

# On-Demand Film Coating Dispersion Preparation

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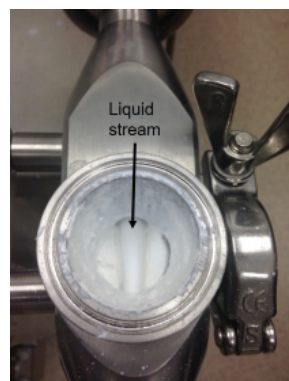
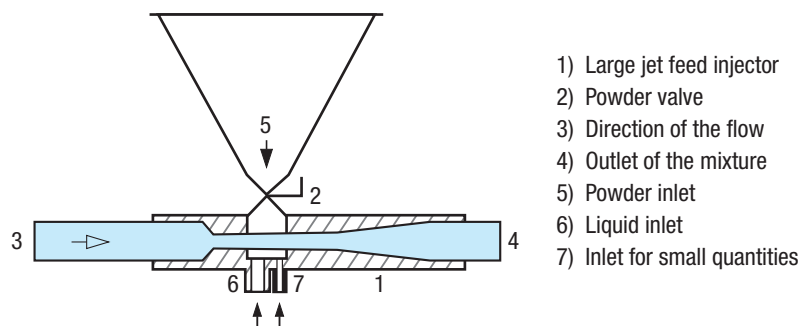
## Purpose

The batch size for film coating dispersions in manufacturing can reach hundreds of liters, depending on the scale of manufacture, and may require large tank and mixing areas. In current batch manufacturing processes, mixing times for coating dispersions are usually recommended between 30 and 60 minutes to ensure homogeneity and avoid the presence of lumps or agglomerates that clog spray guns. Tank size, mixer configuration, mixer placement, volume of liquid in the mix tank and many other factors influence the process. Improperly designed mixing processes can result in foam or lumpy dispersions that require additional time for deaeration or further hydration. If mixer diameter and stirring speeds are not optimized, excessive settling of suspended solids can occur over time. In addition, preparation in advance of large batch sizes intended for use over several days, may introduce the risk of microbial growth. The objective of this study was to evaluate the feasibility of “on-demand”, continuous coating dispersion preparation using an innovative powder injector system.

## Methods

The powder injector system (Model PST, Jet Solutions Inc., ILC Dover LP) functions by creating a liquid jet at controlled speed and pressure. Liquid is pumped through a restriction to increase pressure before entering the powder injector. This results in high liquid velocity, and creates a vacuum through the Venturi effect. When the powder inlet valve is open, the powder will be introduced particle by particle and directly incorporated into the liquid stream (Figure 1). The speed of the liquid pump controls the recirculation rates and velocity of liquid through the injector. Increasing the speed of liquid through the injector will increase the vacuum in the injector and subsequently the rate of powder addition into the liquid stream.

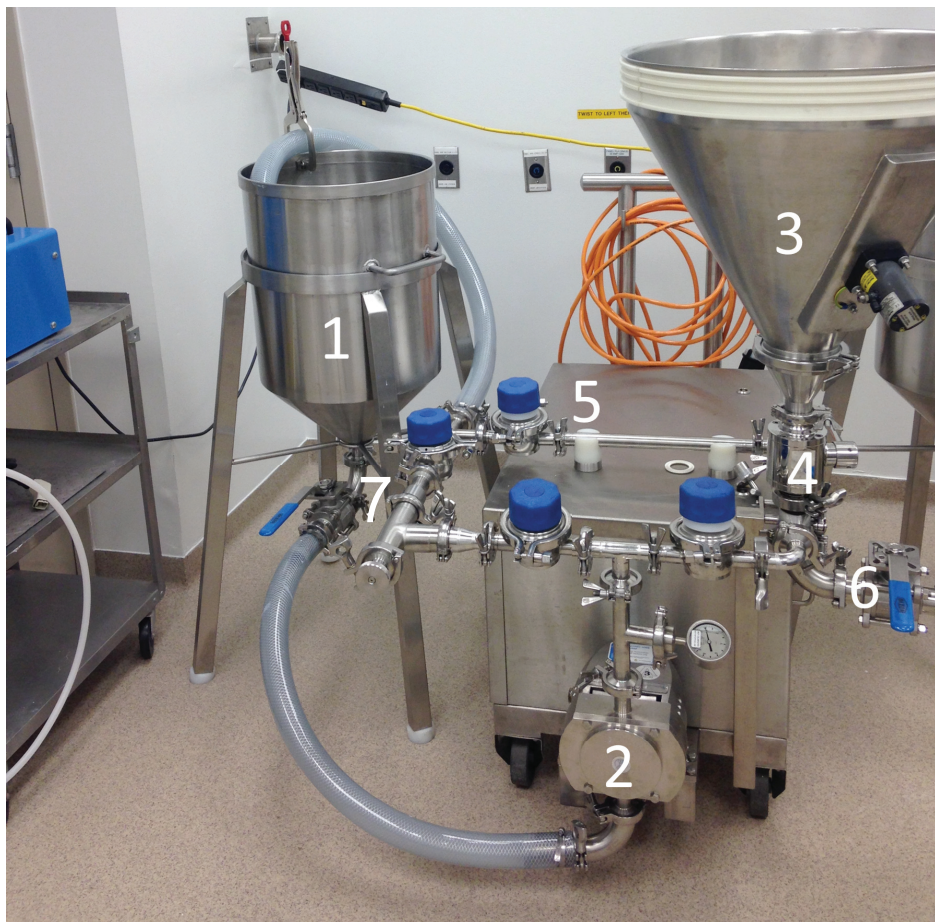
**Figure 1. Injector System Schematic and high Velocity Liquid Stream Passing Through the Powder Injector with Powder Hopper Removed**



