# Prediction of the Drying Characteristics of Colloidal Suspensions


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The drying process is responsible for the quality of products which relates to the micro structures of dried films. Especially, there are two characteristics such as skin layers [(1),(2)] and stratification [(3)] in drying a colloidal mixture. The skin layers are due to the phase separation between solutes such as binders and particles. The stratification is due to the phase segregation between particles having different sizes. Both of them caused by condensation during drying depend on Peclet number, *Pe* (=*ud/D*, *u*; drying rate, *d*; particle diameter, *D*; diffusion coefficient of particles).

The drying characteristics shown in Fig.1 (A) strongly depend on the concentration layers and the dry layers as shown in Fig.1 (B). The falling rate period begins at point ① where the concentrated layers appear. The falling rate reaches the inflection point ② where the dry layers appear. The characteristics of falling period are determined by the permeability of solvent, because the diffusion through concentrated layers limit the drying rate. In other words, since the permeability in the concentrated layers goes down with the increase of their thickness, the drying rate falls down. The dry layers appear when the concentrated layers reach a substrate. Then, the menisci appearing among particles enhances the penetration rate of solvent because of the capillary force, which results in the inflection point.

Our particle simulator, SNAP (Structure of Nano-Particles), can predict the drying characteristics by calculating the permeability based on the structure formed during drying. The skin layer of binders due to phase separation from a concentrated layer is simulated by using SNAP as shown in Fig.2. In general, the skin layers having poor permeability are avoided by decreasing the contents of binders. The colloidal particles usually have wide size distributions. It is great interest to know the particle size distribution in vertical direction after drying. The bimodal colloidal suspensions containing particles of two different sizes are simulated by using SNAP. As a result, the segregation of the smaller particles to the top surface is obtained in the case of *Pe*=5 as shown in Fig.3. It is indispensable to understand the drying characteristics in fabricating nanomaterials.

**References**


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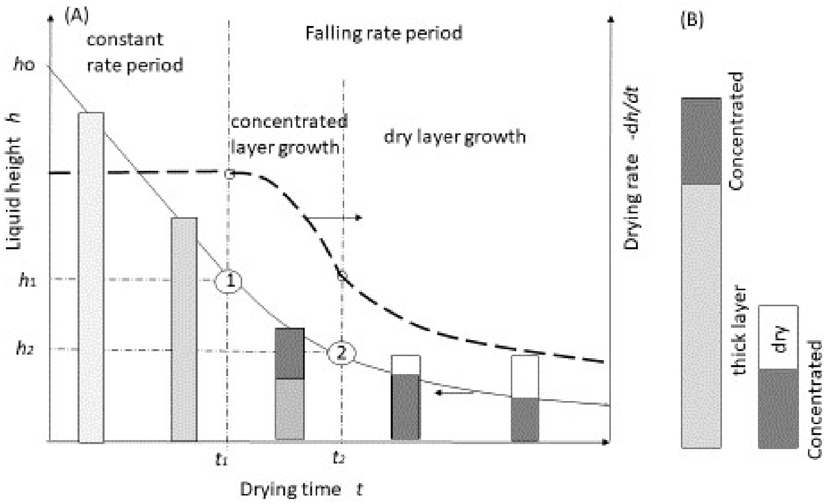


Fig. 1 The drying characteristics. The liquid height decreases with drying time as shown in (A). The constant rate period lasts until point ①, and then the concentrated layer appears in front of the free surface as shown in (B). Exceeding the poit ②, the dry layer appears in front of the free surface in (B).

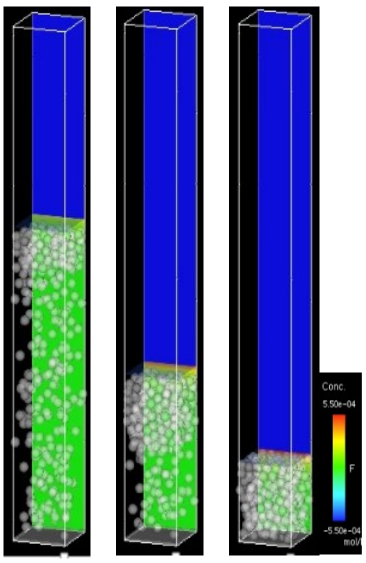

Fig. 2 The phase separation between binders and particles takes place during drying. The red color shows the concentrated binder.

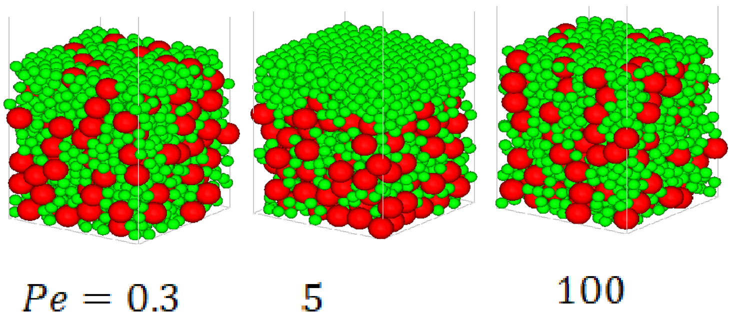


Fig. 3 The phase segregation between small particles and large particles takes place. *Pe* number about 5 shows the maximum segregation.