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FILM COATING ONTO COHESIVE FINE PARTICLES BY A NOVEL ROTATING FLUIDIZED BED COATER

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ABSTRACT

In this study, film coating onto cohesive fine particles was conducted by using a novel rotating fluidized bed coater (RFBC). In order to avoid the formation of agglomeration, baffle plates were equipped inside the RFBC. Coating experiments were conducted under various operating conditions and the coated particles were evaluated based on their physical properties. As a result, coated particles having extremely small degree of agglomeration and favorable prolonged release property of a tracer material could be obtained.

INTRODUCTION

Development of a fine particle coating technique has been strongly required lately because of their great potentials. For example, in a pharmaceutical industry, fine particle coating process is expected to design functional fine particles for a drug delivery system and dry powder inhalation. Fluidized bed is one of the most promising techniques for coating fine particles because of its advantage of high heat and mass-transfer rates, temperature homogeneity and high flowability of particles (1). Therefore, the fluidized bed coating process has been extensively used. However, cohesive force acting on fine particles, which belong to Geldart's group-C (2), is extremely higher than the external forces such as gravity and fluid drag, leading to cause poor fluidization and formation of agglomerates between coated particles.

Despite use of complicated devices such as vibration, mechanical agitation and etc. to improve the flowability of cohesive fine particles, handling of fine particles is still extremely difficult. As a result, lower limit of particle size to maintain the smooth fluidization in a conventional fluidized bed exists, which is reported as 100 micron (1). In order to overcome this limit, Ichikawa etc. conducted particle coating onto micrometer-sized particles by a spouted fluidized bed, which has a draft tube and a bottom spray nozzle, called “Wurster type fluidized bed” (3). However, prevention of agglomerates was extremely difficult and the coating film was not formed firmly, resulting in insufficient prolonged release properties. So a novel fluidization process, which can give strong external force to even fine particles, gathers a special interest.

In this study, a novel rotating fluidized bed coater (RFBC) (4) has been developed to fluidize fine particles in a high centrifugal force field, which is much larger than the other external force fields. The developed RFBC has been used for film coating onto cohesive fine particles. In order to avoid the formation of agglomerates and poor fluidization, baffle plates were equipped inside the RFBC. Effect of the operating conditions on film coating performance was quantitatively analyzed. The physical properties of the obtained coated particles such as their size distribution and degree of agglomeration were evaluated and performance of the coated particles was confirmed by analyzing release profile of a tracer material. Based on the results, performance of RFBC as the coating system was evaluated.

EXPERIMENTAL

Apparatus

Figure 1 shows a schematic diagram of experimental apparatus (RFBC). The system consists of a stationary plenum chamber and porous cylindrical air distributor rotating around its axis of symmetry inside the plenum chamber. Due to rotational motion of the air distributor, particles are forced to move toward the air distributor by centrifugal force, forming annular particle bed on the air distributor. Fluidization air flows inward through the distributor, and particles are balanced by drag force and centrifugal force, leading to achieve uniform fluidization in a high centrifugal force field. Inside diameter and depth of the rotating vessel are 0.25 m and 0.10 m, respectively, and a sintered stainless steel mesh with 20 μm openings is used as the air distributor. A binary spray nozzle is mounted on a support fixed to center of the vessel, and sprays mist of a coating material liquid directly to fluidized particles from the top of the air distributor in which particle layer expansion by fluidization is relatively large and fluidized particles are most uniformly distributed. Here, coating liquid is sprayed in the direction of co-current flow against the vessel rotational direction so as not to interrupt the flow of the particle. Heated air is used as the fluidization air.

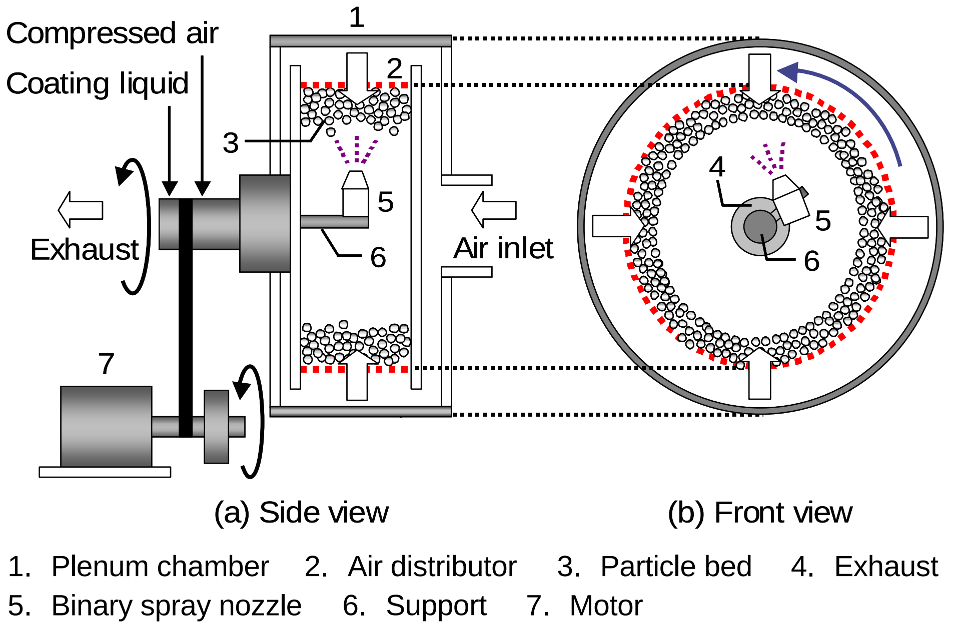

Fig. 1. Schematic diagram of a novel rotating fluidized bed (RFBC).

