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Research Article

A Study on In-Line Tablet Coating—the Influence of Compaction and Coating on Tablet Dimensional Changes

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Abstract. Prior to coating, tablets are usually stored for a definite period to enable complete strain recovery and prevent subsequent volumetric expansion-related coating defects. In-line coating is defined as the coating of tablets immediately after compaction. In-line coating will be expected to improve manufacturing efficiencies. In this study, the possibility of in-line coating was studied by evaluating the influence of compaction and coating on tablet dimensional changes. The use of tapered dies for compaction was also evaluated. Two types of tablet coaters which presented different coating environments, namely the Supercell™ coater and pan coater, were employed for coating. The extent of tablet dimensional changes was studied in real time using optical laser sensors in a controlled environment. After compaction, tablet dimensional changes were found to be anisotropic. In contrast, coating resulted in isotropic volume expansion in both the axial and radial directions. Pan coating resulted in significantly greater tablet dimensional changes compared to Supercell™ coating. There was no significant difference in dimensional changes of tablets coated in line or after complete viscoelastic strain recovery for Supercell™ coating. However, significantly different dimensional changes were observed for pan coating. The use of tapered dies during compaction was found to result in more rapid viscoelastic strain recovery and also significantly reduced tablet dimensional changes when tablets were immediately coated after compaction using the pan coater. In conclusion, the Supercell™ coater appeared to be more suitable for in-line tablet coating, while tapered dies were beneficial in reducing tablet dimensional changes when the pan coater was employed for in-line coating.

KEY WORDS: continuous manufacturing; in-line coating; tablet coating; tapered dies; viscoelastic strain recovery.

INTRODUCTION

Freshly compacted tablets have been shown to display considerable post-compaction viscoelastic strain recovery (1). In order to avoid subsequent coating defects, tablets are typically aged before coating to allow the complete viscoelastic recovery of materials. The possibility of true continuous manufacturing, from powder to coated tablets, is therefore hampered. In-line tablet coating is defined as the coating of tablets immediately after compaction (2). Tablet compaction and coating can be made markedly more efficient if coating can be carried out in line. Although much work has been carried out to study the phenomenon of post-compaction viscoelastic recovery, no publication has evaluated viscoelastic recovery in relation to in-line tablet coating.

Coating of tablets is commonly a unit batch operation. As the pharmaceutical industry gears towards continuous manufacturing, there is growing interest in continuous tablet coaters. A continuous coater is especially suited for in-line coating, as tablets post-compaction can be directly fed into it for coating. The Supercell™ coater is capable of quasi-continuous tablet coating (3,4) where tablets are continuously coated as multiple small batches. Recently, the continuous pan coaters were also shown to be capable of coating tablets in a uniform and consistent manner (5).

The successful implementation of in-line tablet coating is strongly dependent on the balance of internal stresses between the tablet core and the polymer film coat. When the internal stresses present within the film coat exceed the film adhesion strength or tensile strength of the film coat, coating defects such as bridging of intagliations, cracking, or splitting of the film coat will occur (6,7). In addition to post-compaction viscoelastic recovery, the coating process also generates internal stress on the film coat. Several studies have evaluated the dimensional changes of tablets as a result of viscoelastic recovery post-compaction (8–10) and post-coating (11). However, no studies have evaluated these effects in tandem. In contrast to the pan coater where tablets are coated while tumbling in a rotating perforated drum, the Supercell™ coater utilizes air fluidization for tablet suspension and coating. These two coaters' operation is based on very different principles which will indivertibly influence their development for in-line coating and, possibly, the product.

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The use of outward tapered dies during tablet compaction has been suggested to be a practical measure to promote easier ejection of an expanding compact leaving the die cavity (12). Tapered dies will allow the tablet to slowly expand while it is being ejected from the die, even when the tablet is still within the die cavity. On the other hand, the sudden expansion of tablets upon ejection when an untapered die is used can cause stress that may result in capping and lamination. In addition, tapered dies also allow trapped air in the product to be removed as the upper punch enters the die at the beginning of the compression cycle (13). It was therefore postulated that the use of tapered dies during compaction would lead to the production of tablets which would be more suitable for in-line coating.

In-line coating is expected to result in improved productivity of the tablet manufacturing process due to the elimination of hold-up time associated with the post-tableting storage of the newly compressed tablets. Hence, this study aimed to investigate the influence of compaction and coating on the dimensional changes of tablets in order to evaluate the possibility of in-line tablet coating. Two types of tablets with different post-compaction strain histories were prepared by using tapered and untapered (straight) dies. Tablets were coated either in line or after complete viscoelastic strain recovery using both the Supercell™ and the pan coater.

