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NOVEL CONCEPT OF TABLET DESIGNS AND ITS CHARACTERISTICS

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ABSTRACT

Tablets, a time-tested dosage form, have progressed from simple uncoated tablets for oral administration that provide an instant release to sustained release devices that can be implanted into the body. With the trend toward worldwide marketing and regulatory requirements, facility, process, and product specifications have become more severe in recent years. A large number of research scientists are working with industry and academic partners to propose and implement greater levels of tablet technology. The end outcome will be higher yields, fewer tablet faults, higher productivity, and less downtime. The purpose of this review was to focus on novel tablet designing concepts and their respective characteristics.

KEYWORDS: tablets, novel, characteristics, route, difficulties, inference, advantages, disadvantages.

INTRODUCTION

According to the Indian Pharmacopoeia, Pharmaceutical tablets are solid, flat, or biconvex dishes, unit dosage form, prepared by compressing drugs or a mixture of drugs, with or without diluents. They vary in shape and differ greatly in size and weight, depending on the number of medicinal substances and the intended mode of administration.

Solid-dosage forms are thought to account for over 90% of all dosage forms utilized in clinical practice to deliver systemic administration of medicinal substances. The convenience of tablets, as well as the variety of tablet models, has resulted in their widespread adoption. The majority of tablets are made by compressing granules or powder mixtures, with a small number made via molding. The majority of tablets are used for oral medication delivery. Many of these are made with various types of colorants and coatings. Other tablets, such as sublingual, buccal, or vaginal tablets, are made with properties that are specific to their administration route.[1]

- General properties of Tablets.

1. To withstand mechanical shock during production, packing, shipping, dispensing, and use, a tablet must be sturdy and hard.
2. The tablet's drug content must be bioavailable, which means that it must be able to release its contents in a predictable and repeatable manner.
3. To preserve its chemical and physical properties during manufacture, storage, and usage, the tablet must be chemically and physically stable.
4. The tablet should have a beautiful product identity that is free of tablet flaws.
5. The weight and medication content of tablets must be consistent.

- Advantages of Tablets.

1. It is more impervious to tampering.
2. It allows a greater dose of an active substance.
3. They come in a variety of forms, including immediate-release, extended-release, sustained-release, and delayed-release.
4. The level of stability is higher.
5. Dosage adjustments are possible.
6. It is cost-effective.

- Disadvantages of Tablets.

1. Tablet production necessitates a number of unit operations (weighing, milling, drying, mixing, and so on), resulting in a higher rate of product loss at each stage of the formulation process.
2. The absorption of the medication from tablets is influenced by physiological parameters such as stomach resident/emptying time and consequently varies from patient to patient.
3. Certain medicinal substances have poor compression qualities, which can cause issues when they are formulated and manufactured into tablets.

- Novel Drug Delivery System:

It is the evolution of an existing drug molecule from a conventional form that significantly improves its performance in terms of patient compliance, safety, and efficacy.[2]

The following are the main goals of the Novel Approach: Should be an elegant product with its own personality that is devoid of flaws like chips, cracks, discoloration, and contamination.

1. Should be able to endure the rigors of shocks encountered throughout the manufacturing, packaging, shipping, and dispensing processes.
2. Should be physically stable enough to sustain its physical characteristics over time.
3. The medicament agent(s) must be able to be released in the body in a predictable and repeatable manner.
4. Must have adequate chemical stability over time to prevent the therapeutic substance from being tampered with (s).

CONVENTIONAL TYPES OF TABLETS

- Tablets Injested Orally.

1)Compressed Tablets: Tablets that have been compressed through direct compression, wet granulation, or dry granulation with no specific coating are used. These tablets are designed to disintegrate quickly in the stomach fluid after ingestion, allowing for rapid drug release and, eventually, systemic absorption of the dosage form.

2)Multiple Layered Tablets: It's a type of tablet that has two or more layers of contents. Depending on the number of different fills, layered tablets are made by compressing additional tablet granulation on top of previously compressed granulation to create two-layered or three-layered tablets. Each layer may contain a different medicinal ingredient, separated due to physical or chemical incompatibility, staged drug release, or the multilayer tablet's distinct look.

