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Formulation Development

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Abstract: *The creation of a commercial drug product is closely tied to the identification of a new drug ingredient, which is a key aspect of pharmaceutical formulation development. Formulation experts must assess patient requirements and determine the optimal approach for effective drug delivery. This involves enhancing the formulation's characteristics by understanding its bioavailability and the processing needs of the therapeutic product.*

Keywords: commercial drug product

I. INTRODUCTION

The creation of a commercial drug product is closely tied to the identification of a new drug ingredient, which is a key aspect of pharmaceutical formulation development. Formulation experts must assess patient requirements and determine the optimal approach for effective drug delivery. This involves enhancing the formulation's characteristics by understanding its bioavailability and the processing needs of the therapeutic product.

Drug Delivery System:

Drug delivery refers to the process of administering pharmaceutical compounds to humans or animals with the aim of achieving a therapeutic outcome. Common methods of drug delivery include transmucosal (e.g., nasal), topical (applied to the skin), and oral (taken by mouth). Additional delivery routes include inhalation, parenteral (injection into the bloodstream), buccal, sublingual, vaginal, ophthalmic, and rectal methods.

A targeted release system is designed to administer medication in specific doses, such as tablets, capsules, or oral liquids, while ensuring that the drug is absorbed through biological membranes. Other forms include semisolids like ointments, lotions, and creams used in parenteral applications.

Drug delivery systems are primarily categorized into two types:

1. Traditional drug delivery methods

2. Innovative drug delivery methods

1. Traditional Drug Delivery Methods: Traditional drug delivery systems are commonly referred to as classical approaches to administering drugs into the body. Some examples of these systems include:

- Oral Delivery: This includes medications such as tablets, capsules, and syrups that are ingested and travel through the gastrointestinal tract.
- Buccal/Sublingual Delivery: This involves placing chewing gum or tablets in the mouth, either between the cheeks (buccal) or under the tongue (sublingual), where they are absorbed.
- Intramuscular Delivery: In this method, medication is injected directly into muscle tissue using a syringe.
- Rectal Delivery: Suppositories are inserted into the rectum, where they melt at body temperature to release the medication.
- Subcutaneous Delivery: A liquid medication is injected under the skin using a syringe for slow absorption.
- Subcutaneous Delivery: Subcutaneous delivery involves injecting a liquid medication directly into the subcutaneous tissue beneath the skin. This method allows for slower absorption compared to other routes, making it suitable for medications that require a steady release.
- Intravenous Delivery: In intravenous (IV) delivery, a liquid medication is administered directly into the bloodstream through a vein. This method allows for immediate drug action, as the medication is rapidly distributed throughout the body.

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Establishment of a Traditional Drug Delivery System:

i) Tablets:

A tablet is a solid oral dosage form, consisting of a specific quantity of the active pharmaceutical ingredient combined with excipients. These ingredients are typically in powdered form and are compacted into a solid unit.

Tablets come in various shapes, including round, oval, oblong, cylindrical, or triangular, with the most common being the disc-shaped variety. Their size and weight depend on the dosage of the active ingredient and the intended method of administration. Tablets can also be classified into different types, such as coated, effervescent, buccal, chewable, and traditional, each designed to meet specific therapeutic needs and delivery requirements.

ii) Capsules:

Capsules are solid dosage forms where the active pharmaceutical ingredient is enclosed within a shell made of gelatin or a soft or hard soluble material. These dosage forms provide a convenient way to deliver medication in a controlled amount.

There are two main types of capsules:

• Hard-shelled capsules, which typically contain dry, powdered substances or small pellets. These pellets are often created using methods like extrusion or spheronization.

• Soft-shelled capsules,

generally used for liquids such as oils or medications that are suspended or dissolved in a solution.

Oral Liquids:

Oral liquid preparations are uniform solutions where one or more active ingredients are dissolved, emulsified, or suspended in a suitable liquid medium. These formulations are intended for oral consumption, either as-is or after dilution. Oral liquids are particularly useful for patients who have difficulty swallowing tablets or capsules, or when precise dosing flexibility is required. Common types of oral liquid dosage forms include syrups, solutions, suspensions, emulsions, drops, mixtures, linctuses, and elixirs.