1. Jet feed injector 2. Powder valve 3. Direction of flow 4. Mixture outlet 5. Powder inlet 6. Liquid inlet 7. Inlet for small quantities

For this evaluation, the jet mixer system was connected to a temporary arrangement of tanks, hoses and manually operated valves as shown in Figure 2. Two low viscosity fully formulated coating systems were used in the evaluation of the jet mixer; PVA based Opadry<sup>®</sup> II and PVA-PEG co-polymer based Opadry<sup>®</sup> QX (Colorcon Inc.). To start the system, the recirculation water tank and powder hopper were filled with the required quantity of water and Opadry powder respectively to produce 15 kg of dispersion at the desired solids concentration. The water was pumped through the injector and powder addition valve opened. Once powder addition was completed (2-3 min), the powder valve was closed and the dispersion was continually recirculated from the small holding tank through the pump and injector. Simultaneously with the completion of powder addition, dispersion began pumping from the recirculation tank using a separate peristaltic pump and semi-rigid plastic tubing to simulate coating delivery to the spray apparatus at a manufacturing scale rate of 1000g/min.

**Figure 2. Testing Arrangement**



1. Recirculation and initial water tank 2. Recirculation pump 3. Powder hopper 4. Injector 5. Liquid recirculation lines back to tank 6. Auxiliary water supply to injector for top off operation 7. Optional homogenizer (not used in this study)

At periodic intervals, the dispersion was passed through individual 60 mesh sieves for a fixed time of 45 seconds. The screens were then dried in a 60°C oven for 60 minutes. The screen retains were calculated on a dry solids basis (corrected for dispersion flow rate and % solids).

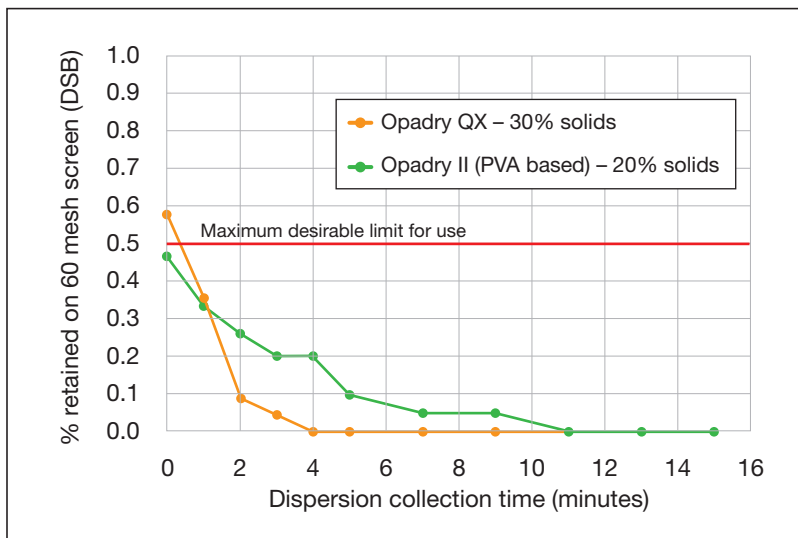
A separate trial for preparation of dispersion using Opadry QX at 20% solids was conducted to evaluate a system replenishment (or top-off) operation. As the coating dispersion in the recirculation tank was depleted over time, the auxiliary water supply at the bottom of the injector and the powder valve was opened to incorporate additional coating material into the recirculating mix. The additional water and powder were manually metered at the appropriate ratio to maintain the desired solids concentration of the recirculating dispersion. Throughout this operation, samples were obtained and tested to determine if the system could be replenished without variation in dispersion solids concentration.

