body, reducing severe side effects.

The intended environment or desired outcome can influence the nanoparticle's composition. In order to reduce the risk of buildup and toxicity after the therapeutic payload has been discharged, liposome based nanoparticles, for instance, can be biologically destroyed after delivery.

Nanomaterials describe the optical properties of metal nanoparticles, such as gold nanoparticles, that enable less

invasive imaging methods. Additionally, tumour therapy can directly benefit from the photo thermal reaction of nanoparticles to optical stimulation.

Polymeric nanoparticles, inorganic nanoparticles, viral nanoparticles, lipid based nanoparticles, and nanoparticle albumin bound (nab) technologies are some of the different categories into which current nanoparticle drug delivery systems can be categorized depending on their platform composition. Each family has distinctive qualities of its own.

Synthetic polymers with sizes ranging from 10 nm to 100 nm are known as polymeric nanoparticles. Chitosan, polyacrylamide, and polyacrylate are often seen synthetic polymeric nanoparticles. Drug molecules may be added before or after the polymerization process. The medication may be covalently bound, enclosed in a hydrophobic core, or conjugated electrostatically depending on the polymerization chemistry. Microfluidic techniques, electro dropping, high pressure homogenization, and emulsion based interfacial polymerization are typical synthetic methods for polymeric nanoparticles.

In the body, hydrolysis of biodegradable polymer based nanocarriers yields biocompatible small molecules like lactic acid and glycolic acid. Self-assembly and other techniques, such as particle replication in nonwetting templates (PRINT), can be used to make polymeric nanoparticles, which can then be customized in terms of composition, size, and form using microscopic moulds.

Due to their well-defined and highly programmable characteristics, including size, shape, and surface functionalization, inorganic nanoparticles have become extremely valuable functional building blocks for drug delivery systems. The use of inorganic nanoparticles in biological and medical applications, including imaging, diagnosis, and medication administration, has become widespread.

While application of inorganic nanoparticles in bio nanotechnology shows encouraging advancements from a materials science perspective, the use of such materials *in vivo* is limited by issues related with toxicity, bio distribution and bioaccumulation. Because metal inorganic nanoparticle systems degrade into their constituent metal atoms, challenges may arise from the interactions of these materials with bio systems, and a considerable amount of the particles may remain in the body after treatment, leading to buildup of metal particles potentially resulting in toxicity.