Semisolids (Ointments, Creams, Lotions):

Semisolid dosage forms are typically used for topical application to treat medical conditions or provide protection. These forms can be applied directly to the skin or inserted into other accessible mucosal areas such as the nose, vagina, or rectum. Semisolids work by either delivering active ingredients to a targeted area or creating a protective barrier to shield the skin from environmental influences.

Parenterals:

The term "parenteral" comes from the Greek words "para" (outside) and "enteron" (intestine), referring to the method of delivering medication outside of the gastrointestinal tract. Parenteral dosage forms are administered by injection, infusion, or implantation directly into body tissues. These sterile solutions or suspensions contain active ingredients and are designed to bypass the digestive system for faster action. Parenteral preparations are available in both single-use and multi-dose containers.

II. INNOVATIVE DRUG DELIVERY METHODS

A Novel Drug Delivery System (NDDS) refers to innovative technologies, formulations, and approaches designed to deliver pharmaceutical compounds efficiently and safely within the body, ensuring the desired therapeutic effect. In contrast to traditional drug delivery methods, NDDS incorporates advanced techniques and modern dosage forms that aim to enhance drug efficacy and improve patient outcomes.

NDDS provides a contemporary solution to overcome the limitations of conventional delivery systems. It enhances drug targeting, reduces side effects, and increases the overall effectiveness of treatments.

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Objectives :

• Target the drug precisely to the intended site of action while minimizing or eliminating side effects.
• Minimize drug degradation and loss during the delivery process.
• Improve bioavailability, ensuring a larger portion of the drug reaches the target area.

Key Features :

• Enhanced bioavailability of the drug.
• Controlled and sustained release of the drug.
• Safe, dependable, and easy-to-administer.
• Cost-effective and medically optimal.

III. TYPES OF INNOVATIVE DRUG DELIVERY SYSTEMS

1. Controlled Drug Delivery Systems
2. Nanocarriers
3. Vesicular Drug Delivery Systems
4. Gastroretentive Drug Delivery Systems
5. Nose-to-Brain Drug Delivery Systems

1. Controlled Drug Delivery System:

This system is designed to release the drug at a predetermined rate, either at the site of action or systemically, over a defined period. It helps maintain consistent drug levels in the body, improving therapeutic effectiveness while reducing dosing frequency.

2. Nanocarriers:

Nanocarriers are advanced drug delivery tools that transport drugs to specific sites within the body, such as targeted tissues or organs. This selective delivery minimizes side effects and enhances the drug's therapeutic impact. Types of nanocarriers include:

• Liposomes
• Phytosomes
• Nanoparticles
• Microspheres

a. Liposomes:

Liposomes are tiny spherical vesicles made up of lipid bilayers that surround an inner water-based compartment. These vesicular structures are formed from phospholipids and are colloidal in nature. They are used to carry both hydrophilic and hydrophobic drugs, with the aqueous core encapsulated entirely by one or more lipid bilayers. Their size typically ranges from 25 to 500 nanometers.

b. Phytosomes:

Phytosomes are advanced complexes formed by combining natural plant-derived active compounds (phytochemicals) with phospholipids. This binding typically occurs through a reaction involving phosphatidylcholine or other polar head group lipids and plant extracts in an aprotic solvent. The result is a structure that enhances the stability and absorption of the phytochemicals within the body.

c. Nanoparticles:

Nanoparticles are solid or colloidal particles that range in size from 10 to 100 nanometers. These tiny delivery systems are biocompatible and biodegradable, providing full protection for the encapsulated drug. Due to their small size, nanoparticles facilitate enhanced targeting of drug delivery to specific areas within the body.