MATERIALS AND METHODS

Preparation of Tablet Cores

A directly compressible blend consisting of 49.5% *w*/*w* microcrystalline cellulose (MCC) (PH102, FMC, UK), 49.5% *w*/*w* pregelatinized starch (PGS) (STA1500, Colorcon, USA), and 1% *w*/*w* magnesium stearate (M125, Productos Metallest, Spain) was used to prepare the tablets. PGS is well known to exhibit substantial volume expansion after tableting and coating (14,15). MCC was added to prepare a good directly compressible powder blend.

MCC and PGS were first mixed using a double cone blender (AR 400E, Erweka, Germany) at 40 rpm for 50 min. Magnesium stearate was subsequently added, and mixing was continued for another 10 min. The resultant powder blend was used to prepare round and biconvex tablets with a diameter of 6 mm using a rotary tablet machine (Courtoy R190F, GEA Pharma Systems, Belgium). Tablets were compacted using either tapered or untapered (straight) dies. The critical dimensions of a standard die taper (tableting specification manual standards) are 0.003 in. outwards and 0.187 in. deep (16). A diagrammatic representation of tapered and untapered dies is shown in Fig. 1a. Tableting was carried out at a speed of 300 tablets per minute with precompression. The compression force applied was approximately 10 kN (88 MPa). Tableting dwell time was approximately 11 ms. Tableting was carried out in a temperature- and humidity-controlled room (25°C/50% relative humidity, RH). No sticking was observed during compaction.

Characterization of Tablet Cores

Tablet weight (B220C, Fisher Scientific, Switzerland), hardness (HT1, Sotax, Switzerland), height, and diameter (293-761-30, Mitutoyo, Japan) were determined. Twenty randomly selected tablets were used for each test and the results averaged. Table I shows the physical properties of the two types of tablet cores prepared.

Measurement of Ejection Force

Ejection force was measured during the tableting process using a data acquisition and analyzing system (DASS, Puuman, Finland) with the aid of a small pressure cell and transducers. The analog signal was digitized using an alternating/direct current converter. During tableting, ejection forces were measured periodically. Ten revolutions of data acquisition were carried out for tableting using the tapered or untapered dies. The data acquisition was triplicated.

Coat Formulation

The coating formulation used was 20% *w*/*w* Kollicoat IR (Red, BASF, Germany) which contained polyvinyl alcohol–polyethylene glycol copolymer as the film-forming polymer. The coating formulation was stirred for at least 15 min prior to use, and agitation was maintained throughout the coating runs.

Tablet Coating

Tablet coating was carried out using the Supercell™ coater and the pan coater. Process conditions for Supercell™ and pan coating are shown in Table II. Tablets were coated to 3% *w*/*w* theoretical weight gain. Theoretical weight gain was defined as the theoretical increase in dry weight of tablets after coating. Tablet coating was carried out either immediately after compaction (in line) or after complete viscoelastic strain recovery of tablets. Tablets were allowed to fully recover by storing them for at least 72 h prior to use. Each Supercell™ coating run took 2.5 min to complete while each pan coating run took about 45 min to complete. Coated tablets prepared using the Supercell™ and pan coaters were of good visual quality and appeared uniform with no apparent surface coat defects.

Evaluation of Tablet Dimensional Changes

Tablet dimensional changes in a controlled environment of 25–30°C and 42–45% RH were measured. A chamber containing a saturated potassium carbonate solution was used to provide the above conditions. The experimental setup is shown in Fig. 1b (17). An instrument consisting of a rotating turntable with 18 angled platforms was enclosed in the chamber. Each platform held an individual tablet. Two laser optical sensors (optoNCDT 1700–20, Micro-Epsilon, Germany) were mounted at positions perpendicular and parallel to the rotating surface. The calibrated laser optical sensors were used for the determination of changes in tablet displacement in both the axial and the radial directions, respectively. Measurements were taken continuously as the turntable rotated, generating real-time data. The displacement sensors operated on the basis of laser triangulation with a resolution of 1.5 μm and a sampling rate of 2.5 kHz. The data obtained were transferred

