Review Article

Tablet Coating Techniques: Concept and Recent Trends

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ABSTRACT

Tablet coating is a common pharmaceutical technique of applying a thin polymer-based film to a tablet or a granule containing active pharmaceutical ingredients (APIs). Solid dosage forms are coated for a number of reasons, the most important of which is controlling the release profiles. Tablets are usually coated in horizontal rotating pans with the coating solution sprayed onto the free surface of the tablet bed. There are various techniques for tablet coating such as sugar coating, film coating, and enteric coating. In these latest technologies coating materials are directly coated onto the surface of solid dosage forms without using any solvent. Magnetically assisted impaction coating, electrostatic dry coating in solventless coatings, aqueous film coating and Supercell coating technology are also available recent technique of coating. An ideal tablet should be free from any visual defect or functional defect. The advancements and innovations in tablet manufacture have not decreased the problems, often encountered in the production, instead have increased the problems, mainly because of the complexities of tablet presses; and/or the greater demands of quality. This review deal in detail about history, recent tablet coating technique and remedies associated with the tablet coating. Pharmaceutical solid dosage forms include tablets, pellets, pills, beads etc. Tablets are coated for many reason such as masking odour, taste, colour of the drug, providing physical and chemical protection to drug, protecting drug from the gastric environment. Coating is a process by which a layer of coating material is applied to the surface of a dosage form. The amount of coating on the surface of a tablet is critical to the effectiveness of the oral dosage form. Recent trends in tablet coating focuses on overcoming disadvantage of solvent based coating. This review concerns with the coating process, equipments involved, coated tablets evaluation and specialized coating techniques.

Keywords: Tablet Coating, History of coating, Supercell Coating, Magnetically Assisted Impaction Coating, Pharmaceutical solid dosage, coated tablets, Sugar Coating.

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INTRODUCTION

Tablet is a pharmaceutical dosage form. The tablet is composed of the Active Pharmaceutical Ingredient together with various excipients which are usually in powder form, compressed into a solid dosage form. Coating is a process by which a layer of coating material is applied to the surface of a dosage form in order to obtain certain benefits that mainly ranges from ease of product identification to modifying drug release from the dosage form.[1] Coated tablets are tablets which are covered with one or more layers of mixture of various substances such as resins, gums sugar, plasticizer etc. Substances used for coating are usually applied as solution or suspension under conditions where vehicle evaporates.[2] Coating composition is applied to a batch of tablets in tumbled coating pan so that the tablet surfaces become covered with a tacky polymeric film. During the process the tablet surface changes from a sticky liquid to tacky semisolid, and eventually to a non-sticky dry Surface.[3]

Objectives of Coating [4-6]

The objectives of tablet coating are as follows: To mask the disagreeable odor, color or taste of the tablet and increase patient compliance.

To offer a physical and/or chemical protection to the drug and protect drug from external environment (particularly air, moisture and light) in order to improve stability.

- To prolong the shelf life of the drug.
- To enhance ease of swallowing large dose forms.
- To retard loss of volatile ingredients.
- To modify and/or control the rate of drug release as in repeat-action, delayed release (enteric coated) and sustain-release products.
- To incorporate incompatible drugs together in a single dosage form
- Increasing the mechanical strength of the dosage form.
- Improving product appearance and help in identification by the manufacturer, the pharmacist and the patient (mostly colored).
- Masking batch differences in the appearance of raw materials.

• In improving product robustness.

Benefits of Tablet Coating

Tablets coating mask the taste, odour, or colour of the drug. Tablets coating control the release of the drug from the tablet. It provides physical and chemical protection and protects the drug from the gastric environment of the stomach (acid resistant enteric coating). Incorporate of another drug or formula adjuvant in the coating to avoid chemical incompatibilities or to provide sequential drug release, improvement of pharmaceutical elegance by use of special colors and contrasting printing can also be obtained from tablet coating.