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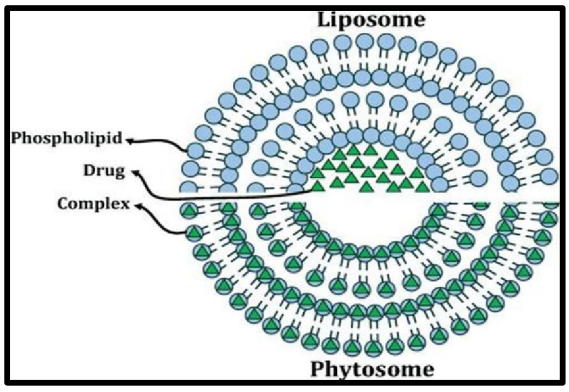

Fig No.Liposomes

d. Microspheres:

Microspheres are spherical particles with diameters between 1 micrometer and 1000 micrometers (1 mm), and they are often referred to as microparticles. These systems are utilized to encapsulate drugs for controlled and sustained release, which improves both drug stability and the efficiency of delivery.

3. Vesicular Drug Delivery System:

Vesicular drug delivery systems involve encapsulating active pharmaceutical agents within vesicles, which helps improve drug bioavailability and minimizes toxicity by directing the drug specifically to its target site. First introduced by Bingham in 1965, these systems, also known as Bingham bodies, are particularly useful for controlled, localized therapies.

4. Gastroretentive Drug DeliverySystem:

The gastroretentive drug delivery system is designed to stay in the stomach for extended periods, allowing for gradual drug release in the upper gastrointestinal tract. This approach ensures sustained and consistent absorption, thereby enhancing the overall effectiveness of the drug.

Examples of gastroretentive systems include:

- Bioadhesive drug delivery systems
- Expandable drug delivery systems
- High-density drug delivery systems

5. Nose brain Drug delivery system

A critical component for effective nose-to-brain drug delivery is the olfactory epithelium, which is found in the upper section of the nasal cavity. This area contains olfactory nerve cells that can bypass the blood-brain barrier (BBB), enabling the direct transport of medications to the brain and cerebrospinal fluid (CSF).

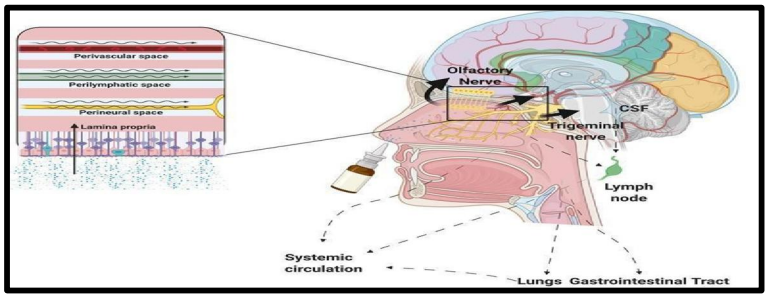

Fig: Nosebrain Drug delivery system

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6. Transdermal Drug Delivery System:

Transdermal drug delivery systems, commonly referred to as patches, are specially designed forms that deliver therapeutic amounts of medication through the skin. These systems offer a non-invasive method of administering drugs while helping to maintain steady drug levels in the bloodstream. A key feature of these systems is the adhesive, which ensures effective skin contact and plays a crucial role in the patch's performance, safety, and overall effectiveness.

Preformulation Studies and Data Sheet Preparation:

Definition:

Preformulation studies are an early phase in drug development where the physical, chemical, mechanical, and biopharmaceutical properties of a drug are comprehensively analyzed. The goal of these studies is to gather the necessary data to design a safe, stable, and effective drug formulation.

Key Physical Characteristics Evaluated:

1. Organoleptic Properties – Includes sensory characteristics such as color, taste, and odor.
2. Bulk Characterization – Involves analyzing particle size, surface area, flow behavior of powders, density, compressibility, crystalline form, polymorphism, and moisture absorption (hygroscopicity).
3. Solubility Studies – Evaluates factors such as the drug's ionization constant (pKa), partition coefficient, solubility in various solvents, thermal stability, common ion effects, and dissolution behavior.
4. Stability Analysis – Includes testing the stability of the drug in both solid and liquid states, helping determine shelf life and degradation patterns.