3)Enteric Coated Tablets: Enteric-coated tablets are compressed tablets with a time delay. They are coated with polymeric substances (including cellulose acetate phthalate/cellulose acetate butyrate, hydroxypropylmethylcellulose succinate, and methacrylic acid copolymers) that resist solution in stomach fluid(acidic environment)but break down in the intestine, allowing medication dissolution and absorption.

4) Sugar-Coated Tablets: These are compressed tablets that have been coated with a concentrated sugar solution to improve patient compliance, increase visual appeal, conceal undesirable tastes or odors, improve stability, and/or change therapeutic agent release (s).

5)Film Coated Tablets: These are compressed tablets with a polymer film coating, such as hydroxy propyl cellulose and ethyl cellulose. The medication is protected from the effects of the environment by a film coating.

6)Inlay Tablets: A compressed tablet with a center that is partially encircled which is prepared by inserting previously crushed tablets into a pre-filled die cavity, where the coating material forms the side when squeezed.

7)Chewable Tablets: Chewable tablets are large, difficult-to-swallow tablets that are chewed within the buccal cavity before swallowing. They are particularly beneficial for administering large tablets to children and adults who have trouble swallowing conventional tablets or antacid formulations in which the tablet size is typically large and the neutralization efficacy is related to particle size within the stomach.

- Tablets used in the Oral Cavity:

1)Buccal and Sublingual Tablets: These are tablets that are put in the buccal pouch (the space between the lip and the gum in the mouth) which may dissolve or erode slowly (15-30 minutes) for absorption from the oral mucosa, but they should not disintegrate quickly because first pass metabolism is skipped. Tablets that are put in the sublingual portion (under the tongue) disintegrate quickly, allowing medication ingredients to be absorbed quickly.

2)Dental cones tablets: Tablets that are meant to be loosely put in the empty socket left after tooth extraction. The main goal of using this tablet is to either prevent germs from multiplying in the socket by using a slow-release antibacterial component or to stop bleeding by using an astringent or coagulant-containing tablet.

3)Lozenges and troches: These are disc-shaped solid preparations with a hard candy or sugar foundation that contain therapeutic ingredients and, in most cases, a flavoring element. They are designed to dissolve slowly in the mouth, mainly for local effects.

- Tablets administered by Other Routes

1)Implantation Tablets: These are tablets that are introduced through surgical procedures into the subcutaneous tissue, where they are slowly absorbed over time. The rod-shaped tablet is administered using a customized injector with a hollow needle and plunger. The diameter should not exceed 8mm. Typically they are used to provide hormones such as testosterone steroids for contraception.

2)Vaginal Tablets: Vaginal tablets are uncoated, ovoid, or bullet-shaped that are intended to be administered through the vaginal canal. They are compressed and molded to fit perfectly inside the plastic inserter devices that come with the product. Tablets are frequently buffered to achieve a pH that is favorable for the antibacterial agent's action.

- Tablets used to prepare Solution:

1)Effervescent Tablets: These tablets are designed to compress active substances with a mixture of sodium bicarbonate and organic acids like citric and tartaric acid to make solutions that release carbon dioxide concurrently. The release of carbon dioxide gas improves Active Pharmaceutical Ingredient solubility in water as well as the taste masking effect.

2)Hypodermic Tablets: These tablets contain one or more readily water-soluble components and are meant to be mixed with WFI(Water For Injection) or sterile water to make a clear solution for parenteral injection. Medications with low water stability are used here.

3)Dispersible Tablets: Tablets are designed such that they dissolve in the mouth without the aid of water.

4)Tablet Triturates: Small, usually cylindrical, molded, or compressed tablets carrying small doses of usually strong medications combined with sucrose, lactose, or any other acceptable diluent.

MODIFIED DRUG RELEASE DOSAGE FORMS

1)Extended-Release Dosage Forms: These tablets are divided into three categories: those that release the drug in response to a physiological condition, such as enteric coatings; those that release the drug in a relatively steady, controlled manner; those that combine multiple mechanisms to release drug pulses, such as repeat action tablets.

1a)Sustained-Release Tablets: Drug release is not particularly at a predetermined rate

1b)Controlled-Release Tablets: Drug release takes place at a predetermined rate.

2)Delayed Release Dosage Forms: These tablets release a discrete portion of the drug at a time.

