

### Measurement of Powder Adhesion by Centrifugal Separation Method Using the Compact Ultracentrifuge

CS-FNX Series Compact Ultracentrifuge, S110AT Angle Rotor, and NS-C200 Adhesion Measurement Equipment

Understanding and properly evaluating adhesive force -one of the physical properties of powder-, is particularly important for the appropriately design of products in the manufacturing segment that uses powder material. For measuring the adhesion of toners as a representative example, the centrifugation method is generally adopted as the first choice due to its superior quantitative property and reproducibility.<sup>(1),(2),(3)</sup> This method utilizes centrifugal force for adhesion, where particles applied on a flat surface are separated under the condition of stepwise centrifugal force at several levels.<sup>(4),(5)</sup> In recent years, adhesion has become stronger as toners diameter sizes are getting smaller and smaller. Attributed to the effects of electrostatic charge and the van der Waals force, this stronger adhesion results in insufficient centrifugal force, particularly for charged toners on general-purpose centrifuges, and often disables the measurement of adhesion.

This article reports the results of measuring the adhesion of toner particles having very strong adhesion by using the centrifugation method on an ultracentrifuge that can achieve a maximum centrifugal force of 691,000xg.

#### Content

##### 1. Sample

Commercially available toner (manufactured by company "A," in black color)

##### 2. Test conditions

Centrifuge: CS150FNX compact ultracentrifuge

Rotor: S110AT angle rotor

Adapter: T-AL adapter (The particle adhesion surface consists of acryl\_material.)

Centrifugal acceleration: Seven levels at 10,000, 16,000, 32,000, 64,000, 128,000, 256,000 and 512,000xg

Time: 5 minutes

Temperature: 25°C

Adhesion measurement device: NS-C200 (configured by tele-centric lens, image analyzing system, and other components; manufactured by Nano Seeds Corp.)

##### 3. Adhesion measurement method

1) Apply toner on the base plate surface and record the initial adhesive state of the toner in the form of images.

2) Centrifuge for 5 minutes at several levels of centrifugal force.

3) Record the state of the residual toner on the base plate in the form of images.

4) Calculate the residual toner rate by comparing the projected area (or number of particles) of adhered toner before centrifugation to such area (or number of particles) of residual toner after centrifugation.

5) Calculate the toner adhesion.

Toner separation occurs instantaneously when the centrifugal force applied to particles exceeds the toner adhesion relative to the base plate. Calculate the centrifugal force acting at this moment by the following equation:

$$F(N) = (\pi/6) \cdot \rho \cdot d^3 \cdot r \cdot (2\pi N/60)^2$$

Where:

$\rho$ : Particle density (kg/m<sup>3</sup>)

d: Particle diameter (m)

r: Centrifugal radius (m)

N: Speed (rpm)

6) Calculate the average adhesion.

In the method using projected areas, the residual toner rate after centrifugal separation is plotted on the lateral axis with separation force acting on the toner at respective revolutions on the vertical axis, and then the average adhesion ( $F_{50}$ ) or force at a residual rate of 50% on the approximated curve is calculated (Figure 1). This method simplifies the measurement thanks to the use of average particle diameter for the calculation, thereby enabling prompt analysis of a number of samples.



4. Result

The average adhesion of  $F_{50} = 98 \text{ nN}$  (using projected areas) was calculated. Based on this result, the centrifugal separation method using the ultracentrifuge is considered to enable the measurement of toner base particles or deteriorated toner (outside the measurement target in conventional methods), or electrostatically adhered toner particles (which are difficult to measure).

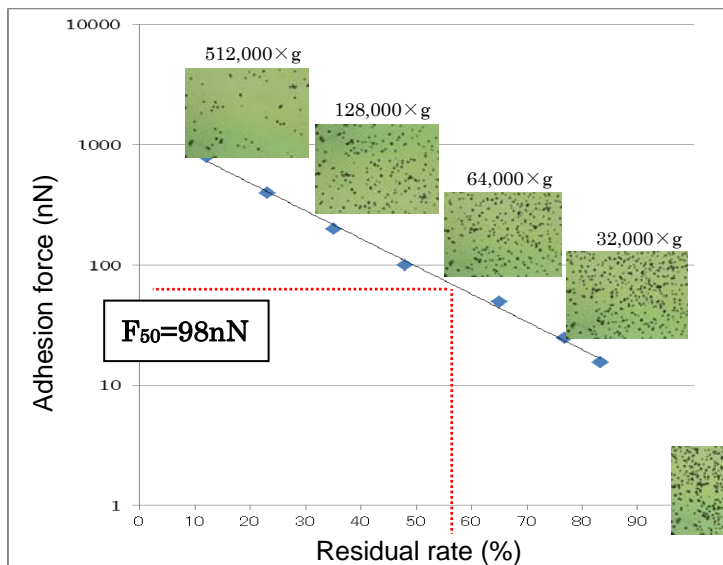


Fig. 1 Relative adhesion force and residual toner rate

References:

- (1) Takeuchi, M., et al., Discussion on Powder, *Collected Articles for Lectures 31*, p.59, 1993
- (2) Imura, H., Study of Adhesion of Toner, *Ricoh Technical Report 26*, p.34, 2000
- (3) *Chemical Toner*, edited by the Imaging Society of Japan, Tokyo Denki University Press, p.177, 2008
- (4) Jinbo, G., *Materials - 16*, Society of Materials Science - Japan, p.291, 1967
- (5) Asakawa, S., et al., *Materials - 16*, Society of Materials Science - Japan, p.358, 1967

\* The data was obtained in cooperation with Nano Seeds Corp.

Adhesion force measurement system



CS-FNX



S110AT



T-AL adapter & holder



NS-C200

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