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A BRIEF REVIEW ON RECENT ADVANCEMENT OF TABLET COATING TECHNOLOGY

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ABSTRACT
A tablet can be defined as a solid unit dosage form. There are several reasons for coating of solid dosage form, the most important reason is to control the release profile & also to control the bioavailability parameters of the APIs (Active Pharmaceutical Ingredients). Tablets containing active pharmaceutical ingredients (API) can be coated with thin polymer-based film for various advantages. Generally, horizontal rotating pans are used for coating purposes & coating solution can be spread through the spraying systems over the surface of tablets. Bitter taste masking, odor masking, physical and chemical protection, and also environmental protection are all benefits of the tablet coating. Despite that, Tablet coating also plays an important role in controlling the action site. Sugar-coating, film coating, and enteric coating are some of the conventional tablet coating processes. The primary objective for creating tablet coating technologies is to eliminate the numerous disadvantages of solvent-based coating. Coating solution preferentially applied on the surface of solid dosage forms without the need for any solvent in these novel technologies. This review article provides information regarding the techniques of conventional tablet coating, the recent advancement of tablet coating procedures, and tablet coating components.

INTRODUCTION

Tablet is an example of unit dosage, which is being compressed after mixing of active constituents and another additive so that a proper shape may be given to the tablet. This is the medication in a compressed form.

Solid measure formulations unit of measurement necessary measure forms in prescription drugs. Solid dosage form includes tablets, capsules, granules, sachets, powders, dry powder inhalers, and chewable. A unit dose of one or more medications

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is contained in the solid measure kind. Binders, glidants, sweeteners, and other excipients are all examples of excipients [1].

Objective of tablet coating

1. Increase shelf-life of drugs.
2. Loss of volatile ingredients can be reduced.
3. Enhancement of mechanical strength of solid dosage form.
4. Drug release rate can be modified through this process specifically delay release tablets or enteric-coated tablets and sustained-release medicines.

Drawbacks of tablet coating

1. Tablet coating is expensive than normal formulation.
2. Sometimes, tablet coating leads to the degradation of active ingredients such as chipping, capping, mottling, and bridging.
3. Some drugs are much more sensitive to the coating that leading to serious adverse effects.

Coating process

Coating pans that rotate are widely employed for this purpose. During the process of coating the tablets, liquid coating solutions are spread over the uncoated tablet beds inside the pan and after the transfer of air passes over the uncoated tablets, the liquid part of the coating solution is evaporated and leaving a solid coated layer over tumbling tablets. Various stages are mentioned below [2, 3]

i. Batch identification and selection of the type of coating. (Film or Sugarcoating)
ii. Dispensing (accurately dosing of all required raw materials)
iii. Loading of tablets into the pan.
iv. Warming of tablets.
v. Spraying (application of coating materials and rolling of the tablet are carried out simultaneously)
vi. Drying.
vii. Cooling and unloading.

Types of Coating

1) Sugar Coating.
2) Film Coating.
3) Enteric Coating.
4) Controlled Release Coating.
5) Specialized Coating.

a. Compressed Coating,
b. Electrostatic Coating.
c. Dip Coating.
d. Vacuum Coating.

Sugar Coating:

The sugar-coating process includes five major steps:

a. Waterproofing/Sealing: creates a wetness barrier while conjointly hardening the pill surface.

b. Sub-coating permits the pill size to quickly increase and also the pill edges to spherical off.

c. Grossing/Smoothing: The surface of the tablets is smoothing out and pills are adjusted to the required sizes.

d. Coloring determines the tablet's final color and scale.

e. Sprucing provides a shiny look [5].

Film Coating:

Major requirements for film coating ingredients are:

i) Selection of the coating solution depends upon the solubility profile of the active ingredients.

ii) Film coating also depends upon some other solubilities such as free pH-dependent solubility, slow water solubility, and free water solubility.

iii) Able to supply sublime products.

iv) Highly stable at different environmental conditions such as air, heat, moisture, and light.

v) No such impact on color, style, or odor.

vi) Highly compatible with alternative coating.

vii) Non-toxic, non-irritant, and no such interaction with active pharmaceutical ingredients.

viii) Cracking can be overcome through this process.

ix) Bridging and filling problems can be overcome through this process.

x) Printing process can be done easily with this coating process [6, 7].

