REVIEW ARTICLE

Overview of Multi-Unit Pellet Systems

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Abstract

When an elderly patient requires a customized release pattern for a medication, an oral route of administration presents a challenge because the patient may find it difficult to swallow. In situations where rapid disintegration without sacrificing the original release profile is preferred, multiparticulates are the recommended dose form. As will be discussed later in this review article, compressed multi-particulate systems made using pellets have a number of pharmacokinetic, pharmacodynamic, and commercial benefits. It covers not only the various kinds of controlled-discharge pellets that may be condensed, forming multiple unit pellet systems (MUPS) but also the characteristics of those pellets, the core material, and the compressible excipients that control how the pellets compress. In addition, a thorough discussion of the physicochemical characteristics of pellets and MUPS formation techniques is provided in this article.

Key words: Delayed-release, drug stacking, multiunit pellet system, pellet compression, sustained-release

INTRODUCTION

An adequate dose form for senior people is highly anticipated, given the large number of elderly individuals in contemporary culture. Owing to the slower physical processes, like swallowing, the traditional types of dosing have limited applicability. Research suggests that pills measuring 7–8 mm are the simplest to ingest, whereas 8 mm tablets are the easiest to manage. Consequently, tablets have certain inherent issues as dosing forms for older patients because it is difficult to create a tablet size that is at the same time simple to swallow and handle.[1,2]

There have been attempts to create a fast-disintegrating tablet since elderly individuals prefer pills that are simple to grip and swallow.[3] This kind of tablet is easy to swallow by patients of any age or location, and it dissolves in a little water in the mouth.

Orally disintegrating tablets are designed to quickly release medication by dissolving in the oral cavity. In this instance, specific dosage forms that can administer the medication in a predetermined way must be designed. When saliva comes into touch with the fast-disintegrating drug delivery tablet, the medication dissolves as well as disintegrates quickly in the oral cavity, creating a solution or suspension that can be administered.

Particles that are breaking down from the tablets in the suspension situation have a changed release profile. In this instance, the modified release system's dosage option is multi-particulates. These dosage forms, known as multiparticulate systems, use small, discrete particles with a consistent release profile to generate a therapeutic dose.[4] Pellets packed into capsules are the most commonly utilized multi-particulates. Multi-particulates that are delivered orally include granules, mini-tablets, powder crystals, and ion-exchange resin particles. Parenterally administered multi-particulates include liposomes, nanoparticles, nanospheres, nanocapsules, microparticles, and various vesicular formulations.

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THE MULTIPARTICULATE DOSAGE FORM'S FEATURES

There are several reasons why multiple dose forms are preferable to single units when it comes to drug delivery[5]

The individual components of these oral multiple-unit formulations disperse over a sizable portion of the digestive system when taken orally. These microscopic particles (<2 mm) function as liquids and quickly exit the stomach. Multi-particulates' small size allows for equal dispersion throughout the gastrointestinal tract, which may enhance bioavailability and lower local drug concentrations. It helps lower the possibility of toxicity and adverse effects as a result.[6-8] A change in the medicine's bioavailability brought on by a decreased meal effect or an early release of the medication from enteric-coated doses in the stomach may cause the drug to degrade or irritate the stomach mucosa. Compared to enteric-coated tablets, coated pellets have a faster transit time, which can reduce or eliminate these effects.[6,8]

The entire pharmacological dosage is split up into several units in multiple-unit systems. Unlike a single-unit system, some devices in the system failing would not have a substantial effect on the dosage. This phenomenon can be seen in sustained-release single-unit forms of administration, when a medication failure could result in dose dumping.[5] Additional benefits of this multiplied dose include the simplicity with which the concentration of a dosage unit can be adjusted, the ability to administer drugs that are incompatible in only one dosage unit by dividing them into distinct multi-particulates, and the ability to combine multi-particulates with varying drug release rates to achieve the intended overall release profile.[9]

System compressed multiparticulate

Particles that are discrete and have the desired release characteristic can be compacted into tablets or put into capsules. Because compression in tablet form is more economically viable and has higher industrial productivity than filling in capsule form, it is preferred. Compared to a capsule, a compressed tablet made with a super disintegrant dissolves quickly in water and is easier for the patient to swallow. The compressed multi-particulate technology reduces dusting during manufacture as well.