2a)Enteric Coated Dosage Form.

3)Targeted Release Dosage Forms: These tablets release drug at /or near the intended physiological site of action and may have extended release characteristics.

4)Repeat Action dosage forms: These tablets release one dose or drug initially followed by a second dose of the drug at a later time.

5)Orally disintegrating tablets(ODT): These are tablets that disintegrate rapidly in the saliva after oral administration.

RECENT NOVEL CONCEPTS OF TABLET DESIGN

1)Tablet-in-a-tablet technology

In recent years, tablet-in-a-tablet technology has piqued curiosity for developing modified released products, while being less popular. It requires using tableting equipment built expressly for this purpose to condense granular materials around a prefabricated tablet core. Compression coating is done in a dry environment. This type of tablet has two parts: an internal core and a surrounding coat (compression-coated tablet). One turret is in charge of preparing the core, which is a little porous tablet. It is then moved (in the center) to a slightly larger die, which is partially filled with coating powder. Coating powder is applied to the top of the core and squeezed again, resulting in a tablet within a tablet. Because the tablet may be slanted when carried to the second die chamber, it's a tricky mechanical procedure. The coat is normally water soluble and disintegrates quickly after eating to enable rapid release. This tablet works well as the outer layer of a repeat action tablet. When the core releases the medicine quickly, however, an entirely different blood level is reached, posing the risk of toxicity from overdosing. The core tablet is coated with enteric polymer to prevent the medicine from being released into the stomach too quickly, while the first dose is administered slowly.

Challenges related to Tablet in Tablet technology: a)There is the likelihood of cross-contamination between the layers. b)Because of the high elastic modulus ratio between nearby layers, there is insufficient layer adhesion and low interfacial strength. c)There may be difficulties in preserving the device's physical and chemical integrity over time. d)Because of the big tablet size, it is difficult to swallow. e)When the core tablet is not in the center of the system, the coating performance varies.

Inference:a)Film and sugar coatings are an important part of the formulation of the tablet to achieve superior appealing quality like color, texture, mouth feel, and taste masking but they have a number of drawbacks, the most significant of which is that the use of an aqueous or organic solvent causes toxicity. Thus, The Tablet in Tablet approach is the most effective way to solve the difficulty outlined above. For example, Chlorambucil has 6-month overall stability, but when made as a tablet under tablet technology, it has 2-year overall stability.

The Tablet in Tablet technique can be used to develop a modified release mechanism for a similar drug or different pharmaceuticals from a different category or to achieve drug release at distinct sites of absorption.

2)Orodispersible tablets(ODT's)

Orodispersible tablets are solid unit dose forms similar to normal tablets, but they contain super disintegrants that allow them to dissolve in the mouth in the presence of saliva in less than a minute, with no trouble in swallowing. It has various advantages in terms of stability, water-free administration, precise dosing, ease of manufacture, small packing size, and handling.

Challenges related to Orodispersible tablets(ODT's): a)Because they are hygroscopic, they should be stored in a dry environment. b)For well-stabilization and packaging, special packaging is required for the stability of the product. c)Dose uniformity is a difficult and technical problem to solve.[3]

Inference: This Drug Delivery System (DDS) helps to solve some of the issues associated with traditional Solid Dosage Form, such as difficulty in swallowing tablets in children and geriatric patients which is related to a variety of illnesses such as Parkinsonism, Motion Sickness, Unconsciousness, ODT's have potential advantages over conventional solid oral dose forms. Thus it is one of the most innovative of the revolutionary DDS.

3)Liquisolid Technique

The Liquisolid approach is an innovative and promising method for increasing the rate of dissolution of poorly water-soluble medicines. The liquid form of the drug is turned into a dry-looking, non-adherent, free-flowing, and immediately dispersible powder using this approach, which involves the use of carrier and coating ingredients. The liquid drug is absorbed into the carrier's internal framework first. Once the interior of the carrier has been saturated with liquid medication, a liquid layer forms on

the carrier particles' surface, which is quickly absorbed by the tiny coating materials. As a result, a powder combination that appears to be dry, free flowing, and compressible are generated. The formation of a liquid-solid system is demonstrated.