Enteric Coating:

Ideal properties for enteric coating materials are:

i) Resistance to internal organ fluids.

ii) Susceptible/permeable to enteral fluid.

iii) Compatibility with most coating resolution parts and therefore the medication substrate.

iv) Formation of continuous film.

v) Nontoxic, low-cost and easy application.

vi) Ability to be promptly written.

Different polymers involved in the enteric coating process are as follows:

1) Acrylate polymers.
2) Polyvinyl acetate phthalate.
3) Cellulose acetate phthalate (CAP).
4) Hydroxypropyl methylcellulose phthalate [8], [9].

TABLE 1: PROPERTIES OF SUGAR COATING

TYPE	PROPERTIES	SUGARCOATING
Tablet	Appearance	With a serious level of cleanliness, it's adjusted.
	The weight has expanded Due to the covering material	30-50%
	Logo or 'break lines'	It is not possible.
Process	Administrator preparation is required	Considerable
	Flexibility to Good Manufacturing Practices (GMP)	Difficulties could emerge.
	Phases of the strategy	A multi-stage system
	Coatings with utilitarian properties	This is generally unrealistic, except for enteric covering.

TABLE 02: MATERIALS USED IN FILM COATING

S. NO	MATERIALS	TYPES	USES	EXAMPLES
1	**Film Former**	Enteric Non-enteric	To control the release of the drug	Hydroxy Propyl Methylcellulose (HPMC), Methyl Hydroxy Ethyl Cellulose (MHEC).
2	**Solvents**	----------	To dissolve or disperse the polymers	Iso Propyl alcohol (IPA) and Methyl Chloride.
3.	**Plasticizer**	Internal plasticizer	It pertains to the chemical modification of the basic polymer that alters the physical properties of the polymer	Glycerol, Propylene glycol, PEG 200- 6000 grades.
		External Plasticizer	It fused with the essential polymeric film previous, changes the adaptability, Rigidity, or bond property of the subsequent film.	Diethyl phthalate (DEP), Dibutyl phthalate (DBP), and Tributyl citrate (TBC)
4	**Colorant**	Inorganic Materials	For Light Shade: Concentration of less than 0.01% may be used	Iron oxides
		Natural coloring Materials	For Dark Shade: A concentration of more than 2.0% may be required.	Anthocyanins, Caramel.
5	**Opaquant – extenders**	----------	For more pastel tones and expanding film inclusion detailing must be given	Titanium dioxide, Silicate (Talc & aluminum silicates), Carbonates (Magnesium Carbonates)

TABLE 03: CHARACTERISTIC OF FILM COATING

ITEMS	CHARACTERISTICS	IMPORTANCE
Tablet	Appearance	Retain contour of original core. Not as shiny as the sugar coat type.
	Weight increase because of coating materials	2-3%
	Logo of 'Break lines'	Possible
Process	Operator training required	The process tends to automation and operator training.
	Adaptability to GMP	High
	Process Stages	Usually, Single-stage.
	Functional Coating	Easy adaptable for controlled release.

MODERN TABLET COATING TECHNIQUES

1) Aqueous Film coating technology:

The glossing over the measure is exceptionally tedious and it is relying upon the abilities to cover administrator, this method has been supplanted by film covering innovation. This procedure was begun with the utilization of natural solvents like methylene chloride however presently has been supplanted with fluid film covering because of ecological and administrative contemplations. Additionally, the expense of any natural dissolvable is undeniably more than the expense of cleansed water. Day by day watery-based framework or aqueous film coating technology has been gaining too much interest to the researchers. After getting some disadvantages of the aqueous coating technology, film covering innovation has now progressed to a high level. "The successful introduction of a large type of liquid primarily based film coating merchandise (below the name INSTACOAT) has resulted in straightforward conversion from organic solvent-based coatings to liquid film coating for many companies; several of them still use the standard coating instrumentation"[10],[11].

Development of film coating formulation: -

Improvement of the coating adhesion properties to the core materials required the optimization of the film coating formulation, reducing intagliation bridging, raising coating hardness, or improving any other attribute that the formulator considers insufficient. The development scientist must take into account three major factors that can affect film quality: elasticity, tensile strength, and film–tablet surface interaction [12].

