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Review Article

# An Updated Comprehensive Review on Novel Drug Delivery Systems (NDDS) In the Pharmaceuticals

**Vinay Kumar Rao Khadam*, Dr. Ravindra Pal Singh, Deepak Prajapati, Mohammad Yunus, Balkishan Prajapat, Santosh Kumar Rai, Prakriti Kumari, Dipon Gogoi**

Nims Institute of Pharmacy, Nims University Rajasthan, Jaipur, 303121, India.

## A B S T R A C T

The field of pharmaceutical sciences has witnessed a paradigm shift with the advent of Novel Drug Delivery Systems (NDDS), which aim to enhance therapeutic efficacy, reduce side effects, and improve patient compliance. This comprehensive review explores the latest advancements and innovations in NDDS, encompassing a diverse range of delivery platforms and strategies.(NDDs are transforming the landscape of pharmaceutical treatment, offering unparalleled potential for enhanced therapeutic efficacy, improved bioavailability, controlled release, targeted delivery, and enhanced stability. This comprehensive review explores the diverse landscape of NDDS, highlighting recent advancements and addressing key challenges. Prominent NDDS include liposomes, nanoparticles, micelles, polymeric drug conjugates, monoclonal antibodies, implants, and patches. Each system possesses unique properties and applications, tailored to specific drugs and therapeutic needs. Recent breakthroughs in targeted nanocarriers, gene therapy vectors, and 3D-printed personalized dosage forms are pushing the boundaries of innovation. The main highlights of the present review firstly the basics on NDDs, the several approaches of nano drug carriers for the drug delivery with their preparation methods and example. The middle version of review discuss the recent advancements techniques in the preparation of NDDs carriers and lastly the marketed formulation of particular drug carrier.

**Keywords:** novel carriers; liposomes; niosomes; advancement; microspheres; nanoparticles; microencapsulation's; novel advances; monoclonal antibodies; nano-carriers.

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*Address for Correspondence:
Vinay Kumar Rao Khadam, Nims Institute of Pharmacy, Nims University Rajasthan, Jaipur, 303121, India.

## INTRODUCTION:

The landscape of drug delivery is undergoing a transformative journey with the emergence of Novel Drug Delivery Systems (NDDS), promising a new era of precision and efficacy in therapeutic interventions. This comprehensive review endeavors to unravel the intricate tapestry of NDDS, delving into the latest breakthroughs, advancements, and their potential to revolutionize the way we administer and experience pharmaceuticals.Historically, conventional drug delivery methods have faced challenges related to suboptimal bioavailability, off-target effects, and poor patient adherence. In response, NDDS has emerged as a dynamic field, driven by the pursuit of enhancing drug delivery precision, improving therapeutic outcomes, and minimizing adverse effects [1]. This review seeks to provide a holistic understanding of NDDS by exploring their diverse modalities and applications.

The pharmaceutical landscape is undergoing a transformation driven by groundbreaking advancements in NDDs. These innovative approaches are breaking free from the shackles of traditional delivery methods, offering unparalleled potential for safer, more effective, and personalized treatments [2-3]. This comprehensive review delves deep into the exciting world of NDDS, unearthing their secrets and showcasing their transformative power. The various nano drug carriers shown in the given **Fig. 01** as below followings:

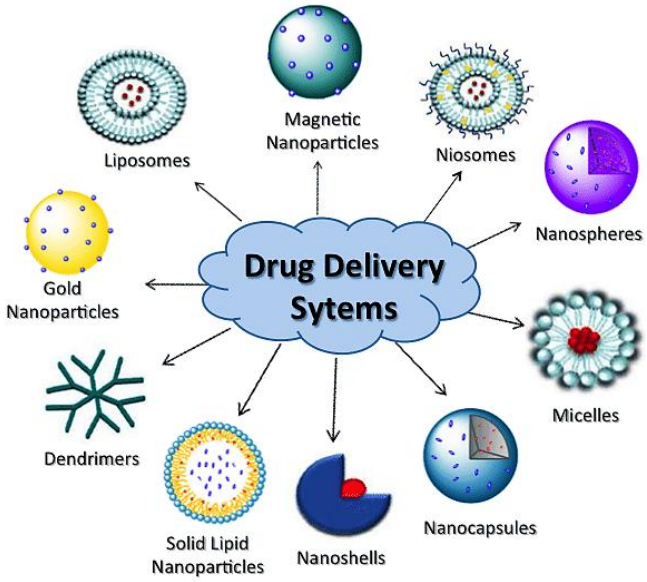


**Figure 1:** The several advance drug carrier in the novel drug delivery system (NDDS)

This future, once a mere dream, is rapidly becoming a reality thanks to the ingenuity of NDDS. This review serves as your guide to this fascinating realm, illuminating the diverse array of systems and exploring their distinct advantages:

- ***Nano-sized warriors:*** Nanoparticles, micelles, and liposomes, smaller than the width of a hair, infiltrate diseased tissues with targeted precision, delivering their healing payloads directly to the source.
- ***Controlled release champions:*** Polymeric implants and biodegradable patches transform drug delivery into a marathon, not a sprint, releasing medications in a sustained and controlled manner for extended periods.
- ***Gene therapy pioneers:*** NDDS act as Trojan horses, ferrying therapeutic genes into cells to correct genetic malfunctions or activate the immune system against cancer.
- ***Personalized pioneers:*** 3D printing technology joins forces with NDDS, creating customized dosage forms with precise drug release profiles, tailored to individual patient needs [3-5].

As the review unfolds, it not only celebrates recent successes and clinical milestones but also critically examines the challenges and potential future directions in NDDS. The convergence of interdisciplinary research, bringing together expertise from materials science, pharmacology, and engineering, emerges as a key catalyst for the ongoing evolution of drug delivery systems. In summation, this comprehensive review serves as a beacon in the ever-evolving domain of NDDS. By synthesizing knowledge from various fronts, it aims to inspire researchers, academicians, and pharmaceutical professionals to explore and contribute to the unfolding narrative of precision drug delivery [6]. NDDS exhibit various characteristics that aim to enhance therapeutic outcomes, improve patient compliance, and minimize side effects. These characteristics discuss in the given **Table. 01** as below followings:

**Table 01:** The list of characteristics, description, example and their application of novel drug delivery system **[**5-8]

| Characteristic | Description | Example | Application |
|---|---|---|---|
| **Controlled release** | Drug is released at a predetermined rate over an extended period of time. | Transdermal patches, Implants, Oral extended-release tablets | Chronic diseases (e.g., hypertension, diabetes), Pain management, Vaccines |
| **Targeted delivery** | Drug is directed to a specific site in the body, reducing side effects and increasing efficacy. | Liposomes, Nanoparticles, Antibody-drug conjugates | Cancer therapy, Gene therapy, Infectious diseases |
| **Mucosal delivery** | Drug is absorbed through the mucosal membranes of the nose, mouth, or lungs. | Nasal sprays, Inhalers, Buccal patches | Allergies, Asthma, Pain relief |
| **Transdermal delivery** | Drug is absorbed through the skin. | Patches, Gels, Creams | Pain relief, Hormone replacement therapy, Smoking cessation |
| **Implantable delivery** | Drug is released from a device implanted in the body. | Biodegradable implants, Pumps | Cancer therapy, Chronic pain management, Contraception |
| **Responsive delivery** | Drug release is triggered by a specific stimulus, such as changes in pH, temperature, or enzymes. | Glucose-responsive insulin delivery systems, Tumor-activated drug delivery systems | Diabetes, Cancer therapy |

This review article summarized the basics of novel drug delivery system, their classification, recent advancement in the NDDS with the marketed view on the various novel drug carrier.

## TYPES OF NOVEL DRUG DELIVERY SYSTEM (NDDS):

Novel Drug Delivery Systems (NDDS) represent a diverse range of innovative approaches to enhance drug administration, efficacy, and patient compliance. One type of NDDS is liposomes, which are microscopic vesicles composed of lipid bilayers that encapsulate drugs, improving their solubility and bioavailability. Nanoparticles, another category, consist of particles with dimensions in the nanometer range and can be engineered to deliver drugs to specific tissues or cells, allowing for targeted therapy. Novel drug delivery systems offer diverse strategies to overcome challenges associated with conventional drug delivery, providing more effective and targeted therapeutic interventions. NDDS can be broadly classified into various categories based on their mechanisms and routes of delivery. Two significant classifications within this context are Carrier-Mediated Delivery Systems and Transdermal Delivery Systems respectively [09].