Further tests, using a dispersion of Opadry QX at 30% solids concentration (pigmented with iron oxide) were conducted to determine if constant recirculation, over an extended time, through the jet mixer (pump and high velocity liquid stream) would cause changes in coating color or polymer properties. At intervals starting with Time 0 (immediately after powder addition completion), samples were taken for polymer characterization and coating onto round placebo 350 mg tablets (for color assessment). Coatings were performed as rapidly as possible after the samples were taken. Each coating trial on 300 gms of tablets took 10 minutes (including switchover to the next sample). The coated tablets were then measured for any color change using a spectrophotometer (Datacolor 600, Datacolor, Lawrenceville NJ). Tests for polymer assay and molecular weight distribution were done using reverse phase HPLC-5 (Waters Alliance 2695, Waters Corp., Milford, MA) and ELSD detection (Sedex 75 ELSD Alfortville Cedex, France).

## Results

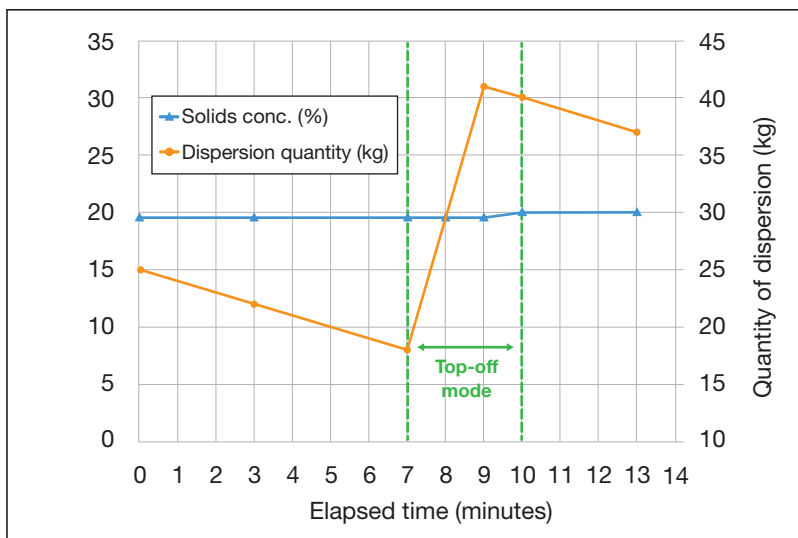
The coating formulations were easily incorporated into the water stream and were absent of lumps or particulates within a very short recirculation period. Both low viscosity coating systems were free of unacceptable particulates (< 0.5% retain on 60 mesh) within 2-3 minutes of powder addition (Figure 3).

