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REVIEW ARTICLE ON NOVEL DRUG DELIVERY SYSTEM

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INTRODUCTION

NDDS refers to advanced methods and technologies used to deliver drugs in a controlled, targeted and efficient manner. The field of pharmaceutical sciences has evolved significantly over the past few decades, particularly in the area of drug delivery. While the discovery of new drugs continues to be essential, the success of any therapeutic agent heavily depends on how effectively it reaches its target site within the body, at the right time, in the right concentration, and with minimal side effects.[1]

This critical aspect of healthcare has led to the development of Novel Drug Delivery Systems (NDDS)—a revolutionary advancement that has transformed conventional approaches to drug administration. This system aims to overcome limitations of traditional drug delivery, such as poor bioavailability, short half-life or non-specific distribution. NDDS refers to the strategic design and application of new techniques, formulations, and technologies aimed at improving the delivery, absorption, and therapeutic action of drugs.

NDDS offers innovative solutions to these issues by ensuring controlled, sustained, and targeted delivery of drugs to the desired site of action. It seeks not only to enhance the efficacy of medications but also to ensure patient safety and compliance. From this, new ideas on controlling the pharmacokinetics, pharmacodynamics, non-specific toxicity, immunogenicity, biorecognition, and efficacy of drugs were generated. These new strategies, often called drug delivery systems [DDS]

With the integration of nanotechnology, biotechnology, polymer science, and biomedical engineering, researchers have developed a wide range of advanced delivery systems including liposomes, nanoparticles, microspheres, transdermal patches, hydrogels, and implantable devices, each tailored for specific therapeutic needs.

To minimize drug degradation and loss to prevent harmful side effects and to increase drug bioavailability and the fraction of the drug accumulated in the required zone, varies drug delivery and drug targeting systems are currently under development.[1,2]

DEFINITION

A Novel Drug Delivery System (NDDS) refers to the formulation and development of new technologies and strategies for delivering drugs to the body in a manner that increases the drug's effectiveness, safety, and patient compliance. NDDS aims to overcome the limitations of conventional drug delivery methods by enabling controlled, targeted, and sustained release of therapeutic agents.[3]

OBJECTIVES OF NOVEL DRUG DELIVERY SYSTEM

The primary goal of a drug delivery system is not merely to transport a pharmaceutical compound into the body but to ensure it reaches the desired site of action with maximum therapeutic effect and minimal adverse effects. Novel Drug Delivery Systems (NDDS) are designed with a set of specific objectives that aim to overcome the limitations of conventional drug delivery and optimize the clinical outcomes of therapy. The key objectives of NDDS are as follows.

Enhanced bioavailability

Many drugs have poor solubility or stability, resulting in reduced absorption. NDDS aims to improve the bioavailability of such drugs by using carriers or formulation techniques that enhance solubility, permeability, and protection from enzymatic degradation.

Improved patient compliance

By reducing the frequency of drug administration (e.g., once-daily dosing or depot formulations), NDDS significantly improves patient adherence to treatment regimens, especially in chronic diseases.

Protection of drug from degradation

NDDS helps protect labile drugs from degradation due to pH, enzymes, or light, thus enhancing their shelf life and therapeutic efficacy.

Site- specific and time- specific delivery

NDDS can be designed to release drugs at specific sites (organ or tissue) or specific times (chronotherapy) to align with the biological rhythms of disease progression.

Facilitation of delivery of new drug molecules

Many biopharmaceuticals such as proteins, peptides, nucleic acids, and vaccines are unstable in the GI tract or poorly absorbed. NDDS provides innovative platforms like nanoparticles, liposomes, and microneedles to deliver these drugs effectively.[1,2]

IDEAL PROPERTIES OF NOVEL DRUG DELIVERY SYSTEM

1. Controlled Release: it should Maintains drug levels within a therapeutic window for an extended period.

Targeted Delivery: it should Delivers the drug specifically to the site of action, minimizing systemic side effects.

2. It should be Safe for human use without causing an immune response. Made from non-toxic, biodegradable, or bioinert materials.

3. It should be Physically and chemically stable during storage and after administration.

Protects the drug from degradation (e.g., by enzymes or pH) before reaching the target site.

4. It should be Easy to administer, preferably non-invasive (e.g., oral, transdermal) Reduces dosing frequency, improving adherence.

5. Reproducibility and Scalability Manufacturing process should be consistent, cost-effective, and suitable for large-scale production Allows for predictable and tunable release kinetics. It should Compatibility with Various Drugs.

6. It should Capable of high drug loading without affecting release behaviour.

7. It Should accommodate hydrophilic, hydrophobic, large molecules (proteins, peptides, genes).

8. It Utilizes ligands, antibodies, or receptors for active targeting. Reduces off-target effects and enhances efficacy.

9. Avoidance of First-pass Metabolism, Routes such as transdermal, buccal, nasal, or parenteral can bypass hepatic first-pass metabolism, improving bioavailability.

