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A REVIEW ON NOVEL DRUG DELIVERY SYSTEM

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ABSTRACT
Despite being widely adopted, traditional medication delivery technologies fall short when compared to more modern, cutting-edge drug delivery techniques in terms of effectiveness. Some medications have a range of optimal concentrations, and within this range, the greatest effect is obtained. If a drug's concentration is above or below this range, it may be harmful or have no therapeutic effect at all. On the other hand, a multidisciplinary approach to the delivery of medicines to the targets in the tissues is becoming increasingly necessary given the relatively modest improvement in the effectiveness of the treatment of severe diseases. Many drug delivery and drug targeting methods are now being developed with the goal to decrease drug degradation, boost drug bioavailability, limit negative side effects, and raise the proportion of the drug accumulating in the desired zone. Transitioning a drug from a standard form to an unique delivery mechanism can significantly improve its performance in terms of patient adherence, safety, and efficacy. The release of a medicine at a precise spot at a specific pace presents a number of challenges that can be greatly reduced by a novel drug delivery system that is properly developed. Pharmaceutical companies are developing innovative drug delivery systems as a result of the desire to provide medications to patients effectively and with fewer side effects. Novel drug delivery systems (NDDS) are carriers that keep drug concentrations in the therapeutic range for longer periods of time and, if needed, can also carry drug material to the site of action.

KEYWORDS: Drug delivery system, target site, drug, drug carrier, therapeutic dose, pharmacological effect etc.

INTRODUCTION

Substantial advances in drug delivery systems have been made in the realm of pharmaceutical sciences, opening the door for ingenious ways of giving patients their drugs. A novel drug delivery system is an umbrella term used to describe cutting-edge techniques and tools created to boost the therapeutic effectiveness of medications while reducing potential negative effects while improving patient compliance. These devices have been engineered to deliver medication in a regulated and precise manner to the intended site of action.

Traditional medication delivery techniques, including oral tablets or injections, frequently struggle to maintain sustained release, achieve desirable drug concentrations at the envisioned region, or reduce systemic toxicity. By utilizing a variety of techniques, including as nanotechnology, specialized carriers, targeted distribution, and implanted devices, new approaches to drug delivery provide options to get beyond these restrictions.

These innovative approaches—often referred to as drug delivery systems (DDS)—combine polymer science, pharmaceutics, bioconjugate chemistry, and molecular biology. Novel drug delivery systems offer improved drug stability, controlled release, targeted dispersion, and enhanced bioavailability by using revolutionary technologies like nanoparticles, liposomes, micro-needle patches, or implantable devices. These advancements not solely improve therapy results but also patient satisfaction and compliance.

With regard to oncology, transmissible diseases, chronic disorders, and personalized medicine, the emergence of novel drug delivery methods has broad ramifications. These technologies have the potential to completely change how medicines are administered, creating prospects for more effective avenues of treatment and personalized therapy.

The fabrication of imaginative drug delivery systems holds promise in maximizing treatment outcomes, dropping side effects, and enabling catered medications in this era of precision medicine and individualized healthcare.

Conventional Drug Delivery System is the established framework that incorporates the routine techniques for delivering medications into the body. Although popularized, they had many limitations like

- Frequent administration of drug is necessary.
- The regular dosage form is administered at a specific frequency and at a specific dose.
- Patient compliance may be negatively impacted by a lower half-life and a greater possibility of missing the medication dose.
- Achieving the steady state condition is challenging due to the peak valley plasma concentration-time profile.

In order to alleviate these drawbacks, a break-through was made and the Novel Drug Delivery System was introduced and developed.

A revolutionary technique that combines innovative development, formulations, new technology, and novel methodology for delivering pharmaceutical substances in the body as necessary to safely achieve their targeted pharmacological effects is known as a Novel Drug Delivery System (NDDS). It may also improve drug potency, control drug release with a sustained pharmacological effect, and scientific site-targeting throughout the body. It entails the creation of brand-new, improved, and safer medications with protracted half-lives and significant therapeutic indices. In comparison to the pre-existing delivery systems, NDDS offers many advantages like

- Decreased dosing frequency.
- Decreased rate of increase in blood drug concentration.
- Blood level that is constant and sustained within the therapeutic window.
- Enhanced bioavailability.
- Ability to achieve a targeted drug release.
- Reduced side effects.
- Improved patient compliance.