Shortcomings of Tablet Coating

Sugar coating carries relatively high cost, long coating time and high bulk due to the use of other coating materials. It is tedious, time-consuming and requires the expertise of highly skilled technician.[13]

Disadvantage of Tablet Coating

Tablet coating increase the cost of formulation.
Tablet coating may interfere in Something coating may result in various film defects like, mottling, capping, chipping, bridging. The process remained complicated.[7]

History of Coating Technique

"Panning" was the original word for the process of adding a coating to a tablet. The word panning is still a common term which is used in the confectionary business. In past years coating perform basically using a rotating drum (pan) on a stand. A coating solution was added, while the rotation of the pan distributed the solution throughout the bed of tablets. The main disadvantage of this technology was slow waiting for the coating solution to dry; and the trick was to get it to dry evenly. With the advent of film coating a film or thin membrane, usually representing 1-3% of the total tablet weight, was sprayed on using a perforated pan. To decrease the overall process time, holes were made through the pan so that treated air (hot or cold) could be pulled through the pan, much like a clothes dryer, allowing the tablets to dry more quickly. With this advent of improved drying came the ability to switch the film coating solution from a solvent based solution to a water-based solution. [13]

Coating of pharmaceutical dosage forms has been practiced for many centuries[14].The historical development of coating technique is mentioned below:-

Last 40 Years

Features

- Introduction of the side- vented tablet coating pans (with perforations), Figure 1,
- Evolution was required for the introduction of aqueous based film coating polymers to the pharmaceutical industry
- Carbon steel construction except for pan
- Many screws, not welded in places
- Does not complies GMP

Last 30 Years

Introduction of reliable microprocessor-based process control systems required to insure process control and repeatability.

Features

- Improved design spray nozzles for tablet coating
- specific applications (all stainless steel)
- Improved air preparation systems required for consistent aqueous process drying
- Improved GMP coater design, more cleanable, all stainless steel
- Improved tablet handling
- All required for the optimization of aqueous film coating process

Last 20 Years

Features

- Potable water storage tank.
- Washing nozzles (coater mounted).
- Reduced cleaning time
- Cleaning of the areas, that are difficult to access
- Conservation of cleaning solution
- Standardization of the cleaning process
- Energy conservation (As shown in Figure 1)

Figure 1. Advanced automatic Coating in Place (CIP) and Washing in Place (WIP) systems

Last 10 Years

- More advanced film coating spray nozzles with anti- bearding designs
- More reliable industrial automation for accurate and repeatable control of process parameters ie:

dewpoint, mass solution flow, air flow etc.

- The evolution of the improvements to the batch tablet coater has allowed the recent advancements in continuous tablet coating .

Coating Process

Rotating coating pans are commonly used for coating purpose. Uncoated tablets are placed inside the pan and the liquid coating material is brought into the pan during the tumbling of tablets.[7] Air is passed over the tumbling tablets so that liquid part of coating material gets evaporated leaving the layer of solid coating material.

The coating method is normally such as the subsequent steps:

- Batch identification and selection of type of coating. (film or sugar coating)
- Dispensing (accurate dosing of all required raw materials)
- Loading of tablets into pan.
- Warming of tablets
- Spraying (application of coating material and rolling of tablet are carried out simultaneously) [8]
- Drying
- Cooling
- Unloading [9]

Factor Affecting Tablet Coating

Tablet Properties

To tolerate the intense attrition of tablets striking other tablets or walls of the coating equipment, the tablets must be resistant to abrasion and chipping. [6] The ideal shape for coating is sphere [10]

Coating Process

Type of coating Equipments and its automation also affects coating.

The key parameter which affect coating process are Temperature humidity air flow.

Coating Composition [6]

Polymers, Solvents, Plasticizers, Colorants.

Various Kinds of Tablet

Coating 1. Sugar Coating

Sugar coating was done to mask bitter taste of tablets. Bitter tablets are coated with sugar coat in order to mask the taste of tablet. It also provides good appearance to tablets.

The process of sugar coating consists of several steps, which are as follows:

Sealing:

It provide moisture barrier to tablet and hardens it. [8]

Sub coating:

This step is done to round the edges and increase the tablet weight.[4]

Grossing/Smoothing:

This fills up the imperfection of sub coating and increases the tablet size to predetermine dimension.

Coloring:

This gives the final color to the tablet.