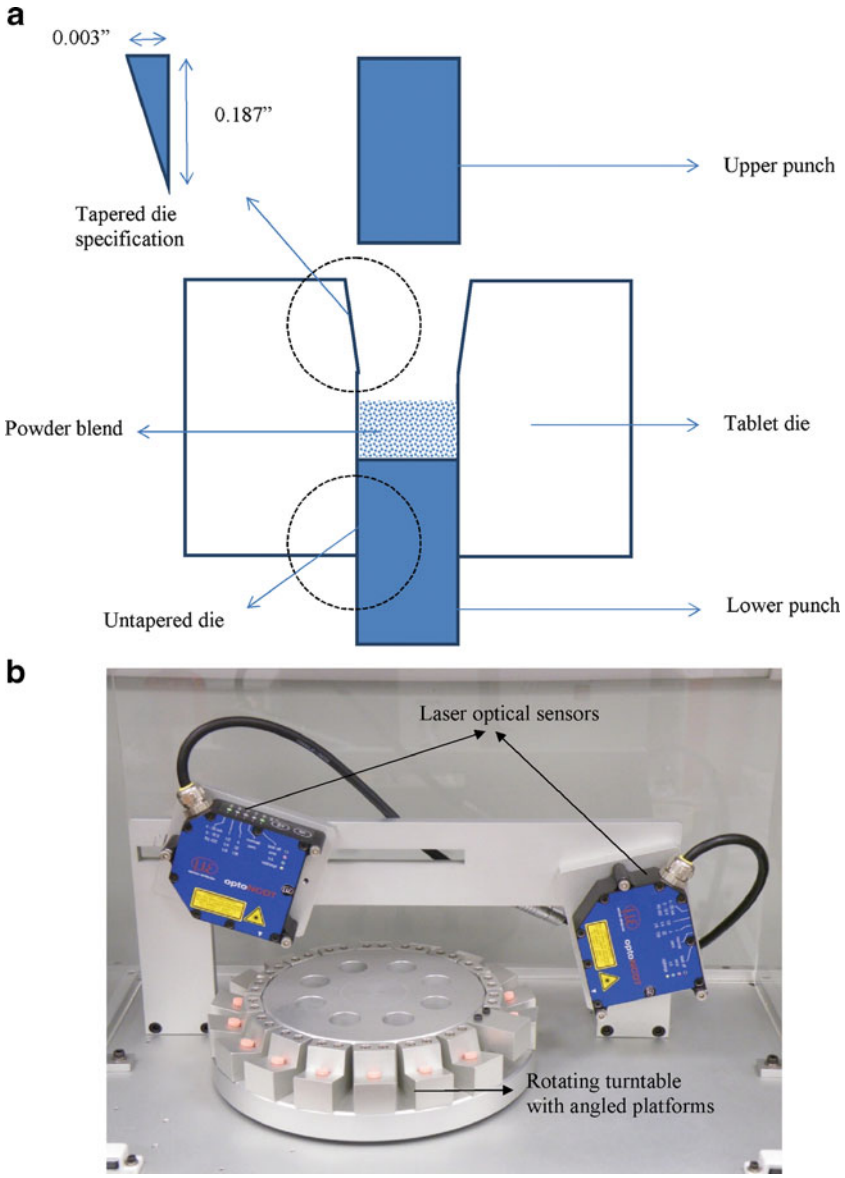

Fig. 1. **a** Diagrammatic representation of tapered and untapered dies. **b** Experimental setup for the evaluation of tablet dimensional changes

Table I. Properties of Tablet Cores Used for Coating

Tablet properties	Dies	
	Tapered	Untapered (straight)
Weight (mg)	118.4±1.5	118.4±1.8
Crushing force (N)	51±2	49±3
Height (mm)	3.966±0.025	3.977±0.034
Diameter (mm)	6.020±0.002	5.994±0.003
Friability (%)	0.0	0.0
Ejection force (N)		
Minimum	592	622
Mean	677	695
Maximum	990	1,253
SD	77	87
RSD	11.4	12.4

SD standard deviation; *RSD* relative standard deviation

to a computer using RS232 cables, and data processing was carried out using MATLAB (R2010a, The MathWorks, USA). Tablet dimensions were recorded every 5 min during the first hour and every 30 min subsequently for 64 h. The dimensional change of tablets in the axial or radial direction was expressed by the following equation:

$$\text{Dimensional change } (\%) = (D_t - D_\text{i})/D_\text{i} \times 100$$

where D_t is the tablet dimension at time = t and D_i is the initial tablet dimension. When tablet dimensions ceased to change over 2 h, the final tablet dimension, D_f, was achieved. Tablet dimensional changes were monitored within 30 s after coating was completed for 65 h, and five tablets were analyzed for each test condition and results averaged. Variability among tablets of each batch was generally low, with relative standard deviations of less than 2% at all the time points and for all conditions.