Novel Drug Delivery Systems

Since its debut, NDDS has undergone a variety of changes, including the utilization of extracellular matrices and nanoparticles as well as microencapsulation, epithelial and transdermal administration, liposomal vesicles, and nanoparticles. In addition to being less burdensome and simpler to follow, the constantly evolving delivery methods benefit patients by lowering the risks connected with the introduction of drugs into the body. Two major approaches are used in the practice of drug delivery using novel methodologies – Carrier Based DDS and Transdermal Drug Delivery System which are further classified as

➢ **Carrier Based Drug Delivery System**

1. Nanoparticles,
2. Microspheres
3. Liposomes
4. Niosomes
5. Monoclonal Antibodies
6. Resealed Erythrocytes as Drug carriers

➢ **Transdermal Drug Delivery System**

1. Microencapsulation
2. Sonophoresis

- Supramolecular Delivery Systems
- Mucoadhesive Delivery Systems
- Variable Release Delivery Systems

3. Osmotic pump

Before proceeding with a detailed classification, it is imperative to focus the various terminologies used in the broad categorization of NDDS.

- **Sustained/ Controlled Release Forms:** Pharmaceutical preparations that release (liberate) a medication at a predetermined rate in order to maintain a steady drug concentration for a predetermined amount of time with the fewest possible side effects.

- **Localised Drug Delivery Systems:** A technique that restricts the presentation of a drug to a specific bodily site for release and absorption or the subsequent transfer of the active components to the site of action across biological membranes.

- **Targeted Drug Delivery Systems:** A technique that places the drug moiety precisely where it is needed (at the organ, cellular, and subcellular levels of a particular tissue) to avoid the general toxicity of traditional drug administration, hence lowering the dosage needed for therapeutic efficacy.

Carrier Based Drug Delivery System

In pharmaceutical science, a carrier-based drug delivery system is a technique that makes use of specific carriers to enhance the selectivity, efficacy, and safety of drug delivery. These carriers can improve the solubility, stability, and transport of drugs to specific targets, leading to more effective therapeutic results.

Liposomes, polymeric micelles, micro- and nanoparticles, and capsules are typical examples of carrier systems. These transporters can encapsulate medications and transfer them to certain locations inside the body, enabling controlled release and sustained drug administration while preserving the ideal blood concentration.

Carrier Based Drug Delivery System

1. Nanoparticles,
2. Microspheres
3. Liposomes
4. Niosomes
5. Monoclonal Antibodies
6. Resealed Erythrocytes as Drug carriers

1. Nanoparticles

Colloidal drug delivery systems called nanoparticles (NP) are made of natural, synthetic, and semi-synthetic polymers. The diameter of NP particles varies from 10 nm to 1,000 nm. Controlling particle size, surface characteristics, and the release of pharmacologically active compounds are the main objectives while designing nanoparticles as a delivery system in order to achieve the site-specific action of the medication at the therapeutically ideal rate and dose regimen. By avoiding the reticuloendothelial system, leveraging increased permeability and retention impact, and using target-specific targeting, nanoparticles exert their site-specific drug delivery. Nanoparticles can be characterized as

1. Solid lipid nanoparticles (SLNs)
2. Liposomes
3. Nanostructured lipid carriers
4. Fullerenes
5. Nanoshells
6. Quantum dots
7. Super paramagnetic nanoparticles

2. Microspheres

The typical particle size of microspheres is between 200 and 500 um, and they typically contain proteins or synthetic polymers that are biodegradable in nature. Numerous methods for creating microspheres provide a variety of chances to control drug administration processes and improve a drug's therapeutic effectiveness. Numerous drawbacks of traditional therapy can be overcome, and the therapeutic effectiveness of the medicine can be increased. There are many ways to deliver a medicinal chemical with a continuous and controlled release to the target region. Microspheres' regulated and sustained release makes them suitable for a variety of applications. They are classified into two types