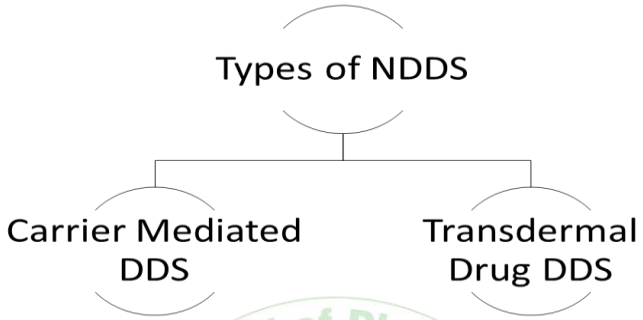


**Figure 2:** The major types of NDDS as carrier medicated and Transdermal DDS

These systems utilize carriers, such as liposomes, nanoparticles, or polymers, to encapsulate and transport drugs throughout the body. The carriers protect the drug from degradation, facilitate targeted delivery to specific sites, and control the release rate for sustained therapeutic effects.These systems deliver drugs directly through the skin for systemic or local effects. The skin acts as a reservoir for sustained drug release, eliminating the need for oral or injectable administration, and improving patient compliance.

## CARRIER MEDIATED DRUG DELIVERY SYSTEM:

Involves the use of carriers or vehicles to transport and deliver drugs to specific target sites.Carrier-mediated drug delivery systems utilize tiny carriers to encapsulate and transport drugs within the body, revolutionizing drug delivery with targeted action, controlled release, and improved bioavailability. Generally, carrier mediated DDS having five major types:

**A) LIPOSOMES (LIPID BASED VESICLES):** They are Tiny Bubbles Revolutionizing Drug Delivery. Liposomes (**Fig. 03 A.)** are like microscopic submarines, navigating the body to deliver drugs precisely where they're needed. These nano-carriers, typically ranging from 25 to 1000 nanometers in size (imagine 1000 liposomes lining up could fit on the head of a pin!).

**Composition:** Liposomes are formed by phospholipid bilayers, similar to the membranes of our cells. These bilayers consist of two layers of phospholipid molecules, with a hydrophilic (water-loving) head and a hydrophobic (water-fearing) tail.

**Liposome structure:** The phospholipid bilayer with hydrophilic heads and hydrophobic tails

- **Hydrophilic heads:** Face the watery inside and outside of the liposome, allowing interaction with the surrounding environment.
- **Hydrophobic tails:** Pack together in the bilayer's interior, protecting the encapsulated drug from the aqueous environment [10-11].

The **Fig. 03 A. & B.** comprise to shown the schematic structure of Liposome and Niosome as below followings:

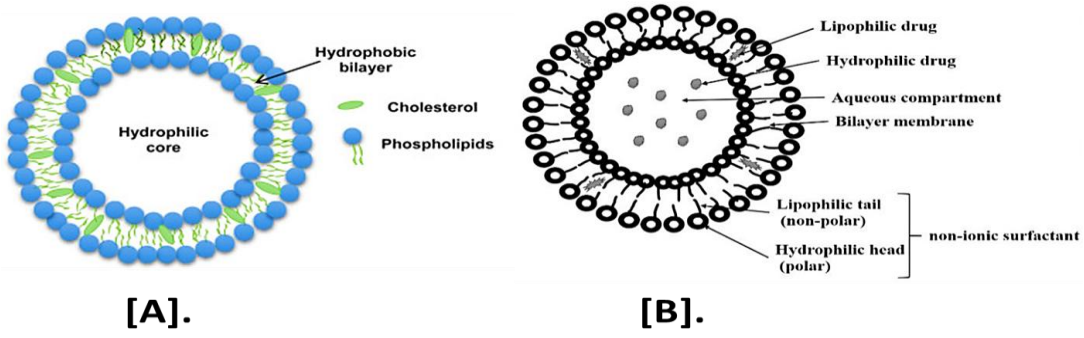


**Figure 03:** The schematic representation of [A]. Liposome and [B]. Niosome structure

Liposome, having several applications, benefits, and types which discussed in the given **Table. 02** as below followings:

**Table 02:** The types, description, applications and benefits of liposome [12-14]

| Type | Description | Applications | Benefits |
|---|---|---|---|
| **Conventional Liposomes** | Composed of naturally occurring phospholipids. Offer basic drug encapsulating and delivery functionalities. | Drug delivery for a variety of diseases, including cancer, infectious diseases, and neurological disorders. | Enhanced drug solubility, improved bioavailability, controlled release, targeted delivery potential. |
| **Cationic Liposomes** | Possess positively charged surface, facilitating interaction with negatively charged cell membranes. | Gene therapy, DNA delivery, non-viral vector delivery. | Efficient gene transfection, enhanced cellular uptake, potential for targeted delivery. |
| **Stealth Liposomes** | Modified with polyethylene glycol (PEG) chains, reducing immune system recognition and prolonging circulation in the bloodstream. | Cancer therapy, drug delivery to specific tissues. | Reduced clearance by the reticuloendothelial system, longer circulation time, improved tumor targeting. |
| **Stimuli-Responsive Liposomes** | Engineered to release their cargo in response to specific stimuli like pH changes, temperature, or enzymes. | Targeted drug delivery to diseased tissues, controlled release based on biological cues. | Enhanced therapeutic efficacy, reduced side effects, improved drug targeting potential. |
| **Multifunctional Liposomes** | Combined with targeting ligands, imaging agents, or other functionalities for enhanced targeting and monitoring. | Targeted therapy for specific diseases, diagnosis and treatment integration. | Increased drug delivery efficiency, real-time tracking of drug delivery, personalized medicine potential. |

Liposome research is still ongoing, and their clinical usage for certain applications is limited. The choice of specific liposome type depends on the drug properties, target site, and desired therapeutic effect.

