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Review Article

A MALLEABLE TECHNIQUE FOR FUTURE COATING PROCESS–SOLVENTLESS COATING

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ABSTRACT

Coatings are a vital part in the formulation of pharmaceutical dosage form to attain grander aesthetic quality, physical and chemical protection for the drugs in the dosage forms, and modification of drug release characteristics. Most film coatings are pragmatic as aqueous-or organic-based polymer solutions. Both organic and aqueous film coating bring their own shortcomings. Solvent less coating technologies can flabbergasted several of the hindrances associated with the use of solvents in pharmaceutical coating. Dry coating is a coating technology for solid pharmaceutical dosage forms plagiaristic from powder coating of metals. In this technology, powdered coating materials are directly coated onto solid dosage forms without using any solvent and then heated and cured to form a coat. As a result, this technology can flabbergasted such drawbacks caused by solvents in conventional liquid coating as serious air pollution, high time and energy consumption and expensive operation cost encountered by liquid coating. Solventless coating eludes the use of water or it lessens to very trivial amounts with respect to the coating material hence it incapacitates the precincts of orthodox coating such as need for time, energy consuming, drying steps and the most important drug stability issues. In addition, it can ominously shrink the processing time because there is no drying step. These environment-friendly processes are performed without any heat in most cases and thus can deliver an unconventional technology to coat temperature-sensitive drugs. This review converses and associates different solventless coating methods compression coating, hot-melt coating, supercritical fluid spray coating, electrostatic coating, dry powder coating, and photo curable coating that can be used to coat the pharmaceutical dosage forms.

Keywords: Solventless coating technology, Plasticizer-dry-coating, Photocurable coating

INTRODUCTION

At present, the commercially used technology for coating solid dosage forms is the liquid coating technology. Generally a mixture of polymers pigments and excipients is thawed in an appropriate organic solvent or water to form a solution, or dispersed in water to form a dispersion, and then sprayed onto the dosage forms and dried by uninterruptedly providing heat until a dry and smooth coating film is designed. [1, 2] Organic solvents are toxic, flammable, vapor of organic solvent causes environmental pollution and hazard to coating equipment operator, long processing time due to evaporation of solvent, vaporization of organic solvents is energy consumptive, high cost of solvent, strict environmental regulation placed on use of organic solvent [3-6].

Pharmaceutical solid dosage forms include tablets, pellets, pills, beads, spherules and so on, thus are often coated for various reasons: [7-9]

✓ Protection of the drug from the surrounding (environment, air, light and moisture) and thus improve stability

✓ Modifying drug release, as in enteric coating and extended-release formulation.

✓ Masking unpleasant taste or odor of the drug

✓ Improving product appearance and helping in brand identification

✓ Facilitating rapid identification by the manufacturer, the pharmacist and the patient (mostly colored)

✓ Increasing the mechanical strength of the product.

✓ Masking batch differences in the appearance of raw materials

✓ Prevention from destruction by gastric acid or gastric enzymes

✓ Making it easier for the patient to swallow the product.

Organic solvent based coating delivers assortment of expedient polymer alternatives, as most of the polymers are soluble in the wide range of organic solvents. But there are numerous hindrances associated with its use: [10-12]

✓ They are flammable and toxic.

✓ Their vapor causes hazards to coating equipment operator.

✓ High cost of solvent.

✓ Solvent residue in formulation

Strict environmental regulations by US Food and Drug Administration (USFDA), Environmental Protection Agency (EPA) and Occupational Safety and Health Administration (OSHA).

All above complications with organic solvents occasioned in shift to use of water as the preferred coating solvent. Aqueous-based coatings have been progressively used equated with organic-based coatings. However water-based coatings also suffered from following glitches:

✓ Heat and water involved in coating process can vitiate the drug

✓ Validation of coating dispersion for controlling microbial presence

✓ Solvent removal process is time consuming and extremely energy consumptive.

Types of solvenless coating

✓ **Powder/dry coating: different method employed of powder coating-**

Plasticizer electrostatic heat dries coating

Plasticizer-electrostatic-heat-dry-coating (PEH-dry-coating) is named here mainly because this technology is featured by combined usage of plasticizer, electrostatic and heat. In this technology, the coating process comprises the steps of:

➢ positioning pre-heated solid dosage forms in a chamber of a rotatable, electrically grounded pan coater

➢ spraying powdered coating materials and plasticizer on the solid dosage forms in the pan coater during rotation thereof for a pre-selected length of time using an electrostatic spray gun

➢ curing the coated solid dosage forms to form continuous, uniform and flexile coats. During the whole coating process, the solid dosage forms and the chamber are always kept in a hot state by heating the air in the coater or directly heating the coater [13].

