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Dry particle coating for improving the flowability of cohesive powders

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Abstract

Several dry processing techniques are used to coat cohesive cornstarch powder with different size silica particles. For nanosized silica guest particles, FESEM images show that both the magnetic assisted impaction coater (MAIC) and the hybridizer (HB) produce particles that are significantly more uniformly coated than using either a V-shape blender or simple hand mixing. Image analysis confirms that MAIC and HB provide higher surface coverage for the amount of guest material (flow aid) used. The improvement in flowablity of coated cornstarch is determined from angle of repose measurements using a Hosokawa powder tester. These measurements show that nanosized silica provides the best flowability enhancement, whereas mono-dispersed 500-nm silica does not improve the flow properties of cornstarch at all. This observation agrees with a simple theoretical derivation based on the original Rumpf model, which shows that the flowability improvement is inversely proportional to the guest particle size for a given host particle size or size of surface asperities. Experimental results also indicate that surface-treated hydrophobic silica is more effective in improving the flowability of cornstarch particles than untreated hydrophilic silica. An increase in processing time using MAIC and the V-blender also improves the flowability of the cornstarch since the guest particles are more deagglomerated and better dispersed, the longer the processing time.

Keywords: Dry coating; Flowability; Angle of repose; Cohesive particles; Nanoparticles

1. Introduction

Handling and processing of fine particles (smaller than ~30 μm) is a generic industrial problem. These powders have poor flowability due to the cohesion force arising mainly from Van der Waals attraction. Besides utilizing aeration and vibration, addition of a flow agent is also an effective way to improve the flowability of cohesive particles, as discussed in the pioneering work of Molerus [1] and other researchers [2–5]. For example, a small amount of fumed silica "guest" particles discretely coated onto the surface of cohesive "host" particles can improve the flowability. However, most flow agents like fumed silica consist of very fine particles that have a strong tendency to form agglomerates. Thus, proper dispersion of the flow agent is a very important issue for obtaining discrete coating and flowability improvement.

Previous research by our group [6–9] indicates that dry coating techniques such as magnetic assisted impaction coating (MAIC) and the Hybridizer (HB) can be used to improve the dispersion and adhesion of the flow agent onto the cohesive primary particles. The potential advantages of these processes are their high coating efficiency, low cost and environmentally benign operation. However, a systematic investigation of their performance has not been done as compared to, for example, a commercial V-shaped blender or even simple hand mixing. Therefore, a series of coating experiments using a model cohesive powder (cornstarch) was conducted with various dry coating devices to examine their coating efficiency. We were particularly interested to see how changing the properties of the flow agent (guest particles) would affect the flowability of the coated cohesive particles. For example, what is the effect of the size of the flow agent on flowability? Does it matter whether it is hydrophilic or hydrophobic?

To examine the effect of particle size, different silicas with size range from 20 nm to 2 μm were chosen. This effect was addressed theoretically by Mei et al. [10] by using the JKR theory to analyze the cohesion force before and after coating. The effect of the different surface properties of the

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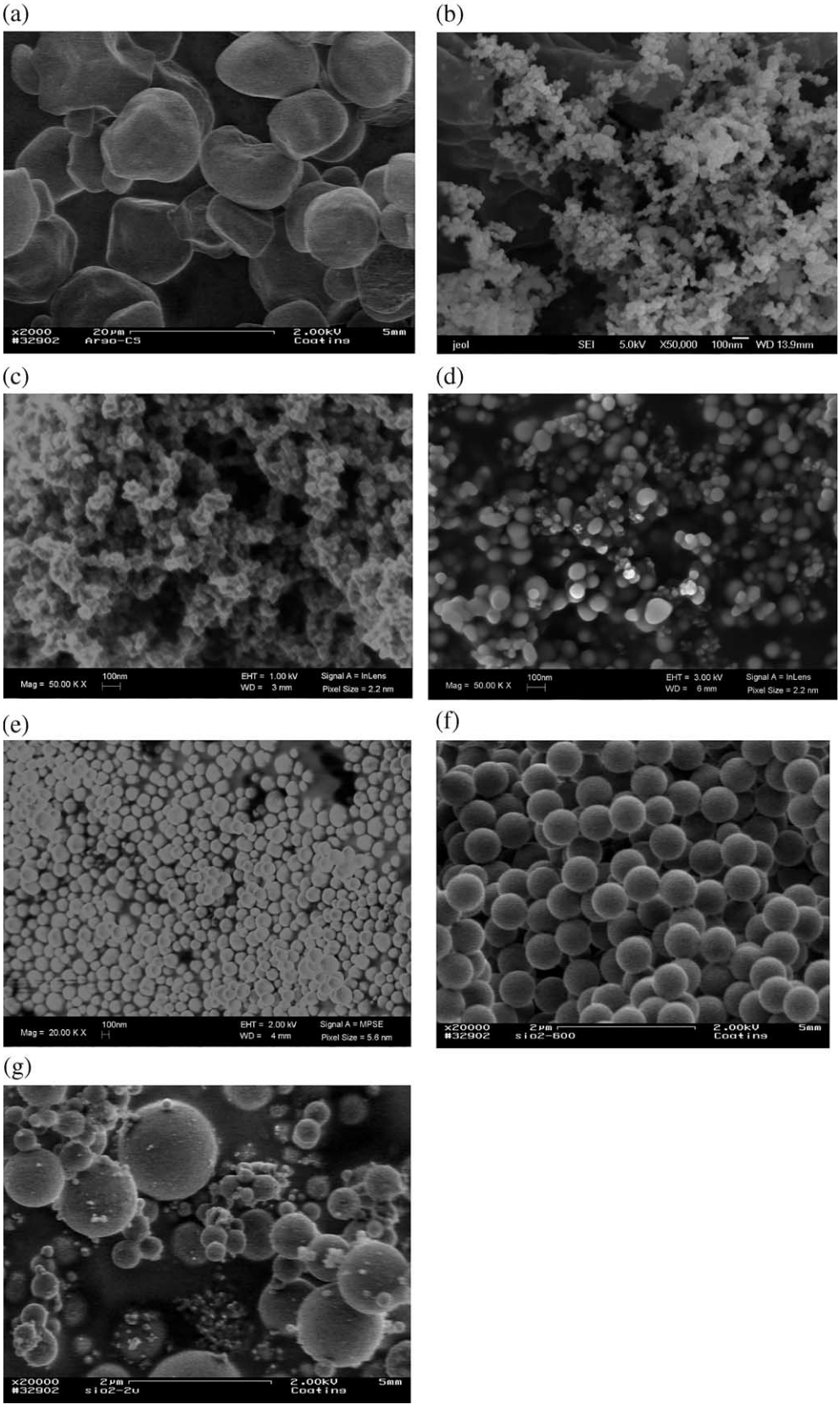

Fig. 1. FESEM images of host and guest particles. (a) Cornstarch; (b) R972; (c) EH-5; (d) OX-50; (e); Lab synthesized 100-nm silica; (f) COSMO55; (g) P-500.