Evaluation of Recent Advances in Continuous Film Coating Technology in Reducing or Eliminating Potential Product Losses

PURPOSE

This study evaluated coating uniformity and tablet appearance in both batch and continuous modes from start-up to shut-down in an improved, fully perforated continuous coater machine. Continuous film coating processes are recognized for their high production rates, but have not gained wide acceptance for pharmaceutical products due to potential product losses during start-up and shut down.[1] Improvements in continuous coater design now allow for processing in both batch and continuous modes. Automatic sequencing of spray guns and additional control mechanisms have been developed to ensure uniform and consistent coating for all tablets, from start to finish, minimizing the potential for product loss.

METHODS

Materials

Calcium and Vitamin D tablets 1500 mg were used as the substrate. The coating system was an Opadry® II, high performance film coating system (85F93169) prepared in water at 20% solids concentration and applied at a target weight gain (WG) of 3.0%.

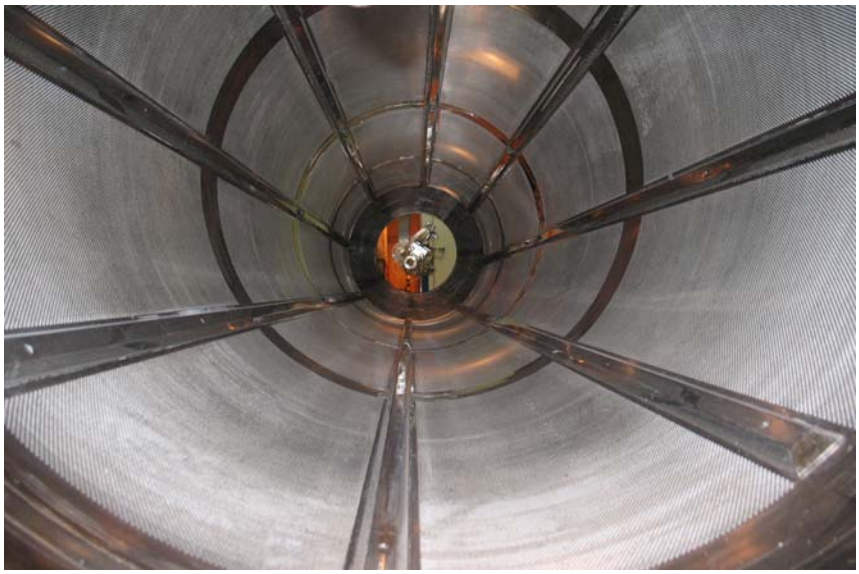
Equipment

Two trials were conducted in a 30” diameter by 15’ long continuous coater (Model HVCC-3015, O’Hara Technologies) (Figure 1) equipped with 28 spray guns (Model S37, Schlick). The spray guns were divided into five independently controlled blocks.

Figure 1. Continuous Coating Pan (O’Hara Technologies)

The continuous coating pan was also equipped with a pneumatically controlled weir plate at the discharge end of the unit that, in a lowered position, contained all tablets within the pan or when raised, controlled the flow of tablets into the discharge zone of the pan. This control mechanism is an enhancement over earlier continuous coater technology and allows for coating of tablets in both batch and continuous modes. Another difference in this equipment versus earlier continuous coating pan designs is the absence of baffles throughout the pan interior (Figure 2). Other than anti-slide bars, tablet movement through the pan is solely controlled via tablet in-feed rates and the height of the weir plate at the discharge end of the pan.

Figure 2. Interior of the Continuous Coating Pan (Spray Gun Manifolds Removed)



Trial 1 - Batch Mode Process

The pan was loaded with tablets via a weigh belt feeder from the in-feed side of the pan to a total fill of 250 kg. The tablets were tumbled gently during the fill process to facilitate tablet movement across the length of the pan. Once the pan was filled, the tablets were heated and the spray was commenced through all 28 spray guns. Spray was continued until the targeted coating amount was applied. Upon completion of the coating, the tablets were cooled and discharged from the pan. Tablet discharge was accomplished by raising the weir plate at the discharge end of the pan and allowing the tablets to flow out under slow (3 rpm) pan rotation. To further facilitate unloading, the entire pan was angled downward toward the discharge via a pneumatic height controller.

Trial 2 - Continuous Mode Process

The continuous mode process was started as described above (batch mode). Once the entire batch reached the target coating application, the weir plate at the discharge end of the machine was lifted, allowing coated tablets to begin discharging. Simultaneously, the weigh belt feeder was started and uncoated tablets began entering the in-feed side of the pan. At the same time, all spray guns were turned off except for the first spray gun block at the in-feed side of the pan. A computerized automatic recipe control system then began sequencing, to the “on” position, the subsequent spray gun blocks as the partially coated tablets progressed down the length of the pan. This was continued until all spray guns were delivering spray and a full

continuous coating mode was achieved. The indexing of the spray guns was controlled to coincide with the rate of tablet feed into the coater. Spray rates were controlled to ensure the target weight gain of coating applied vs. tablet feed rate. The throughput rate of the coater was determined by the rate (kg/hr) setting of the weigh belt feeder introducing tablets into the coater.