10. Minimal Side Effects, reduces the risk of adverse drug reactions by ensuring the drug acts primarily at the intended site.[4]

CLASSIFICATION OF NDDS BASED ON ROUTE OF ADMINISTRATION

1. Oral Drug Delivery Systems

- Most preferred and convenient route.
- NDDS improves solubility, stability, and controls drug release.

Examples

- Osmotic pumps
- Floating tablets
- Colon-targeted systems

2. Transdermal Drug Delivery Systems

- Delivers drugs through the skin into systemic circulation.
- Avoids first-pass metabolism and provides sustained release.

Examples

- Transdermal patches (e.g., nicotine, fentanyl)
- Microneedle arrays

3. Parenteral Drug Delivery Systems

- Includes intravenous (IV), intramuscular (IM), and subcutaneous (SC) injections.
- Suitable for poorly absorbed or fast-acting drugs.

Examples

- Liposomes
- Nanoparticles
- Depot injections

4. Ocular Drug Delivery Systems

For treating eye disorders, bypassing barriers like tear drainage.

Prolongs drug residence time on the eye surface.

Examples

- In situ gels
- Ocular inserts
- Nano micelles

5. Nasal Drug Delivery Systems

- Rapid absorption due to rich blood supply in nasal mucosa.
- Useful for systemic or brain targeting (via olfactory route).

Examples

- Nasal sprays
- Nanoparticle suspensions

6. Pulmonary Drug Delivery Systems

- Delivers drugs directly to the lungs via inhalation.
- Large surface area and rapid onset of action.

Examples

- Dry powder inhalers (DPI)
- Nebulizers
- Liposomal aerosols

70. Buccal and Sublingual Systems

- Placed in the cheek (buccal) or under the tongue (sublingual).
- Rapid absorption and avoids first-pass effect.

Examples

- Mucoadhesive films
- Fast-dissolving tablets

8. Rectal and Vaginal Drug Delivery Systems

- Useful when oral route is not feasible (e.g., vomiting, unconscious patients).
- Provides local and systemic effects.

Examples

- Suppositories
- Vaginal rings

- Bio adhesive gels.

Table 1: Types of NDDS dosage forms.

Type	Description	Example
Liposomes	Phospholipids vesicles carrying hydrophilic/hydrophobic drugs	Doxorubicin
Noisome	Non-ionic surfactant vesicles	Anti-cancer drug delivery
Nanoparticles	Colloidal particles for drug targeting	Paclitaxel nano particles
Microsphere	Bio-degradable polymer particles for sustained release	Anti-biotics
Transdermal	Drug patches applied to skin	Fentanyl patch
Osmotic pump	Release drug at controlled rate via osmotic pressure	Glucotrol XL

TYPES OF NOVEL DRUG DELIVERY SYSTEM

Drug release from a formulation plays a crucial role in determining its therapeutic efficacy and patient compliance. Novel Drug Delivery Systems (NDDS) can be classified based on how they control the release of the drug into the body. These classifications help in designing drug delivery system tailored to the desired rate, time, and site of action. The main categories based on d rug release profile are

Immediate release system

These formulations release the drug immediately after administration

Used when a rapid onset of action is desired, such as in pain relief or emergency conditions.

Example: Soluble tablets of paracetamol, aspirin.

Sustained release system

These systems release the drug slowly and steadily over an extended period. Designed to maintain a constant drug level in the bloodstream for longer durations.

• Reduces dosing frequency and improves patient compliance.

Example: Sustained-release tablets of Diclofenac, Propranolol.

Controlled release system

Similar to sustained release but with more precise control over drug release rate.

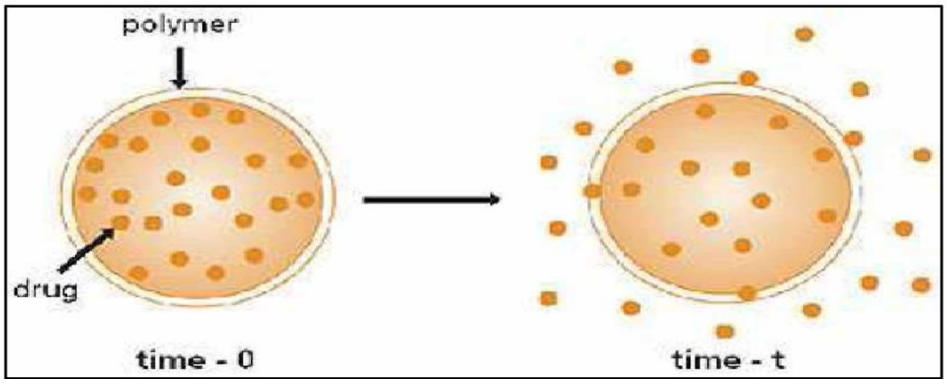

Fig:1 constant rate independent of external factors.