**B) NIOSOMES (NON-IONIC SURFACTANTS VESICLES):** Niosomes are defined as nanocarriers or nano-vesicles composed of non-ionic surfactants, usually in combination with cholesterol and other lipids. These nanocarriers have a structure similar to liposomes but are more stable due to the presence of non-ionic surfactants. The term "niosome" is derived from "non-ionic surfactant vesicles". Niosomes (**Fig. 03 B.)** are emerging as versatile and promising nano-carriers in the world of drug delivery. Imagine them as tiny, bubble-like spheres, around 10 to 1000 nanometers in size [15].

**Composition:** They just like liposomes, niosomes have a bilayer structure. However, instead of phospholipids, they utilize non-ionic surfactants, molecules with both hydrophilic (water-loving) and hydrophobic (water-fearing) parts. These surfactants self-assemble in aqueous solutions, forming the niosome bilayer:

- **Hydrophilic heads:** Face the watery inner and outer sides of the niosome, allowing interaction with the surrounding environment.
- **Hydrophobic tails:** Pack together in the bilayer's interior, creating a pocket to encapsulate drugs.

Niosomes have the ability to encapsulate drugs within their aqueous or lipid bilayer core, protecting the drug from degradation and improving its bioavailability [16-17].

Niosomes, tiny vesicles formed by non-ionic surfactants, are emerging as promising next-generation drug delivery systems. The several types, applications and benefits of niosome discussed in the given **Table. 03** as below followings:

**Table 03:** The brief description with types, examples, benefits and applications of niosomes **[**15-18]

| Aspect | Description | Examples | Benefits | Applications |
|---|---|---|---|---|
| **Types of Niosomes** | Unilamellar Niosomes: Single lipid bilayer | Span and Tweens | 1. Improved Drug Encapsulation Efficiency 2. Controlled Release of Drugs 3. Enhanced Stability of Encapsulated Drugs | Drug Delivery Systems, Cosmetic Formulations |
| | Multilamellar Niosomes: Multiple lipid bilayers | Proniosomes | 4. Varied Composition for Versatile Drug Loading | Gene Delivery, Vaccine Delivery |
| **Benefits of Niosomes** | 1. **Versatility:** Encapsulation of both hydrophilic and lipophilic drugs | Niosomes with Specialized Ligands | Improved Drug Stability, Reduced Toxicity<br>Enhanced Bioavailability, Controlled Release of Drugs | Targeted Drug Delivery, Treatment of Various Diseases |
| | 6. **Biocompatibility:** Generally well-tolerated by biological systems | Ethosomes | Non-Invasive Administration (e.g., Topical and Transdermal Delivery) | Treatment of Cancer, Infectious Diseases, Skin Disorders |
| | 9. **Stability:** More stable than liposomes due to non-ionic surfactants | Stealth Niosomes (PEGylated Niosomes) | Ease of Preparation and Scale-Up, Cost-Effective Production | Sustained and Controlled Drug Release, Personalized Medicine |

| | | | | |
|---|---|---|---|---|
| **Applications of Niosomes** | 1. **Drug Delivery Systems:** Targeted and controlled release | Curcumin-loaded Niosomes, Doxorubicin Niosomes | Cosmetic Formulations (e.g., Skin Care Products) | Treatment of Inflammatory Diseases, Anti-Cancer Therapy, Cosmetic Industry |
| | 2. **Vaccine Delivery:** Enhancing vaccine stability and efficacy | Niosomal Vaccine Carriers | Gene Delivery, Improved Oral Bioavailability of Drugs | Enhancing Vaccine Efficacy, Genetic Medicine, Oral Drug Delivery |
| | 3. **Cosmetic Formulations:** Encapsulation of cosmetic agents | Coenzyme Q10 Niosomes, Vitamin-loaded Niosomes | | |

This table provides a concise overview of the types, benefits, and applications of niosomes as nano carriers in drug delivery and related fields. Niosomes hold immense potential for revolutionizing drug delivery and improving healthcare outcomes across diverse medical fields.