The system of multiple unit pellets (MUPS)

The compressing system of pellets known as MUPS has the same releasing characteristics as uncompressed pellets. Some cushioning excipients are used in their formation, which aid in the compressing of pellets. It is possible to combine drugs that are incompatible as one of the dose form's components. MUPS can be used to achieve varied release patterns of the same medicine or distinct pharmaceuticals.

The benefits of multiple unit-specific systems

Compared to other traditional dosage forms like tablets and capsules, modified release dosage forms, such as prolonged release and postponed release dosage formats with multiple units, like pellets, offer a number of advantages. Because MUPS's smaller pellets move through the small intestine quickly and uniformly, there is a decreased risk of localized discomfort, uniform absorption of medication, and increased bioavailability.[10] Pellets dissolve more quickly in the small intestine when they are uniformly emptied from the stomach, which leads to an earlier tmax (peak time) as well as Cmax (peak plasma content). With controlled-release formulations, there is less probability of inter-subject differences and more uniform drug release, hence reducing the risk of dose dumping.[10]

The elderly and pediatric populations, who are unable to swallow tablets or capsules, benefit more from multi-unit pharmaceutical supplies (MUPS), such as PrevacidSoluTab.[11] Since the formulation of this prescription is meant to be an oral disintegrating preparation with flavors and sweeteners that stimulate salivation and swallowing, it can be taken without any fluid, such as water, especially when traveling. Divided dosage forms for MUPS tablets are possible without sacrificing the coated particles' ability to release medication. When swallowing, MUPS are less likely to stick to the esophagus.[12] Because of compression, tablets with smaller volumes or sizes can nevertheless have a complete release profile.[13] One way to minimize the need for gelatin is to compress coated pellets inside tablet forms instead of filling them into capsules. Being a tablet dose form, MUPS provides all the processing benefits of tablets over capsule preparation. Pellets' ability to entrap medication within the matrix contributes to their stability both physicochemically and microbiologically.

Since manufacturing capsules take longer than making MUPS, a quick manufacturing procedure can reduce processing costs. The dose forms for MUPS exhibit a low degree of tampering. Pellets help to lessen dust issues, which are noticeable in the production of tablets.[14] In contrast to non-uniform-sized granules, pellets have a nearly spherical shape, excellent flow characteristics, and ease of compaction processing. Less lubrication is typically needed in these compositions to improve flow. By prolonging the product's patent life or line extension, MUPS technology can prolong the life cycle of a product. While MUPS is an extremely versatile dosage form, it is also very challenging to develop and tough for rivals to simply copy.

Attributes of MUPS

MUPS is a dose form in the form of tablets that have all the characteristics of a traditional compressed tablet. The crushed pellets are not supposed to fuse to form a matrix that is challenging to break apart throughout the compression process. In gastrointestinal fluids, this causes quicker disintegration and breakdown into individual pellets.[15] The

final medication release profile cannot be impacted by the compression procedure. MUPS is composed of coated pellets in the reservoir type; the polymeric coating is designed to sustain compression forces and not break even during deformation. For a tablet containing compressed pellets to survive mechanical shocks during production, packaging, shipping, and dispensing, it must have the highest possible physical strength.[6] Compressed MUPS should make film coating easier if necessary because of their extremely smooth, uniform surface that is free of pinholes and other flaws. Smaller, coated particles compress more readily than larger ones. Smaller particles, however, have difficulty with the covering.[16]

Smaller particles can be efficiently covered by side sprinkling on a twirling motion of particles when the small fragments have an irregular shape.

Pellets: An Ambitious Choice for a multi-particulate structure, the properties of the multiple-particulate system can be affected by the pellets' density, porosity, content, and size. Understanding the compressible characteristics of uncoated pellets can help in the formulation of multiple-unit tablets. Pellet consolidation and compact behavior deviate from the same material's compressive strength. Nevertheless, the technique of creating films with aqueous dispersions is difficult.[4] Aqueous dispersions of polymer particles come into close proximity to other particles in a closed, compact order during the drying process. The strong frictional tension between the water and air causes the copolymer spheres to become saturated with water.[17]

The aqueous dispersions also contain other ingredients, such as surfactants, which act as regulators throughout the production process. Other materials, like polymers and anti-tacking agents, are also employed to enhance the coating process and the properties of the film. The plasticizers are added to the polymer particles to promote their coalescence, which softens the particles and lowers the minimum film-making temperature (MFT).[18] Polymer films form at the glazing temperature of the polymer or at the minimum film-making point of the aqueous phase of the dispersion. The minimum film temperature (MFT) is the temperature that is needed to produce a continuous film under uniform drying conditions.[19] Below MFT, the dry latex is transparent and powdery, but it does not possess the same qualities as when it dries.