2) Electrostatic Dry Coating

For the first time, an electrostatic dry powder coating process was developed in a pan coater gadget system for solid dosage forms. This process helps to provide the tablet with a smooth surface bed, excellent coating uniformity, and release at a particular solvent grade.The electricity coating method played a very important role in several manufacturing industries such as paint technology, food technology, metal coating process, and pharmaceutical industries to the coating of solid dosage forms. The principle involved in the electrostatic dry coating process, directly spreading of particle and polymer mixture on the surface of tablet bed without the addition of solvent and heating will be applied until its form a film over the surface of tablets [13], [14]. Mainly two types of charging units can be found out based on charging mechanism as, a) Corona charging mechanism, b) Tribo charging mechanism.

Mechanism of Tribo Charging: -

The principle involved in the Tribo charging is friction charging conjugated with dielectric properties and there are no such free ions or electrical fields present in between the spray gun and grounded substance. Electrical forces present in the Tribo charging gun are the repulsive force that exists in between the particles. Charged particles are able to enter into the space adjacent where attraction forces exist between ground substrate that leads to deposition of the particles on the substrate. Mechanical forces lead to the uniformity of the charged particles onto the earthen substrate [15].

At last, Forces are equal as repulsion force equals the attraction force, which leads to particles cannot adhering to the substrate and thickness of coating materials do not enhance. Electrostatic coating of pharmaceutical tablet core and electrically non-conducting substance is very much difficult than other coating processes. To protect the core of the tablet, powder transformed into the film without damaging the core materials of the tablet, especially organic materials [16].

3) Super-Cell Coating Technology

Supercell coating technology is an amazing coating technology of the cutting-edge tablet that can withstand extremely hygroscopic materials and friable coating ingredients can be deposited into it. Sometimes this technology gives non-homogenous output due to imperfections and inconsistency. The process involved in the supercell coating technology is that edges of tablets are ground off and corners of the tablet are not coated with the same thickness applied in tablet faces otherwise tablets can be stacked in the rotating pans and airflow cannot pass throughout the pan. That's why the modified release of coating is limited due to the deposition of the coating materials [17]. Supercell coating technology was invented by Niro Pharma Systems which helps with various problems employing a small modular design.

Features of Super-Cell coating technology

1) Coating of multiple layers over the surface bed of solid dosage forms.
2) Modular designs are easily flexible.
3) Coating can be continuous and easily adaptable.
4) Production capacity is more & can be 6 cells coats up to 120mg
5) Can be used in the R & D department withstand of the minimum batch size range 30mg
6) Much more accurate than other technology.
7) Having a low humidity process that is suitable for low moisture-sensitive materials.
8) Enabling technology.
9) Friable tablets.

Defects in tablet coating

Tablet coating plays an important role in the stability of the core materials from environmental conditions. Several problems can find out during the manufacturing process and the majority of the visual faults caused by insufficient technical skills, improper machine settings, and might be moisture contained in granules before compression. Several defects can be found during the manufacturing process as follows [18], [19]. [20].

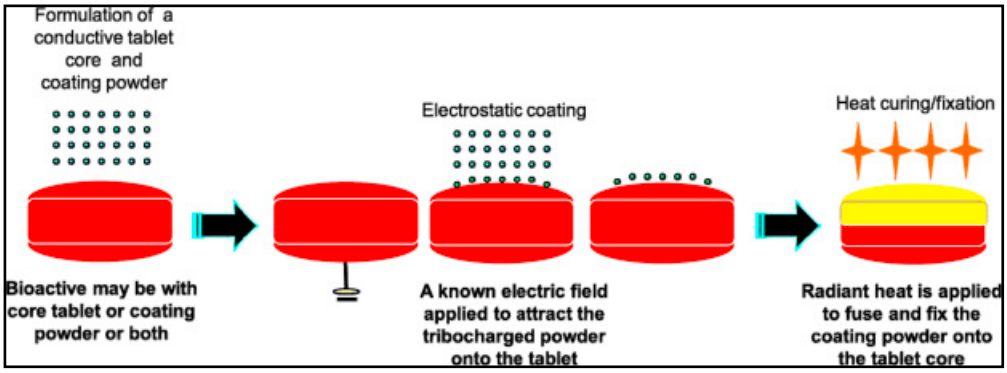

Figure 01 -Diagrammatic representation of Electrostatic Dry Coating System

Table 04 – Disadvantages of the coating of the tablet

Defects	Definition	Reason	Remedies
Blistering	It is a local detachment of film from substrate forming blister.	Entrapment of gases in the film due to overheating either during spraying or at the end of the coating run	Milder drying conditions are warranted in this
Chipping	It is a defect where the film becomes chipped and dented, usually at the edges of the tablet.	Decrease in fluidizing air or speed of rotation of the drum in pan coating	Be careful not to over-dry the tablets in the preheating stage. That can make the tablets brittle and promote capping.
Picking	It is a defect where isolated areas of the film are pulled away from the surface when the tablet sticks together and then parts.	Conditions similar to cratering produce an overly wet tablet bed where adjacent tablets can stick together and then break apart.	A reduction in the liquid application rate or increase in the drying air temperature and air temperature and air volume usually solves this

