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REVIEW ARTICLE OPEN ACCESS

COMPREHENSIVE REVIEW ON TABLET COATING, FORMULATION, PROCESS, EVALUATION AND INDUSTRIAL SIGNIFICANCE

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ABSTRACT

Atablet is defined as a solid unit dosage form. There arevarious reasonsfor coating of solid dosage formthe very important reason is to control the drug release rate and also to control bioavailability parameters of the APIs (Active pharmaceutical ingredients) Tablet coating is a process of applying a thin polymer based filmcoatedfor various advantages, Coating solution can be spread through the spraying systems over the surface of tablets to improve itsappearance, stability, taste and performance of tablets. Tablet coating have different types like sugar coating, film coating , enteric coating, specialized coatings etc. Coatings allow modified drug release and patient acceptability, improve the therapeutic activity. The present review summarizes the objectives, defects, evaluation parameters, and recent trends in tablet coating technology.

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INTRODUCTION

A **tablet** also known as pill, The Pharmaceutical solidoral dosage forms are available mostly in unit dosage forms. Tablets aredeliver a precise dose of drug substances, typically combined with excipients to ensure stability and manufacturability. Tablets are solid dosage forms created by compressing or molding a blend of active pharmaceutical ingredients and various excipients, typically in powdered form. They are widely used because they provide a precise, uniform drug dose and are convenient for oral administration. In the manufacturing process, tablets are produced either by compression or molding, depending on the formulation requirements. Excipients play essential roles — diluents increase the bulk of the formulation, binders provide cohesion to the powder mix, granulating agents assist in particle agglomeration, glidants and lubricants improve powder flow and prevent sticking, while disintegrants ensure that tablets break apart appropriately in the digestive tract. Additionally, sweeteners, flavoring agents, and colorants enhance palatability and help in identification or aesthetic appeal. A polymeric coating is often applied to improve the tablet's appearance, facilitate swallowing, protect the active ingredients from environmental factors such as moisture, light, andtemperature, and regulate the release rate of the drug from the dosage form. Initially, medicinal tablets were mostly flat or biconvex discs with their color determined by their ingredients. Modern tablets, however, come in a variety of shapes, sizes, and colors to aid in differentiation and patient compliance.

Many are engraved or imprinted with identifying symbols, letters, or numbers, and some include a scoring line to allow them to be split accurately by hand.About 90% of drugs are Available in the form of tablets to produce a therapeutic effect when administered by the oral route.

Objectives or purpose of tablet coating

- To mask the unpleasant taste, odor, color of the drug.
- To control therelease rate of the drug from the tablet. (Ex :- Sustained release tablets, delayed release tablets).
- To providethe mechanical strength of solid dosage form.
- Increase shelf life of drugs.
- To protect the drug from environmental conditions (light, moisture, air, temperature).
- To provide appearance and identification of tablets.
- Loss of volatile ingredients can be reduced.
- To protect the drug from the gastric environment of the stomach.(ex – enteric coating)
- To avoid chemical incompatibilities or to provide sequential drug release.

Drawbacks of tablet coating

- The major drawback of this technology was that, drying time of tablets is long.
- Tablet coating is expensive than normal formulation.

- Some times tablet coating leads to the degradation of API such as chipping, capping, mottling and bridging.
- Certain drugs aremuch more sensitive to the coating that leading to serious adverse effects.

Ideal characteristics of a good coating: Ideal characteristics of a good coating include strong adhesion, durability through resistance to corrosion, abrasion, and chemicals, and an even, attractive finish. Other key properties are consistent quality, ease of application, controlled thickness, and the ability to retain its color and protect the substrate over time.

History of Tablet Coating: The first Coating process was started in the ninth century. A variety of materials was used to coat tablets such as talc, gelatin, and sugar. The first sugar coated tablets produced in the United States came out of Philadelphia in 1856. In the year of 1880 developed a enteric and gastric resistantCoating.In 1954 Film coated tablet was marketed for the first time. The coating solution was evenly applied across the tablet bed using a rotating pan mechanism.

Types of tablet coating:

The main types of tablet coatings are

- sugar coating
- film coating
- enteric coating
- specialized coatings (controlled-release, compressed, and electrostatic coatings).

Sugar coatings improve taste and appearance, film coatings apply a thin polymer layer, and enteric coatings are designed to dissolve in the intestines, not the stomach.

A) Sugar coating: The sugar coating process involves various steps the duration of which ranges from a few hours to a few days. a successful product greatly depends on the skill of the coating operator. This is especially true in the pan-landling method, in a successful product development depends on factors like quantity of solution to be added, method and rate of pouring, when to apply drying air, temperature, speed of spraying. A successful sugar coating process gives elegant, highly glossed tablets. The basic Sugar coating process involves the following steps. The sugar-coating process generally progresses through several key phases — from waterproofing and subcoating to smoothing, coloring, and final polishing — each enhancing the tablet's durability and appearance."