TECHNIQUES FOR PELLET PREPARATION

Extrusion and spheronization

The four basic processes for spheronization and extrusion are as follows:

- Moist granulation: Making the dough or granules from a moist bulk
- Spheronization: This process breaks the extrudate and rounds it off into round spheres
- Extrusion: This process turns the moist dough into cylinders
- Drying: This process dries the spheres or pellets.

Using granulating liquid, powder ingredients, and medication are combined to create dough, which then explodes from an extruder. Pellets are formed by spheronizing extrudates into spherical beads. Extrudates go through a number of changes to become pellets [Table 1], which are then dried.[20]

Extrusion with hot melt (HME)

This process involves subjecting the mixture to high pressure and temperature, which causes the medication to solidify and extrude, dispersing it at the molecular level throughout the matrix. Pellets can then be created by further processing the extruded material. Due to its ability to boost the medications' solubility, acceptance, and therapeutic efficacy through the mechanism of action of a solid solution, hot melt extrusion is frequently utilized in the administration of poorly soluble pharmaceuticals.[21]

Layering of powder

With the aid of binding solutions, this approach entails depositing repeated layers of dry medication powder and excipients on ready-made nuclei, such as sugar beads and MCC spheres. Powder layering calls for specific tools like a spheronizer because it entails applying dry powders and binding agents at the same time. To prevent powder loss in the goods chute as the powder is scooped up by the moist mass of pellet being layered, a crucial prerequisite for this

Table 1: Phases of the spheronization process's pellet formation

Phase	Description
Extrudate	Spheronization is applied to the end result of the extrusion process.
Chopped Cylinders	It breaks up extrudates into tiny cylindrical pieces.
Round-ended Cylinders	The hatch plate gives the cylinder's terminal section a rounded appearance.
Dumbbells	Later cylinder shapes brought about by spheronization
Ellipsoids	Later types of cylinders as a result of ellipsoidal product pheronization
Pellets	The finished product is spherical and round.

operation is that the product container has solid walls devoid of any holes.[22,23]

Suspension/solution stacking

The Fluid Bed Coater is used to spray coating or drug ingredients onto the pellets or cores. Solvents used for coatings can be aqueous or organic, and the liquid might be in the form of a solution or dispersion. When layering by solid dispersion, the coating must be completed at the glass transition temperature and then cured. The Wurster technique is frequently employed for layering solutions or suspensions.[24]

The globular is a procedure that creates the droplets and then turns them into solid pellets or beads.[22,25] There are two procedures connected to globulation: Spray drying is the process of spraying a medication suspension or solution – free of excipients – against a heated stream to create more spherical and dry particles. This procedure is frequently used to increase the bioavailability and dissolution rates of medications that are not very water- soluble [Table 2].

Spray congealing

To create spherical congealed pellets, the medication is broken down or distributed in a hot melt of gums, waxes, or fatty acids and then sprayed into an air chamber that is heated below the point of melt of the formulation's constituent parts.

Pellet compression without coating numerous theories have been put forth to explain how uncoated pellets shrink

The most well-known mechanism consists of five steps: Repositioning, fragmentation (the breaking up of pellets into smaller particles), densification (a decrease in the porosity of the pellet), and attrition of tiny parts.[26-28] Pellet compression is a four-step procedure that starts with (1) minimizing the volume of the pellets by rearranging the pellets to fill in spaces between particles. (2) Pellet bed volume decreases through localized surface deformation requiring flattening of the pellets' surface. Pellet bulk deformation, or a change in pellet dimensions, occurs concurrently with pellet densification. (4) The volume reduction stops due to low intra- and intergranular porosity.[29]

Pellet compression with coatings

Pellets are coated to promote mechanical integrity, stability, elegance, and taste masking. If the coated pellets possess specific qualities, they can be compacted into tablet dosage forms. Throughout compression, the coat needs to stay joined to the pellets and not break. For a coating polymer to be compressed, it must possess sufficient flexibility and deformability. Pellets with coatings can sustain compression or undergo plastic deformation. Hard pellets resist compression, but soft pellets experience plastic deformation. The elongation value is used to quantify plastic deformability and flexibility.[30]