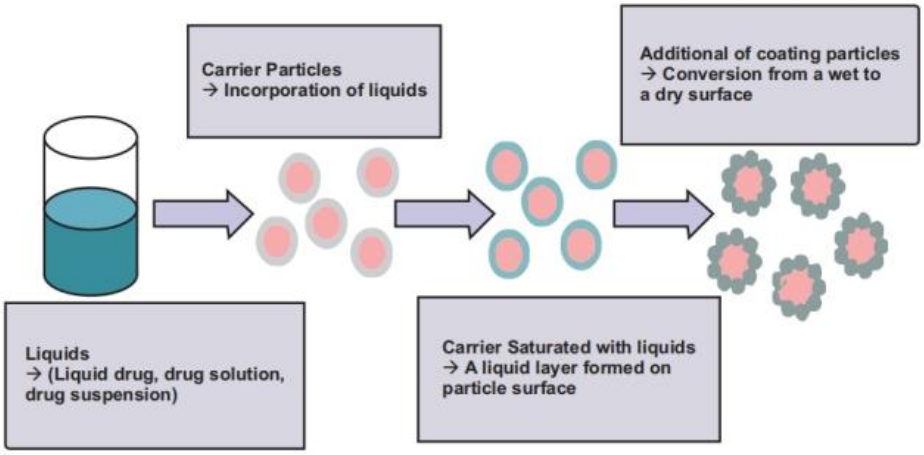

Fig. No. 01: Diagrammatic representation of Liquisolid Technique.

Challenges related to the Liquisolid Technique: a)The technology works well for low-dose water-insoluble medications, but its fundamental drawback is the inability to incorporate high-dose water-insoluble drugs into liquisolid systems. b) Because these medications require a substantial volume of liquid vehicle, large amounts of carrier and coating material are necessary to produce a liquid-solid powder with good flow and compressible qualities. This may cause the weight of the tablet to exceed the limit, making it difficult for patients to swallow. Several approaches to overcome the mentioned barrier have been documented like adding some additives (i.e., PVP and PEG 35000) into the liquid medications to increase the viscosity which can reduce the quantities of carrier and coating material.

Inference: Example-Ranolazine ER which has a short biological half-life was prepared using the Liquisolid Technique for the treatment of chronic stable angina and the results are as follows.
With two distinct R-values (force on the upper and lower punches) and drug: solvent ratios, liquid-solid tablets were effectively manufactured utilizing Neuslin US2 as a carrier material, Aerosil 200 as a coating material, and PEG-400 as a non-volatile solvent.
The dissolution of Ranolazine was found to be the proper sustained effect to drug release due to the presence of:

- Increased Quantity of polymer(Eudragit L100 55)
- Decreased Quantity of Neusilin US2
- Increased Quantity of Aerosil 200

Thus, the Liquisolid approach is not only a useful tool for improving the dissolving rate of poorly water-soluble pharmaceuticals, but it's also a unique and effective way to make sustained release tablets with a zero-order release pattern.[4-7]

4)Tablets of Multi-unit pellet system for controlled drug delivery(TMUPs).
MUPs (multiple-unit pellet systems) are dosage forms made up of pellets that have been crushed into tablets. The tablet multi-unit pellet system (TMUPS) uses coated pellets for controlled drug release, is a viable therapeutic alternative to traditional immediate-release dose forms. TMUPS have two key advantages: a) they are easy to swallow, and b) they are divisible without impairing the drug release characteristics of the individual units.

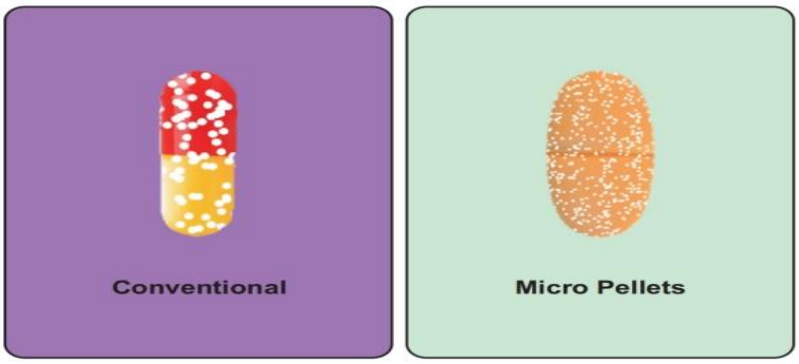

Fig. No. 02: Conventional and Micro Pellets.