**C) NANOPARTICLES (NPs):**Nanoparticles (NPs) are like microscopic superheroes, revolutionizing medicine and technology with their remarkable properties. These tiny particles, ranging from 1 to 100 nanometers in size.Nanoparticles are defined by their nanoscale size, providing a high surface area-to-volume ratio. This size range allows them to interact with biological systems at the cellular and molecular levels.

**Composition:** Nanoparticles can be composed of different materials depending on their intended use. Common materials include gold, silver, silica, polymers, and lipids. Each material offers specific properties that can be tailored for particular applications [19].

**Types:** The nanoparticles (NPs) classified (**Fig. 04)** in the major 4 types as followings:

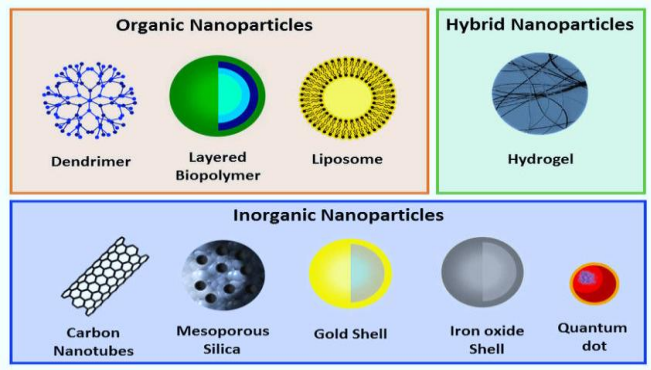


**Figure 04:** The schematic classification of Nanoparticles (NPs)

- **Metallic Nanoparticles:** Made from metals like gold and silver, often used in diagnostics and therapeutics.
- **Polymeric Nanoparticles:** Composed of biocompatible polymers, suitable for drug delivery and imaging.
- **Lipid Nanoparticles:** Liposomes and solid lipid nanoparticles used for drug delivery and gene therapy.
- **Ceramic Nanoparticles:** Inorganic materials with applications in catalysis, electronics, and biomaterials.

Nanoparticles are extensively used in drug delivery systems. They can encapsulate drugs, protect them from degradation, and provide controlled release. The enhanced permeability and retention (EPR) effect allows nanoparticles to accumulate selectively in tumor tissues.Nanoparticles continue to be a focus of extensive research due to their unique properties and potential applications in diverse fields [20].

**D) MICROSPHERES:** Microspheres are spherical particles with diameters typically ranging from 1 to 1000 micrometers (μm), falling within the micrometer scale. These particles can be composed of various materials, including polymers, proteins, ceramics, and metals. Microspheres are utilized in a wide range of applications due to their unique properties, and they find extensive use in drug delivery, diagnostics, cosmetics, and materials science [21].Microspheres (**Fig. 05)** fall within the micrometer size range, making them visible under a microscope but not visible to the naked eye.

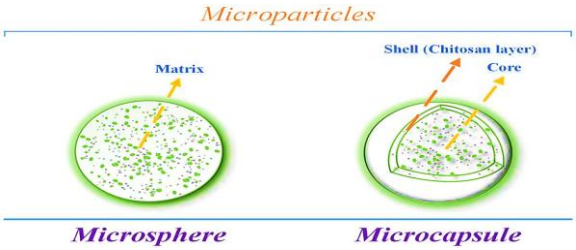


**Figure 05:** The schematic representation of microcapsule and microsphere

**Composition:** Microspheres can be made from diverse materials, and their composition depends on the intended application. Common materials include biodegradable polymers (e.g., poly(lactic-co-glycolic acid) or PLGA), proteins, glass, and metals.

Microspheres are widely employed as drug delivery carriers. They can encapsulate drugs and release them in a controlled manner, allowing for prolonged therapeutic effects.Biodegradable microspheres, often made from polymers like PLGA, gradually degrade over time, releasing their payload and eliminating the need for removal from the body [22].

**E) MONOCLONAL ANTIBODIES:** Monoclonal antibodies (mAbs) are laboratory-produced molecules designed to mimic the immune system's ability to fight off harmful pathogens such as viruses or cancer cells. These antibodies are engineered to specifically target and bind to particular proteins, known as antigens, with a high degree of precision [23]. Monoclonal antibodies have become vital tools in medicine and biotechnology, finding applications in diagnostics, therapeutics, and research.

**Production:** Monoclonal antibodies (**Fig. 06)** are produced by identical immune cells derived from a single parent cell, known as a hybridoma.