To shut-down the coating process, the start-up process was reversed with closure of the discharge end of the pan and reverse sequencing of the spray guns. The aim of this process was to ensure that all of the tablets were consistently coated to the same level throughout the start-up, continuous process and shut-down modes. Once all the spray gun blocks turned off, the pan was discharged as described above in batch mode. The process was controlled to maintain coating temperatures and conditions similar to how these tablets would be coated in a typical (non-continuous) batch coater. The target process conditions are listed (Table 1).

Table 1. Target Coating Process Conditions

	Batch Mode Process Parameters	Continuous Mode Process Parameters
Inlet temperature (ºC)	80-85	80-85
Exhaust temperature (ºC)	50-52	47-52
Product temperature (ºC)	44-49	44-49
Airflow (cfm)	9500	9500
Pan pressure (ΔP)	-0.01	-0.01
Pan speed (rpm)	16	16
Bed depth (in.)	8.5	5.5
Weigh belt feed rate (kg/hr)	n/a	1100-1300
Solution flow rate (g/min)	3000	3000
Coating solids concentration (%)	20	20
Batch size (kg)	250	250 initial fill - continuous thereafter

Color Development and Uniformity Testing

In the batch mode operation, samples were taken every minute from the center of the pan for the duration of the trial. In continuous mode, samples were taken every 10 minutes from the discharge of the pan for the duration of the trial and every minute during the tablet unloading cycle.

These samples were tested instrumentally for color development and uniformity testing using a Diano Color Products Milton Roy Colormate employing the Commission Internationale de l'Eclairage (CIE) L* a* b* system. Total color difference from target reference was determined by calculating the distance between two points in the color space using the following equation:

$$\Delta E^* = [(L^*1 - L^*2)^2 + (a^*1 - a^*2)^2 + (b^*1 - b^*2)^2]^{1/2}$$

The standard deviation of color difference between calculated ΔE values of the individual tablets from each set of samples were compared as a measure of coating uniformity. A ΔE value of <2 indicates no visual difference in color from the target reference color.

This spectrophotometric method for assessing the color development and uniformity of coated tablets in relation to coating process parameters is well documented.[2]

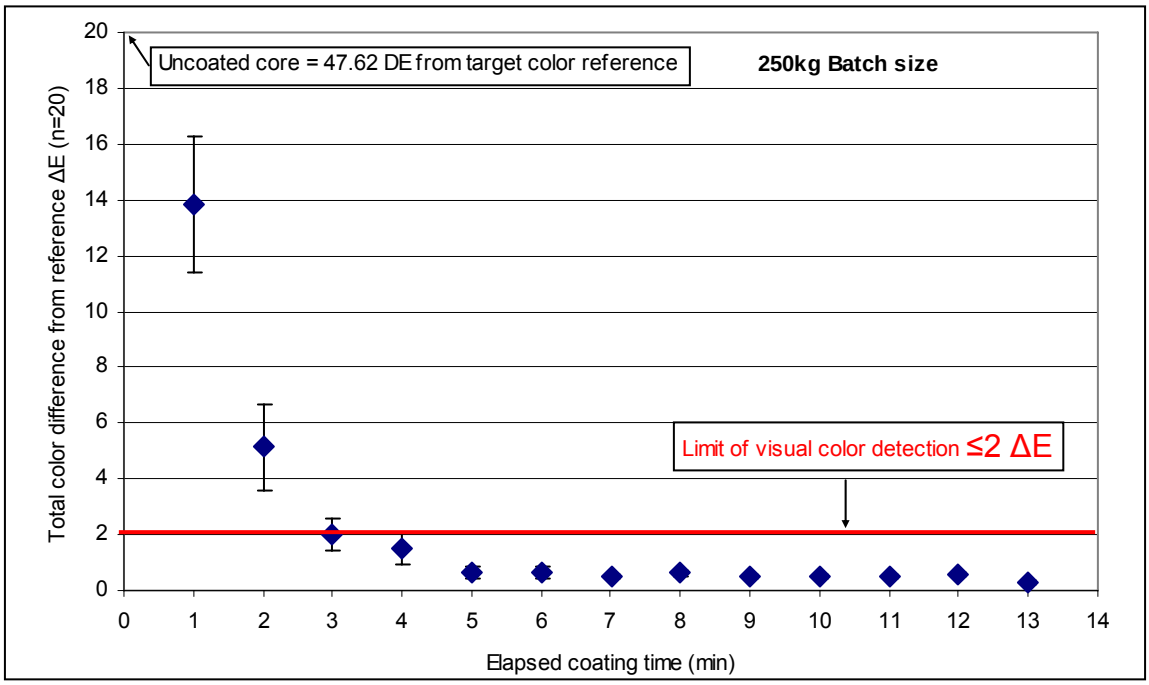
RESULTS

In either batch mode or continuous mode, the coated tablet appearance was good. The coated tablets were visually uniform and free of defects (Figure 3).

