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Application Note 1

The Pendant Drop Method with the DataPhysics OCA 20

Surface chemistry characterization of an important solvent for the paint and ink industry

The Problem

Knowledge of the networking properties of liquids is very important for many technical applications. These include the manufacture and processing of paints and inks, gluing and soldering, the development of special tensids for the cosmetics industry or controlling the surface chemistry properties of silicon wafers and the chemical process involved in the production of microprocessors. It is therefore important that the networking properties of individual liquids can be quantitatively recognized in order to make predictions about the networking process. To do this, knowledge of the surface tension as well as its polar and dispersed components is necessary. Using the example of dipropylen-glycol-monomethylehter (DPM), we demonstrate how by using the so-called pendant drop method and the contact angle measuring unit OCA20, the polar and dispersed components of the surface tension can easily be established. DPM was chosen as the example because its surface chemistry properties have not previously been analyzed in depth even though they are of significant interest for the paint industry. The method used is of principal interest and can be applied to all liquids in order to analyze their networking properties.

DPM is mostly used in the paint and ink industry. It universal solution properties are put to good use. In particular DPM serves as a solution agent for water based systems. DPM is also useful for the application of acrylic resin. For all these processes it is necessary to establish the surface tension with its polar and dispersed components in order to predict the networking properties.

Method

A drop of the liquid to be analyzed is formed on the bottom of a capillary using either the automatic or manual dosing system. The surrounding medium can be either gaseous or liquid. The contour of the drop can be photographed using CCD camera as shown in diagram 1.

Two forces determine the outer shape of the drop. One is the effect of the force of the weight and lengthens the drop in a vertical direction and the other works on the upper surface tension, keeping the drop in a spherical form in order to minimize the surface.

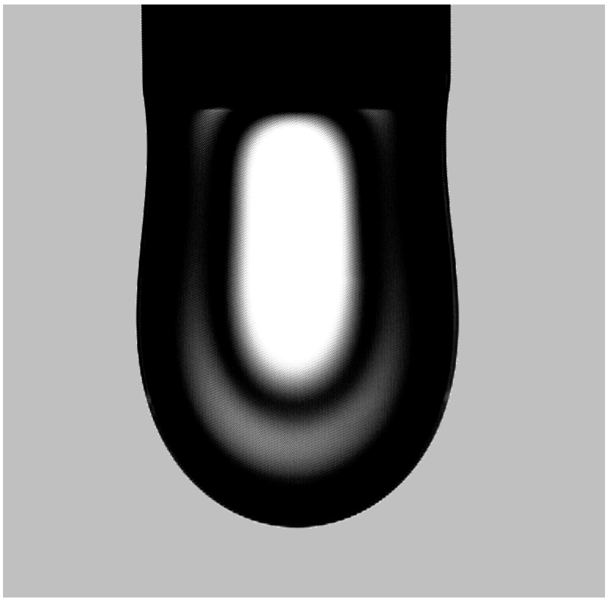

Diagram 1. Contour of a hanging drop

Characteristic for the equilibrium is the change in the bend along the contour of the drop. This force equilibrium is described mathematically by the Young- Laplace comparison. Once the contour of the drop is known, the surface tension limit can be determined. The SCA 22 software automatically carries out the detailed analysis of the drop contour. The dispersed e.g. Non polar components of the upper surface tension are calculable when the outer surface tension of the test liquid is measured against a completely non polar liquid. The polar component results from the difference of the total upper surface tension and the dispersed components.

Process

The surface tension σ_1 of DPM was established in air with the OCA 20 and the SCA 22 software. To calculate the non polar components of the outer tension $\sigma_{1/2}$ was measured against perfluorhexan.

Perfluorhexan (d = 1.669 g/ml, σ = 11.91 mN/m) was chosen because DPM is very soluble in high alkaline which is mostly used in this case.

According to Owens & Wendt, the following is valid for the surface tension $\sigma_{1/2}$:

$$\sigma_{1/2} = \sigma_1 + \sigma_2 - 2\left(\sqrt{\sigma_1^d \cdot \sigma_2^d} + \sqrt{\sigma_1^p \cdot \sigma_2^p}\right) \qquad (1)$$

In this σ_1^d and σ_1^p represent the respective components of the non polar surrounding medium, in this case perfluorhexane.

Therefore $\sigma_2^d = \sigma_2$ because $\sigma_2^p = 0$.

The dispersed component result comes from changing the equation (1):

$$\sigma_1^d = \frac{\left(\sigma_2 + \sigma_1 - \sigma_{1/2}\right)^2}{4\sigma_2} \qquad (2)$$

The polar component is calculated as:

$$\sigma_1^p = \sigma_1 - \sigma_1^d \qquad (3)$$

Results

Measured upper surface tension of DPM:

σ_1 = 28.41 ± 0.15 mN/m

Measured surface tension of DPM in Perfluohexan:

$\sigma_{1/2}$ = 8.66 ± 0.17 mN/m

(2) and (3) together result in the polar and dispersed components:

σ_1^d = 21.04 ± 0.30 mN/m

σ_1^p = 7.37 ± 0.34 mN/m

The result of a relatively high polar component of 7.43 mN/m of the surface tension of DPM reinforces the good solubility of the substance in polar liquids referred to previously.

Summary

Using the contact angle measuring unit OCA 20 with the SCA 22 software and the pendant drop method results in a quick and easy way of characterizing the networking properties of a liquid. The upper surface tension is directly accessible and the polar and dispersed components can easily be calculated after determining the outer surface tension compared with a non polar liquid.

In the case of the frequently used solvent DPM the previously unknown polar and dispersed components of the upper surface tension were established, knowledge of which for many networking processes e.g. coatings is of decisive importance.