Application Note
C-216

Printability of Polymer Sheets & Films

Dun Chen, Thermo Fisher Scientific, Process Instruments, Newington, USA

Key words:

- Printability
- Film
- Polarity
- Surface
- Contact Angle

Introduction

In today's marketplace, the ability to graphically display company identity and product information has become of paramount importance. Polymers have become an active ingredient, if not the total base media for many advertisements printed today. Due to their durability they have replaced many paper and card products including labels, packaging, displays etc. However changes in product and printing technologies give rise to other problems, a once effective material to print on has now become problematic.

There are a number of criteria required in order to print effectively, the ink must not "bleed" into the substrate causing blurred images. It must evenly coat the surface and give the correct color. On drying, it must remain affixed to the surface and not peel or chip. A means to quickly qualify both printing media and inks is required.

Dynamic Contact Angle (DCA) has long been used to resolve many surface property issues and can be used in this case. The Dynamic Contact Angle method uses the Wilhelmy plate technique. This method continuously records the weight of a solid sample that either attracts, or repels a liquid into which it is suspended. As the solid is advanced and extracted from the liquid, the liquid may adhere and travel up or be repelled from the solid surface. The resultant forces exerted between the liquid and solid are thus measured, and defined by the Wilhelmy equation.

$$F = \gamma \, p \cos\theta$$

Where, **F** is the wetting force between the liquid and solid, $\boldsymbol{\gamma}$ is the liquid's surface tension, **p** is the wetted perimeter, and $\boldsymbol{\theta}$ is the contact angle between the solid and the liquid.

To test this method two polymer sheets reinforced with fiber, one with good printability and one having poor printability were tested using a Thermo Scientific Cahn Radian DCA.

Using a Thermo Scientific Cahn DCA315 with optional DCA Applications software, the samples were tested and analyzed as follows:

Samples measuring 20 mm x 30 mm were cut. Each sample consisted of two pieces of material, mounted together using double-sided tape, so that the same surface faced out. The samples were then immersed into the liquid to a depth of 8 mm, using a stage speed of 65 µm/sec.

First the contact angle for each sample was obtained using distilled water as the test solution (Table 1). The differences in contact angle were found to be small.

Results & Discussion

A further set of contact angle values was obtained, this time using ethlyene glycol as the test solution. The resulting data from each test solution was exported into Cahn's applications software for further analysis.

This applications software package allows for various calculations to be performed including Zisman plot, Geometric /Harmonic Mean, Lewis acid/base, and Liquid Surface Tension Components. The Geometric Mean calculation[1-4] was chosen, and the equation for calculation is expressed as follows.

$$\gamma_l(1+\cos\theta) = 2\sqrt{\gamma_s^d\gamma_l^d} + 2\sqrt{\gamma_s^p\gamma_l^p}$$

Where γ_l is the liquid's surface tension, which equals to $\gamma_l^d + \gamma_l^p$, γ_s is the total surface energy of the unknown solid and is the summation of γ_s^d and γ_s^p. Superscripts d and p in γ_l^d, γ_l^p, γ_s^d, and are the dispersive and polar components respectively.

By using at least two known liquids with known sets of γ_l, γ_l^d, **and** γ_l^p to obtain the contact angle values, the surface energy of the solid sample can then be calculated. The results for the tested samples, based upon the advancing contact angles, are listed in the Table 2.

It now becomes very clear as to the differences between each sample. Sample #1 is a much more polar solid, while the sample #2 is almost completely dispersive. Since the

	Advancing θ	**Receding θ**
S1	92.75° ±0.0103	59.96° 0.0117
S2	91.69° ±0.0213	50.44° ±0.0238

Table 1. Contact Angle Values, in degree.

	Sample #1	**Sample #2**
Printability	Good	Poor
γ_s^d - Dispersive	11.357	47.748
γ_s^p - Polar	6.917	0.130
γ_s – Total	18.274	47.878
Polarity	37.85 %	0.27 %

Table 2. Surfe Energy Results for Two Polymer Sheets, in Dyne/cm.

ink that was used is a water-based ink, it will provide a better printability if the solid's surface is more polar. From the data in Table 2, Sample #1 will prove to be a better printing media for these kinds of inks.

By using the same techniques, ink's surface properties, especially polarity, can also be obtained. This provides a means to alter the ink's surface properties to that of the printing media, thereby minimizing or maximizing its adhesion to that surface.
Finally the inks themselves may be used as test solutions to provide realistic data about their application to the surface to be printed.

Conclusion

Dynamic Contact Angle provides an effective means to measure the surface properties and modifications to sheets, films etc. It provides a means to help to formulate inks and printing media for consistent and reproducible results for a variety of applications.
This effective tool may be used for Research & Development, Quality Control, or wherever the need to qualify liquid and/or solid material surface properties is required.

Reference

[1] *Good, R.; J. Adhesion Sci. Tech., Vol 6. (1992) No 12. pp. 1269 – 1302.*

[2] *Girifalco, L. A. and Good, R. J., J. Phys. Chem., 61 (1957) 904.*

[3] *Fowkes, F. M., J. Phys. Chem., 66 (1962) 382.*

[4] *Owens, D. K. and Wendt, J., J. Appl. Polym. Sci., 13 (1969) 1741.*

Thermo Fisher Scientific
Process Instruments

USA
25 Nimble Hill Rd.
Newington, NH 03801
Tel. 603 436 9444
info.mc.us@thermofisher.com

www.thermo.com/cahn

C019_05.07.07