Table II. Coater Settings for Pan and Supercell™ Coating

Parameter	Value
Pan coating	
Pan diameter (in.)	12
Batch size (kg)	1
Gun to bed distance (cm)	12
Average spray rate (g/min)	3.4
Atomizing air pressure (bar)	2
Pattern air pressure (bar)	2
Pan difference pressure (mbar)	1
Pan speed (rpm)	10
Supplied air velocity (m^3/h)	165–175
Supplied air temperature (°C)	60–65
Tablet bed temperature (°C)	40–45
Supercell™ coating	
Batch size (g)	100
Spray rate (mL/min)	6
Atomizing air pressure (bar)	2
Plenum pressure (mm WC)	1,200
Inlet temperature (°C)	80
Air flow rate (m^3/h)	26.1

Percentage Loss on Drying

The percent loss on drying (LOD) was expressed as the weight lost as a percentage of the initial tablet weight (before drying) and was a reflection of the residual moisture present in the tablets. Tablets were dried at 60°C until constant weight. Percent LOD was measured before and after coating. The percent LOD of tablets equilibrated to 25–30°C and 42–45% RH was also evaluated.

Statistical Analysis

All statistical analyses were performed using Minitab Release 14 (Minitab Inc, USA). Independent sample *t* test was used to compare any two samples at $\alpha=0.05$.

RESULTS AND DISCUSSION

Influence of Die Tapering on Ejection Force

Table I shows the minimum, mean, and maximum ejection forces of tablets compacted using the tapered and untapered dies. Die tapering was generally found to decrease the minimum, mean, and maximum ejection forces. However, only minimum ejection force was significantly lowered ($p<0.05$). The lowering of tablet ejection force demonstrates that the compacts were ejected with greater ease, possibly reflecting more efficient compact stress relief. Tableting problems, such as capping or lamination, could be reduced by the use of tapered dies. The decrease in ejection force during tableting is also useful to prolong the lifespan of the lower punch heads and the ejection cam. Friction is reduced, and it is possible to operate the tablet press at a lower temperature (13).

Tablet Dimensional Changes Post-Compaction

Various methods have been used to quantify the extent of stress relaxation. Some examples include measuring changes in tablet dimensions, changes in porosity (18), or quantifying the energy that is elastically stored after compaction. This energy is regarded as the driving force for stress relaxation (19).

Viscoelastic recovery is commonly defined as the percentage of expansion of the compact after ejection from the die, relative to the initial dimension of the compact (20). Typical analytical methods to measure tablet dimensional changes utilize the micrometer screw gauge (10,21), thermomechanical analysis (10), or linear voltage displacement transducer (8,22). An ideal analytical technique to measure gradual tablet recovery by dimensional measurements should be contactless, continuous, and convenient. The instrument should also be capable of measuring many samples continuously at multiple dimensions and yield precise and accurate measurements (9). In this study, axial and radial dimensional changes of tablets were measured using laser optical sensors capable of contactless, continuous, and accurate analysis of multiple tablets.

Immediately after compaction, the tablets were found to have a percent LOD of between 6.3% and 6.7% (Table III). On the other hand, tablets equilibrated to the environmental condition employed for measurement of dimensional changes had percent LOD of between 5.8% and 5.9%. The moisture loss during equilibration of the tablets caused the tablets to shrink in both the axial and radial directions. Tablet dimensional changes post-compaction were affected by tablet shrinkage due to moisture loss during equilibration and viscoelastic recovery due to compaction. The increase in dimensions due to compaction was corrected for the shrinkage that occurred due to moisture loss at every time point. For instance, if the tablet dimension increased 1% 5 min after compaction but decreased 0.1% during the 5 min, the overall dimension increase is 0.9%.

The height and diameter changes of tablets prepared using tapered and untapered dies are shown in Fig. 2. Freshly compacted tablets were found to increase in height (tapered, +0.30%; untapered, + 0.21%). However, the tablet diameter was found to decrease (tapered, −0.21%; untapered, −0.13%). Shrinking of the tablet has been attributed to the reorganization of the material as a consequence of relaxation (9). This is due to Poisson's effect as viscoelastic recovery related relaxation of molecular bonds within the material matrix axially, in the direction of applied load, shorten in the other direction, the diametrical dimension of the tablet.