Challenges related to Tablets of Multi-unit pellet system for controlled drug delivery:a)TMUPS should break down quickly in the gastrointestinal tract after oral administration or swallowing, resulting in a drug release pattern that is similar to that of uncompressed MUPS. Compression-induced degradation to the functional coating, which results in the loss of modified-release, taste-masking, or drug stabilizing capabilities, is the main issue in the fabrication of TMUPS.b) When using functionally coated MUPS, the polymeric coating must be prevented from rupturing during tableting, as fissures in the coating can affect drug release qualities. c)To maintain the appropriate drug release properties of the pellets, pellet size, coating formulation, properties of tableting excipients, and compaction parameters must all be carefully managed.

Inference: Hyperacidity-related problems are many but when and how many times a day the medication has to be taken creates huge confusion which results in less than optimum outcomes for some patients. To overcome such a problem TMUPS (Tablet of multi-unit pellet) was developed.

Example: Nexen Maps 20 tablets introduced by Square Pharma contain a large number of micro pellets of Esomeprazole (used to treat gastroesophageal reflux disease). Nonpareil seeds (starch, lactose) are coated with the drug followed by an enteric coating of each micropellet which are then compressed into tablets demonstrated below.

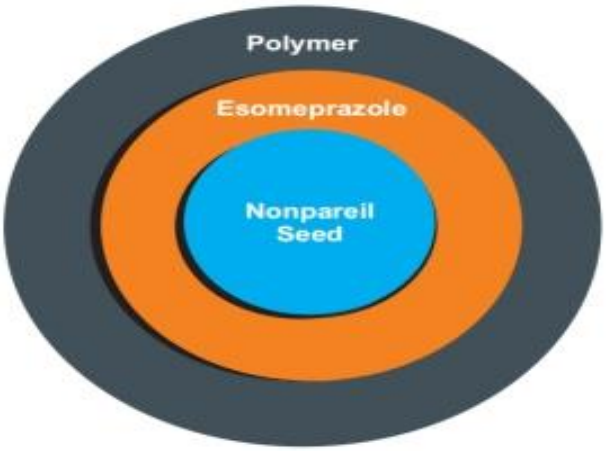

Fig. No. 03: Diagrammatic representation of Nexen Maps 20 tablets.

5) Tablets of Pre-liposomes forming in situ liposomes.
The delivery method was evaluated for: a) the dry powder characteristics, b) mechanical tablet properties and drug release, c) liposomal characteristics of the delivery method were also studied. The pre-liposomes powder was free-flowing, and all excipients were used to make tablets of comparable quality to those made from physical mixtures. Depending on the type of tablet excipient utilized, liposomes were generated in situ during disintegration, dissolution, or erosion. The tablet excipient was discovered to affect liposomal properties and drug release. The innovative delivery strategy combines the ability of liposomes to encapsulate and protect drugs with the improved stability given by compressed formulations for a unique combination. The freeze-drying or spray-drying of liposomal dispersions is a crucial step that results in more stable dry powder formulations that can be rehydrated in the water while keeping their structure and functionality. Spray-drying is a well-known method for creating particles with certain physicochemical properties, such as particle size, density, shape, and solid form. It can be customized for oral, buccal, and vaginal drug administration. [8-12]

Challenges related to Tablets of Pre-liposomes forming in situ liposomes: Liposome aqueous dispersions may be exposed to a number of stability issues such as aggregation, fusion, and phospholipid hydrolysis, all of which can shorten their shelf life.

Inference: A novel drug delivery method for complex medications that have the potential for scale-up manufacture and controlled drug release was developed.

Example: Pre-liposomes powder containing Metronidazole, Lecithin, and Mannitol was prepared by spray drying along with the tableting excipients (Microcrystalline Cellulose, Lactose Monohydrate, Mannitol) which were compressed into tablets.