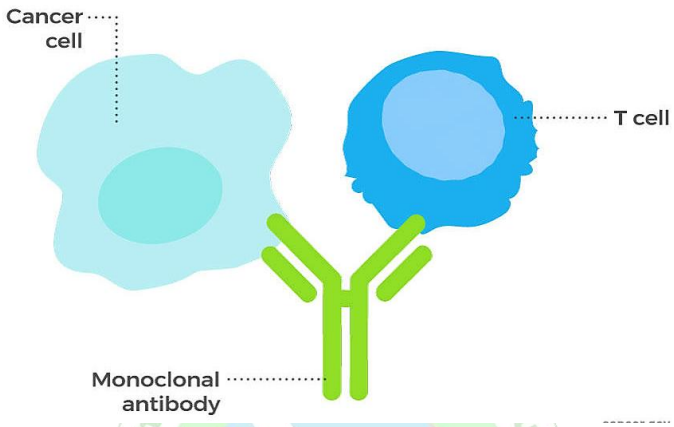


**Figure 06:** The schematic representation of Monoclonal antibody

The hybridoma is created by fusing an antibody-producing B cell with a myeloma cell, resulting in a stable cell line that continuously produces identical antibodies.

**Examples of Monoclonal Antibodies:**

- **Rituximab:** Used in the treatment of certain types of lymphoma and autoimmune diseases.
- **Bevacizumab:** Inhibiting angiogenesis in some cancers.
- **Infliximab:** Used for inflammatory conditions by targeting tumor necrosis factor-alpha (TNF-α) [24].

## TRANSDERMAL DRUG DELIVERY SYSTEM:

Transdermal Drug Delivery Systems (TDDS) offer a unique approach to drug delivery, bypassing the digestive system and delivering medications directly through the skin. A transdermal drug delivery system is a method of administering medication through the skin for systemic distribution. This system involves the application of a specially designed patch or gel containing the drug onto the skin, allowing the medication to be absorbed directly into the bloodstream. The skin serves as a barrier, but transdermal delivery systems utilize various technologies to enhance drug permeation.

**Advantages of TDDS:**

- **Convenience:** Easy to apply and remove, improving patient adherence.
- **Avoids gastrointestinal side effects:** By bypassing the digestive system, reduces potential for nausea, vomiting, or irritation.
- **Reduced dosing frequency:** Controlled release allows for less frequent administration, enhancing patient convenience.
- **Targeted action:** Can focus drug delivery on specific areas, maximizing therapeutic effects and minimizing systemic exposure [25].

**A. SONOPHORESIS:** Sonophoresis (also known as phonophoresis) is a non-invasive technique that utilizes low-frequency ultrasound waves to enhance the transport of drugs or other therapeutic substances across biological barriers, primarily skin. It's a promising approach for delivering medications to specific target sites, improving bioavailability, and potentially reducing side effects.

## MUCOADHESIVE DELIVERY SYSTEMS:

Sonophoresis can be combined with mucoadhesive systems to improve the retention and absorption of drugs at mucosal surfaces like buccal, nasal, ocular, vaginal, and rectal tissues. The ultrasound waves can temporarily disrupt the mucus layer, allowing for better penetration of mucoadhesive carriers and their associated drugs. This combination can potentially extend the drug's residence time at the site of application, leading to prolonged therapeutic effects.

**SUPRAMOLECULAR DELIVERY SYSTEMS:** Supramolecular systems, such as liposomes, micelles, and dendrimers, can be engineered to encapsulate or entrap drugs for targeted delivery. Sonophoresis can facilitate the transport of these supramolecular carriers through biological barriers, potentially enhancing their delivery efficiency. The ultrasound waves can create transient pores or pathways in

the skin or other tissues, allowing the supramolecular systems to penetrate deeper and reach their intended target sites.

**VARIABLE RELEASE DELIVERY SYSTEMS:** Sonophoresis can be used to control the release kinetics of drugs from variable release systems, such as hydrogels, implants, or microneedles. The ultrasound waves can trigger drug release from these systems in a pulsatile or sustained manner, depending on the treatment needs. This allows for more precise and personalized drug delivery regimens [26-27].

Sonophoresis has promising potential to enhance the efficacy of various drug delivery systems, including mucoadhesive, supramolecular, and variable release systems.

**B. OSMOTIC PUMP:** The osmotic pump is a drug delivery system that utilizes osmotic pressure to deliver a controlled and constant rate of drug release over an extended period.