Defects	Definition	Reason	Remedies
			problem. Excessing tacking may be an indication of a poor formulation.
Twinning	This is the term for two tablets that stick together.	A common problem with capsule-shaped tablets	Assuming you don't wish to change the tablet shape, you can solve this problem by balancing the pan speed and spray rate. Try reducing the spray rate and increasing pan speed. In some case, it is necessary to modify the design of tooling by very slightly changing the radius. The change is almost impossible to see, but it prevents the twinning problem.
Pitting	It is a defect whereby pits occur on the surface of a tablet core without any visible disruption of the film coating.	The temperature of the tablet core is greater than the melting point of the materials used in the tablet formulation.	Control the temperature of the tablet core during the formulation.
Cratering	It is the defect of film coating whereby volcanic-like craters appear exposing the tablet surface.	The coating solution penetration the surface of the tablet, often at the crown where the surface is more porous, causing localized disintegration of the core and disruption of the coating.	----------
Blooming	It is a defect where coating becomes dull immediately or after prolonged storage at a high temperature	It is due to collection on the surface of low molecular weight ingredients included in the coating formulation. In most circumstances, the ingredient will be a plasticizer.	----------
Blushing	It is a defect best described as whitish specks or haziness in the film	It is through to be due to precipitated polymer exacerbated by the use of high coating temperature at or above the thermal gelation temperature of the polymers	-----
Color variation	A defect that involves variation in color of the film.	Alternation of the frequency and duration of appearance of tablets in the spray zone or the size/ shape of the spray zone	A reformation with different plasticizers and additives is the best way to solve the film instabilities caused by ingredients.
Cracking or splitting	It is a defect in which the film either crack across the crown of the tablet (Cracking) or splits around the edges of the tablet (splitting)	Internal stress in the film exceeds the tensile strength of the film.	The tensile strength of the film can be increased by using higher molecular weight polymers or polymer blends.
Infilling	It is a defect that renders the integrations indistinctness	The inability of foam, formed by air spraying of polymer solution, to	Judicious monitoring of fluid application rate and thorough mixing

Defects	Definition	Reason	Remedies
		break. The foam droplets on the surface of the tablet break down readily due to attrition but the ingredients from a protected area allow the foam to accumulate and "set". Once the foam has accumulated to a level approaching the outer contour of the tablet surface, normal attrition can occur allowing the structure to be covered with continuous film.	of the tablets in the pan can prevent filling
Orange peel/ roughness	It is a surface defect resulting in the film being rough and nonglossy. Appearance is similar to that of an orange.	Inadequate spreading of coating solution before drying.	Thinning the solution with additional solvent may correct this problem.
Mottling	Mottling is an uneven distribution of the color on the surface of the tablet, with dark and light patches on it.	It is mainly due to different coloration on excipient or the degradation product of tablet is colored.	Coating solution prepares properly insufficient quantity.

CONCLUSION

Coating of the pharmaceutical dosage form is a wonderful advantage and remarkable development in recent decades to the enhancement of the quality of the solid dosage form.

Several development techniques have come to market to elegance the look, reduction of the error, stability of the tablet and easy way to control and operate. Each technique has its own set of benefits and drawbacks. This technology has undergone significant development and advancement in terms of energy consumption, film processing, and drying quality. In the future, there is still a lot of opportunities for improvement in coating technique. More research into better coating solvents, drying techniques, and spaying methods is required.

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CONFLICT OF INTEREST

The authors declare no conflict of interest

AUTHOR CONTRIBUTION

Soumyadip Ghosh, Debgopal Ganguly, Pubali Chakraborty and Ananta Choudhury designed the work and made the required corrections and revisions in the manuscript. Debgopal Ganguly and Soumyadip Ghosh collected the content and performed literature survey and also contributed in designing the manuscript. All the authors designed the final manuscript.

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