Heat dry coating

The advantages of heat-dry-coating include abandoning plasticizer for lower *T*g film-forming polymers or avoiding high concentrations of plasticizer because of pre-plasticization. However, it is still a challenge for heat-dry-coating technology to get a smooth, uniform and thick coating only by the help of the said heat-based adhesion. Heat-dry-coating since only heat was used as a binding force to realize the dry coating of tablets. In this coating technology, Eudragit EPO (a copolymer based on dimethyl aminoethyl methacrylate and methacrylates) particles were continuously spread onto the tablets contained in a lab-scale spheronizer by way of a motorized single screw powder feeder, with an infrared lamp positioned on the top of the spheronizer as a heating source, without using any solvent and plasticizer [14].

Plasticizer dry coating

The first dry coating technology is mainly based on the usage of plasticizers. Here, this technology is referred to as plasticizer-dry-coating. For solid dosage coating, low *T*s or *T*g of the film-forming polymer is essential to protect active pharmaceutical ingredients (APIs) in the dosages from being damaged at a high temperature. Powdered materials are spread onto dosage surface simultaneously with the plasticizer spraying from separate spraying nozzle. The sprayed liquid plasticizer would wet the powder particles and the dosage surface promoting the adhesion of particles to dosage surface. The coated dosage forms are then cured for predetermined time above the glass transition temperature (Tg) of the polymer, forming a continuous film. Dry powder coating can be used for extended release coating with Eudragit-RS and ethyl cellulose powders, and for enteric coating with shellac powder. By means of plasticizer-dry coating technology both tablets and pellets could be coated. The former (tablets) were generally coated in a pan coater. For latter (pellets) a fluidized bed coater is required in order to avoid the formation of agglomerates caused by the smaller size and higher specific surface area of pellets and thus strong interaction [15, 16].

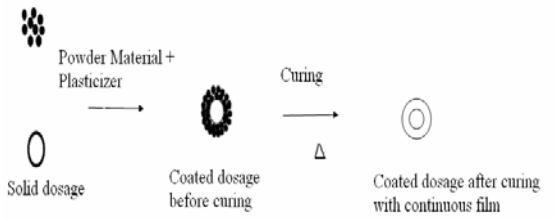

Fig. 1: Schematic illustration of the film formation in the plasticizer-dry coating

Electrostatic dry coating

The principle of electrostatic powder coating involves 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. According to the charging mechanism, there are two types of spraying units:

➢ corona charging

➢ tribo charging

Steps in the deposition of charged particles onto the substrate are a) Charged particles are uniformly sprayed onto the earthen substrate in virtue of mechanical forces and electrostatic attraction, b) Particles accumulate on the substrate before the repulsion force of the deposited particles against the coming particles increase and exceed the electrostatic attraction, c) Finally once the said repulsion becomes equivalent to the said attraction, particles cannot adhere to the substrate any more, and the coating thickness does not increase any more [17, 18].

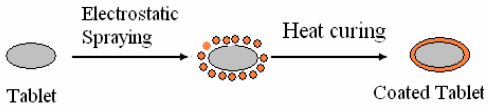

Fig. 2: schematic diagram of electrostatic dry coating

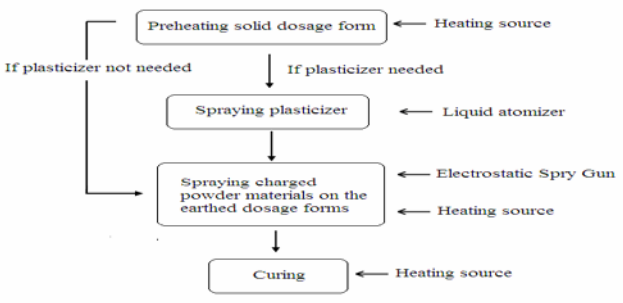

Fig. 3: Flow chart for dry powder coating

Magnetically assisted impaction coating (MAIC)

The magnetically assisted impaction coating (MAIC) devices can coat soft organic host and guest particles without causing major changes in the material shape and size. Although there is some heat generated on a microscale due to the collisions of particles during MAIC, it is negligible. This is an added advantage when dealing with temperature sensitive powders such as pharmaceuticals.

Mechanism of coating in the MAIC process

Mechanism of coating in the MAIC process is:

Stage-I: Excitation of magnetic particle.

Stage-II: De-agglomeration of guest particles.

Stage-III: Shearing and spreading of guest particles on the surface of the host particles.

Stage-IV: Magnetic-host-host particle interaction.