**Mechanism:**

- The device consists of a semi-permeable membrane surrounding a compartment containing the drug and an osmotic agent.
- When the system is exposed to bodily fluids, water permeates through the membrane into the device, creating osmotic pressure.
- This pressure drives the drug solution or suspension out through a delivery orifice at a controlled rate.

**Applications:** Used for the controlled delivery of various drugs, including those requiring a sustained release profile [28].

**C. MICROENCAPSULATION:** Microencapsulation involves enclosing active substances, such as drugs or other materials, within microscopic particles or capsules.

**Mechanism:**

- The active substance is surrounded by a protective coating, usually made of polymers, lipids, or proteins.
- This coating serves to control the release of the encapsulated substance and protect it from external factors.

**Applications:**

- Used in pharmaceuticals, food and flavor industries, cosmetics, and agriculture.
- Drug delivery applications include sustained release formulations and targeted delivery.

The osmotic pump relies on osmotic pressure to achieve controlled drug release, while microencapsulation involves encapsulating substances within protective coatings, providing benefits such as sustained release and enhanced stability [29]. Both technologies contribute to the development of advanced drug delivery systems with specific advantages depending on the desired release profile and application requirements.

This approach offers several advantages, including sustained and controlled release of medication, reduced side effects, improved patient compliance, and avoidance of the digestive system. Transdermal patches are commonly used for delivering medications such as pain relievers, hormone therapies, and nicotine replacement, providing a convenient and non-invasive alternative to traditional oral or injectable routes of drug administration.

## 3. THE ADVANCEMENT IN FORMULATION OF NOVEL DRUG DELIVERY CARRIERS:

The advancement in formulation of novel drug delivery carriers is a rapidly evolving field with the potential to revolutionize medicine. These new carriers promise to overcome the limitations of traditional drug delivery methods, offering: The various methods of preparation of liposome, niosome, nanoparticles (NPs) and microsphere as a novel drug delivery carrier discussed in the given **Table. 04** as followings:

**Table 04:** The brief of preparation of nano drug carriers, liposome, niosome, NPs and microsphere[30-33]

| Advance Carrier | Method | Description |
|---|---|---|
| Liposomes | Thin-film hydration | A lipid film is formed by evaporating a solution of phospholipids and cholesterol in organic solvent. The film is then hydrated with an aqueous solution containing the drug, resulting in the formation of liposomes. |
| | Reverse-phase evaporation | An aqueous solution of the drug is mixed with a solution of lipids in organic solvent. The organic solvent is then evaporated, leading to the formation of liposomes. |
| | Microfluidics | This technique uses microfluidic channels to precisely control the formation of liposomes with defined size and properties. |
| Niosomes | Thin-film hydration | Similar to the liposome preparation method, a thin film of the surfactant is hydrated with an aqueous solution containing the drug, leading to the formation of niosomes. |
| | Solvent evaporation | The drug and surfactant are dissolved in a common organic solvent, which is then evaporated, resulting in the formation of niosomes. |
| | Bubble extrusion method | A mixture of the drug, surfactant, and water is passed through a membrane with tiny pores under pressure. The pressure forces the mixture through the pores, forming niosomes of uniform size. |
| | Nanoprecipitation | A drug solution is mixed with a polymer solution under controlled conditions, leading to the formation of nanoparticles through spontaneous precipitation. |

| | | |
|---|---|---|
| **Nanoparticles (NPs)** | Emulsion-solvent evaporation | The drug and a polymer are dissolved in separate organic phases, which are then emulsified. The organic solvent is evaporated, resulting in the formation of nanoparticles. |
| | Microfluidic synthesis | Similar to liposome preparation, microfluidic channels can be used to precisely control the formation of nanoparticles with defined size and properties. |
| **Microspheres** | Spray-drying | A solution of the drug and polymer is sprayed into a hot drying chamber, where the solvent evaporates rapidly, forming microspheres. |
| | Solvent evaporation | Similar to the nanoparticle preparation method, the drug and polymer are dissolved in a common organic solvent, which is then evaporated, resulting in the formation of microspheres. |
| | Double-emulsion technique | An aqueous solution of the drug is emulsified in an organic solution containing the polymer. This double emulsion is then poured into another aqueous solution, leading to the formation of microspheres. |

This above table provides a concise overview of the preparation methods for these four major drug delivery carriers. Each method has its own advantages and disadvantages, making it suitable for different drugs and applications. The choice of method ultimately depends on the specific requirements of the therapeutic agent and the desired delivery profile.The development of these novel carriers holds immense promise for improving the efficacy and safety of drug delivery, paving the way for more effective treatments and personalized medicine.

