Enhance Powder Density and Flow by Dry Particle Coating

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BACKGROUND AND OBJECTIVES

Many active pharmaceutical ingredients (API) exhibit deficient bulk powder properties such as poor flowability, low bulk density, high cohesion, etc. These deficiencies may cause some major issues for the performance of downstream processing thus affect content uniformity in final product.

One of the effective methods to improve powder flow and bulk density is via the dry powder coating. This study performed by J-star Research provides details on this dry coating technology.

METHODS

The mechanism of the dry powder coating is illustrated in Figure 1, in which the host particles (API) are coated with the guest particles (such as SiO_2) via mechanical forces. This coating can effectively increase the spacing between the host particles and the apparent surface roughness; hence it reduces the cohesive forces between the hosting particles, resulting in significant improvement in flow properties.

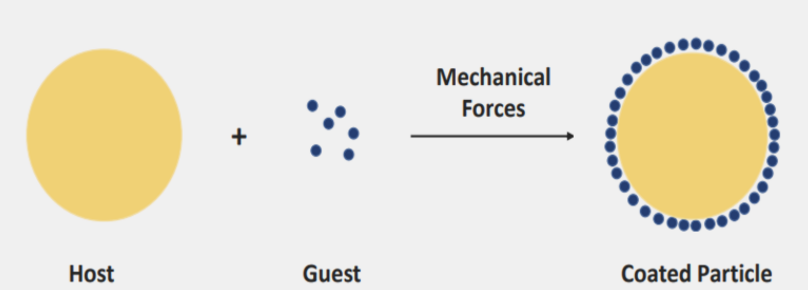

Figure 1. Dry coating mechanism.

There are four coating techniques available at J-Star, which have been proved successful in dry coating in this study by coating host materials corn starch (excipient) and Ibuprofen (API) with guest material hydrophobic silica R972P (Evonik).

Table 1. Coating Techniques available at J-star.

Coating Devices	Batch Mode	Continuous Mode
Comil (Quadro, Engineering, Canada)	Yes	Yes
Pharma RAM II (Resodyn Acoustic Mixer, USA)	Yes	No*
Sturtevent Micronizer® jet mill (Sturtevant, Inc, USA)	Yes	Yes
High shear Mixer (Waring LB10G Blender, USA)	Yes	No

*: Continuous mode is not available on presented model (RAM II) but available on other models from the same vendor.

1. Conical Screen Mill (Comil)

- Host particles and guest particles (SiO_2) are charged to the mill after blending. Then retained and mixed in the middle of the conical vessel.
- The rotation of the impeller generates centrifugal forces pushing the mixed particles toward the screen.
- Significant shear forces are conveyed to deagglomerate the silicon dioxide and make them preferentially attach to the larger host particles.

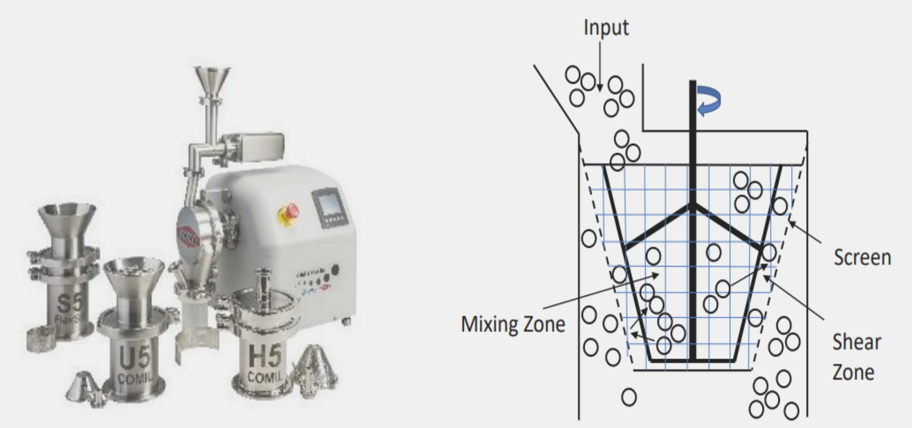

Figure 2. Setup and illustration of mixing and shear zones of Comil.