There is inherent mechanical anisotropy within tablets as the materials are confined radially by a rigid die while being compressed axially by moving punches (23). Radial and axial stresses and strain exist in the compact due to the highly unidirectional nature of the compaction process. High-pressure zones within the compact were expected to show more expansion than low-pressure zones. Therefore, it is generally well accepted that the radial recovery is less extensive than axial recovery due to the axial nature of compaction (10,24). Consequently, most studies had focused on evaluating changes in tablet height post-compaction. However, this study showed the importance of evaluating both tablet height and diameter changes concurrently.

During compression and air evacuation, the dusty, fine, light, and uncompressed particles are lifted upwards concomitantly. These particles can potentially form a line of uncompressed particles along the point of air evacuation between the cap and band of the tablet, causing capping. As previously mentioned, tapered dies provide an avenue for air to evacuate during compression and promote easier ejection of the expanding compact as it exits the die cavity. Therefore, without die tapering, capping is more likely to occur. In this study, a precompression step was also included during tableting, allowing more time for plastic deformation, and also allows a more gradual escape of air (12).

In this study, die tapering was significant ($p>0.05$) in influencing the extent of dimensional changes in both the axial and radial directions. In the radial direction, rapid contraction and leveling of diameter were observed for tablets prepared using the tapered and untapered dies. However, the modes of axial expansion between tablets prepared using the two types of tablet dies were distinctly different. Tablets prepared using the tapered dies experienced rapid expansion followed by subsequent leveling. On the other hand, expansion was found to increase continually in an almost linear manner for tablets prepared using the untapered dies. Rapid recovery of tablets was viewed to be advantageous for in-line tablet coating as it ensured that viscoelastic recovery was more or less complete prior to coating. Therefore, the use of tapered dies in combination with suitable precompression may be advantageous for successful in-line tablet coating.

Tablet Dimensional Changes Post-Coating

During film formation, individual polymer particles coalesce and fuse together to form a continuous film. Before solidification, polymer chains are mobile and can effectively minimize the level of stresses generated. As the film solidifies, only the film thickness can contract inwards. Film movement in the lateral direction is constrained by the adhesion of the film to the tablet substrate, thus producing internal stress within the film. The anisotropic nature and magnitude of internal stresses are potentially greater with nonuniform volumetric expansion of the tablet core. Polymer chain mobility is restricted, and the stresses are set in. Tablets undergo substantial amounts of dimensional change both during and after film coating. Film adhesion appears to depend on the magnitude of dimensional changes (11). Exposure to different temperatures and relative humidities during coating or storage was found to influence the magnitude and rate of dimensional changes in tablets due to water adsorption and evaporation (7,15). Processing parameters used during coating must be carefully controlled to ensure an appropriate balance between rate of water removal and the need for the coating to remain wet long enough for a high-quality coherent film to be formed (25). The magnitude of the total internal stress in a film coat is greatly influenced by the conditions in which the films are formed, and this magnitude changes on exposure of the product to subsequent ambient storage conditions (26). Large dimensional changes following application of the film coating will increase the internal stresses within the film as flexibility decreases with drying (7).

Figure 3 shows the height and diameter changes of fully recovered tablets which were coated using the Supercell™ and pan coaters. Supercell™-coated tablets were shown to shrink between 0.01% and 0.05%, but pan-coated tablets were shown to swell between 0.27% and 0.90% in both axial and radial directions. Pan coating resulted in significantly higher extents of tablet dimensional changes in comparison to Supercell™-coated tablets ($p<0.05$). Table III shows the percent LOD of tablets used in this study. At the end of Supercell™ coating, the tablets had a percent LOD between 5.6% and 5.9%. This was very similar to the percent LOD of the tablets equilibrated in the measurement chamber (5.3–5.7%). However, at the end of pan coating, the percent LOD of tablets ranged from 3.7% to 3.8%. The Supercell™ coating process appeared to be too short to induce significant moisture loss from the tablets despite the higher temperatures employed during coating. Okutgen *et al.* (7) determined dimensional changes in tablet cores as a function of temperature and RH

Table III. Percent LOD of Coated and Uncoated Tablets Prepared Using Tapered or Untapered Dies

