A Parameter Model for Wurster Fluid Bed Filmcoating

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ABSTRACT SUMMARY:

Wurster filmcoating parameters can be predicted from vehicle volatility, atomization efficiency, coat/vehicle affinity, material properties, solution solids, temperature effects, and airflow dynamics. Several Wurster systems were studied to extend a cursory parameter model. This model can serve to speed optimization of new applications or aid in trouble shooting existing processes.

INTRODUCTION:

Wurster fluid bed filmcoating of particulate materials involves repetitive (cyclic) movement of core particles through an atomized spray region in a relatively controlled manner. Each cycle of the movement involves wetting followed by drying and it is a balance of this cycle that provides the appropriate quality and consistency in the product for the critical product parameters. Because this balance involves many critical parameters it is challenging to predict where the balance lies.
Nevertheless, an understanding of the parameter relationships provides a predictive tool for filmcoating processes.
In this work, filmcoating processes were looked at from an application perspective to impart application guidelines. Included in this evaluation are drying capacity factors such as atomization/droplet size, solvent volatility, airflow, and solvent/solid interactions involving both core and coating materials. The influences of filmcoat and core material properties are also considered. Findings and conclusions are supported by process observations and final product performance.

EXPERIMENTAL METHODS:

Wurster fluid bed coating work was performed on research and production coaters designed and manufactured by Coating Place, Inc.

RESULTS AND DISCUSSION:

Wurster fluid bed filmcoating is a dynamic process that is influenced as much by application conditions as it is by the materials used in the process. Drying capacity is inherently a central concern of the process and is influenced by atomization properties, solvent volatility, airflow, and solvent/solid interactions.

Atomization is typically a key parameter. Too much atomization leads to spray drying of the coating material while too little may lead to overwetting and granulation. Common spray droplet size ranges from near 10 to 40µm. 10µm and 40µm droplets of water contain nearly 1.74×10^{13} and 1.12×10^{15} molecules of water, respectively. This equates to a radius of nearly 13,000 and 52,000 molecular layers, respectively, and likely four times the drying time required for the 40µm droplet compared to the 10µm droplet. It is also important to recognize that conditions for good atomization may also result in particle attrition, which will influence product quality.

During filmcoating, droplets contain coating solids. These solids have varying affinity for solvent molecules depending on chemical structure. The drying process is slowed by the degree of these interactions. In addition, as the film forms, the outer surface dries first and becomes a barrier to inner solvent molecules that have not yet escaped. If the developing filmcoat is a good barrier, it eventually prevents escape of trapped solvent molecules. Any agglomeration of particles during the coating process further entraps solvent molecules within the agglomerated particle.

Solvent volatility clearly influences drying ability. Vapor pressure data[1] shown in Figure 1 indicate that acetone and ethanol are ~28 and ~5 times more volatile than water, respectively. The volatility of acetone at 85°F is similar to that of ethanol at 150°F while ethanol at 85°F is similar to water at 150°F.

Volatilized solvent must be removed during the process. Data in Figure 1 indicate that acetone, ethanol, and water vapors can be removed at rates of 25 g/ft^3, 4.7 g/ft^3, and 0.9 g/ft^3, respectively, at 85°F and 57 g/ft^3, 18 g/ft^3, and 3.0 g/ft^3, respectively, at 130°F. Water removal rate is actually lowered further to an extent dependent on the amount of water in the process air. In actual practice spray rates are often well below these capacity values. Typical organic solvent process spray rates are near 1 to 3% of the actual air capacity to remove these materials. This limit is due to either high solvent affinity for coating/core materials or safety factors. Organic solvent processes are restricted to safe spray conditions that are below the lower explosive limit for the solvent. Maximum safe rates are near 0.5 to 1.2 g/ft^3 for common solvents depending on the solvent. Water removal rates are in the range from near 1% to 100% of capacity depending on core and coating material properties and the goal of the coating process.