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A Review on Targeted Drug Delivery System - Nanoparticles

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Review Article

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ABSTRACT

Nanotechnology is defined as the technology that allows manipulation, control, study, and manufacture of structures and devices in the "nanometre" size range. The nanoparticles have novel properties and functions which are different from items made of identical materials. The nanoparticles can open many doors and create new biomedical application by having small particle size, improve solubility, customized surface and multi-functionality. This article presents an over view on nanoparticles and targeted drug delivery system.

INTRODUCTION

Drug delivery is a process of administering a pharmaceutical dosage form or therapeutically active substance through different routes to achieve a desirable therapeutic effect [1-5]. The major challenge of drug delivery is to target the drug and to make it available at the site of action to achieve more safety and efficacy. Targeted drug delivery system is designed in such a way that the medicament releases the drug in the targeted area which results maximum therapeutic benefit and less side effects. The advancement of a wide range of Nano scale innovations is starting to change the scientific landscape in terms of disease diagnosis, treatment and symptoms. These Nano scale innovations, referred to as Nano medicines by the National Institutes of Health, can possibly transform sub-atomic disclosures emerging from genomics and proteomics into boundless advantage for patients [6-18].

TARGETED DRUG DELIVERY SYSTEM

Targeted drug delivery system is a novel form of drug delivery system where the drug or medicament is directly targeted or delivered only to the site of action and not to the other organs or cells or tissues and it is also called as smart or advanced drug delivery system [18-24]. This delivery system specifically delivers high concentration of drug or medicament at the infected organs compared to the other organs or tissues which improves efficacy and reduces side effects [25-30].

There are two basic requirements to keep it in the mind to achieve an effective drug delivery system in the design of nanoparticles. The first one is medicament should be able to reach the desired affected cell or organ after its administration and the second one is drug should only act on that particular cell or organ or tissue without effecting the healthy cells or organs or tissues. This can be achieved by mainly two strategies. One is passive and the other is active targeting of the drugs [30-35].

Strategies of Targeting Drug delivery System

There are two basic requirements to keep it in the mind to achieve an effective drug delivery system in the design of nanoparticles. The first one is medicament should be able to reach the desired affected cell or organ after its administration and the second one is drug should only act on that particular cell or organ or tissue without effecting the healthy cells or organs or tissues. This can be achieved by mainly two strategies. One is passive and the other is active targeting of the drugs [36-40].

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Passive targeting

Passive targeting drug delivery can be achieved by clocking the macromolecules or nanoparticles with some sort of coating materials like polyethylene glycol (PEG) by which the medicament passively reaches the target organ. This delivery system mainly uses to target the tumor cells through EPR effect [41-44].

Active targeting

Active targeting can be achieved by conjugating the medicament or therapeutic agent to a particular tissue or to a specific ligand or to make more specific to target site [45-48].

Characteristics of Targeted Drug delivery system

It should be biodegradable, biocompatible, nontoxic, and physicochemical stable *invitro* and *invivo*. Distribution of the drug or medicament should restrict to target cells or tissues or organs and should be uniform. Drug or medication discharge should be controlled and predictable. Drug release does not impact its activity. The drug release should reach the therapeutic level. The delivery system should formulate in such a way that it should be easy, simple and cost effective. Carriers utilized must be bio-degradable [49-53].

Advantages

Higher desired effects can be achieved by administering the smaller doses. The availability of the drug at the site of action is more and lowers the harmful systemic side effects. Targeted molecules like peptides and particulates can be enhanced. Lesser dose compared to conventional drug delivery system. It is selectively targeted to the infectious cells compared to normal or non-infectious cells. Avoidance of first pass or hepatic metabolism [54-59].

Disadvantages

Disposition of the drug at the targeted site many lead to toxic effects. Rapid clearance of drug targeted systems. Requires more knowledge and skills for manufacturing, storage and administration. It is difficult to maintain stability of the dosage form. Diffusion and redistribution of released dosage form [60-65].