6) Novel Double Coating Enteric System
To speed up the drug release in the upper small intestine, a new double-coating enteric technology was devised. The outer EUDRAGIT coating begins to inflate and dissolve when the DuoCoat formulation enters the duodenum at pH=5.5. Intestinal fluid enters the system and reaches the neutralized inner coating, causing the coating to dissolve quickly and the medication to be released.[13-15]

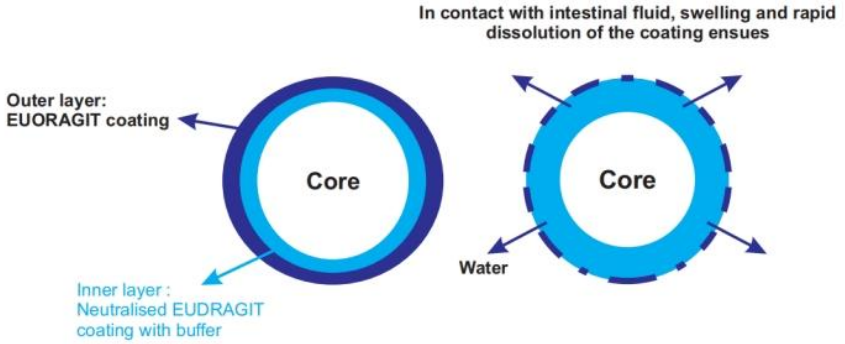

Fig. No. 04: Novel Double Coating Enteric System.

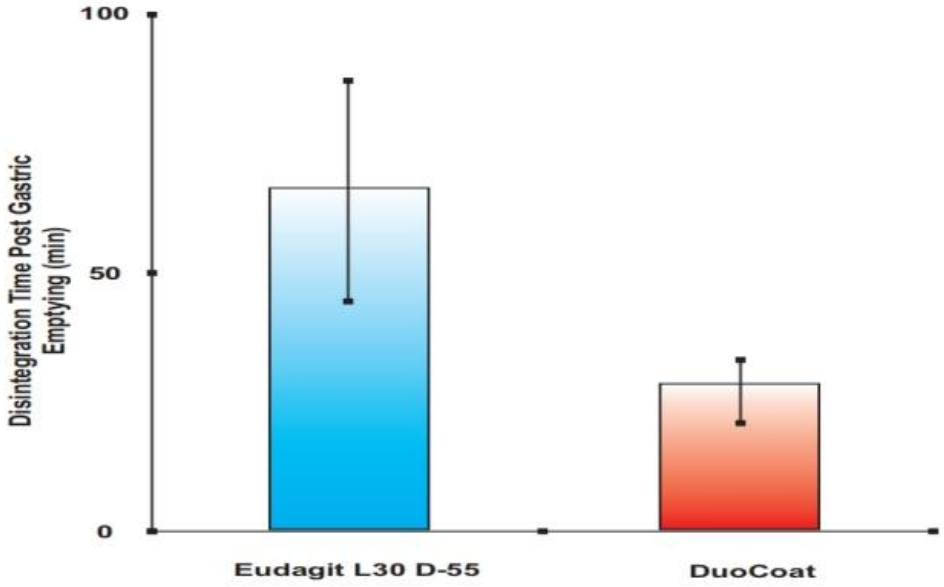

Fig. No. 05: Disintegration Time Post Gastric Emptying(min) of Eudragit L30 D-55 v/s DuoCoat.

Challenges related to Novel Double Coating Enteric System: Selecting an appropriate polymer for rapid drug release from a double-coating enteric system is a major challenge.

Inference: The presence of organic acid and salts in the inner coat resulting in increased ionic strength, buffer capacity, and osmotic pressure, are assumed to be the primary processes behind the double-coating system's rapid dissolution. This innovative double-coated technology overcomes the limits of traditional enteric coatings by allowing for rapid medication release in the upper small intestine.

7)Bilayer Vaginal Tablet

The vaginal tablet is a typical formulation that is simple to make, easy to insert into the vagina, and has a cheap manufacturing cost, making it excellent for usage in underdeveloped nations.