2. Resodyn Acoustic Mixer (RAM II)

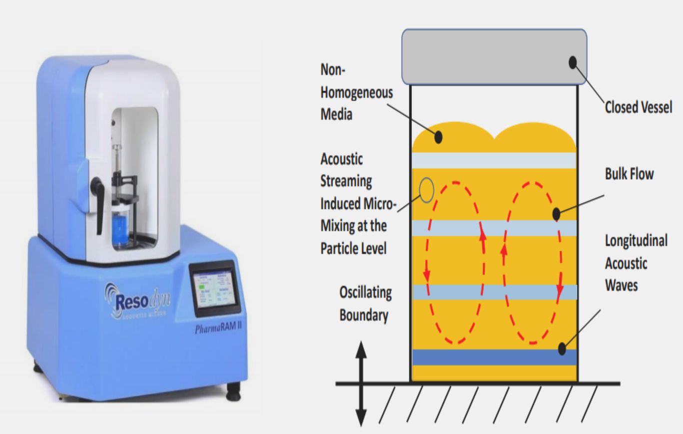

Figure 3. Pharma Ram II mixing mechanism.

- The RAM mixer uses acoustic energy to mix the desired media in the vessel.
- The efficient mixing is accomplished by creating a homogeneous shear zone throughout the vessel without the aid of mixing media or impeller.
- At a high acceleration, a significant shear strain within the bulk powder can be induced within a very short time.
- The high degrees of shear disperse fine particles and make them adhere to the surfaces of lager host particles to accomplish the coating process.

3. Jet Mill

- Particles are fed to the funnel and then sucked into the grinding chamber through the venturi region by the feed air into the vortex trajectory.
- High pressure grind air (nitrogen) is injected in the grinding chamber causing the particle collisions resulting in the reduction of particle size.
- The smaller particles after the collisions move at lower velocities hence are subjected to a lower centrifugal force. While, large particles are held in the grinding chamber until micronized to a desired size by optimizing the grinding pressures and feed rates.

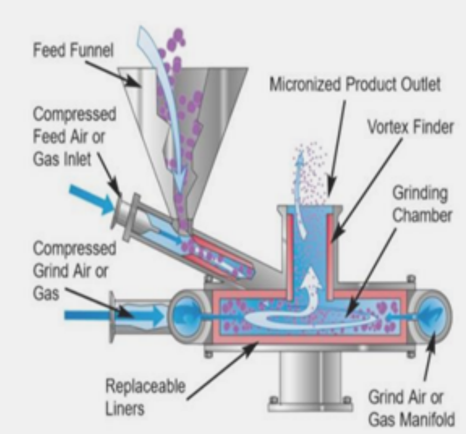

Figure 4. Jet mill mixing mechanism.

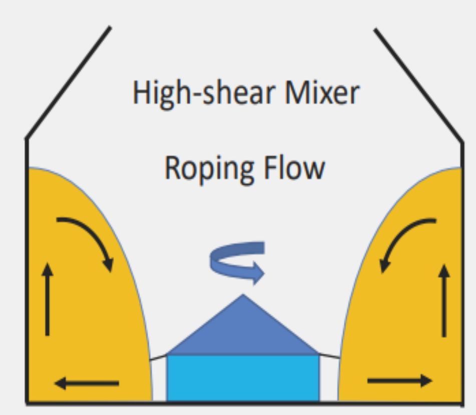

Figure 5. High-shear mixing mechanism.

4. High Shear Mixer

- Both the host and the guest particles are charged to the mixer subjected to a designated tip speed.
- At a high speed, particles from the bottom of the bed are forced up the vessel wall and then tumbled down the angled bed surface to the center of the bowl.
- As the impeller rotates, both the host and guest particles are subjected to the force from the impeller and travel at both radial and vertical directions at different velocities, resulting in particle-particle collisions.

RESULTS

Apply four different dry coating techniques on Corn Starch (A) and Ibuprofen (B) with silica R972P.