**Figure 3. Screen Retains vs. Recirculation Time**



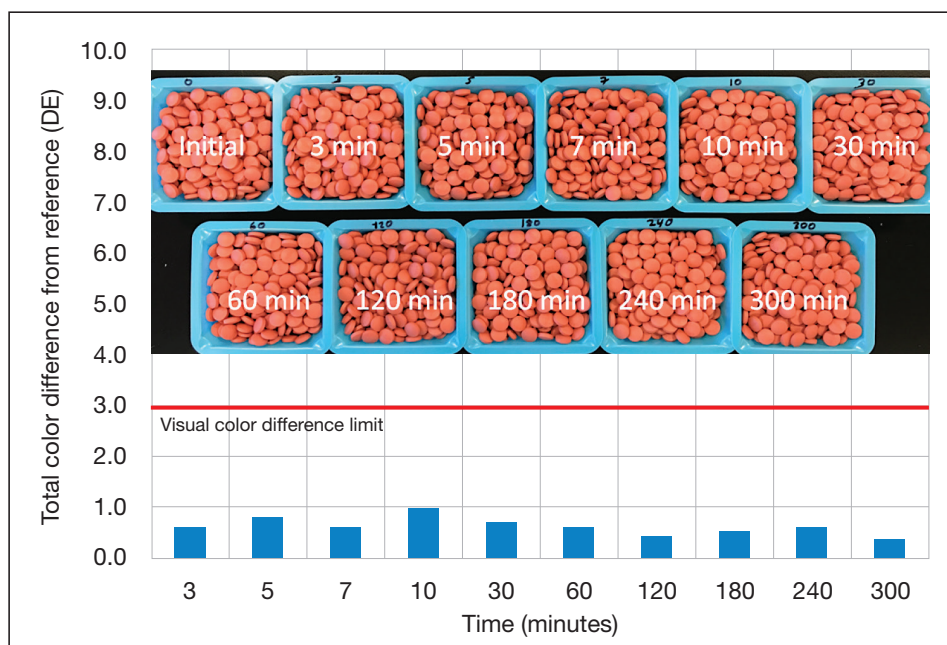
As the volume of dispersion in the holding tank decreased, the “top-off” operation was easily accomplished by metering additional coating powder and water at the proper ratio into the injector. Samples taken throughout this process indicated no change in solids concentration of the dispersion being recirculated from the holding tank (Figure 4).

**Figure 4. Tank volume vs. Solids Concentration During Constant Use and Top-off (Opadry QX)**



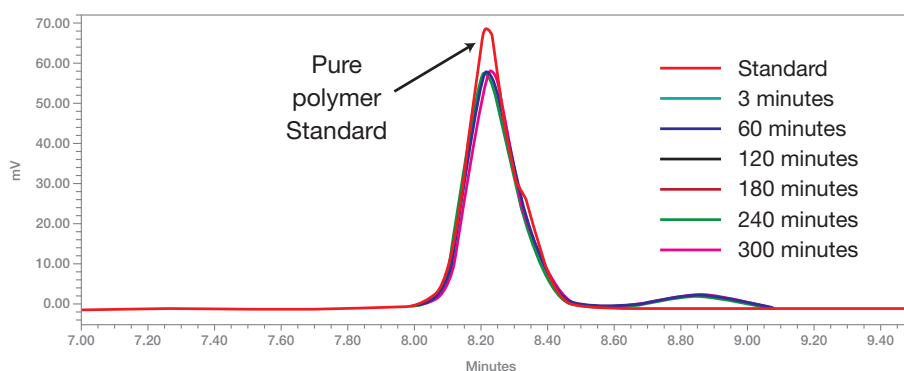
Tablets, coated at intervals throughout 5 hours of constant recirculation time through the jet mixer, showed no difference in color either visually or instrumentally (Figure 5); including tablets coated within 3 min of initial powder addition into the water. This indicates that not only was the dispersion free of any undispersed particles large enough to cause clogging of the spray nozzle, but the polymer was sufficiently hydrated to form a uniform film consistent with samples taken after much longer periods of hydration. This indicates that shear forces on the liquid dispersion are low enough to have no impact on changing the pigment color characteristics.

**Figure 5. Five-hour Recirculation Test - Visual and Instrumental Color Uniformity (Opadry QX 30% Solids Concentration)**



Polymer assay and molecular weight distribution testing of the Opadry QX dispersion showed no changes over 5 hours of recirculation through the jet mixer (Figure 6). This indicates that shear forces on the liquid dispersion are low enough to have no impact on polymer molecular weight characteristics.

**Figure 6. Overlay of Standard (Pure Polymer) and Sample Injections**



## Conclusions

The Model PST jet mixer provided a rapid method for the preparation of fully formulated coating dispersions. The mixing was carried out using a small equipment footprint and in this test case, the total quantity of coating dispersion in the system at any given time was low (15 - 43 kg). This concept will allow for film coating dispersions to be prepared as needed or in a continuous manner, rather than in large batch tanks with long hold times. The system could easily be automated using flow meters, loss in weight control, and coupled with a large coating powder delivery system. The low viscosity Opadry II and Opadry QX film coating systems hydrated rapidly and were shown to be well suited for this technology.

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