Table 1: Characteristic of Sugar Coating

Type	CHARACTERISTIC	SUGAR COATING
Tablet	Appearance	Rounded with high degree of polish
	Weight increase because of coating Material	30-50%
	Logo or 'break lines'	Not possible
Process	Operator training required	Considerable
	Adaptability to GMP	Difficulty may arise
	Process stages	Multistage process
	Functional coatings	Not usually possible apart from enteric coating[6]

Polishing

This is done to obtain desired luster.[9]

Film Coating

As the sugar-coating process is very time consuming so this technique has been replaced by film coating technology. The process involves spraying of a solution of polymer, pigments and plasticizer onto a rotating tablet bed to form a thin, uniform film on the tablet surface.[10] The choice of polymer mainly depends on the desired site of drug release (stomach/ intestine), or on the desired release rate.[4] According to desired site it is of two types:

Table 2: Materials Used in Film Coating

Sr. No.	Material	Type	Uses	Examples
1.	Film Former	Enteric Non-Enteric	To control the release of drug	Hydroxy Propyl Methyl Cellulose (HPMC), Methyl Hydroxy Ethyl Cellulose (MHEC)
2.	Solvents	----------	To dissolve or disperse the polymers	IPA and Methylene chloride
3.	Plasticizer	Internal Plasticizing External Plasticizing	It Pertains to the chemical modification of the basic polymer that alters the physical properties of the polymer. It incorporated with the primary polymeric film former, changes the flexibility, tensile strength, or adhesion properties of the resulting film	Glycerol, Propylene glycol, PEG 200- 6000 Grades Diethyl phthalate (DEP), Dibutyl phthalate (DBP) and Tributyl citrate (TBC)
4.	Colourants	Inorganic materials Natural coloring materials	For light shade: concentration of less than 0.01% may be used For dark shade: concentration of more than 2.0% may be required.	Iron Oxides Anthocyanins, Caramel, Carotenoids,
5.	Opaquant- Extenders	----------	Formulations to provide more pastel colours and increase film coverage	Titanium dioxide, silicate (talc & aluminum silicates), carbonates (magnesium carbonates) 3

Compression Coating

It involves the compaction of granular materials around a preformed tablet core using specially designed tableting equipment. Compression coating is a dry process. it has advantages in some cases in which the tablet core cannot tolerate organic solvents or water and yet needs to be coated for taste masking, or to provide delayed or enteric properties to the product.[2]

Development of Film Coating Formulations

If the following questions are answered concomitantly then one can go for film coating:

i) Is it necessary to mask objectionable taste, color and odor?

ii) Is it necessary to control drug release?

iii) What tablets size, shape, or color constrains must be placed on the developmental work?

Table 3: Characteristic of Film Coating

Type	Characteristic	Film Coating
Tablet	Appearance	Retain contour of original core. Usually not as shiny as sugar coat type
	Weight increase because of coating material	2-3%
	Logo or 'break lines'	Possible
Process	Operator training required	Process tends itself to automation and easy training of operator
	Adaptability to GMP	High
	Process stages	Usually, single stage
	Functional coatings	Easily adaptable for controlled release[6]

Ideal requirements of film coating materials:

i) Solubility in solvent of choice for coating preparation

ii) Solubility requirement for the intended use e.g. free water-solubility, slow water solubility or pH - dependent solubility

iii) Capacity to produce an elegant looking product

iv) High stability against heat, light, moisture, air and the substrate being coated

v) No inherent colour, taste or odor

vi) High compatibility with other coating solution additives

vii) Nontoxic with no pharmacological activity

viii) High resistance to cracking

ix) Film former should not give bridging or filling of the debossed tablet

x) Compatible to printing procedure[3]

Dip coating

Coating is applied by dipping tablet into coating liquid then wet tablets are dried in conventional coating pans. Alternate dipping and drying steps can be repeated several times until the desired coating is achieved.

Press Coating

Compression is used to form coat around a pre-formed core. Used mainly to separate chemically incompatible materials.

Enteric coating

An enteric coating is a barrier that controls the location of oral medication in the digestive system where it is absorbed. The word "enteric" indicates small intestine; therefore, enteric coatings prevent release of medication before it reaches the small intestine. The enteric coated polymers remain unionize at low pH, and therefore remain insoluble. But as the pH increases in the GIT, the acidic functional groups are capable of ionization, and the polymer swells or becomes soluble in the intestinal fluid.

