DataPhysics Instruments GmbH · Raiffeisenstraße 34 · D-70794 Filderstadt
phone ++49 (0)711 770556-0 · fax ++49 (0)711-770556-99
e-mail info@dataphysics.de · internet http://www.dataphysics.de

Application note 17

Calculation of a new reference liquid by measurement on a known solid surface

Task

From the contact angle of a liquid on a purely dispersive solid surface, the unknown polar and dispersive contributions are to be determined.

Method

The following steps show the equations and conditions required to determine the surface tension and its polar and dispersive contributions of a reference liquid.

1. Required is a known solid with a purely dispersive surface free energy, from which results:

$$\sigma_S = \sigma_S^d \qquad (1)$$

2. The surface tension of the liquid can be determined with a pendant drop or with contact angles. The dispersive and polar contributions, however, still remain unknown. The surface free energy is divided into polar and dispersive contributions according to Owens-Wendt:

$$\sigma_L = \sigma_L^d + \sigma_L^p \qquad (2)$$

3. The calculation of the dispersive contribution of the surface free energy from the measured contact angle towards the reference solid surface is made as follows:

$$\sigma_L^d = \frac{\sigma_L^2 \left(1 + \cos\Theta\right)^2}{4\sigma_S^d} \qquad (3)$$

4. The polar contribution of the new reference liquid is calculated as the difference to the total surface free energy.

$$\sigma_L^p = \sigma_L - \sigma_L^d \qquad (4)$$

5. The reference solid surface has a surface free energy with a standard deviation, which is calculated as follows:

$$\sigma_S = \sigma_S^d \pm \Delta\sigma_S^d \qquad (5)$$

The standard deviation of the polar contribution can be determined as follows:

$$\Delta\sigma_L^p = \sqrt{\left(\Delta\sigma_L\right)^2 - \left(\Delta\sigma_L^d\right)^2} \qquad (6)$$

From (5) and (6) in (4), there results:

$$\sigma_L^p \pm \sqrt{\left(\Delta\sigma_L\right)^2 + \left(\Delta\sigma_L^d\right)^2} = \left(\sigma_L \pm \Delta\sigma_L\right) - \left(\sigma_L^d \pm \Delta\sigma_L^d\right) \qquad (7)$$

The standard deviation of the dispersive contribution can be derived from the above equation. For this purpose, the contact angle Θ must be entered in rad.

Results

An example from literature [1] is calculated by means of an Excel sheet. The purely dispersive solid surface has a surface free energy of 24.6 ± 1.2 mN/m.. The surface tension of the liquid is 44.8 ± 0.4 mN/m. Here, the contact angle of the liquid was 76.0 ± 2.1°. The standard deviations of the measuring results, unless stated in literature, were estimated.

By the example of an Excel sheet, the surface free energies could be calculated. Fig. 2 shows such a data sheet.

The result of this calculation is a polar contribution of the surface free energy of 13.34 mN/m and a dispersive contribution of 31.46 mN/m. The calculation of the standard deviation in both cases was approx. ± 2.4 mN/m.

Calculation of the polar and dispersive contributions of the surface free energy from contact angle measurements towards a non-polar solid surface

		SFT in mN/m	± SFT in mN/m (SD)
Solid	dispersive contribution	24.60	1.20
	polar contribution:	-	-
	Sum SFT:	24.60	1.20
Contact angle	CA in °	76.00	2.10
	in rad	1.32645	0.0367
Test liquid	Sum SFT:	44.80	0.40
	dispersive contribution:	31.46	2.43
	polar contribution:	13.34	2.46

Fig. 2 Excel data sheet

Summary

It could be shown that by means of the contact angle measurement of a test liquid on a purely dispersive solid surface, with an Excel data sheet the polar and dispersive contributions could be calculated. Moreover, the standard deviation of the polar and dispersive contributions could be calculated from the standard deviations of the data.

Literature

[1] Panzer, J. (1973): Components of Solid Surface Free Energy from Wetting Measurements; J. Colloid Interf. Sci.; Vol. 44; 142-161