1. Sealing/Water proofing:- Provides a moisture barrier and harden the tablet surface.
   Meterialsused:- Shellac, Zein, Cellulose acetate phthalate (CAP), Polyvinyl acetate phthalate (PVAP)
2. Subcoating causes a rapid buildup to round off the tablet edges.
   Meterialsused:-Gelatin, Acacia (Gum arabic), Sucrose syrup (thick), Starch / Dextrin, Calcium carbonate (as filler)3). Grossing/Smoothing/syruping: Smoothes out the sub coated surface and increases the tablet size to Predetermine dimension.

Meterialsused:-Sucrose solution, Titanium dioxide (to provide whiteness/opacity), Calcium carbonate

4). Coloring gives the tablet its color and finished size.

Meterialsused:- Water-soluble dyes (e.g., Tartrazine, Sunset Yellow), Lakes & pigments (e.g., Iron oxides), Titanium dioxide (for opacity).

5). Polishing produces the characteristics gloss.

Meterialsused:-Beeswax, Carnauba wax, Candelilla wax, Paraffin wax.

B) Film coating: Film coating has largely replaced sugar coating due to shorter processing time and better reproducibility."There are basically 2 methods of film coating they are

I. Pan-Pour methods: In this method Tablets are coated by application of alternate solution, mixing and drying steps are similar to pan pour sugar coating. This method is relatively slow and relies heavily on the skill of operator.

II. Pan-Spray methods: The introduction of spraying equipment was the next evolution in improving the film coating process allows for automated control of liquid application. Broad flat spray patterns are usually chosen by appropriate nozzle systems.

Meterialsused:- Film-forming polymers (HPMC, HPC, PVA), plasticizers (PEG, triacetin), solvents (water, alcohol), colorants (dyes and lakes), opacifiers (titanium dioxide), and optional flavors or sweeteners. These materials help to form a smooth, uniform, and quick-drying coating layer applied through a screen.

C) Enteric coating:

The enteric coating material ideal properties are:

1) Resistant To gastric fluids.
2) Compatibility with most of the coating solutions
3) Non toxicity.
4) Low cost.
5) Ease of application
6) Formation of continuous film.

Polymers used in enteric coating are: - Cellulose acetate phthalate (CAP), Acrylate polymers, Hydroxypropyl methylcellulose Phthalate. (HPMCP), HPMC, Polyvinyl acetate phthalate, and Eudragit to ensure the tablet dissolves in the intestine and not in the stomach. Plasticizers (PEG, triethyl citrate), solvents (water, alcohols), fillers (talc, titanium dioxide), and colorants may also be included.

D) Specialized coating techniques:

- **Physical Vapor Deposition (PVD):** A vacuum-based process that deposits a thin film of vaporized material onto a surface. Used for applications requiring precise control over thickness and composition, such as the application of diamond-like carbon (DLC) or titanium nitride (TiN) for friction reduction.
- **Chemical Vapor Deposition (CVD):** A process where a substrate is exposed to a vapor of reactants that then react and deposit a coating.
- **Thermal Spraying:** A group of processes where a material is heated and sprayed onto a surface. Plasma spray is a type of thermal spraying used for applying ceramic coatings for heat resistance.
- **Electrostatic Deposition:** Uses an electric field to charge the coating material and the substrate, attracting the material to the surface. This is used for techniques like electrostatic painting and powder coating.
- **Anodizing:** A process primarily used on aluminum, where an electric current is passed through the metal in an electrolyte solution, creating a durable and protective oxide layer.
- **Fluidized-bed process:** A method where the part is dipped into a bed of fluidized powder to create a coating.
- **Spin Coating:** A technique where a substrate is spun at high speed while a liquid coating is dispensed onto its surface. It is commonly used in the semiconductor and pharmaceutical industries to create uniform films on flat surfaces, such as in tablet coating.
- **Electrophoretic Deposition:** A process where charged particles in a liquid suspension are moved to a substrate using an electric field. It can be used to apply a wide variety of coatings, including paints and ceramics.

Applications of specialized coatings

- **Pharmaceuticals:** Techniques like spin coating and fluidized-bed coating are used to coat tablets to improve their appearance, taste, and to control drug release.

- **Aerospace and Automotive:** Coatings are applied for corrosion protection, wear resistance, and heat resistance, using methods like PVD and thermal spraying.
- **Electronics:** Functional coatings, like epoxies for electrical insulation or thin films, are used in components like motors and other devices.
- **Industrial:** Anodizing and intumescent coatings are used to protect surfaces from corrosion and extreme heat, respectively.

