Application Report

Surface energy of textiles

Application report:	AR251e
Industry section:	Textiles
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Date:	02 / 2006

Drop Shape Analyzer – DSA100

Method: captive bubble	
Keywords:	fibers, textiles, contact angle, surface free energy, wettability, captive bubble, compound materials, polymers

Upside down: Surface energy measurement of textiles by captive bubble method

Abstract

The wetting behavior of textiles can hardly be quantified by standard contact angle measurements due to unevenness of the sample and rapid ad- or absorption of sample liquids. This may be remedied by the captive bubble method which allows contact angle measurements on wetted samples. By means of this method, the surface energy and its polar and disperse part of two cotton materials, one mixed with synthetic fibers, could be measured. Thereby, the changes of water wettability occurring from this polymeric additive could be measured exactly.

Method

Whoever wants to perform ordinary contact angle measurements on textiles will face a couple of difficulties. First, textile samples easily absorb the drop liquid so that the measurement must be done in only a few milliseconds and no one can talk of a stationary value. Second, a tissue sample often is uneven due to protruding fibers and it is difficult to determine a baseline. Both problems can be minimized by the captive bubble method.

As for the standard method, i.e. measurement at the sessile drop, the sample liquid is dosed on to the sample from above, normally in a phase of ambient air. However, apart from the contact angle between liquid and solid, there also is a second contact angle, which most users are normally not interested in: the complementary angle jointly formed by solid and gas phase at the three phase point. Both angles together add up to 180°.

The captive bubble method puts everything upside down. The solid is initially wetted from below by the adjoined sample liquid. Then, a bubble is produced in the liquid below the sample which mounts and forms a contact angle at the bottom side of the sample. This bubble contact angle is – like the one of a liquid – determined by video evaluation. The liquid contact angle results from the difference between this angle and 180° and will be calculated automatically by the software.

In case of ad- or absorbing samples, what appears to be a detour actually is the easiest way. On the one hand, the angle can be determined when the sorption process is finished – you easily get a stationary. On the other hand, wetting by liquid smoothes the sample and one gets an even baseline.

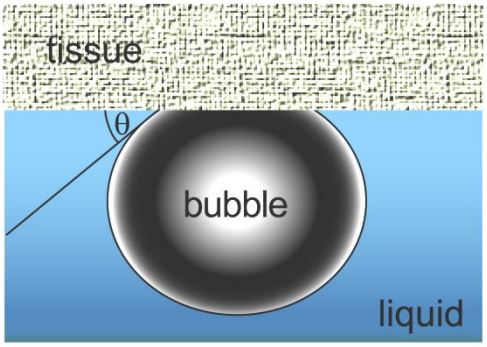

Fig. 1: Schematic view of the captive-bubble arrangement

Experiment

By means of this arrangement, a comparison could be made between the surface energy of two textile samples: one of a pure cotton material and one of a compound material with synthetic fibers. Measurements were made with the three standard test liquids: water, ethylene glycol and diiodomethane. Calculation of the surface energy from the contact angle data was done as per Owens-Wendt-Rabel-Kaelble.

Results

It could be shown that the surface energy of the textile material decreases in relation to its content of polymers. It also became obvious that the main difference lies in the polar part of the surface energy which is reduced by the synthetic fiber. As for the macroscopic behavior this means that compound materials show a minor wettability by polar liquids like water and are, e.g. more suitable for rainwear.

Following pictures show both contact angle evaluations, below listed are the results of the surface energy determination.

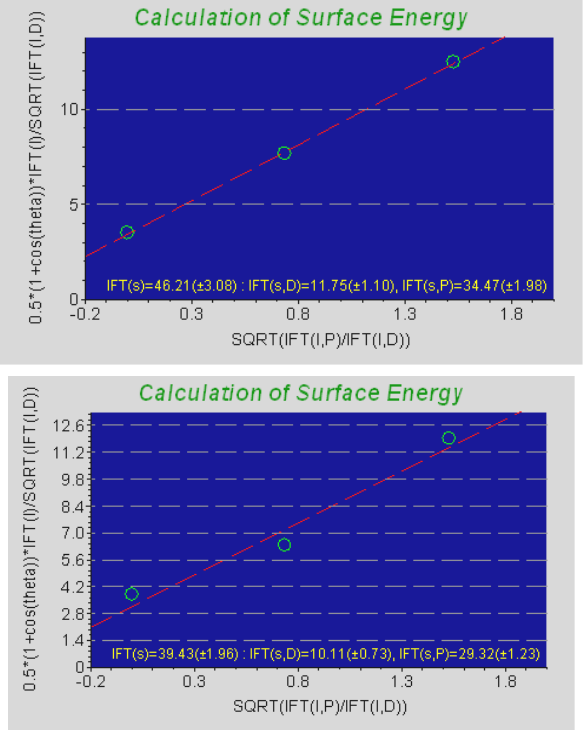

Fig. 2: Evaluation according to OWRK for pure cotton (top) and polymeric compound material (bottom)

	Pure cotton material	Polymeric compound material
Surface energy (mN/m)	46.2	39.4
Polar part (mN/m)	34.5	29.3
Dispersive part (mN/m)	11.7	10.1

Tab. 1: Surface energy of two textile samples

Summary

The captive bubble method allows via a detour of measuring the contact angle of a bubble with a solid sample in liquid phase to determine the surface energy of samples that normally are difficult to be measured. The possibilities and advantages of the captive bubble method could be demonstrated for two textile samples. It could be shown how the surface energy of cotton can be reduced by the concentration of added polymeric fibers. Especially the polar part of the surface energy and with it the water wettability can be influenced by adding synthetic fibers.