Drug is released at a predetermined Maintains plasma drug levels within the therapeutic window throughout the treatment duration. Example: Zero-order release osmotic pump systems like Glucotrol xl.[1,2]

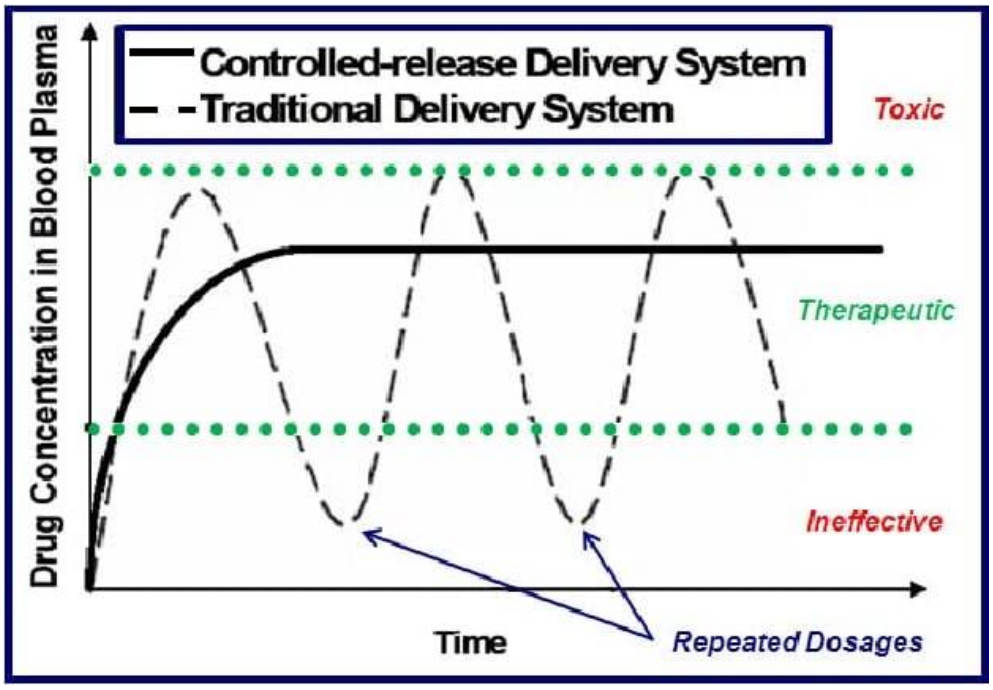

Fig:2 graphical representation of NDDS.

Delayed Release Systems

Drug release is delayed for a specific period after administration.

Often designed to release the drug in a particular part of the gastrointestinal tract, such as the intestine.

Example: Enteric-coated tablets that resist stomach acid and dissolve in the intestine (e.g., ome prazole EC tablets).

Targeted release drugs in Novel Drug Delivery Systems (NDDS)

Aim to deliver medications to specific sites in the body, enhancing therapeutic effectiveness and minimizing side effects.

Types of Targeted Release

1. Site-specific targeting
2. Cell-specific targeting

Benefits

1. Improved efficacy
2. Reduced side effects
3. Enhanced patient compliance

Applications

1. Cancer treatment
2. Gene therapy
3. Inflammatory diseases.[1,2]

Advantages

1. Increased specificity
2. improved safety
3. enhanced therapeutic outcomes.[1,2]

Advantages of novel drug delivery system

1. Decreased dosing frequency Reduced rate of rise of drug concentration in blood.
2. Sustained and consistent blood level within the therapeutic window.
3. Enhanced bioavailability.
4. To achieve a targeted drug release.
5. Reduced side effects.
6. Improved patient compliance.
7. Enhanced drug stability and minimized degradation
8. Optimized drug distribution, leading to increased target concentration, and reduced adverse reaction.
9. precise drug localization, timing, and targeted release, such as breaking through the blood–brain barrier for drug delivery
10. Decreased therapeutic dosage, reduced the toxicity, and elevated therapeutic index.[5]

Disadvantages of novel drug delivery system

1. High Cost: Development and production involve expensive materials and processes. Leads to increased treatment cost.

2. Complex Formulation and Manufacturing: Requires sophisticated techniques and trained personnel. Increases manufacturing complexity and chances of error.

3. Stability Issues: Certain systems like liposomes and nanoparticles are sensitive to light, heat, and pH. Limited shelf life.

4. Lengthy Regulatory Approval: Novel systems require extensive safety, efficacy, and stability studies. Delays time-to-market.

5. Limited Drug Loading Capacity: Some carriers have limited space to encapsulate drugs. May not be suitable for drugs requiring high doses. In case of system failure, the entire drug dose may be released suddenly. Can cause serious side effects

6. Storage and Handling Challenges: May require controlled temperatures, light protection, or humidity control. Increases cost and complexity of storage.[6]

Applications of novel drug delivery system

1. Direct delivery of drugs to specific cells or tissues, reducing side effects.
2. Maintains therapeutic drug levels over an extended period.
3. Enhances absorption and effectiveness of poorly soluble drugs.
4. Reduces the frequency of drug administration.
5. Limits drug exposure to healthy tissues, minimizing toxicity.
6. Increases patient convenience and adherence to treatment.
7. Suitable for paediatric and geriatric patients with easier dosage forms.
8. Protects drugs from degradation by external factors.
9. Allows delivery to specific organs like brain or colon.
10. Supports effective management of chronic diseases like cancer and diabetes.[7]

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