Challenges related to Bilayer Vaginal Tablet: a)Lack of sufficient bonding and adhesion at the interface between adjacent compacted layers, which is typically the outcome of an interfacial crack and layer separation, is one of the key challenges in bilayer formation. b)Children and unconscious individuals may find it difficult to swallow. c)If the compacted layers are too soft or too hard, they will not bind firmly with each other, resulting in mechanical integrity issues as well as layer separation.d)Establishing the order of layer sequence, layer weight ratio, elastic mismatch of neighboring layers, initial layer tamping force, and cross contamination between layers are among the other obstacles encountered throughout development. e) Because the adjacent layers of a bilayer tablet are mechanically connected together, the parameters that impact the stress state are critical. f)Mechanical features of each layer and tablet, as well as compression parameters, specific procedures, and compression

conditions, all play a key role in this. g)The use of a sustained-release bilayer tablet does not allow for the early conclusion of therapy. h) Bitter-tasting substances, pharmaceuticals with an unpleasant odor, and drugs that are oxygen-sensitive may need to be encapsulated or coated. j)The physician has less freedom when it comes to changing dosing regimens.[16-21]

Inference: For a synergistic effect, two medications are released at the same time. Disulfiram (alcohol antagonist) and 5-Fluorouracil (cancer treatment) are two examples of drugs that help destroy, shrink, or regulate malignant cells.

10 Defects of Tablets

Name of Defect	Causes	Remedy
Sticking refers to the tablet material adhering to the die wall.	Improperly dried or improperly lubricated granules. Too much binder.	Dry the granules properly. Increase or change lubricant. Reduce the amount of binder or use a different type of binder.
Lamination is the separation of a tablet into two or more distinct horizontal layers.	Separation of a tablet into two or more distinct horizontal layers because of air entrapment during compression and subsequent release on ejection. The condition is exaggerated by higher speed of turret	**Lamination** is the separation of a tablet into two or more distinct horizontal layers.
Orange Peel appearance is similar to that of an orange.	It is surface defect resulting in the film being rough and nonglossy.	Use mild drying conditions, and use additional solvents to decrease viscosity of solution.
Chipping is defined as the breaking of tablet edges, while the tablet leaves the press or during subsequent handling.	Sticking on punch faces. Too dry granules. Too much binding causes chipping at bottom.	Dry the granules properly or increase lubrication. Moisten the granules to plasticize. Add hygroscopic substances.
Twinning A defect wherein two tablets are sticking together.	Drying is ineffective in the coating process.	Optimize binding, or use dry binders.This could be remedied by reducing spray rate and increasing pan speed.
Cracking Small, fine cracks observed on the upper and lower central surface of tablets, or very rarely on the sidewall are referred to as Cracks	It is observed as a result of rapid expansion of tablets due to air entrapment, especially when deep concave punches are used. Large size of granules.	Reduce granule size. Add fines. Use tapered die. Use special take-off
Binding Sticking of the tablet to the die and does not eject properly out of the die.	Usually due to excessive amount of moisture in granules, lack of lubrication and/or use of worn dies.	Dry the granules properly. Increase or change lubricant.
Mottling or the unequal distribution of color on a tablet	Colored drug, whose color differs from the color of excipients used for granulation of a tablet. Improperly mixed dye, especially during `Direct Compression'.	Use appropriate colorants. Mix properly and reduce size if it is of a larger size to segregation.
Double Impression having two engraving or monogram on the punch faces.	It is due to free rotation of punches which have some engraving or monogram on the punch faces. During his free travel, the punch rotates and at this point, the punch may make a new Impression on the bottom of the tablet, resulting in 'Double Impression.	Use keying In tooling, I.e. Inset a key alongside of the Punch, so that it fits the Punch and prevents punch rotation.
Bridging coating fills In the letter or logo on the tablet	Tablet core ingredients do not promote good coating adhesion.	Increase levels of hydrophilic ingredients. Optimize levels of lubricants

Fig. No. 06: Tablet Defects.

CONCLUSION

In today's scientific landscape, where novel drug delivery systems are being recognised for their tangible benefits, the unique potential of providing physical stability, sustained, and site-specific drug delivery for a predetermined period of time can open up new vistas for precise, safe, and high-quality treatment. It not only minimizes the number of times a drug must be given to overcome noncompliance, but it also helps to improve therapeutic value by lowering toxicity and enhancing

bioavailability, among other things. As a result, the commercialization of novel drug delivery systems should be undertaken on a big scale in order to broaden the industry's perspective.

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CONFLICT OF INTERESTS
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