Drug-Excipient Compatibility Studies:

These studies are crucial for identifying any potential physical or chemical interactions between the drug and excipients, which could affect the drug's stability or manufacturability. Compatibility testing ensures that the final product will be safe and effective throughout its shelf life.

Common Techniques Used:

- Differential Scanning Calorimetry (DSC)
- Fourier-Transform Infrared Spectroscopy (FTIR)

3. Evaluation of Dosage Forms:

Pharmaceutical dosage forms, such as tablets, capsules, creams, ointments, pastes, jellies, inhalers, saline solutions, injections, and more, are regularly used in clinical practice. These are typically categorized into solid, liquid, and semisolid forms, with further subdivisions based on their mode of administration and therapeutic requirements.

To ensure the safety, efficacy, and stability of these products, they undergo rigorous quality control procedures, which include a series of tests, sampling protocols, and adherence to established specifications and acceptance criteria. Only after passing all necessary evaluations can these products be authorized for market distribution.

A. Solid Dosage Form Evaluation:

i. Dissolution Test:

Dissolution testing is conducted to evaluate how drugs are released from solid dosage forms, like tablets. During this test, the tablets are immersed in a USP Apparatus II (Paddle Method) filled with either a 6.8 pH phosphate buffer or 0.1 M hydrochloric acid (HCl), both maintained at 37°C to simulate body temperature. The paddles rotate at either 50 or 100 rpm. After the specified period, the drug release is analyzed using a UV spectrophotometer at a wavelength of 238 nm, which helps determine both the rate and extent of dissolution.

ii. Friability Test:

The friability test measures a tablet's resistance to physical damage from handling, packaging, and transportation. Using a Roche friabilator, the tablets are subjected to controlled abrasion to assess their durability under these conditions.

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iii. Hardness Test:

The hardness test assesses the crushing strength of tablets, ensuring they are firm enough to endure handling and transportation without breaking. The test indicates if any adjustments are necessary in the tablet press during production. Tablet hardness is typically expressed in kilograms, with a minimum of 4 kg being required for standard tablets. The hardness of oral tablets generally ranges between 4 and 10 kg, with certain tablets like chewables or hypodermic pills being softer (10–20 kg), and extended-release tablets being firmer (around 3 kg). Tablet hardness is influenced by factors such as density, porosity, and the tablet's overall physical structure.

B. Liquid Dosage Form Evaluation:

Liquid dosage forms require several tests to verify that they possess the desired drug properties and function as expected.

i. Leakage Test:

In this test, 10 containers filled with the liquid dosage form are inverted and left for 24 hours to check for any leakage, especially when rubber closures are used.

ii. Clarity Test:

To evaluate the clarity of the liquid preparation, the solution is diluted and observed for cloudiness. The test involves comparing the liquid against a control (clean water). Transparent or white particles are assessed against a black background, while dark or black particles are evaluated against a white background.

C. Evaluation Test for Plastic Containers:

1. Leakage Test:

For this test, 10 containers are filled with water, sealed with the intended closures, inverted, and kept at room temperature for 24 hours. If no leakage occurs from any container, it indicates that the closure is intact.

2. Collapsibility Test:

This test is for containers that are designed to be squeezed to dispense their contents. The container must collapse inward when pressure is applied, ensuring that at least 90% of its nominal content is dispensed at the required flow rate under normal temperature conditions.

D. Evaluation Test for Closure:

1. Penetrability:

This test measures the amount of force required for a hypodermic needle to
penetrate the container's closure. Using a piercing machine, the force needed to break the closure should not exceed a certain threshold, as excessive force could damage the needle.

2. Light Absorption:

To assess light absorption, solution A is filtered through a membrane filter, and the absorbance of the filtrate is measured within the 220–360 nm wavelength range using a blank solution prepared in the same way. The absorbance should not exceed a specified limit to ensure the quality and integrity of the solution.

Labeling for Different Dosage Forms:

Definition:

Labeling refers to the written, printed, or graphic information provided with a drug product or its container. It is vital for identifying the drug and giving clear instructions on how to use, store, and dispose of the product.