1. Synthetic Polymers
2. Natural polymers

1) Synthetic polymers are further divided into:

1. Non-biodegradable polymers e.g. Poly methyl methacrylate (PMMA), Acrolein, Glycidyl methacrylate Epoxy polymers
2. Biodegradable polymers e.g. Lactides, Glycolides & their co-polymers Polyalkyl cyanoacrylates, Poly anhydrides

1) Natural polymers may be obtained from different sources like proteins, carbohydrates and chemically modified carbohydrates.

- Proteins: Albumin, Gelatin, and Collagen
- Carbohydrates: Agarose, Carrageenan, Chitosan, Starch
- Chemically modified carbohydrates: Poly dextran, Poly starch.

3. Liposomes

An aqueous volume is completely encased by a membrane made of lipid bilayers in a liposome, a microscopic vesicle. Liposomes, also known as vesicles or colloidal spheres, are composed of cholesterol, non-toxic surfactants, sphingolipids, glycolipids, long-chain fatty acids, even membrane proteins, and medicinal molecules. With regard to lipid composition, surface charge, size, and manufacturing process, liposome properties vary greatly. Additionally, the 'rigidity' or 'fluidity' and the charge of the bilayer are determined by the components used in the bilayer. Both hydrophobic and hydrophilic compounds can be trapped by liposomes, which can also prevent the combination's decomposition and release the trapped substances at specific locations with greater efficiency as an exploratory system and a commercial drug delivery system.

4. Niosomes

When synthetic non-ionic surfactants are hydrated, whether or not cholesterol or their lipids are incorporated, niosomes, which are non-ionic surfactant vesicles, are produced. Drugs that are hydrophilic or lipophilic can both be captured by niosomes, which also helps the medicine stay in the body for longer. An amphiphile, or non-ionic surfactant, like Span-60, which is often stabilised by the addition of cholesterol, and a little quantity of an anionic surfactant, like diacetyl phosphate, which also aids in stabilising the vesicle, make up a typical niosome vesicle. Although they share a bilayer with liposomes structurally, niosomes are more stable due to the materials utilised in their manufacturing. The following are the two primary components utilized to prepare niosomes

1. Cholesterol
2. Non-ionic surfactants

Cholesterol is used to provide rigidity and proper shape, conformation to the niosomes preparations. The role surfactants play a major role in the formation of niosomes. The following non-ionic surfactants are generally used for the preparation of niosomes.

E.g.

- Spans (span 60, 40, 20, 85, 80)
- Tweens (tween 20, 40, 60, 80)
- Brijs (brij 30, 35, 52, 58, 72, 76)

5. Monoclonal Antibodies

Monoclonal antibodies (MAb(s)) are collections of homogeneous antibody molecules with affinity for a particular antigen, frequently produced by fusing a B-cell with a single descent of cells carrying a specific antibody gene. When coupled with cytotoxic medications, monoclonal antibodies produced against specific antigens can deliver pharmaceuticals to cancer cells while sparing normal cells from harm (generally administered as an infusion).

In addition to these monoclonal antibodies, their complexes are currently being studied as incredibly sensitive probes that can be directed to target cells or organs. They have been applied to the delivery of enzymes or cytotoxic medicines to particular cell types.

Antibodies against several T lymphocyte subsets, especially suppressor cells, are expected to continue to be very useful in the diagnosis and treatment of individuals with multiple sclerosis, various heart conditions, various leukemias, and malaria.