Need of enteric coating

To protect the stomach from the drug

To protect the drug from the stomach

To protect the acid liable drugs from the gastric fluid

To forbid gastric distress or nausea due to irritation from a drug [11]

Recent Trends In Tablet Coating Techniques

Electrostatic dry coating

An electrostatic dry powder coating process for tablets was developed for the first time by electrostatic dry powder coating in a pan coater system. The optimized dry powder coating process produces tablets with smooth surface, good coating uniformity and release profile that are comparable to that of the tablet cores. This novel electrostatic dry powder coating technique is an alternative to aqueous or solvent based coating process for pharmaceutical products. [17]

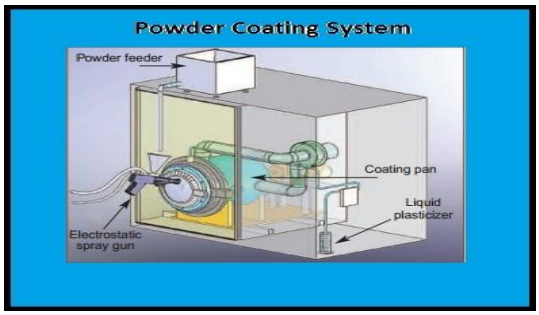

Figure 2: Electrostatic Powder Coating System [16]

The electrostatic coating process is widely useful in food technology, paint technology, metal coatings, coating of living cells and coating of tablets as well as capsules. The principle of electrostatic powder coating states that spraying of a mixture of finely grounded particles and polymers onto a substrate surface without using any solvent and then heating the substrate for curing on oven until the powder mixture is fused into film (Figure 2) [18]

According to the charging mechanism, there are two types of spraying units:

a) Corona charging

b) Tribo charging.

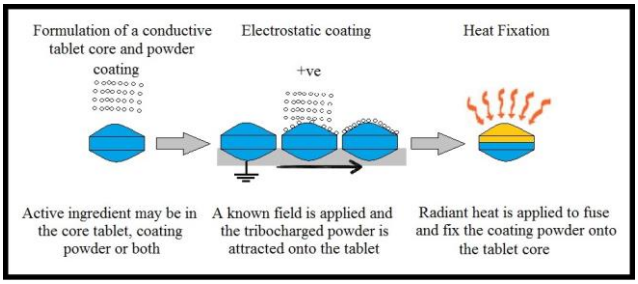

Figure 3: Schematic diagram of electrostatic dry coating.

Mechanism of Corona charging

In this mechanism, the electrical breakdown and ionization of air by imposing high voltage on a sharp pointed needle like electrode (i.e., charging pin) at the outlet of the gun. The powder particles pick up the negative ions on their way from the gun to the substrate. The movement of particles between the substrate and the charging gun is done by the combination of electrical and mechanical forces. The mechanical forces generated by the air blows the powder towards the substrate from the spray gun. The electrical forces are derived from the electrical field between the earthen substance and the charging tip of the spray gun, and from the repulsive forces between the charged particles. The electrical field can be adjusted to direct the powder's flow, control pattern size, shape, and powder density as it is released from the gun.

Mechanism of tribo charging

In the tribo charging, it makes the use of the principle of friction charging associated with the dielectric properties of solid materials and so that no free ions and electrical

field will be present between the spray gun and grounded substance. For tribo charging guns, the electrical forces are only regarded to the repulsive forces between the charged particles. After spraying, charged particles come into the space adjacent to the substrate and the attraction forces between the grounded substrate and the charged particles makes the particle to deposit on the substrate. Charged particles are sprayed uniformly onto the earthen substrate in virtue of mechanical forces and electrostatic attraction. Particles deposit on the substrate before the repulsion force of the deposited particles against the coming particles increase and exceed the electrostatic attraction. Finally once the repulsion force becomes equivalent to the attraction force, particles cannot adhere to the substrate any more, and the coating thickness does not increase any more. Electrostatic dry coating of electrically non-conducting substrates and pharmaceutical tablet cores is more difficult. For secure the coating to the core, the powder must be transformed into a film without damaging the tablet core, which usually includes organic materials. In addition, an even coating is required and it is difficult to obtain an even coating of powder on a tablet core. Various properties of powder such as particle size distribution, chemical

composition, tribo and corona charging characteristics, electrical resistivity, hygroscopicity, fluidity and shape distribution play significant role on the performance of powder coating such as transfer efficiency, film thickness, adhesion and appearance. Distance, nozzle geometry, and composition of the precursor solution play an important role in the electrostatic coating process.