Excipient's used in tablet coating:

- **Polymers**
  Hydroxypropyl Methylcellulose (HPMC): A common, versatile polymer used in many sugar-free film coatings.
  Polyvinyl alcohol and acrylates: Also used as film formers.
  Ethyl cellulose: Used for its excellent film-forming properties.
  Shellac: A natural resin used for moisture-protective coatings.
- **Plasticizers:** These are added to polymers to increase flexibility and prevent cracking of the coating.
  Glycerides: Used to make the film coating more flexible.
  Mineral or vegetable oils: Can also be used as plasticizers.
- **Colorants and opacifiers:** Used to give the tablet color for identification and to protect the drug from light.
  Titanium dioxide: An inorganic pigment that opacifies the coating.
  Iron oxides: Another inorganic pigment option.
  Water-insoluble lakes: Such as quinoline yellow, tartrazine, and indigo carmine.
- **Glidants:** Improve the flow of the coating mixture.
  Talc: Also used as a glidant and for its smoothing properties.
  Colloidal silicon dioxide:- A common glidant.
- **Other excipients:**
  Sweeteners and flavors: Improve palatability.
  Gums: Such as acacia and xanthan gum, can be used.
  Carbohydrates: Such as polydextrose and lactose, can be included

General Steps in Coating Process

Step	Description
1.Preheating	Tablets are heated to remove moisture.
2. Spraying of Coating Solution	Coating material (polymer, color, plasticizer) is sprayed on rotating tablets.
3. Drying	Hot air is passed to evaporate solvent and form a thin coating layer.
4. Repetition	Spray–Dry–Repeat until desired thickness is reached.
5. Cooling & Polishing	Final polish for smooth appearance.

Equipment Used

Coating Pan

- Traditional rotating pan
- Used mainly for sugar coating

Perforated Pan (Modern Film Coating Pan)

- Has holes to allow airflow
- Efficient drying
- Used widely for film coating

Fluidized Bed Coater (FBD Coater)

- Tablets are suspended in air
- Coating sprayed from bottom or top

Common Coating Defects

Defect	Cause
Chipping / Peeling	Poor adhesion or over-drying
Cracking	Low plasticizer or brittle polymer
Sticking / Picking	Excess moisture or high spray rate
Color Variation	Uneven mixing or spraying
Roughness / Orange Peel	Rapid drying causing droplets to solidify before spreading.

Evaluation of coated tablets:

1) General Appearance:-Tablet should have uniform color, smooth surface, no cracks, no roughness, and no sticking or mottling.
2) Thickness Test:-Measured using Vernier calipers. Ensures coating is even and not too thick or too thin. Ensures uniform coating thickness.
3) Weight Variation Test: A group of tablets is weighed individually. Difference between average weight and individual weight should be within IP / USP limits.
4) Hardness Test : Performed using Monsanto / Pfizer hardness tester.Ensures coated tablet has enough mechanical strength
5) Friability Test: Done using Roche Friabilator.Acceptable loss is not more than 1%. Ensures coating resists abrasion during handling.
6) Disintegration Test :-
   Enteric coated tablets → Must not disintegrate in 0.1 N HCl for 2 hours, but disintegrate in pH 6.8 buffer.Film coated tablets → Should disintegrate within official time limits.
7) Dissolution Test: Determines rate and extent of drug release.Uses dissolution apparatus (USP Type I – Basket or Type II – Paddle).
8) Moisture Content: Measured by Karl Fischer titration or loss on drying.Ensures coating does not absorb moisture and degrade.
9) Adhesion Test: Coating should adhere properly to tablet surface.Checked by visual inspection and handling test (no peeling or flaking).

Advantages

- Protects tablet from moisture, air, and light.
- Masks bitter taste and improves appearance.
- Makes tablet easy to swallow.
- Helps in identification (color, printing).
- Can control drug release (e.g., enteric coating).

Limitations

- Expensive and time-consuming process.
- Requires skilled operation and special equipment.
- May cause defects like cracking or sticking.
- Increases tablet weight and size.

Recent Advances in Tablet Coating: Modern advances include electrostatic dry powder coating and hot-melt coating, which reduce or eliminate the use of solvents, making the process faster and eco-friendly. UV-curable coatings and computer-controlled fluidized bed systems provide more uniform coating, improved drug stability, and better control of drug release.

CONCLUSION

Coating of a pharmaceutical dosage form is a wonderful advantages and remarkable developments in resent decades to enhancement of the quality of solid dosage form. Tablet coating remains a vital pharmaceutical process that improves therapeutic efficacy, patient acceptability, stability, taste, appearance of solid dosage forms continued advancements in polymers processing techniques and automation are enhancing efficiency and precision in coating technologies.

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