Sample ID	Materials and Operating Conditions	Bulk Density	Standard Deviation	FFc Value	Standard Deviation
A1	**Raw Corn Starch**	**0.47**	**0.01**	**3.07**	**0.33**
A2	Labram 90G, 1min	0.75	0.01	26.60	10.65
A3	Comil, 2000RPM, 20g/min	0.76	0.01	18.30	2.65
A4	High Shear Tip Speed:10m/s, 2min	0.75	0.01	24.25	6.58
A5	Jet Mill, Grind Pressure: 40 psi, 20g/min	0.70	0.01	27.20	4.24
B1	**Raw Ibuprofen**	**0.34**	**0.01**	**4.77**	**0.08**
B2	Labram 90G, 1min	0.53	0.01	20.30	2.47
B3	Comil, 2000RPM, 20g/min	0.48	0.01	14.80	4.67
B4	High Shear Tip Speed:10m/s, 2min	0.49	0.01	9.82	3.94
B5	Jet Mill, Grind Pressure: 40 psi, 20g/min	0.27	0.01	1.16	0.07

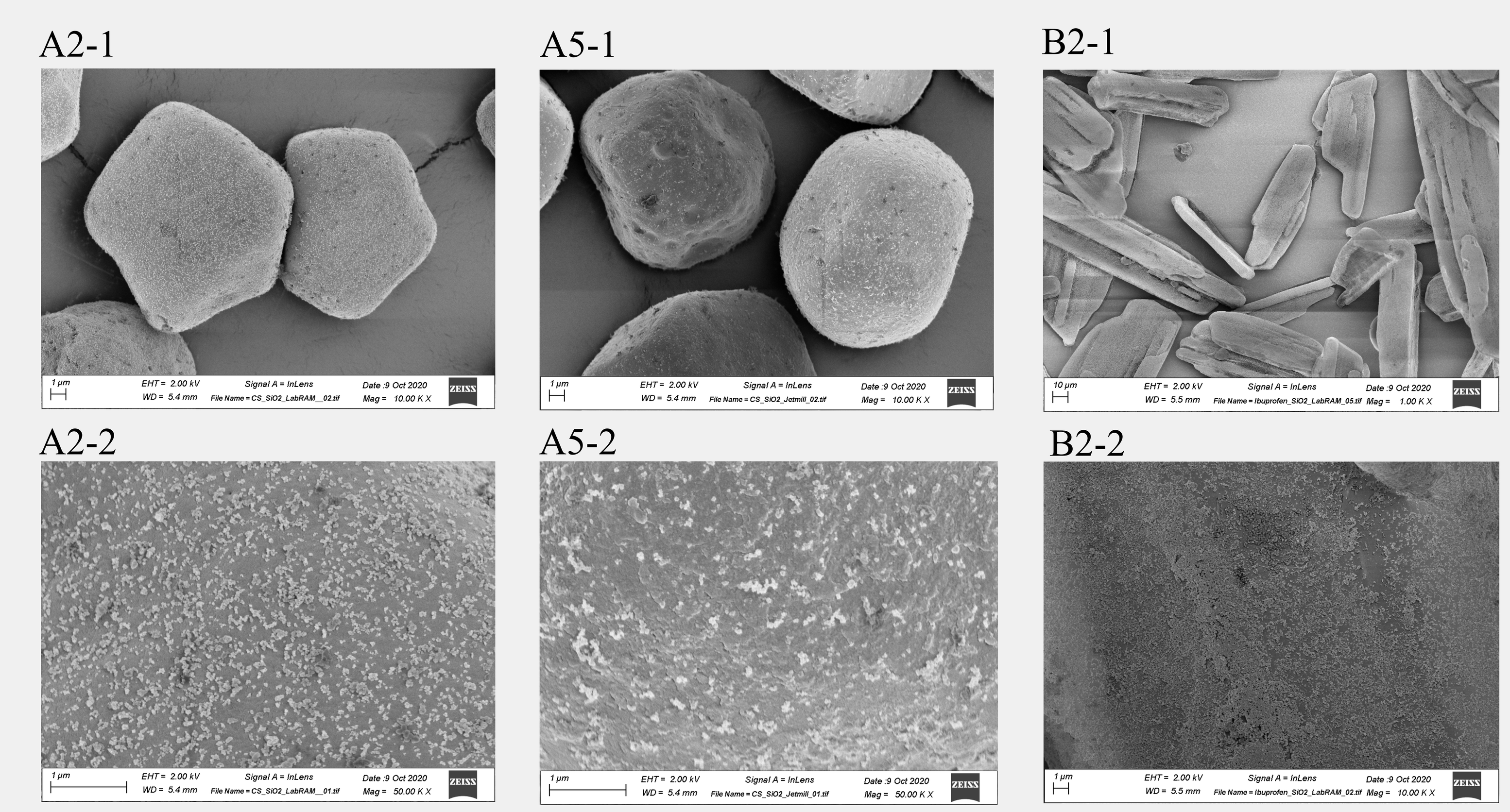

Figure 6. FESEM analysis of dry coating on both host materials by different techniques: A2) Corn Starch – R972, Labram 90G 1min; A5) Corn Starch – R972, Jet Mill 40 psi, 20g/min; B2) Ibuprofen – R972, Labram 90G 1min.

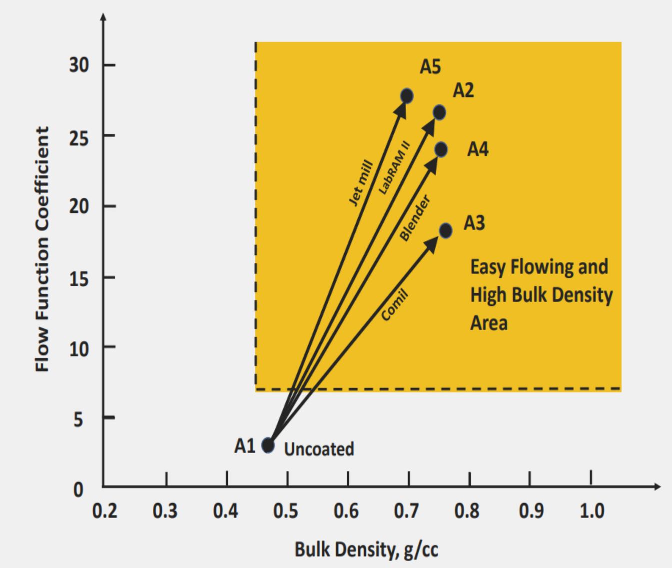

Figure 7. Enhancement in density and flow function coefficient on corn starch particles.