Released Erythrocytes as Drug Carriers

Red blood cells (RBCs), also known as erythrocytes, have received a lot of attention and have been researched for possible medication delivery capabilities and drug-loaded microspheres. These erythrocytes are known as "resealed erythrocytes" because they are made by taking blood samples from the target organisms, isolating the erythrocytes from the plasma, entrapping the drug inside the erythrocyte, and then resealing the resulting cellular carriers. Erythrocytes can contain a wide range of physiologically active chemicals, ranging in size from 5000 to 600,000 D but the molecules should typically be polar, hydrophilic, non-polar, and hydrophobic. The drug-laden erythrocytes work as slow circulation depots after reinjection, target the drug to the reticuloendothelial system (RES), limit loaded drug degradation from endogenous chemical inactivation, achieve steady state drug concentration, and lessen loaded drug side effects.

Transdermal Drug Delivery System

Transdermal drug delivery systems are self-contained, discrete dosage forms of patches that, when applied to the skin, deliver drugs through the skin portal to systemic circulation at a predetermined and controlled rate over a prolonged period of time in order to improve therapeutic efficacy and minimize side effects. Drug levels are kept within the therapeutic window for a longer period of time thanks to TDDS, which prevents them from rising over the maximum effective concentration or falling below the minimum effective concentration.

Transdermal drug delivery (TDD) differs significantly from topical drug administration, which can only target the localized afflicted regions. TDD refers to the transport of medications over the skin and into the systemic circulation. Transdermal delivery systems are broadly categorized into:

1. Microencapsulation
2. Sonophoresis
   - Supramolecular Delivery Systems
   - Mucoadhesive Delivery Systems
3. Osmotic pump

1. Microencapsulation

Solids, liquids, or even gases can be encased in minute particles to create thin wall coverings surrounding them through the process of microencapsulation. The microencapsulation technology has a number of advantages, including the ability to shield and conceal the active component, slow the rate of dissolution, make handling easier, and focus the active ingredient spatially. This method allows for precise distribution of modest doses of strong medications and lowers drug concentrations at locations other than the target organ or tissue.

2. Sonophoresis

Low molecular weight medications and large molecules can be quickly and conveniently delivered into the skin by sonophoresis, a technique that has received much research. As a mechanical augmentation method for systemic distribution of medicinal drugs, sonophoresis is a technique that makes use of ultrasound. Despite their electrical qualities, this method has also been shown to effectively transport a variety of medications; it may easily be combined with other transdermal techniques to improve drug delivery rate.

2.1 Supramolecular Drug delivery System

Multiple non-covalent interactions are combined using supramolecular chemistry resulting in endearing characteristics like specificity, reversibility, and tunability. Whilst supramolecular affinities are often modest, majority of them are able to provide unique molecular recognition. A delicate balance between various supramolecular interactions and biological systems results in the organized and tiered form and function of living things. Supramolecular nanoscale drug carriers can provide engineered drug-release profiles after drug incorporation and have carefully planned chemical compositions. Supramolecular interactions' adaptability additionally renders it potential to easily integrate targeting units and incorporate multiple medications into a single delivery system. In verdict, there are several prospects for pharmaceutical practice to become increasingly specific thanks to supramolecular design. Features of supramolecular design may be particularly beneficial in the context of clinical translation since they facilitate quantitative drug loading, molecularly independent delivery devices, and prior understanding of carrier deterioration and clearance strategies.

2.2 Mucoadhesive Drug Delivery System

Mucoadhesive dosage forms have been devised to facilitate a monitored rate of drug release for a better therapeutic result by enabling sustained retention at the area of application. Since mucoadhesive application has a large surface area and an excellent blood flow, it offers quick absorption alongside excellent bioavailability. Drug distribution through the mucosa bypasses first-pass hepatic metabolism as well as gastrointestinal enzyme degradation. Past variants of mucoadhesive drug delivery strategies encompassed powders, compacts, sprays, semisolids, as well as films. For instance, powders alongside nanoparticles have been employed to assist in administration of medication to the nasal mucosa, while compacts have been used to deliver medications to the oral cavity. Recently, lingual or buccal cavity oral strips have been introduced. In comparison to other drug delivery strategies, drug delivery through the oral mucosa has shown to be particularly promising and offers an array of upsides, including steering clear of

hepatic first-pass metabolism, increasing drug bioavailability, improving patient compliance, having outstanding access, unidirectional drug flux, and optimizing barrier permeability.