Figure 3. Coated Tablets Sampled from the Discharge of the Coating Pan While Running in Continuous Mode

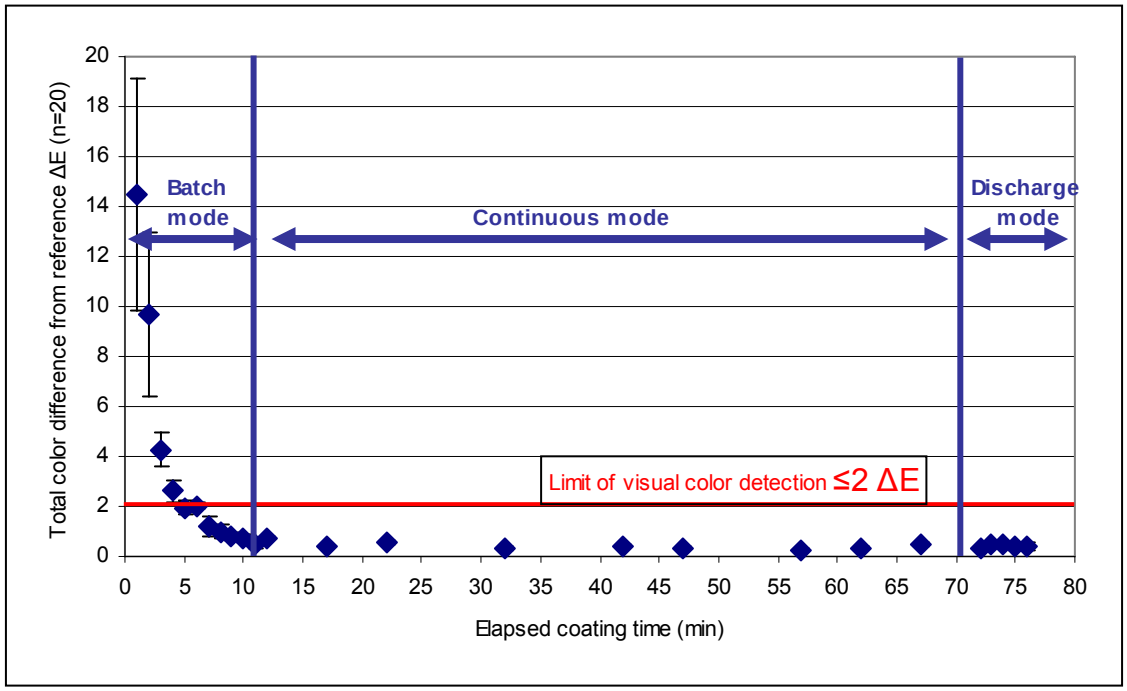
Instrumental color testing of samples pulled throughout the trials confirmed the positive visual assessment of color uniformity. In the batch mode trial, 250 kg of tablets were uniformly coated to the 3.0% target weight gain in < 14 minutes. Uniform target color of < 2 ΔE from reference (actual 0.4 ΔE) was achieved in < 9 minutes of coating time (Figure 4).

Figure 4. Color Development and Uniformity of Tablets from Batch Mode Trial



In earlier versions of continuous coating pans, the initial discharge of tablets upon start-up as well as the final load of tablets in the pan upon shut-down were not typically coated to a uniform level thus prompting re-work of the tablets or even discard of the partially coated product.[1] In this study, a continuous coated tablet throughput rate of 1300 kg /hr was achieved with no sample exceeding the 2 ΔE color limit throughout the start-up, continuous and discharge modes (Figure 5).

Figure 5. Color Development and Uniformity of Tablets from Continuous Mode Trial



In both the batch operation and batch start-up for the continuous mode of operation, color development and color uniformity was achieved in significantly less time than would be seen in a traditional batch coater. In a similar application (tablet size, shape, coating material, and coating weight gain) conducted in a traditional 48" diameter (non-continuous design) batch coater, color uniformity was only achieved after 40 minutes of coating time rather than the 9-10 minutes achieved in this continuous coater.[3]

One significant difference between a traditional batch coater and a continuous coater is the depth of the tablet bed. The bed depth is significantly greater in a traditional batch coater than in the continuous coater. Consequently, in the shallower bed, the tablets are exposed much more frequently to the spray zone and the duration that the tablets are isolated from the spray is much less. The increased number of spray guns and elongated coating chamber may also play a role in improving coating uniformity by improving the consistency of spray distribution across the tablet bed.

CONCLUSIONS

The fast attainment of color uniformity was attributed to the shallow bed depth and resultant frequency of tablet presentations to the elongated spray zone. These continuous coater advantages have long been debated, but no definitive data has been previously published to demonstrate these effects.[1] The data generated in this study fully support these concepts.

The Opadry II 85 Series coating formulation was well suited for this application due to its low viscosity and capability of being applied at high solids concentration. This allowed the target 3% coating weight gain to be achieved at the high tablet throughput rates during the continuous mode of operation.

These trials also demonstrated that improvements in continuous coater design enable the production of tablets without the product losses earlier associated with the start-up and shut-down of continuous coating processes.

Reprint of poster presented at AAPS – Nov 2008. Authors: Charles Cunningham, Frank Nuneviller III, Christian Venczel, and Florent Vilotte.

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