Coated/uncoated tablets	Tapered/untapered dies	In-line/recovered	Equilibrated/unequilibrated	% LOD
Uncoated	Tapered	–	Unequilibrated	6.3±0.0
Uncoated	Untapered	–	Unequilibrated	6.7±0.1
Uncoated	Tapered	–	Equilibrated	5.9±0.1
Uncoated	Untapered	–	Equilibrated	5.8±0.1
Supercell™ coated	Tapered	In-line	–	5.7±0.2
Supercell™ coated	Untapered	In-line	–	5.7±0.1
Supercell™ coated	Tapered	Recovered	–	5.9±0.1
Supercell™ coated	Untapered	Recovered	–	5.6±0.1
Pan coated	Tapered	In-line	–	4.5±0.1
Pan coated	Untapered	In-line	–	3.7±0.1
Pan coated	Tapered	Recovered	–	3.8±0.0
Pan coated	Untapered	Recovered	–	4.4±0.1
Supercell™ coated	Tapered	–	Equilibrated	5.7±0.1
Supercell™ coated	Untapered	–	Equilibrated	5.6±0.1
Pan coated	Tapered	–	Equilibrated	5.6±0.1
Pan coated	Untapered	–	Equilibrated	5.3±0.1

Tablets were coated in line or after complete viscoelastic strain recovery
LOD loss on drying

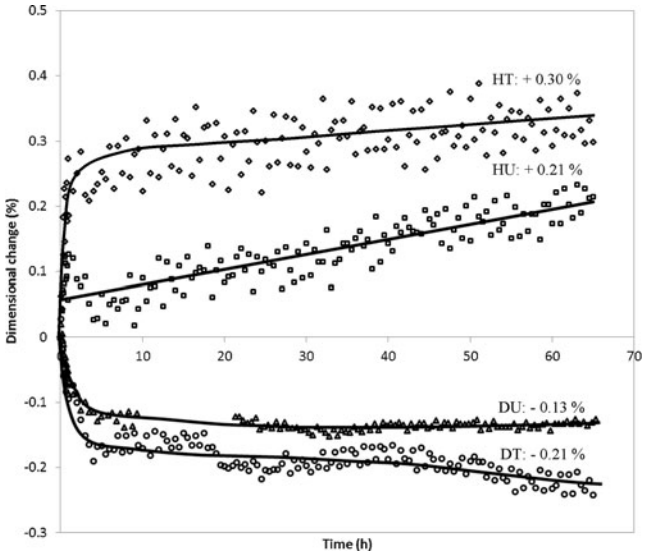

Fig. 2. Height (*H*) and diameter (*D*) changes of tablets prepared using tapered (*T*) or untapered (*U*) dies

to mimic the tablet-coating process. It was shown that the combination of elevated temperature and low RH conditions exacerbated internal stress development in film coats. At this condition, two contrasting effects, firstly, thermal expansion, and secondly, contraction due to water loss, took place. However, contraction due to water loss was found to be predominant leading to a greater extent of recovery subsequently due moisture uptake. Even though the coating conditions employed during Supercell™ coating (high temperature, low RH) were expected to result in greater dimensional changes, optimal process parameters ensured balance in the moisture input and output, thus not affecting the volumetric stresses experienced by the tablets to a large extent. In contrast, the moisture loss from the pan coating process was greater. This would explain the greater moisture uptake and dimensional changes experienced by tablets after pan coating. The results show that some dimensional changes could be attributed to the coating process. In fact, the dimensional changes experienced after pan coating (height, + 0.74 to 0.90%; diameter, + 0.27 to 0.32%) were larger than the dimensional changes experienced during viscoelastic recovery of tablets post-compaction (height, + 0.21 to 0.30%; diameter, −0.13 to 0.21%). The use of tapered or untapered dies was not significant in affecting the dimensional changes of tablets in Supercell™ coating. However, the use of tapered dies during pan coating of fully recovered tablets was shown to marginally lower (tapered—height, +0.74%; diameter, +0.27%) the extent of dimensional change relative to untapered dies (untapered—height, +0.90%; diameter, +0.32%). However, this reduction was not statistically significant ($p>0.05$). Nevertheless, this reduction in dimensional changes may play a more obvious and pertinent role in other types of tablet formulations.