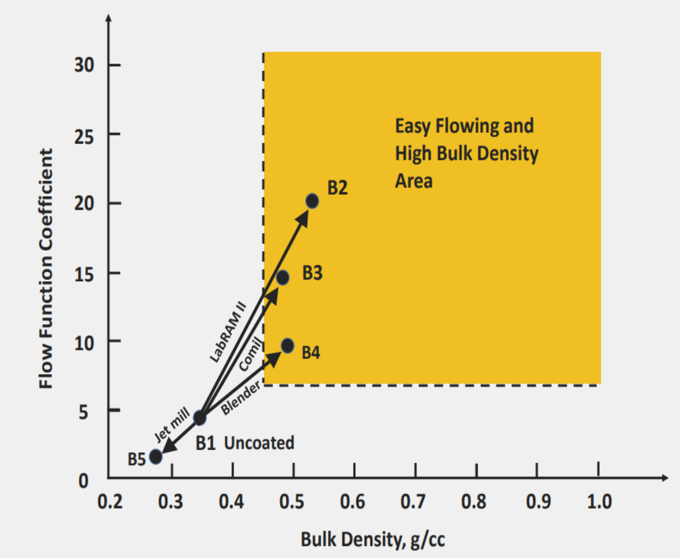

Figure 8. Enhancement in density and flow function coefficient on Ibuprofen particles.

CONCLUSIONS

- The mechanism of the dry particle coating and a short description of four coating techniques including Comil, LabRAM, a high shear mixer and a jet mill are provided.
- A suitable area (a sweet spot) in the map of the bulk density vs. FFC value is identified in which the bulk density is higher than 0.45 g/cc and the value of FFC is higher than 7; API candidates with the bulk density and FFC value are located in this sweet spot can be made into tablets via the direct compression.
- It has been demonstrated that all four coating techniques can be used to bring a cohesive material like corn starch with low bulk density and FFC value into this sweet spot.
- It also shows that three coating techniques except a jet mill can bring a low bulk density material such as ibuprofen into this sweet spot.

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