Drug labeling, also known as prescription labeling, includes key information such as:

- Product Name
- Drug Facts Table
- Active Ingredients
- Purpose and Use
- Warnings
- Directions for Use

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- Allergy Information
- Expiry Date
- Date of Manufacturing

Proper labeling is essential to ensure the safe and effective use of pharmaceutical products and to comply with regulatory standards.

IV. CONCLUSION

Formulation development, along with pre-formulation research, testing protocols, and adherence to Standard Operating Procedures (SOPs), is essential to the success of the pharmaceutical industry. Without these critical components, the industry would face significant operational challenges, and addressing issues in the development process would become increasingly difficult. It is evident that successful formulation development demands considerable effort and expertise. As the saying goes, "small mistakes can lead to significant consequences," underscoring the importance of precision and meticulousness in this domain.

REFERENCES

[1]. Gershberg, S., & Stoll, F. (1946). Apparatus for tablet disintegration, and for shaking-out extractions. Journal of the American Pharmaceutical Association, 35(9), 284-287.
[2]. Patel, P. (2019). Preformulation studies: An integral part of formulation design.
[3]. IntechOpen. Retrieved from https://www.ncbi.nlm.nih.gov/books/NBK562239/
[4]. Stewart, K. D., Johnston, J. A., Matza, L. S., Curtis, S. E., Havel, H. A., Sweetana,
[5]. S. A., & Gellhorn, H. L. (2016). Preference for pharmaceutical formulation and treatment process attributes. Patient Preference and Adherence, 10, 1385-1399. [PMC free article] [PubMed]
[6]. Hajare, A. (n.d.). Industrial Pharmacy (pp. 1.1-1.40). Nirali Prakashan.
[7]. Various disintegration and dissolution tests, USP, Pharmacopoeia stage 4 harmonization, official May 1, 2020, (701-1 to 703-25).
[8]. Indian Pharmacopoeia (2007), Volume 1, Appendices 1, British Pharmacopoeia 2007, Remington: The Science and Practice of Pharmacy.
[9]. Mundada, A. S., Meshram, D. R., Mishra, M., Bhalekar, M. R., & Avari, J. G. (2008). Formulation and evaluation of bitter-less rapidly disintegrating tablet of Famotidine using ion exchange resins. International Journal of Pharmaceutical Excipients, 7, 23-25.
[10]. Shirsand, S. B., Suresh, S., Para, M. S., Swamy, P. V., & Kumar, D. N. (2009). Plantago ovata mucilage in the design of fast disintegrating tablets. Indian Journal of Pharmaceutical Sciences, 71, 41-45.
[11]. Loyd, V. A., Nicholas, G. P., & Howard, C. A. (2005). Ansel's Pharmaceutical Dosage Forms and Drug Delivery Systems (8th ed.). London: Lippincott Williams & Wilkins.
[12]. Aulton, M. E. (2002). Pharmaceutics: The Science of Dosage Form Design (2nd ed.). Sydney: Churchill Livingstone.
[13]. McMillan, A., & Young, H. (2007). The treatment of Pharyngeal Gonorrhea with a single oral dose of Cefixime. International Journal of STD & AIDS, 18, 253-254.
[14]. Journal of Pharmaceutical Sciences, Volume 74, Issue 1, January 1985, Pages 16-20. Research Articles: Preformulation Studies in a Drug Development Program for Tablet Formulation.
[15]. Jones, T. M. (2018). Preformulation Studies. In Pharmaceutical Formulation: The Science and Technology of Dosage Forms (pp. 1-41). DOI: [link]
[16]. Bharate, S. S., & Vishwakarma, R. A. (2013). Impact of preformulation on drug development. Pharmaceutical Science and Technology, 1239-1257. Published online: 27 March 2013.
[17]. Kumar, H., & Devangen, H. (2020). An important approach for novel drug delivery system. Journal of Biomaterials Science, Polymer Edition, 10.1080/09205063.2020.1825304.
[18]. Copper, A., & Guuns, D. (2008). Dispensing for Pharmaceutical Students (12th ed.). PB.