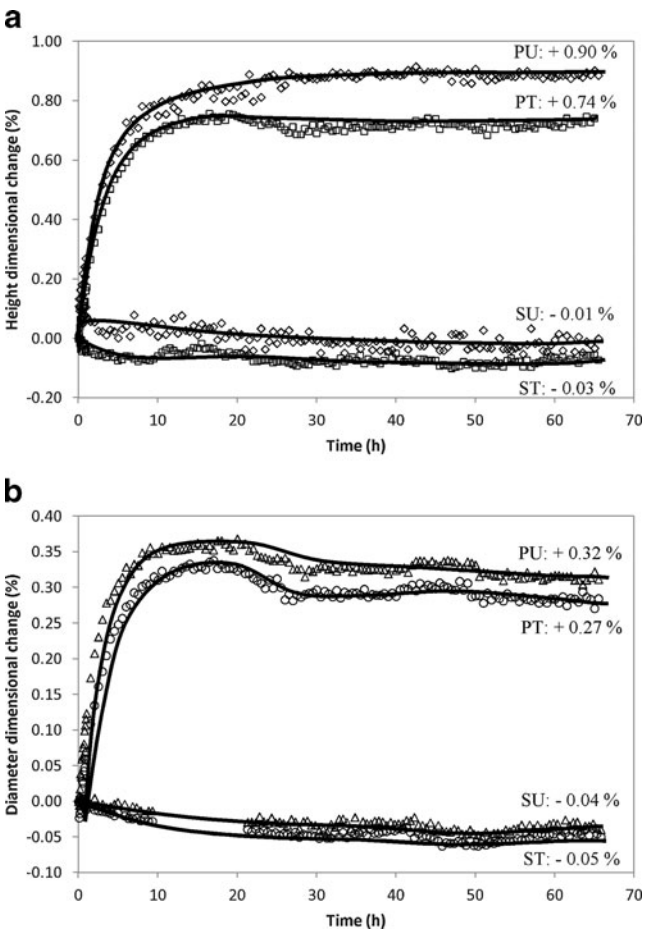

Fig. 3. **a** Height and **b** diameter changes of tablets prepared using tapered (*T*) or untapered (*U*) dies. Tablets were allowed to fully recover before coating with the Supercell (*S*) or pan (*P*) coater

Figure 4 shows the height and diameter changes of tablets after in-line coating using the Supercell™ and pan coater. The use of tapered or untapered dies was not significant in affecting the dimensional changes of tablets coated in line using the Supercell™ coater (tapered—height, −0.15%; diameter, −0.04%; untapered—height, −0.05%; diameter, −0.01%). However, it was significant in affecting dimensional changes of tablets coated in line using the pan coater (tapered—height, + 0.59%; diameter, +0.28%; untapered—height, +1.27%; diameter, +0.50%). In pan coating, the use of tapered dies significantly ($p<0.05$) decreased the extent of tablet dimensional changes. The results suggested that the use of tapered dies was more suitable for in-line coating of tablets when the pan coater was employed. The dimensional changes of tablets after in-line pan coating were also significantly higher than in Supercell™ in-line coated tablets ($p<0.05$), suggesting that the Supercell™ coater was more suitable for the in-line coating of tablets. The percent LOD was 5.7% for Supercell™ in-line-coated tablets and 3.7–4.5% for in-line pan-coated tablets (Table III). Greater dimensional changes were observed in tablets coated in line using the pan coater primarily due to water absorption post-coating. The results are in agreement with the findings obtained from the coating of fully recovered tablets. From the results, it appeared that an effective method to reduce dimensional changes post-coating was to employ coating conditions to achieve final moisture content of tablets as close as possible to the ambient storage conditions. This was the main reason why Supercell™-coated tablets showed excellent dimensional stability.

In Supercell™ coating, the contraction of tablet dimensions in both axial and radial directions was not shown to be significantly different ($p>0.05$). However, in pan coating, the