Table 4: Patents for Electrostatic Coating of Phoqus Pharmaceuticals

Patent Number	Title Of Patent	Date Issued
6783768	Method and apparatus for the coating of substrates for pharmaceutical use	August 31, 2004
7008668	Powder coating composition for electrostatic coating of pharmaceutical substrates	March 7, 2006
7070656	Electrostatic coating	July 4, 2006
7144597	Electrostatic application of powder material to solid dosage forms utilizing an electrically con	December 5, 2006
7153538	Method and apparatus for the coating of substrates for pharmaceutical use	December 26, 2006
7285303	Powder material for electrostatic application to a substrate and electrostatic application of the powder material	October 23, 2007
7384661	Electrostatic application of powder material to solid dosage forms in an electric field	June 10, 2008[10].

Phoqus is a leading-edge drug delivery company which is providing a range of innovative and patented drug delivery systems based on electrostatic dry powder coating technology. There are several patents on the design of apparatus which are used for electrostatic coating of powders onto the pharmaceutical dosage forms. Most of these apparatus are patented by Phoqus pharmaceuticals limited[18]. There are several patents which provide the various coating compositions for the electrostatic coating as mentioned in table no. 4.

Magnetically Assisted Impaction Coating (MAIC)

A Technique is developed for estimating the coating time in a magnetically assisted impaction coating (MAIC) device. The mixture of the host, guest and magnetic particles is assumed to stay in a fluidized state where the distribution of velocities is a Maxwell–Boltzman type. It is assumed that the collisions occurs among the particles are important for impinging the guest particles onto the surface of host particles, and thus forming a semi-permanent coating on the surface of host particles. The coating time is depending on several parameters, including the number density of host particles, the diameter ratio of the host and guest particles, the height of the fluidized particle bed and the material properties of the host and guest particles. There is an optimal value of the bed height for which the coating time is a minimum. The coating time increases sharply the bed height is smaller and larger than the optimal value, and also when the diameter of host particles is increased.[19]

Various dry coating methods have been developed such as compression coating, plasticizer dry coating, heat dry coating and electrostatic dry coating. These methods generally allow for the application of high shearing stresses or high impaction forces or exposure to higher temperature for coating. The strong mechanical forces and the accompanying heat generated can cause layering and even embedding of the guest particles onto the surface of the host particles. Many foods and pharmaceutical ingredients, being organic and relatively very soft, are very sensitive to heat and can quite easily be deformed by severe mechanical forces. Hence, some soft coating methods that can attach the guest (coating material) particles onto the host (material to be coated) particles with a minimum degradation of particle size, shape and composition caused by the buildup of heat are the best candidates for such applications. The magnetically assisted impaction coating (MAIC) devices can coat soft organic host and guest particles without changing in the material shape and size. Although there is some heat generated on a minute level due to the collisions of particles during MAIC, but it is negligible. This is an additional advantage when dealing with temperature sensitive powders such as pharmaceuticals [18].

Magnetically Assisted Impaction Coating (MAIC) is being developed to improve the effectiveness of mixing powders with nano-sized particles without the aid of a solvent or heat. In general, uniform mixing of nano-sized

materials is more difficult than mixing of larger sized materials. Still in development, the technology will aid manufacturing applications in producing higher quality products [20].

Mechanism of coating in the MAIC process

There are few stages in the mechanism of coating of MAIC process is

Stage-I: Excitation of magnetic particles.

Stage-II: De-agglomeration of guest particles (coating material).

Stage-III: Shearing and spreading of guest particles on the surface of the host particles (material to be coated).

Stage-IV: Magnetic-host-host particle interaction. Stage-V: Magnetic–host–wall interaction. and Stage-VI: Formation of coated products.

