Application Note 3

Determination of the surface tension between a printing ink and fountain water during the offset printing process

An application oriented example for the DataPhysics Optical contact angle range, together with the pendant drop method.

The Problem

Offset printing relies on the transfer of a image from an inked surface to the substrate, via a rubber 'blanket'. Used in combination with the lithographic process, based on the the use of oil based inks and a 'fountain water', the inked surface (plate) is diveded into hydrophilic regions, that accept the fountain water and repel the oil based ink and hydrophobic regions which repel the fountain water and accept the ink. This process, when working well, assures that the non-printing areas of the plate are ink free.

In order that the limits between printing ink and fountain water don't mix (a phenomenon known as tinting), it is necessary to establish the surface tension limits between printing ink and fountain water.

Conventional methods for determining the surface tension between two liquid phases, for example the DeNouy ring tensiometer, can be prone to imprecise measurement, particularly when there is a minimal density difference between the two liquids featured.

With the DataPhysics range of Optical Contact Angle measurement instrumentation, along with the software modules SCA 20 and SCA22 a reliable and accurate determination of the interfacial (surface) tension, by the pendant drop method, is readily achievable.

Method

In the case of the liquids of interest here; if the total surface tension, together with the contribution of the polar and dispersed parts of the separate liquids is determined. Then the surface tension limits (when these liquids are combined) can be calculated easily.

The polar and dispersed parts of the different liquids can be measured using the pendant drop method. In one measurement the total surface tension is determined and in a further measurement the dispersed parts are determined by measuring the surface tension limits against a non polar liquid.

First of all the surface tension of the printing ink and the fountain water were measured using the pendant drop method. In order to establish the dispersed and polar parts of the different components, the surface tension limits of the fountain water were established by dispensing a drop into dodecane. The ink of interest, in this instance, is soluble dodecane therefore it isn't possible to establish the surface tension limit within this previously selected liquid. The ink is, however insoluble in perfluorohexane, a completely inert,

Diagram 1: Image of a paint drop in Perfluorohexane

non-polar solvent. Establishing the surface tension limit is this alternative liquid is therefore possible. It is worth noting that perfluorhexane has a higher density than our printing ink so the drop was dispensed 'upwards' from the open end of a specially bent needle. A representation of the drop is shown in diagram 1.

For a more detailed description of the technique see the DataPhysics application note 1 "The pendant drop method".

Results

One colored printing ink and three different types of fountain water were included in our study. In table 1 the total surface tension of each fluid, together with a quantification of the disperse and polar parts of the surface tension, is detailed.

Table 1   Surface tension σ, together with disperse σ^d and polar σ^p parts of printing ink.

	σ [mN/m]	σ^d [mN/m]	σ^p [mN/m]
Printing ink	31.02	27.72	3.30
Fountain Water 1	52.07	26.92	25.15
Fountain Water 2	46.28	27.19	19.09
Fountain Water 3	39.10	18.68	20.42

As anticipated; the calculated surface tension of the printing ink was around 30 mN/m, with a contribution for polar forces of approx.10% this total value.

The three fountain waters selected each displayed a very different ratio of polar to disperse parts (closer to a 50:50 ratio).
In comparison to the data well known for pure water: $\sigma_{Water}^d = 21.8$ mN/m $\sigma_{Water}^p = 51.0$ mN/m the dispersed part of the fountain water's surface tension was sometimes greater than that of water and sometimes less. The polar part, however, of all fountain waters was less than that of pure water.

The calculation for surface tension $\sigma_{1/2}$ **between** fountain water and printing ink can be made using the Owen Wendt formula:

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

In this formula; σ_1 is the surface tension of the printing ink, σ_1^d it's dispersed part and σ_1^p its polar part. The index '2' refers to the fountain waters in each case.

By inserting the values from table 1 in formula (1), the following results were obtained.

Table 2   Surface tension between printing ink and fountain water

	σ [mN/m]	$\Delta\sigma$ [mN/m]
Fountain Water 1	10.23	1.20
Fountain Water 2	6.51	1.18
Fountain Water 3	8.19	1.18

Using the values in table 2 it is clear that the surface tension **between** printing ink and fountain water only partly correlates with the overall surface tension of the fountain water.

Although fountain water 3 shows the smallest surface total tension, our studies would indicate a higher surface tension between it and our printing ink, when in combination, than fountain ink 2.

This behavior of these fluids, in combination, is a practical consequence of the variance in contributions (polar and disperse parts) to the total surface tensions of the ink and fountain waters selected and illustrates that knowledge, limited to that of total surface tension only, might result in an inappropriate selection of water/ink.

Conclusion

A method has been presented that simply and precisely establishes the surface tension between printing ink and fountain water.

With the example of this particular ink and these three fountain water candidates, it has been shown that an exact assessment of the surface tension limits between printing inks and fountain water is only possible if one establishes the exact contributing factors to the overall surface tension.

The overall surface tension alone is not enough to predict the consequences of using these liquids together in our process.

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