Table 2: Marketed MUPS formulations [9]

Brand name	Drug composition	Manufacturer
Losac MUPS	Omeprazole magnesium	Astra Zeneca
Theodur	Theophylline	Key
Tylenol	Paracetamol, Diphenhydramine	Johnson and Johnson
Prevacid Solutab	Lansoprazole	Novartis
Antra MUPS	Omeprazole	Astra Zeneca
Toprol XL	Metoprolol	Astra Zeneca
Beloc ZOK	Metoprolol	OzayPharma

Elements controlling pellet compression behavior

Type of coat

It has been discovered that the most flexible polymers in the acrylic acid polymer class are Eudragit NE 30 D as well as Eudragit NM 30. Even after plasticization, ethyl cellulose is extremely fragile in its natural state. Aquacoat ECD exhibits <5% elongation following triethyl citrate plasticization.[31]

The thickness of the coat

Determines its ability to withstand pellets following compression. However, at a certain thickness, the polymer-polymer binding becomes stronger than the polymer-substrate binding, causing the coat to break.

The plasticized coating

The plasticized coating has good stretching properties that facilitate the plastic formation of pellets under compression, hence increasing its flexibility. Kollicoat® SR 30 D, a polymer for long-lasting release formulations, has an elongation value of less than 1% and is brittle by nature. It is a polyvinyl acetate dispersion stabilized by sodium dodecyl sulfate. Triethyl citrate increases the elongation value of pellets by 150% and supports their compressibility after 20% plasticization.[15] Using strongly bonding polymer-coated beads, the presented study made it possible to manufacture MUPS. The silica covering of polymer top-coated beads was created after moisture activation, providing the required release profile and sufficient mechanical strength.[32]

Pellet size

Smaller pellets require more power to shatter during compression, but larger pellets break easier. In addition, smaller pellets prevent pellet segregation, which in turn prevents issues with content consistency.[33]

Pellet porosity

Extremely porous pellets are easily deformable and can also densify, which modifies the release profile. Less porous and less prone to densification are characteristics of dense pellets. Denser pellets that are smaller in size can tolerate compression without losing their releasing characteristics.[10]

The pellets' mechanical crushing strength

A larger amount of binder is incorporated, which creates the hard pellet but causes the dissolution issue. Pellets with high mechanical strength can bear the increased compression force.

Tableting excipients

A perfect tableting excipient should shield the pellets from one another as they are compressed. Any type of powder, granules, agglomerates, or soft pellets that may be compacted with the pellets can be used as a tableting excipient. The flow property of the tableting excipient is another prerequisite. To prevent segregation during packing into a compression press and preserve uniformity of dosage units, there should be very little variation in the densities of the tableting excipient and the pellets. The compressibility properties of the tableting excipient determine its protective function. The ideal excipient for tableting is a substance with plastic deformation.[34] Excipients other than pellets can be combined with pellets to aid in their compression. Tableting excipients include glycerin behenate, glycerylmonostearate, cellactose, and larger molecules of poly(ethylene glycol) (PEG 3350, PEG 6000). Granular-grade excipients such as Avicel PH 200 can also be utilized.[34] Pellets and grains for cushioning: In nature, cushioning pellets either crumble or distort. Pellets that are disintegrating have a tendency to shatter when compressed, whereas pellets that are deforming experience deformation instead of breaking and aid in the compression of drug-loaded pellets.[35,36] To protect pellets during compression, cushioning excipients are created utilizing a variety of methods, such as co-spray drying with stearic acid.[37] A new cushioning excipient was created. These excipients aid in improving compressibility and lowering yield pressure.[38] After compression, the cushioning layer with a microcrystalline basis on the pellets coated with prolonged-release ethyl cellulose exhibited an intact release profile. Glidants were found to significantly reduce coat rupturing under compression, according to research.[42] A rotary tablet press was used to compress ethylcellulose-coated pellets made of co-spray-dried micronized lactose and mannitol.[39] The MUPS tablet's mechanical strength was greatly enhanced by the longer dwell period during compression. Nonetheless, the mean dissolving time of MUPS decreased with increasing compression force.[40]

Compression force

The force used to compress pellets during tableting is contingent upon the characteristics of the pellets. Certain pellets have an extremely low tensile strength because they rebound elastically after compression. To achieve the appropriate tensile strength for soft pellets, compression force optimization is required.

Compression speed

Pellets that are compressed at a high speed tend to shatter and experience attrition.