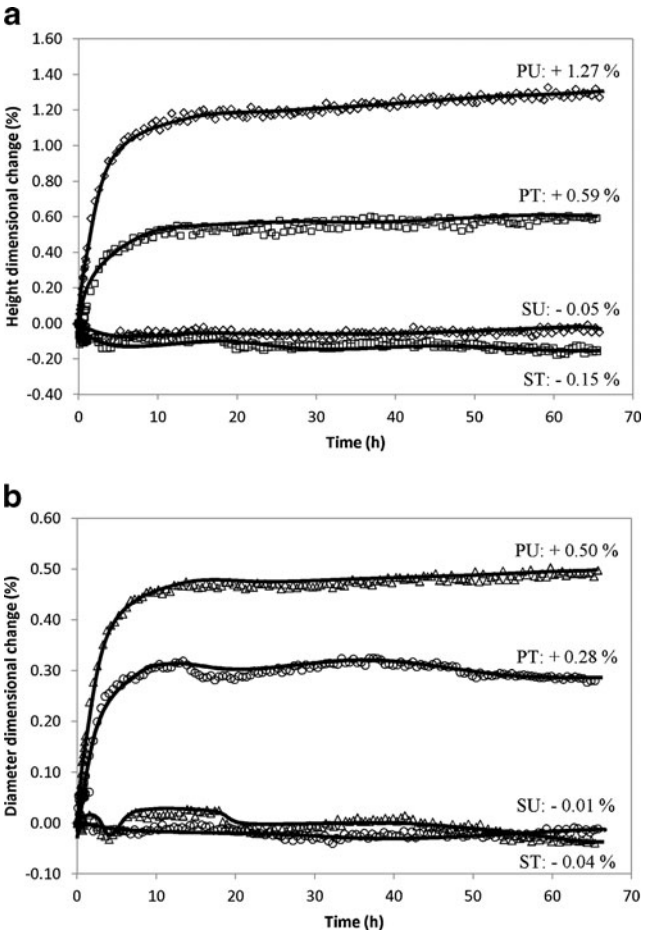

Fig. 4. **a** Height and **b** diameter changes of tablets prepared using tapered (*T*) or untapered (*U*) dies. Tablets were coated in line with the Supercell (*S*) or pan (*P*) coater

axial expansion was found to be significantly higher than the radial expansion ($p<0.05$). This applied to tablets coated both in line and after complete viscoelastic recovery. The reason for this observation could be due to the more uniform application of materials and drying during Supercell™ coating since coating was carried out through air fluidization. Therefore, the extent of dimensional changes due to coating was found to be rather uniform throughout the tablet. In pan coating, the thick tablet bed tumbled in a rotating drum. Therefore, there was less uniform spray and heat applications among tablets which might be exposed or within the tablet bed. The greater expansion of tablets axially than radially is a probable reason as to why the resultant maximum strain or internal stress is often found at the tablet edge (8). Thus, film cracking or splitting are often observed at the tablet edges (27). Increased uniformity of stress application during Supercell™ coating as a result of air fluidization will result in more uniform stress relief. This may lead to fewer stressed zones where coat failures are liable.

In general, the tablets were found to expand or shrink in both the axial and radial directions after coating. This dimensional change behavior was different from that observed as a result of compaction where the tablet expanded axially but shrunk radially. The stress exerted by the coating process, unlike compaction, was in all directions and not just predominantly in the axial direction. Therefore, the same expanding or shrinking behavior was likely to occur in all directions.

Possibility of In-Line Coating

For Supercell™ coating, the coating of tablets either in line or after complete viscoelastic recovery did not result in significantly different tablet dimensional changes ($p>0.05$). The results showed that the Supercell™ coater has immense potential to be used as an in-line tablet coater.

In contrast, the choice of in-line coating or coating after complete viscoelastic recovery had a significant impact on pan-coated tablets ($p<0.05$). When tapered dies were used, greater dimensional changes were generally observed in tablets coated after complete viscoelastic recovery (height, +0.74%; diameter, +0.27%) than in-line-coated tablets (height, +0.59; diameter, +0.28%). On the other hand, when untapered dies were used, greater dimensional changes were observed in in-line-coated tablets (height, +1.27%; diameter, +0.50%) than fully recovered tablets (height, +0.90%; diameter, +0.32%). The results suggest that the use of tapered dies was better for in-line pan coating.

CONCLUSION

In this study, tablets were shown to expand axially but shrink radially post-compaction. The use of tapered dies not only reduced ejection forces in tableting but also resulted in more rapid axial viscoelastic recovery of materials post-compaction.

The coating process caused dimensional changes in tablets. Supercell™ coating resulted in significantly less tablet dimensional changes compared to pan coating for tablets coated either in line or after complete viscoelastic recovery. This suggests that the Supercell™ coater was more suitable than the pan coater for in-line tablet coating. In Supercell™ coating, the dimensional changes in both axial and radial directions were also not shown to be significantly different. However, in pan coating, the axial expansion was found to be significantly higher than the radial expansion. Due to coating using air fluidization, there was uniform distribution of stress during Supercell™ coating. This could possibly result in more uniform stress relief throughout the tablet. Fewer stressed zones within the tablet can help to reduce subsequent coating defects.

In Supercell™ coating, there was no significant difference in the dimensional changes of tablets coated in line or after complete viscoelastic recovery. In contrast, significantly different dimensional changes were observed in pan coating. Die tapering was not shown to be significant in affecting the extent of dimensional changes for Supercell™ coated tablets. However, the use of tapered dies significantly decreased the extent of tablet dimensional changes when tablets were coated in line using the pan coater.

This study has shown the immense prospects of in-line Supercell™ (air fluidization) coating to improve manufacturing efficiencies. With prudent selection of tablet formulations, tableting parameters, coating conditions, and storage environments, it is possible to carry out in-line coating with no visible coat defects.

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