Powder materials and experimental conditions

Fine cornstarch particle (Cornstarch W, Nihon Shokuhin Kako Co., Ltd.) with a geometric mean diameter of 15 μm (Geldart's group-C (2)) was used as a core particle. The original cornstarch particles were preliminary dyed in the RFBC by spraying a 0.1 wt% aqueous solution of a food pigment of brilliant blue FCF (Izumiya Shikiso, Co., Ltd.) selected as a model tracer material. Performance of the film coating was evaluated by release rate of the tracer material. As a coating material for film forming, 3 wt% aqueous solution of hydroxypropylecellulose (HPC-L; Nippon Soda, Co., Ltd.) was used. The coated particles were prepared at various coating levels of HPC-L. Here, the coating level was defined as ratio of the total solid amount of sprayed material to the charged mass of core particles. Experimental conditions are listed in Table 1.

Table 1 Operating conditions

Vessel rotating speed	5.46, 7.72, 8.91	[rps]
Dimensionless centrifugal acceleration, G_0^*	15, 30, 40	[–]
Air flow velocity, u	6.7–19	[cm/s]
u/u_{mf}	1.4–2.5	[–]
Air temperature	323	[K]
Atomizing air pressure	0.20	[MPa]
Liquid flow rate	1.25×10^{-2}	[g/s]
Charged mass	0.30	[kg]

$^*G_0$ = (centrifugal acceleration on surface of air distributor)/(gravity acceleration) (5)

The coating experiments were conducted as follows. The core particles of 0.30 kg were fed into the vessel, and the vessel was rotated in counterclockwise direction. The fluidization air was supplied, and the coating material was sprayed to the fluidized particle bed. After a predetermined amount of the coating material was sprayed, drying of the coated particles was conducted in the RFBC.

In the present study, an interval spray method (6) was also adopted. Table 2 lists the experimental conditions of interval spray method. In addition, baffle plates, which consisted of stainless steel piece, was installed in the RFBC to prevent finer particles from agglomeration. Mounting position of the baffle plates can be changed. Based on the results, effect of baffle plates mounting positions on the properties of coated particles was also discussed. The mounting positions of baffle plates are shown in Fig. 2.

Table 2 Experimental conditions for interval spray

Run	Spraying time	Drying time
No.1	3 [min]	2 [min]
No.2	5 [min]	2 [min]
No.3	10 [min]	2 [min]
No.4	Continuous spray (non-interval spray)	

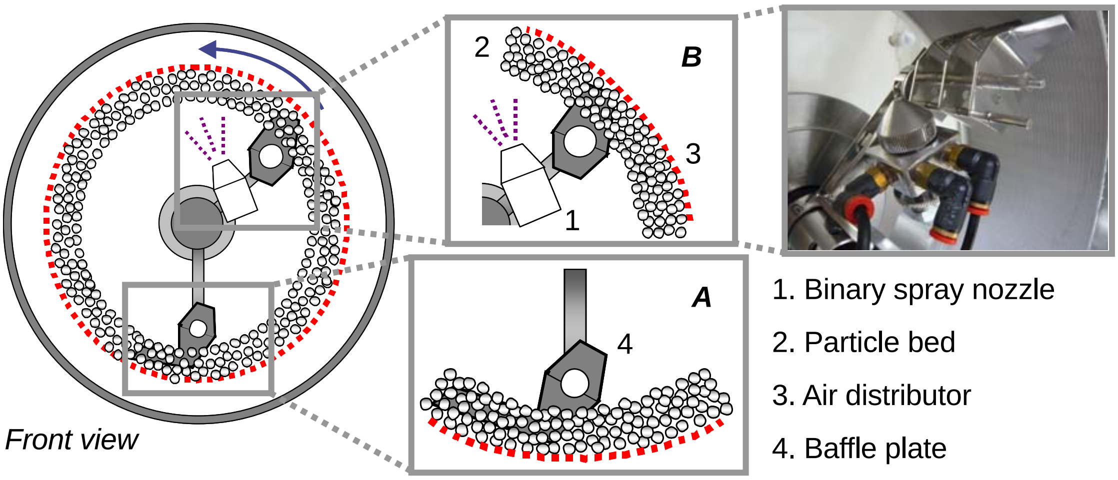

Fig. 2. Schematic diagram of mounting positions of baffle plates.

Evaluation

The size distribution of coated particles was measured by a laser diffraction particle size analyzer (SALD-2100, SHIMADZU Co.). A log-normal distribution was used to determine geometric mean diameter and geometric standard deviation. A degree of agglomeration was defined as the mass fraction of coated particles larger than 68 μm, because there were no particles larger than 68 μm in the original cornstarch particles. The released amount of a tracer material in water was measured in accordance with a paddle method (7) regulated by the Japanese Pharmacopoeia (JP). Surface condition