3. Osmotic Pump

The osmotic pump system has a reservoir-like design, but it also includes an osmotic agent that draws water from the environment through a semipermeable membrane that is impervious to drugs but receptive to water. The release of medication in an osmotic system is regulated through osmotic pressure, not by physiological parameters of the gastrointestinal locale, such as pH, or by hydrodynamic aspects. Osmotic pumps or delivery systems tend to be made of a core containing an osmogene and a medicament. These are lined with a semi-permeable material with one or more drug delivery pores, enabling the medication to be delivered incrementally as a solution or suspension. When trying to construct delivery orifices, a laser beam or mechanical drill is used to compress a tablet core and coat it with a semi-permeable membrane. Osmogenes or osmotic agents so used may also consist of mixtures, such as mannitol + sucrose, dextrose + fructose, sucrose + fructose, dextrose + sucrose, mannitol + fructose, lactose + fructose, mannitol + dextrose, or lactose + dextrose.

Applications of NDDS

There exist numerous potential applications for novel drug delivery strategies in the pharmaceutical and medical sectors. These systems serve to improve patient compliance, maximize treatment efficacy, and eliminate adverse consequences. Here are a few significant uses for novel medication delivery systems

1. **Targeted Drug Delivery**: One of the primary applications of novel drug delivery systems is targeted drug delivery. These systems can deliver drugs specifically to the site of action in the body, such as tumors or specific organs. This allows for localized treatment, minimizing systemic exposure and reducing side effects.
2. **Controlled Release**: Novel drug delivery systems enable controlled release of drugs over a prolonged period of time. This ensures a consistent and optimal concentration of the drug at the target site, improving its effectiveness. Controlled release can also reduce the frequency of drug administration and improve patient compliance.
3. **Personalized Medicine**: Drug delivery systems can be tailored to individual patients based on their specific needs and conditions. This allows for personalized medicine, where drugs are delivered in a manner that maximizes their therapeutic effects and minimizes side effects.
4. **Chronic Disease Management**: Many novel drug delivery systems are designed for the management of chronic diseases. These systems can provide long-acting formulations that deliver the drug over an extended period of time, reducing the need for frequent dosing. This improves patient compliance and simplifies the treatment regimen for chronic conditions.
5. **Combination Therapies:** Novel drug delivery systems can be used to deliver multiple drugs simultaneously or sequentially. This enables combination therapies, where different drugs with complementary mechanisms of action can be delivered together to enhance therapeutic outcomes. Combination therapies are particularly effective in treating complex diseases or drug-resistant infections.
6. **Gene and Cell Therapies**: Drug delivery systems play a crucial role in the field of gene and cell therapies. These systems can deliver genetic material or therapeutic cells to specific sites in the body, facilitating targeted and efficient treatment. They can protect the genetic material or cells from degradation and enhance their uptake by the target cells.
7. **Vaccines:** Novel drug delivery systems can also be used in the development and delivery of vaccines. These systems can improve the stability and efficacy of vaccines, enhance antigen presentation, and provide sustained release of vaccine components, leading to better immune responses and protection against infectious diseases.
8. **Transdermal Delivery**: Transdermal drug delivery systems, such as patches, are widely used for the systemic delivery of drugs. They can provide a controlled release of the drug through the skin, bypassing the digestive system and the first-pass metabolism. Transdermal delivery is particularly useful for drugs with poor oral bioavailability.

CONCLUSION

A Novel Drug Delivery System (NDDS) combines cutting edge methods with recently created dosage forms that outperform traditional dosage forms by a significant margin. A novel medication delivery system serves to improve therapeutic value by lowering toxicity, raising bioavailability, and reducing the need for repeated administration to overcome noncompliance. Even more potential exists for the use of nanoparticulate drug delivery systems in the delivery of vaccines, radiation therapy, antibiotics, anti-tumour therapy, proteins, gene therapy, AIDS therapy, , and as vesicles to cross the blood-brain barrier.

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