Stage-V: Magnetic–host–wall interaction.

Stage-VI: Formation of coated products

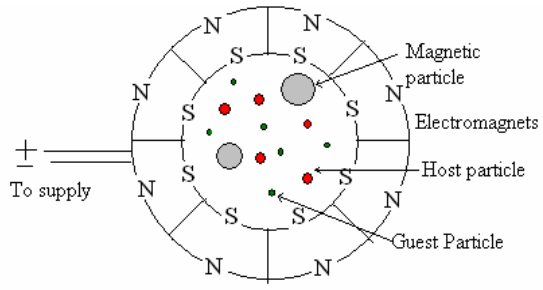

Fig. 4: Schematic diagram of MAIC

The parameters have to 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. [19, 20]

Plasma polymerization is also known as plasma-enhanced chemical vapor deposition (PECVD). It involves the fragmentation of gaseous monomers into activated species, generally free radicals and ions, which then recombine and condense on the surface of the substrate as a solid polymer film (i.e. in situ polymerization). Plasma polymerization, also known as plasma-enhanced chemical vapor deposition (PECVD), a dry coating method, was chosen to deposit thin hydrophobic polymer films on the surface of amorphous ketoprofen (KET)/Methocel™ E5 aggregate particles [21, 22].

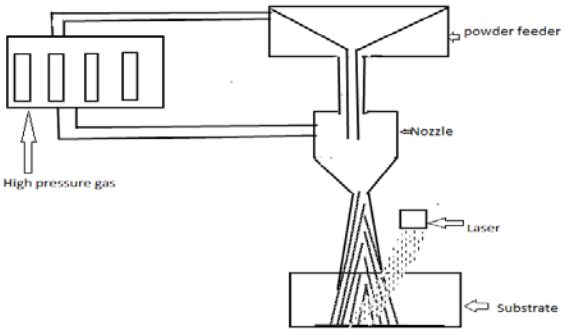

Fig. 5: Plasma enhanced chemical vapor deposition

Hot melt coating

In hot melt coating method, the coating material is applied in its molten state on the substrate then solidified by cooling. Hence, the necessity of the application of any solvent is fully eliminated. The choice of the coating excipients depends primarily on its function (e. g., retarding the drug-release rate, preventing environmental degradation and masking unpalatable taste) in the dosage form. Lipid, waxes, fatty bases and hydrogenated vegetable oils are the most suitable coating material in hot melt coating. It offers several benefits and potential for a wide variety of application in pharmaceutical formulation like tablets and pellets. The various technologies of hot melt coatings are: [23, 24]

- Fluidized bed coating (top spray and bottom spray)
- Spray congealing/coating
- Pan coating (pan spray and pan pour).

Supercritical fluid coating/microencapsulation

A new method for coating polymeric thin films on particles has been achieved by simultaneous nucleation of polymeric material out of a supercritical fluid, encapsulating the particles fluidized in the supercritical fluid, and further curing and binding the material coated on the particles Microencapsulation using supercritical fluid technology combines a liquid-like density and solvating power with gas-like transport properties (like viscosity, diffusivity). Carbon dioxide is the most widely used supercritical fluid because of its relatively low critical temperature (31 °C) and pressure (74 bars). The use of supercritical fluid technology, especially CO2 for encapsulation purposes is mainly due to the mild processing condition, allowing microencapsulation of sensitive ingredients for cosmetics, pharmaceuticals. The coating method involves an enclosed system that provides [25, 26].

- For suspension of the solid particles to be coated,
- For dissolution of the coating material in the supercritical fluid solvent,
- For temperature or pressure swing operations causing film deposition/coating of the suspended solid particles
- Additional chemical addition and/or thermal cycles providing for any additional reactions required (such as polymerization).

Photo curable coating

Photo curing has wide commercial application in dental and medical fields. It is also used to form films of varnishes, paints, and coatings for paper, plastic, wood, metal surfaces, Composite dental fillings, preventive treatment for caries, assembly of medical devices, and wound dressing. The UV-curable coating is strong and photostable. By changing the pore-forming agent and with choice of material, number of layers and thickness of the coating it was reasonable to produce immediate as well as sustained release. Photocuring systems generally consist of 4 major components: [27,28]

- UV/visible light source
- Specially functionalized liquid pre-polymers or monomers
- An initiator
- Pore forming agents.

Photocuring can be divided into two groups, those that cure by free-radical mechanism and those that cure by an ionic mechanism viz. cationic (mostly), anionic mechanism. There are also some compositions that cure simultaneously by both mechanisms.