Apparatus for MAIC

MAIC apparatus consist of processing vessel surrounded by the series of electromagnets connected to the alternating current. The host and guest materials are placed in the vessel and added the measured mass of the magnetic particles. The magnetic particles are made of barium ferrite and they are coated with polyurethane to prevent contamination of the coated particles. When a magnetic field is present, the magnetic particles are agitated and move frequently inside the vessel, resembling a fluidized bed system. These agitated magnetic particles then impart energy to the host particles and guest particles, causing collisions and allowing coating to be achieved by means of impaction or peening of the guest particles onto the host particles. The magnetic particle motion studies suggests that the primary motion due to the magnetic field is the spinning of the magnetic particles, promoting de-agglomeration of the guest particles as well as the spreading and shearing of the guest particles onto the surface of the host particles. However, the effect of the translational speed is also significant as it allows for the impaction of one particle onto another, promoting coating. The parameters must be considered during MAIC are particle size of guest particles and host particles, guest to host size ratio, magnetic to host size ratio, processing time, current or voltage and frequency, magnet to powder mass ratio, current and frequency, magnetic particle speed etc

Ramlakhan M. et al. (2000) conducted an experiment to evaluate the effectiveness of the MAIC device in modifying the surface properties of cornstarch and cellulose (host particles) when they are coated with silica (guest particles). It was observed that very large agglomerates of silica were broken up into smaller primary sizes (de-agglomeration) during the MAIC process and soft organic materials (cornstarch and cellulose) get coated maintaining almost their original shape and size. The number of guest particles (coating particles) on the surface of the host particles (particles to be coated) has only a minor effect on the flowability once the cohesion force is reduced by one or more coating particles and hence even with a very discrete coating on the surface of the host particle there is a significant improvement in the flowability of the material. Similar study was done by Raizza R (2006) where the coating of ibuprofen with two different Silica, R 972 and EH-5 is done to increase its flowability. When the primary guest particles are in the sub-micron range, the attraction forces Van der Waals, electrostatic etc. among the primary particles are relatively very strong and require larger forces to separate them. Smaller host particles can obtain larger velocities than larger host particles from collisions with the magnetic particles, resulting in higher forces of impaction, sufficient to break the agglomerated guest particle structure. Yang J. et al. (2005) observed that the reduction in the cohesion force for the coated particles is inversely proportional to the size ratio of the guest particles and the host particles, indicating that smaller guest particles provide a larger reduction in the cohesive force. According to Singh P. et al (2001) model, the coating time in the MAIC device depends on the density of host particles, the diameters of the host and guest particles, the initial and final bed heights, and the material properties of the host and guest particles. Also, there is an optimal value of the bed height for which the coating time of the host particle is a minimum. The coating time increases sharply when the bed height is smaller or larger than the optimal value, and also when the diameter of host particles is increased. This model also suggests that the coating time decreases when the initial bed height is increased and also when the ratio of host and guest particle diameters is reduced[18,29.)]

Aqueous Film Coating Technology

The sugar-coating process is very time consuming and it is depending on the skills of coating operator, this technique has been replaced by film coating technology. This technique was started with the use of organic solvents like methylene chloride but now has been replaced with aqueous film coating due to environmental and regulatory considerations. Moreover, the cost of any organic solvent is far more than the cost of purified water. Therefore, the conversion from organic solvent-based coating to aqueous solvent based coating makes the coating process more economical, though initially it may need a little more investment to upgrade the coating facility. The need of this upgradation arises due to the need of higher drying capacity (the latent heat of water is 2200 kJ as compared to 550 kJ for methylene chloride which implies that to evaporate water one will need 4 times more energy as compared to methylene chloride)[21].

The problems associated with organic solvent-based film coating and the advantages of aqueous based systems have long been recognized. Film coating technology has now advanced to the level where aqueous coating has become a matter of routine coating rather than the exception. The successful introduction of a wide variety of aqueous based film coating products (by M/s. Ideal Cures Pvt. Ltd., under the brand name INSTACOAT) has

resulted in easy conversion from organic solvent-based coatings to aqueous film coating for several companies; many of them still use the conventional coating equipment.

Development of film coating formulation

The optimization of film coating formulation may be necessary to improve adhesion of the coating to the core material, to decrease bridging of intagliations, to increase coating hardness or to improve any other property that the formulator deems deficient. The development scientist has to consider three major factors which can affect the film quality tensile strength of the film coating formulation (mainly dependent on polymer properties), elasticity of the resultant film (mainly dependent on properties and quantity of plasticizer used) and the film-tablet surface interaction (each and every ingredient used in the coating formulation can affect this interaction and can change the adhesion properties of the film on the tablet surface). Due to these important factors, it becomes very important to use the most optimized coating formulations in order to get the best results[(22).]