## 4. THE MARKETED PRODUCTS FOR ADVANCE DRUG CARRIERS:

Numerous advanced drug carrier systems have been successfully developed and marketed to address challenges in drug delivery, enhancing therapeutic outcomes and patient compliance. The realm of advanced drug carriers has witnessed remarkable progress, translating into a growing number of marketed products that are transforming treatment landscapes. The various marketed products discussed in the below section with **Table. 05, 05, 07, & 08** as description:

The various marketed products of Liposome:

**Table 5:** The list of some marketed products of liposome with their brand name[34]

| **Application** | **Brand Name(s)** |
|---|---|
| **Cancer** | Doxil/Caelyx, Myocet, Marqibo |
| **Fungal infections** | Amphotericin B Lipid Complex, Abelcet |
| **Pain relief** | DepoDur, Onfi |
| **Skin conditions** | Ambisome, Evicel |

The several marketed products of niosome as per discussion below:

**Table 06:** The list of some marketed products of niosome with their brand name[35]

| **Application** | **Brand Name** | **Active Ingredient** |
|---|---|---|
| **Skin conditions** | Estrasorb | Estradiol |
| | Niosome-F | Fluconazole |
| | Niosome-M | Minoxidil |
| **Ophthalmic disorders** | Nepafenac | Nepafenac |
| | Ciclopirox | Ciclopiroxolamine |

The marketed products of microsphere:

**Table 07:** The list of some marketed products of microspheres with their brand name[34-35]

| **Application** | **Brand Name** | **Active Ingredient** | **Release Duration** |
|---|---|---|---|
| **Pain management** | Depo-Medrol | Methylprednisolone acetate | 4-6 weeks |
| | Ziconotide | Ziconotide | 1 week |
| | Duragesic | Fentanyl | 3 days |

| | | | |
|---|---|---|---|
| **Mental health** | Promacta | Risperidone | 2 weeks |
| | AbilifyMaintena | Aripiprazole | 4 weeks |
| | Latuda | Lurasidone | 30 days |
| **Allergy & asthma** | Singulair | Montelukast sodium | 24 hours |
| | Flovent HFA | Fluticasone propionate | 12 hours |
| **Contraception** | Nuvaring | Etonogestrel and ethinylestradiol | 1 month |

The various marketed products of nanoparticles (NPs) as per below **Table. 08** as followings:

**Table 8:** The list of some marketed products of nanoparticles (NPs) with their brand name [35-37]

| Application | Brand Name(s) | Active Ingredient | NPs Type |
|---|---|---|---|
| **Cancer Therapy** | Doxil/Caelyx | Doxorubicin | Liposome |
| | Abraxane | Paclitaxel | Albumin-bound nanoparticles |
| | Onivyde | Irinotecan | Polymer-nanoparticle conjugate |
| **Imaging** | Lumicision Nano | Laparoscopic near-infrared imaging agent | Gold nanoparticles |
| | Feridex | Magnetic resonance imaging (MRI) contrast agent | Iron oxide nanoparticles |
| **Infectious Diseases** | Amphotericin B Lipid Complex | Amphotericin B | Liposome |
| | Ambisome | Amphotericin B | Liposome |
| | Silver-coated nanoparticles | Wound dressings for bacterial infections | Silver nanoparticles |
| **Cosmetics** | La Roche-PosayAnthelios Clear Skin | UV protection | Zinc oxide and titanium dioxide nanoparticles |
| | Olay Regenerist Micro-Sculpting Cream | Anti-aging and skin hydration | Collagen peptides and hyaluronic acid nanoparticles |

These tables presents a selection of marketed drug products that utilize liposomes, niosomes, nanoparticles, and microspheres for delivery. Each carrier offers unique advantages, such as improved drug targeting, reduced side effects, sustained release, and enhanced bioavailability. These features have led to the development of innovative therapeutics for a wide range of conditions.

## CONCLUSION:

In conclusion, NDDS represent a paradigm shift in drug delivery, holding the potential to revolutionize treatment regimens across a wide spectrum of diseases. The field of novel drug delivery systems (NDDS) is undeniably transforming the landscape of medicine. Their ability to optimize drug action, minimize side effects, and personalize therapy for individual patients offers a brighter future for healthcare and improved quality of life for millions. As the field continues to evolve, we can anticipate even more groundbreaking innovations, ushering in a new era of personalized and precise medicine.From cutting-edge nanocarriers delivering drugs directly to diseased cells to personalized 3D-printed dosage forms, the possibilities offered by NDDS are truly remarkable. Recent advancements in gene therapy vectors, stimuli-responsive systems, and organ-on-a-chip technology further push the boundaries of innovation, promising even more targeted and effective treatments in the near future.

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