INTERNATIONAL JOURNAL OF PROGRESSIVE RESEARCH IN ENGINEERING MANAGEMENT AND SCIENCE (IJPREMS)

e-ISSN : 2583-1062

Impact Factor : 5.725

www.ijprems.com
editor@ijprems.com

Vol. 03, Issue 11, November 2023, pp : 211-214

NANOPARTICLE IN DRUG DELIVERY SYSTEM

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ABSTRACT

The integration of nanoparticles in drug delivery has offered exceptional advantages, including targeted delivery and improved bio-availability. This review explores the potential, capacity and ability of nanoparticles in drug delivery, types, applications, advantages, and associated challenges. controlled drug delivery system (DDS) have several advantages compared to the traditional form of drugs. This modern form of drug delivery system is especially important when there is a difference between the dose or the concentration of a drug and its therapeutic results or toxic effects. There has been a significant research notice in the area of drug delivery systems using nanoparticles. Cell-specific targeting can be consummate by attaching drugs to specially planned carriers. They have been used in vivo to save from harm the drug entity in the systemic circulation, control access of the drug to the chosen sites and to deliver the drug at a controlled and sustained rate to the site of action, minimizes undesirable side effects of the drugs and allow for more resourceful use of the drug. It should be present at correct concentrations at the target site, and it should not lose its activity or therapeutic effectiveness while in circulation.

Key word- Nanoparticles, dentrimers, liposomes. Drug delivery system

1. INTRODUCTION

Background on traditional drug delivery system

A traditional drug delivery system refers to the conventional methods used to administer therapeutic agents to achieve a desired therapeutic effect. Here are the primary categories.

1. Oral Route- This is the most common method of drug delivery and includes:
a. Tablets -Solid dosage forms that contain active drug(s) and excipients. They can be swallowed whole.
b. Capsules-Gelatin shells filled with powder, liquid, or pellets.
c. Syrups and Suspensions-Liquid formulations for easier swallowing, especially for children.
2. Topical Route- Drugs are applied directly to the body surface. Examples include:
a. Creams and Ointments-Semi-solid preparations for external application.
b. Gels-Transparent or translucent semisolid systems.
c. Patches Adhesive patches that release the drug over time.
3. Parenteral Route- This route bypasses the digestive system and includes:
a. Injections Intravenous (into the bloodstream), intramuscular (into the muscle), and subcutaneous (under the skin).
b. Infusions Continuous or intermittent drug delivery, commonly via IV.
4. Rectal and Vaginal Routes
a. Suppositories and pessaries are solid dosage forms that liquefy or dissolve at body temperature, releasing the drug.
5. Inhalation Route Drugs are delivered to the lungs. Examples are:
a. Metered Dose Inhalers (MDIs)-.A pressurized system that delivers a specific amount of drug in aerosol form.
b. Dry Powder Inhalers (DPIs)-Deliver powdered drug directly to the lungs.
6. Nasal Route- This is for local or systemic effects.
a. Nasal Sprays or Drops Liquid formulations administered directly into the nose.

Traditional drug delivery systems are contrasted with novel or advanced drug delivery systems, which often aim to enhance efficacy, reduce side effects, and improve patient compliance by controlling the rate, time, and place of drug release in the body.

Importance of improving drug efficacy, potency and also reduce side effect by nanoparticle based drug delivery system.

Nanotechnology manipulates substances at a molecular or atomic scale, producing nanoparticles (NPs) between 1 and 100 nanometers in size. In pharmaceuticals, these NPs have been hailed for transforming drug delivery mechanisms. When drugs is loaded into nanoparticles through physical encapsulation, adsorption or chemicalconjugation, the pharmacokinetics and therapeutic index of the drugs can be significantly improved in contrast to the free drug counterparts. Many advantages of nanoparticle-based drug delivery have been recognized, including improving serum solubility of the drugs, prolonging the systemic circulation lifetime, releasing drugs at a sustained and controlled

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manner, preferentially delivering drugs to the tissues and cells of interest, and concurrently delivering multiple therapeutic agents to the same cells for combination therapy. Nanostructures biomaterials and nanoparticles have unique physicochemical properties such as ultra small and controllable size, large surface area to mass ratio, high reactivity, and functionalizable structure. Biologicalmembranes and access cells, tissues and organs are eligible for entrance of nanoparticles. These cells are not crossed by the larger-sized particles easily i.e. by conventional medicine.