Pre-polymer or monomer

Two major classes of photocurable siloxanes are acrylic acid derivatives and enethiols. Most important resins and reactive diluents used in photocurable coatings are epoxy acrylate, polyester acrylate, polyurethane acrylate, hexanediol diacrylate, unsaturated polyester, trimethylolpropane triacrylate, tripropyleneglycol diacrylate [29].

Photoinitiators or catalysts

Most of the photoinitiators contain a benzoyl group, which is mainly responsible for the absorption of the energy from the light. By the absorption of radiation energy formation of a radical pair takes place. During UV curing these radicals add to the double bounds of the unsaturated reaction partner. The photochemical formation of a radical pair can be monomolecular reaction or bimolecular reaction. Photoinitiators of the monomolecular type are more effective than bimolecular combinations (for instance benzophenone/amine). Photoinitiators derived from phosphine oxides (mono-and bisacyl phosphine oxides) are of special interest these days. The mechanism of the photochemical curing process can be described in following three steps Initiation, Propagation, Termination. Examples of monomolecular-type photoinitiators are Benzoin ether, Diethoxy acetophenone, Hydroxyketones, Aminoketones, Bisacyl phosphine oxides,etc [30].

UV/Vis light source

An often-used lamp type is the 80 W/cm medium-pressure mercury lamp, which emits a broad spectrum in the short wavelength range from 200 to 320 nm but also at discrete wavelength numbers of 360, 410, and 430 nm [31].

Pore forming agents

The initial study performed by Wang and Bonger, where UV light was used to cure derivatized silicon polymer films on non-pareil beads in small-scale coating equipments, but film formed by this method is complete and almost perfect barrier to drug diffuse, such drug release depend on defects or weak points in the coating. Therefore they found need to incorporate pore forming agents in the polymeric film to prepare functional coatings (e. g. Immediate, sustained, or delayed release). Example of pore forming agents are Lactose, sodium chloride, Explotab, Ac-Di-Sol, PEG 800, etc [32].

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. Finished product is a tablet within a tablet. Advantages of the method include the capability to physically separate two incompatible drugs within the same dosage form, which is commonly achieved using multilayer tablets or compression coated dosage forms. In addition incompatible ingredients can be conventionally separated by this process. However this process has disadvantages of mechanical complexity and therefore has not proven the preferred method for the tablet coating. The only requirement for producing the compression-coated tablet dosage form is that the core material should possess

the ability to flow into a die during production. Microcrystalline cellulose, colloidal silica, mannitol, lactose are some directly compressible excipients [33].

Coating process

- Punches form cup of coating material in lower die
- Drug is filled in that cup
- Coating material is compressed on the cup

Machinery employed regarding solvent less coating process:

- ✓ Fluidised bed coating
- ✓ Dry laminating machine
- ✓ 5-roll coating machine
- ✓ Hot melt coating machine
- ✓ Extrusion coating machines
- ✓ Silicon coating machines
- ✓ Solvent less laminating machines
- ✓ Pressure sensitive coating machines
- ✓ Rotogravure coating machines

Liquid coating vs. powder coating

Fig. 6 describes some basic step of liquid coating and powder coating. In liquid coating huge energy is use for evaporating solvent, while in case of powder coating; energy savings can be achieved due to absence of liquid evaporation step is not required.

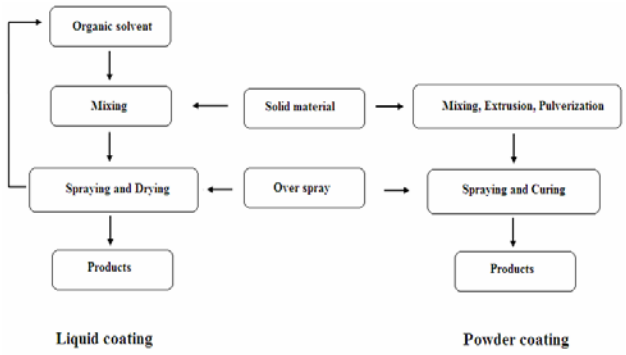

Fig. 6: Difference between liquid coating and powder coating

CONCLUSION

Although these methods have greater assistance than conventional coating methods, before commercialization of these methods further work should be focused on scale-up tests, functional detection of coated solid dosage forms such as drug release profile and clinical tests to make them constructive, cost effective and safe. The solvent less coating techniques mentioned annihilate plentiful drawbacks complying with the conventional solvent based coating systems. Electrostatic dry coating avoids major disadvantages of solvents based coating. Both methods produce uniform coating but needs specialized instrumentation. Electrostatic dry coating requires special type of powder coating composition.

CONFLICT OF INTERESTS

Declared none

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