MUPS characterization

The dissolution of MUPS into media should be used to evaluate the release profile. Evaluations and comparisons with traditional tablets should be made for hardness, friability, and disintegration. To evaluate the intactness of the coating material, the pellet coat can be characterized using scanning electron microscopy.

CONCLUSION

It is a difficult undertaking to create a quickly disintegrating tablet by compressing multiparticulates with an intact release profile. Choosing the right pellet type according to dosage and excipient type for tablet compression are essential step in achieving the right dosage form. The pellets need to have sufficient hardness to endure compression stress. Pellet coats need to be sufficiently flexible so they do not burst under compression. Care must be taken while selecting a tableting excipient to provide improved protection for the pellets under compression and excellent flow properties that avoid pellet segregation.[41]

REFERENCES

1. Sugihara M, Hidaka M, Saito A. Discriminatory features of dosage form and package. Japanese J Hosp Pharm 1986;12:322-8.
2. Que L, Wu W, Cheng X, Hu T. Evaluation of disintegrating time of rapidly disintegrating tablets by a paddle method. Pharm Dev Technol 2006;11:295-301.
3. Chang RK, Guo X, Burnside BA, Cough RA. Fast dissolving tablets. Pharm Tech 2000;24:52-8.
4. Celik M. Multiparticulate Oral Drug Delivery. Compaction of Multiparticulate Oral Dosage Forms. 1st ed., Ch. 9. New York: Informa Healthcare; 1994. p. 181-215.
5. Bechgaard H, Nielsen G. Controlled-release multiple-units and single-unit doses a literature review. Drug Dev Ind Pharm 1978;4:53-67.
6. Bashaiwoldu A, Podczeck F, Newton J. The application of non-contact laser profilometry to the determination of permanent structural change induced by compaction of pellets - II. Pellets dried by different techniques. Eur J Pharm Sci 2004;22:55-61.

