**Determination of the Contact Angle of Personal Care Powders using the Washburn Infiltration Technique**

Personal care powders are used for cosmetic purposes as well as odor/moisture control and will be exposed to oils, water, and cleaning solutions. While cosmetic powders should not smear when exposed to water or oils on our bodies, they also need to be able to be easily removed when cleaned off at the end of the day. Other powders like baby powder or certain deodorants are used to absorb moisture from the applied area for odor control and comfort. Contact angle testing is a great way to characterize the wettability of a sample to estimate how the sample will react in the environment.

Powders are difficult to measure the contact angle through conventional means due to the size of the individual particles. There are three main possible ways to determine the contact angle of powder samples: (1) compress the powder into pellets and measure the contact angle on the surface of the pellet, (2) use a microcontact angle meter to perform measurements on individual particles and, (3) use the Washburn infiltration technique where capillary action allows a fluid to penetrate the powder while packed in a tube. This application note will investigate the Washburn infiltration technique for different personal care product powders with de-ionized (DI) water.

Instead of directly measuring the contact angle using a goniometer, the contact angle is calculated by applying the Washburn equation (Equation 1). The Washburn infiltration technique uses powder packed into a testing tube. When the base of the powder column contacts a liquid, the liquid will infiltrate the void spaces between the powder particles via capillary action. The calculated contact angle of the powder is based on the distance of liquid penetration under equilibrium capillary pressure. According to the Washburn equation, the rate of penetration, $V$, of a liquid into small cylindrical capillaries is expressed as:

$$\text{Equation 1:}\quad V = \frac{R_{eff}\gamma_L \cos\theta}{4\eta l}$$

where $R_{eff}$ is the effective interstitial pore radius of the bundle of capillaries, $\gamma_L$ is the surface tension of the liquid, $\theta$ is the contact angle, $\eta$ is the viscosity of the testing liquid, and $l$ is the depth of liquid penetration.

Table 1 Contact Angle Measurement Results of Different Powders with DI Water

| **Powder Type** | **Capillary Radius** (μm) | **Contact Angle** (degrees) |
|---|---|---|
| Baby Powder A | 0.05 | 0.00 |
| Baby Powder B | 0.06 | 80.04 |
| Cosmetic Powder | 0.18 | 86.02 |
| Foot Powder | 0.09 | 80.21 |

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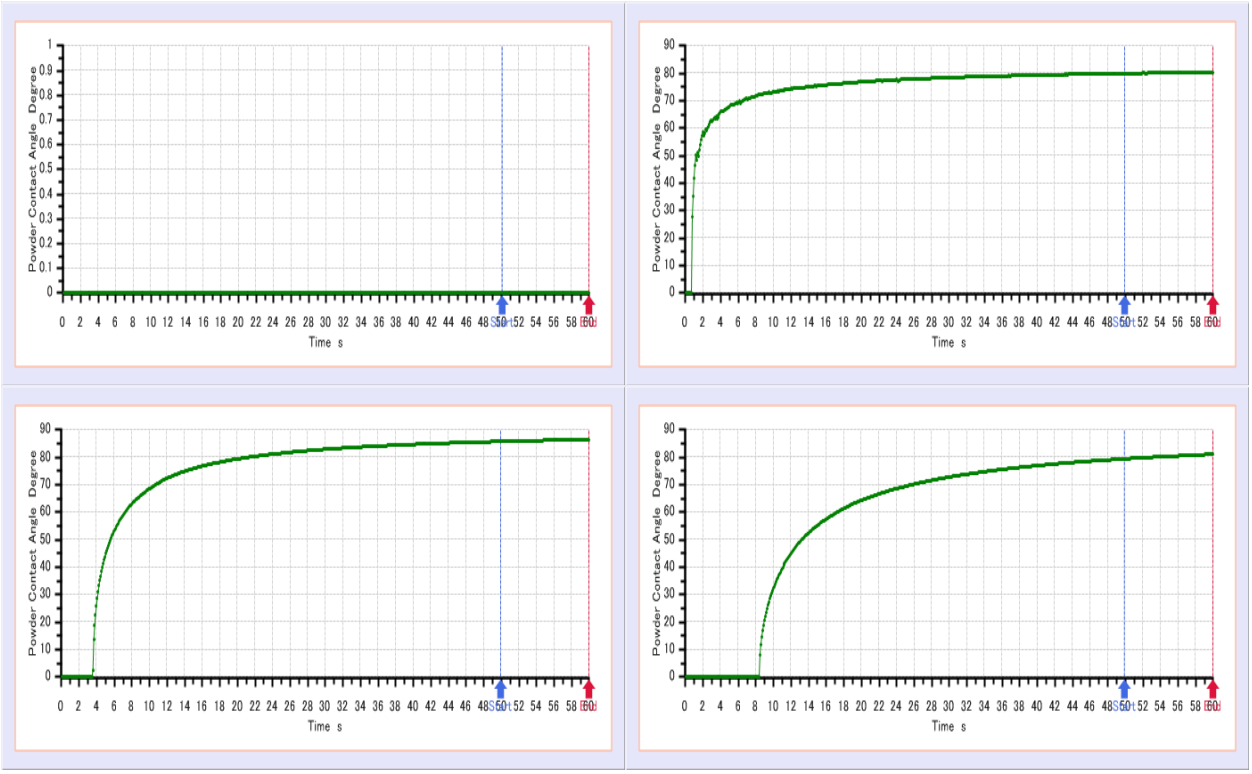


Figure 1. Contact angle plot of Baby Powder A (top left), Baby Powder B (top right), Cosmetic Powder (bottom left), and Foot Powder (bottom right) with DI water.

The Kyowa DY-700 Surface Tensiometer can be adapted for the Washburn infiltration technique by using a powder compressor and a testing tube. Table 1 presents the calculated contact angle results for each powder specimen measured using the Washburn infiltration technique on a DY-300. The reported contact angle was the average of the last 10 seconds of the test. Figure 1 presents plots of the water contact angle measurement results as a function of time for the four kinds of personal care powder samples. After determining the capillary radius of the powder in the tube, the contact angle was calculated via the Washburn equation for each powder sample. As seen in Table 1, Baby Powder A has a powder contact angle of 0˚. Due to the fast absorption of water, the powder expands rapidly before getting a reading, and the resulting powder contact angle is recorded as 0˚. The other samples have contact angles around 80˚ and 86˚. This means the other samples do not absorb or get wet with water as well as Baby Powder A.

As demonstrated above, the Washburn infiltration technique is incredibly useful in determining the contact angle values of fine powders on the condition that the contact angle of the powder with a liquid will be below 90 degrees. The technique will not work with powders that will have higher than 90-degree contact angle with a liquid simply because liquid infiltration is not going to happen.