Supercell Coating Technology

Supercell Coating Technology is a revolutionary tablet coating that accurately deposits controlled amounts of coating materials on tablets—even if they are extremely hygroscopic or friable. Inconsistent and semiperfect condition, this “standard” practice of tablet coating often delivers a non- homogenous product. Because the tablets are loaded in large rotating pans and vented for hot air drying, edges of tablets can get grounded off, intagliations can get filled in by coating material, and edges and corners may not be coated with the same thickness as the tablet faces. The inaccuracy in deposition of coating material limits the use of modified release coatings. In a laboratory, it is necessary to coat several kilograms of tablets at one time, making R&D of a tablet dosage form costly and difficult.

Furthermore, extremely hygroscopic tablets cannot be coated with current technology, nor can flat or other odd shapes be consistently coated. This process must be run slowly to prevent "twinning," where two or more tablets stick together. Tablets may also be coated in a Wurster-type coating apparatus, but tablet attrition generally prevents all but the hardest tablets from being coated this way [23]

The aim of this study is to investigate the nature of Supercell coating, an on-line tablet coater that employed a unique pattern of airflow. Tablets coated at different spray rates (4, 6, 8, 10, and 12 mL/min) are analyzed to investigate the influence of different wetting conditions on the quality of coats formed. At a spray rate of 6 mL/min, surface roughness is found to be lower than at the other spray rates, and the coat appears smoothest, whereby droplets seems fused together. At higher spray rates, the droplets appear as branching arms and scale-like structures. [24]

Supercell Coating Technology

(SCT) is a invention of Niro Pharma Systems effectively solves all of these problems using a small, modular design.

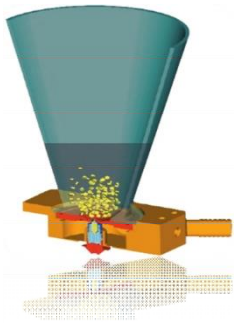

Figure 4: Processing of Coating Technology

SCT's continuous small-batch capable coating process is predictable and efficient. In SCT, the tablets are coated in batches ranging from 30 to 120 grams, which linearly scale up to production capacities. The tablets are coated with the coating spray in the same direction as the drying gas, which results a more efficient process (Figure 4). Due to SCT’s unique air distribution plate design, the tablets move very quickly and predictably through the spray zone, receiving only a small amount of coating per pass, and therefore achieving higher coating accuracy. The process time is short, in seconds or in minutes as opposed to hours, and therefore gentler on the tablets[23].

Niro Company Claims that Conventional Methods of tablet coating have inconsistent and imperfect results, which leads to no-regular results that can affect the behaviour of the tablet. This result can impart an element of variability that gains in significance if a small run of tablets is being produced for clinical trials. In conventional coaters, coating tablets are loaded in large rotating pans and vented for hot air drying, but this means tablet edges can get ground off, intagliations can get filled in by coating material and edges and corners may not be coated with the same thickness as the tablet faces. These types of inaccuracies limit the use of modified release coatings, according to Niro. [25]

SUPERCELL Coating Technology may also use for coating of friable tablets, as well as flat or highly oblong tablet shapes. In this process, drying is very fast, making it possible to coat extremely hygroscopic tablets. The accuracy of deposition is highly enough that Active Pharmaceutical Ingredients can be layered onto tablets, and uniform layers of taste masking or modified release coatings can be applied consecutively within a single continuous batch.

Unique features of super cell coating technology

1. Continuous coating
2. Short processing time
3. Flexible modular design

4. No scale-up to parameters
5. Production capacity of 6 cells coats 200K tph of 120 mg tablets
6. R&D batch size (Minimum batch size of 30 grams)
7. Enhancing technology
8. Multi-layer coating
9. Difficult-to-coat shapes
10. Friable tablets
11. "Low humidity process" suitable for moisture sensitive materials
12. Enabling technology
13. Accuracy of coating (RSD less than 1% demonstrated) [23].