NANOPARTICLES

In the recent years the practices of drug delivery system has changed dramatically. Nanoparticles are used as a novel targeted drug delivery system for many diseases like tumours, brain diseases, Ebola, and some infectious diseases. Nanoparticles are defined as “the particles which are having a size of less than 100nnm’’ or “it is defines as a small objective which behaves as a whole unit with respect to the properties as well as transport” [66-72].

Characteristics of Nanoparticles

Particle size

Currently photon-correlation spectroscopy or dynamic light scattering is the fastest and routine method for determining the size of nanoparticle. In this method viscosity of the medium to be known for determining the participle size by light scattering properties and Brownian motion. The results obtained by this spectroscopic method are verified by transmission electron microscopy or by scanning [73-76].

For nanoparticles particle size and its distribution are the most important characteristics. These characteristics influence the drug loading, drug release and stability behaviour of the nanoparticles. At the same

time these characteristics determines the in vivo distribution of drug, toxicity and targeting ability of the delivery system [77-81].

The particle size influences the release of the drug. Smaller particles have larger surface area and most of the drug associate to the smaller particles and it leads to faster drug release. In contrast larger particles have large cores and it allows higher amount of the drug to be encapsulated per particles thus it results slower release. Thus, control of particle size provides a means of drug release rates [82-86].

Surface properties

The conventional carriers which are associated to the drug leads to the modification of bio distribution profile of the drug as it delivers to mononuclear phagocyte system (MPS) such as lungs, bone marrow and liver. Nanoparticles when administered through intravenously are recognised by the host immune system and cleared by phagocytes from the circulation. Apart from this the blood components determines the hydrophobicity of the nanoparticles that binds to this surface. Hence, the hydrophobicity of the nanoparticles influences the in vivo fate of nanoparticles. Surface non-modified nanoparticles in the blood stream are rapidly opsonized and cleared by MPS [87-91].

It is necessary to lower the opsonization and prolong the circulation of nanoparticles in vivo to increase the likelihood of success in targeting drug delivery. This can be achieved by formulating the nanoparticle by coating the nanoparticles with surfactants or hydrophilic polymers or with biodegradable copolymers with hydrophilic characteristics e.g., polysorbate 80 (Tween 80), polyethylene glycol (PEG) and polyethylene oxide [92-94].

Drug loading

A high drug loading capacity should require for a successful nanodelivery system. The drug loading can be achieved basically by two methods. First one is the adsorption/absorption method by which the drug can be absorbed after formation of nanoparticle. This method can be achieved by incubating the nano-carrier with a concentrated drug solution and the efficiency of drug loading and entrapment depends on the solubility of the drug in the excipient matrix material. The second one is incorporation method which requires the drug should be incorporated at the time of nanoparticle formation. The drug entrapment efficacy and loading depends on drug solubility and excipient matrix material and this related to molecular weight, matrix composition, drug polymer interaction and the presence of functional group in drug or matrix [95-97].

Drug release

When formulating or developing a nanoparticulate delivery system it is important to consider both drug release and polymer biodegradation. The drug release rate depends on solubility of the drug, distribution of the drug, desorption of the surface-bound or adsorbed drug, nanoparticle degradation or matrix erosion and the combination of erosion and diffusion process. Hence the parameters like solubility, diffusion and biodegradation of the particle matrix governs the release process. In the case of nanospheres the drug is uniformly distributed and the drug release occurred by erosion of the matrix or diffusion process. If the matrix erosion of the drug is slower than diffusion the mechanism of the drug is largely controlled by the diffusion process. The drug which is loaded by the incorporation method then the system have a sustained release characteristics and relatively small burst effect. The nanoparticle is coated with a polymer, and then the release of the drug is controlled by diffusion process from the polymeric membrane [98-100].

CONCLUSION

Nanoparticle has multiple advantages in the pharmaceutical formulation. The main advantage of nanoparticles is precise targeted therapy with small doses of drug. Nanoparticle delivery system holds a great potential to overcome obstacles to target a number of diverse cell types. This represents to overcome the problems of drug resistance in targeted organs and facilitates the movement of the drugs across the barriers.

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