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Nanocarriers For Drug Delivery

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Abstract

Nanotechnology advances in drug delivery deal with the development of synthetic nanometer sized targeting delivery systems for therapeutic agents. Nanoparticles (NPs) as drug delivery system have received much attention in recent years. They can provide a selective targeting and can be tailor-made with the desired characteristics offered by the versatility of polymer chemistry. NPs have the high potential to improve the biodistribution of drugs by protecting them from degradation, delivering them directly to the target place and preventing them from affecting healthy tissues.

Keywords: nanoparticels, nanocarrier, drug delivery system …

1. Introduction

Nanotechnology is defined as research and technology development at the atomic, molecular or macromolecular level in the length scale of approx. 1 – 100 nm range. It is widely used in medical science. Reducing the size of a selected material to a nanometric scale makes it possible to utilise them in numerous potential applications. Various nanostructured products have been tested as carriers in target drug delivery systems till now. The versatility of nanostructured materials enables to deliver a drug at its target site in a more accurate and efficient way. Nanoscale materials have provided unprecedented opportunities in building novel vaccine delivery systems because of how they can be designed to mimic natural pathogens and stimulate immune processes [1-5]. There are different types of nanocarriers for drug delivery [6]: lipid based systems (lipid based NPs), metallic NPs, nanotubes, polymeric nanocarriers, polymeric micelles and dendrimers. The main goals of nanopharmacology are the targeted therapy and the controlled drug delivery systems [7]. For the drug delivery an appropriate non-toxic carrier should be used, with the ability to bind the drug properly, making it also possible to release it at the target site. Additional required property of appropriate carrier is to keep the therapeutic concentration range. The therapeutic value of applied drugs could be improved using NPs as carrier by changing their solubility, retention time and the penetration of biological barriers. NPs can be engineered bearing multiple functionalities to achieve optimal therapeutic and diagnostic effects. Nanoparticle-mediated targeted delivery of drugs might significantly reduce the dosage and optimize their release properties, increase specificity and bioavailability, improve shelf life, and reduce toxicity.

Drug immobilization on nanocarriers is carried out by using physical processes: adsorption, absorption and encapsulation, and chemical processes: covalent bonds, ionic bonds and the van der Waals forces.

2. Lipid based NPs

Poorly water-soluble drugs are challenging for the formulation scientists with regard to solubility and bioavailability. Lipid-based drug delivery systems have shown the effective size dependent properties therefore they have attracted a lot of attention [8]. Shrestha et al. [8] gave an overview about novel lipid-based formulations, namely, emulsions, vesicular systems, and lipid particulate systems and their subcategories as well as on their prominent applications in pharmaceutical drug delivery. Formulation approaches for lipid-based drug delivery systems (such as spray congealing, spray drying, supercritical fluid-based method …) and *in-vivo*/*in-vitro* studies are documented, as well. Various nanotechnological routes are currently being developed with the aim to improve the drug delivery. Among these, lipid-based nanoparticles present one of the promising drug-delivery systems and have been the longest-studied nanocarriers [9].

3. Metallic NPs

NPs have attracted considerable attention worldwide because of the unique functional characters such as small particle size, high stability, tunable hydrophilic-hydrophobic balance .... NPs used in the field of biotechnology range in particle size between 10 and 500 nm, seldom exceeding 700 nm. Because of their small size, NPs can readily interact with biomolecules both at surface and inside cells. Additional, better signals and target specificity for diagnostics and therapeutics are achieved. In recent years, NPs such as magnetic NPs (iron oxide), gold and silver NPs, nanoshells, and nanocages have been designed and modified to enable their use as a diagnostic and therapeutic agent. To overcome the intrinsic limitations of the conventional influenza vaccine, dual-linker gold nanoparticles, conjugated with both recombinant trimetric A/Aichi/2/68 (H3N2), hemagglutinin and TLR5 agonist flagellin as a novel vaccine approach have been designed [10]. Gold nanoparticles (AuNPs) are now also being widely utilized in bioimaging and phototherapy due to their tunable and highly sensitive optical and electronic properties (the surface plasmon resonance) [11]. Ulbrich et al. [12] discussed about principles, advantages, and drawbacks of passive and active targeting based on various polymer and magnetic iron oxide NPs carriers with drug attached by both covalent and noncovalent pathways. Tailored conjugation of targeting ligands (e.g., enzymes, antibodies, peptides) to drug carrier systems is also documented. Additional, the approaches toward controlled drug release are discussed. Leitgeb et al. [13] presented some the recent developments in MNPs technology and provided a brief background of their applications and results of *in-vitro* and *in-vivo*, animal and clinical experiments of targeted drug delivery. Finally, some of the recent biological, medical and scientific applications of MNPs are briefly reviewed, and some future trends and perspectives in these research areas are outlined.

4. Nanotubes

Carbon nanotubes have incredible potential for a wide variety of applications (nanotechnology, electronics applications and medicine) due to their strength, flexibility, and other uniquely powerful properties. Carbon nanotubes, functionalised with bioactive peptides, proteins, nucleic acids and drugs, have emerged as a new alternative and efficient tool for transporting and translocating therapeutic molecules to cells and organs. They have separated inner and outer surfaces, can be differentially functionalized either to load desired molecules inside or by suitably designing the chemical features of the outer surface allows for site-specific drug delivery [14]. A variety of organic and inorganic nanotubes have been used to develop effective controlled drug delivery systems. Multiwalled carbon nanotubes may be used for treatment of brain tumors due to their nanostructure, shape and biological properties, which give them the ability to cross the blood–brain barrier [15]. Chen [16] reported about following nanotube-based drug delivery systems: carbon nanotubes, silica nanotubes, self-assembling lipid nanotubes and polymer nanotubes.

5. Polymeric nanocarriers

Polymeric nanocarriers have an increasingly growing potential for clinical applications. There are many studies for developing new generation of polymeric nanocarriers for application in the field of multifunctional nanomedicine. Daglar et al. [17] and Grottkau et al. [18] discussed about the new generation and promising polymeric nanocarriers (e.g. PHA-based and PLGA polymeric nanoparticles), which exhibit active targeting, triggered release of contents, and imaging capability for *in vivo* studies. Polymeric nanoparticles provide significant stability in anti-neoplastic drug research and have demonstrated the ability to solve the problems of therapeutic efficacy and diagnostic sensitivity.

6. Dendrimers

Dendrimers are the emerging three dimensional nanopolymeric architectures that are known for their defined structures, versatility in drug delivery and high functionality whose properties resemble with biomolecules. These nanostructured macromolecules have shown their potential abilities in entrapping and/or conjugating the high molecular weight hydrophilic/hydrophobic entities by host-guest interactions and covalent bonding respectively.

Due to high ratio of surface groups to molecular volume, they are a promising synthetic vector for gene delivery. The contribution of dendrimers in the field of nanotechnology as well as in the field of drug delivery is described by many authors [19, 20, 21].

7. Conclusion

Nanodelivery systems such as nanosuspensions, polymeric NPs, metallic NPs, provide a broad range of techniques and strategies that can optimize the delivery of drug into the targeted cell. Nanoparticles as drug delivery system have received much attention in recent years, especially for cancer treatment. Nanocarriers will account for 40% of a $136 billion nanotechnology-enabled drug delivery market by 2021. They can be conjugated with a ligand such as antibody to favour a targeted therapeutic approach. The empty virus capsids are also being tried to use for delivering drugs as a new therapeutic strategy. Generally, nanoscale size drug delivery systems may revolutionize and bring the entire drug therapy strategy to a new height in near future.

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9. Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

10. References

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