Tablet Coating Defects

An ideal tablet should be free from any visual defect or functional defect. The advancements and innovations in tablet manufacture have not decreased the problems, often encountered in the production, instead have increased the problems, mainly because of the complexities of tablet presses; and/or the greater demands of quality. An industrial pharmacist usually encounters number of problems during manufacturing. Majority of visual defects are due to inadequate fines or inadequate moisture in the granules ready for compression or due to faulty machine setting. Functional defects are due to faulty formulation. Solving many of the manufacturing problems requires an in-depth knowledge of granulation processing and tablet presses and is acquired only through an exhaustive study and a rich experience[26,27,30] Here, we will discuss the imperfections found in tablets along-with their causes and related remedies. The imperfections are known as: 'VISUAL DEFECTS' and they are either related to imperfections in anyone or more of the following factors:

Picking and sticking

This is when the coating removes a piece of the tablet from the core. Over wetting or excessive film tackiness causes tablets to stick to each other or to the coating pan. On drying, at the point of contact, a piece of the film may remain adhered to the pan or to another tablet, giving a "picked" appearance to the tablet surface and resulting in a small, exposed area of the core.[12]

Mottled color

This can happen when the coating solution is improperly prepared, the actual spray rate differs from the target rate, the tablet cores are cold, or the drying rate is out of specification. [12]

Bridging

This occurs when the coating fills in the lettering or logo on the tablet and is typically caused by improper application of the solution, poor design of the tablet embossing, high coating viscosity, high percentage of solids in the solution, or improper atomization pressure.[10]

Erosion

This can be the result of soft tablets, an over-wetted tablet surface, inadequate drying, or lack of tablet surface strength. [10]

Capping and lamination

It is defined as when the lower or upper portion of the tablet separates horizontally i.e., either partially or completely from the main body of a tablet and comes off as a cap, during ejection of the tablet press or during subsequent handling. Separation of the tablet into two or more distinct layers is defined as lamination. It happens due to air entrapment during compression process or because of expansion of the tablet during ejection.[11]

Twinning

Sticking of two tablets together is known as twinning and it is a common problem with capsule shaped tablets.

Peeling and frosting

This is a defect where the coating peels away from the tablet surface in a sheet. Peeling indicates that the coating solution did not lock into the tablet surface. This could be due to a defect in the coating solution, over-wetting, or high moisture content in the tablet core.

Chipping

In this the film becomes chipped, usually at the edges of the tablet.

This is the result of high pan speed, a friable tablet core, or a coating solution that lacks a good plasticizer.

Orange peel

This refers to a coating texture that resembles the surface of an orange. It is defect where the film becomes chipped and dented, usually at the edges of the tablet.[8]

It is usually the result of high atomization pressure in combination with spray rates that are too high.

Blushing

It is defect where the film becomes chipped and dented, usually at the edges of the tablet.

Blooming

In this coating becomes dull immediately or after long time Sticking of two tablets together is known as twinning and it is a common problem with capsule shaped tablets.

CONCLUSION

Coating enhances the quality of products. The coating is applied to a dosage form that already in functionally complete. Coating controls the bioavailability of the drug. Various defects also may arise during coating. These defects can reduce the acceptability by the users and effectiveness of the product. In this review defects of coating, types of coating, factors affecting various coating processes, advantages and disadvantages of coating have been discussed. In future there is enormous possibility of developments in the area of tablet coating to achieve specific benefits. In recent decades, coating of pharmaceutical dosage forms has been subject of remarkable developmental efforts aiming to ensure and enhance the quality of tablet dosage form. Magnetically assisted impaction coating and electrostatic dry coating avoids major disadvantages of solvents-based coating. Methods produce uniform coating but only with specialized instrumentation. Electrostatic dry coating requires special type of powder coating composition. Electrostatic dry coating enables coating of tablet with different colors on either side along-with printing on tablet on pharmaceutical dosage form. Safety aspects of these coatings in humans is still to be unveiled thus further research in health and safety aspects of these technologies will ensure the commercialization of these technologies in pharmaceutical industry. Improvements regarding particle movement, heat and energy transfer, film distribution, drying efficiency and continuous processing have contributed to significantly develop this technology. However, evaluation and success of further constructional improvements in coating methods appear to depend on accurate analytical tools and advanced methods for process modelling and control. In this regard, achieving optimal manufacturing efficiency and high product quality still remains a major challenge for future research.

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