2. TYPE OF NANOPRTICLE USED IN DRUG DELIVERY

Liposomes

Liposomes have been first to be explore as drug carriers. they are micro/nanoparticles usually with 80-300 nm sized range Liposomes are spherical lipid vesicles with a bilayered membrane structure consisting of amphiphilic lipid molecules. liposomes used as drug delivery nanoparticle. It can be made of both natural or artificial lipids. Currently, liposomes are the widely used antimicrobial drug delivery system. One of the characteristic type of liposomes is its lipid bilayer structure, which mimics cell membranes and can readily combine with infectious microbes. By directly fusing with bacterial membranes, the drug payloads of liposomes can be released to the cell membranes or the interior of the bacteria. liposomes carries mutually hydrophobic and hydrophilic compounds without any chemical alteration.

Polymeric nanopartical

Dentrimers

Dentrimers are branched polymers which carries drug molecule both on their surface and in their interior. Dentrimers are in well define structure and shape. In the configuration of dendrimer, in difference to the linear polymer, the following elements can be tell apart a core, dendrons, and surface active groups.

The core of the is a single atom or molecule. The highly branched nature of dentrimers provide large surface area to size ratio and allows great reactivity with microorganisms in vivo with hydrophobic and hydrophilic agent can be weighed down into dentrimers. Hydrophobic drug can be weight down inside the cavity in the hydrophobic core and hydrophilic drug can be attached to the multivalent surface of dentrimers through covalent conjugation or electrostatic interaction.

Carbon nanomaterials

Carbon nanocarries are used in DDS are differentiated into nanotubes and Nanohorns . carbon nanomaterial is extensive family of carbon allotrope consisting of 0 dimensional fullerence and also quantam dots. Carbon nanotubes are in 1-dimension, graphene in 2-dimension and nanohorns are in 3-dimension. Carbon nanomaterial has broad range of application due to their unique physical and chemical properties Carbon nanomaterial contains.

- Fullerence
- Carbon nanotubes
- Graphene
- Nanodiamonds
- Carbon-based quantam dots
- Other carbon nanomaterials

Magnetic nanopaticle

Magnetic nanoparticle exhibit the wide variety of attributes that’s why it is highly promising carrier for drug delivery. Magnetic nanopartical used in MRI ac contrast agent . Also used in hyperthermia treatment.

3. APPLICATION OF NANOPARTICLE IN DRUG DELIVERY SYSTEM

Targeted drug delivery

nanoparticle can be functionalised to target specific cell or tissue minimising side effect. Having a excellence bioavailability, good pharmacokinetic and pharmacodynamic properties and also give quick and instant effect.

Improve and enhanced permability and retention effect (EPR) In cancer therapy, tumers leaky vasculature and limited lymphatic drainage allow nanoparticals to accumulate enhancing drug delivery Overcome biological barriers Nanopartical can cross challenging barriers like blood brain barrier like the blood-brain barrier, enabling treatment of conditions like brain cancer.

Controlled Release- NPs can provide sustained drug release, reducing dosing frequency.

4. ADVANTAGES

Improved Solubility Enhancing the solubility of poorly soluble drugs, improving their bioavailability.

Reduced Toxicity By targeting specific cells or tissues, overall drug toxicity can be reduced.

Stability NPs offer protection to drugs, ensuring they remain stable and potent.

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Challenges and Concerns*

Safety The small size of NPs raises concerns about accumulation in tissues, leading to potential long-term effects.

Scalability Large-scale production of NPs remains challenging and costly.

Regulatory Hurdles Due to their unique properties, NPs face stringent scrutiny from regulatory bodies, potentially delaying market entry.

Future Directions- The combination of NPs with personalized medicine, using patients' genetic information to customize treatments, offers a promising horizon. Moreover, advancements in bioinformatics can provide insights into potential drug-NP interactions, predicting therapeutic outcomes.

5. CONCLUSION

Nanoparticles are redefining the landscape of drug delivery, offering targeted, efficient, and less toxic therapeutic solutions. As research delves deeper into their potential and resolves existing challenges, the future for NPs in pharmaceuticals looks promising.

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