7. Collett J, Moreton C. Pharmaceutics: The Science of Dosage Form Design. Modified-Release Per Oral Dosage Forms. 2nd ed. London: Churchill Livingstone; 2002. p. 289-305.
8. Dechesne J, Delattre L. A new enteric tablet of acetylsalicylic acid. II. Biopharmaceutical aspects. Int J Pharm 1987;34:259-62.
9. Abdul S, Chandewar A, Jaiswal S. A flexible technology for modified-release drugs: Multiple-unit pellet system (MUPS). J Control Release 2010;147:2-16.
10. Johansson B, Alderborn G. The effect of shape and porosity on the compression behaviour and tablet forming ability of granular materials formed from microcrystalline cellulose. Eur J Pharm Biopharm 2001;52:347-57.
11. Shimizu T, Morimoto S, Tabata T. Orally Disintegrating Tablets. US Patient no 6328994 B1; 2001.
12. Marvola M, Rajaniemi M, Marttila E, Vahervuo K, Sothmann A. Effect of dosage form and formulation factors on the adherence of drugs to the esophagus. J Pharm Sci 1983;72:1034-6.
13. Augsburger L, Hoag S, Torrado J. Pharmaceutical Dosage Forms - Tablets. Rational Design and Formulation. 2nd ed., Ch. 3. Hoboken: Taylor and Francis; 2008. p. 509-33.
14. Conine J, Hadley H. Preparation of small solid pharmaceutical spheres. Drug Cosmet Ind 1970;106:38-41.
15. Dashevsky A, Kolter K, Bodmeier R. Compression of pellets coated with various aqueous polymer dispersions. Int J Pharm 2004;279:19-26.
16. Wang L, Heng P, Liew C. Cluster formation and drag reduction-proposed mechanism of particle recirculation within the partition column of the bottom spray fluid-bed coater. J Pharm Sci 2015;104:1303-10.
17. Asa T. Preparation of Tablets from Reservoir Pellets with an Emphasis on the Compression Behaviour and Drug Release, Uppsala University [Ph.D. Theses]; 2003.
18. MacGinity J, Felton L. Aqueous Polymeric Coatings for Pharmaceutical Dosage Forms. 3rd ed. New York: Taylor and Francis; 2008.
19. Wagner K. Aqueous Polymer Dispersions for Extended Release Dosage Forms. Freie Universitaet Berlin, [Ph.D. Theses]; 2002.
20. Lippold B, Monells P. Control and stability of drug release from diffusion pellets coated with the aqueous quaternary polymethacrylate dispersion Eudragit RS 30 D. Pharmazie 2001;56:477-83.
21. Chokshi R, Zia H. Hot-melt extrusion technique: A review. Iran J Pharm Res 2004;3:3-16.
22. Pearnchob N. Evaluation of New Film Coating Processes and Materials. Berlin: Freie Universitaet Berlin [Ph.D Theses]; 2002.
23. Nastruzzi C, Cortesi R, Esposito E, Genovesi A, Spadoni A, Vecchio C, *et al*. Influence of formulation and process parameters on pellet production by powder layering technique. AAPS PharmSciTech 2000;1:14-25.
24. Kovacevic J, Mladenovic A, Djuris J, Ibric S. Evaluation of powder, solution and suspension layering for the preparation of enteric coated pellets. Eur J Pharm Sci 2016;85:84-93.
25. Ghebre-Sellassie I. Pharmaceutical Pelletization Technology. Pellets - A General Overview. 1st ed., Ch. 1. New York: M. Dekker; 1989. p. 1-14.
26. Johansson B, Wikberg M, Ek R, Alderborn G. Compression behaviour and compactability of microcrystalline cellulose pellets in relationship to their pore structure and mechanical properties. Int J Pharm 1995;117:57-73.
27. Johansson B, Nicklasson F, Alderborn G. Effect of pellet size on the degree of deformation and densification during compression and on compatibility of microcrystalline cellulose pellets. Int J Pharm 1998;163:35-48.
28. Nicklasson F, Johansson B, Alderborn G. Occurrence of fragmentation during compression of pellets prepared from a 4 to 1 mixture of dicalcium phosphate dihydrate and microcrystalline cellulose. Eur J Pharm Sci 1999;7:221-9.
29. Johansson B, Alderborn G. Degree of pellet deformation during compaction and its relationship to the tensile strength of tablets formed of microcrystalline cellulose pellets. Int J Pharm 1996;132:207-20.
30. Ghebre-Sellassie I, Kramer J, Blume H. Multiparticulate oral Drug Delivery. Biopharmaceutical Aspects of Multiparticulates. 2nd ed., Ch. 12. New York: M. Dekker; 1995. p. 307-32.
31. Bodmeier R, Paeratakul O. Mechanical properties of dry and wet cellulosic and acrylic films prepared from aqueous colloidal polymer dispersions used in the coating of solid dosage forms. Pharm Res 1994;11:882-8.
32. Osei-Yeboah F, Lan Y, Sun C. A top coating strategy with highly bonding polymers to enable direct tableting of multiple unit pellet system (MUPS). Powder Technol 2017;305:591-6.
33. Béchard S, Leroux J. Coated pelletized dosage form: Effect of compaction on drug release. Drug Dev Ind Pharm 1992;18:1927-44.
34. Torrado J, Augsburger L. Effect of different excipients on the tableting of coated particles. Int J Pharm 1994;106:149-55.
35. Beckert T, Lehmann K, Schmidt P. Compression of enteric-coated pellets to disintegrating tablets. Int J Pharm 1996;143:13-23.
36. Vergote G, Kiekens F, Vervaet C, Remon J. Wax beads as cushioning agents during the compression of coated diltiazem pellets. Eur J Pharm Sci 2002;17:145-51.
37. Li X, Xu D, Li M, Liu L, Heng P. Preparation of co-spray dried cushioning agent containing stearic acid for protecting pellet coatings when compressed. Drug Dev Ind Pharm 2015;42:788-95.
38. Lin X, Chyi C, Ruan K, Feng Y, Heng P. Development of potential novel cushioning agents for the compaction of

coated multi-particulates by co-processing micronized lactose with polymers. Eur J Pharm Biopharm 2011;79:406-15.
39. Hosseini A, Körber M, Bodmeier R. Direct compression of cushion-layered ethyl cellulose-coated extended release pellets into rapidly disintegrating tablets without changes in the release profile. Int J Pharm 2013;457:503-9.
40. Xu M, Heng P, Liew C. Formulation and process strategies to minimize coat damage for compaction of coated pellets in a rotary tablet press: A mechanistic view. Int J Pharm 2016;499:29-37.
41. Patel NG, Patel SA, Joshi AB. Multiple unit pellet system (mups technology) for development of modified release fast disintegrating tablets: A review. J Pharm Sci Innov 2017;6:50-6.

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