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Application Report

Characterization of coated papers

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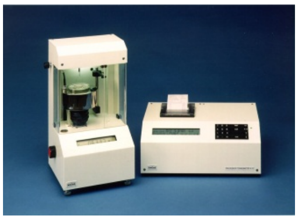
Drop Shape Analysis System DSA10


Force Tensiometer – K12

Wettabilities and Surface Tensions of Different Paper Types

Abstract

Paper is a solid being porous from the structure of the basic material, but can also possess a tight surface. Taking into account the different applications of paper and the different ways to modify its properties it becomes clear that there is no unique way to characterize its surface properties. Paper used for writing or printing is generally covered with a coating. This coating is generally a mixture of pigments and polymer lattices yielding a tight or bibulous surface, depending on the latex/pigment ratio and the structure of the pigment used. Paper tissues for hygiene and kitchen use are usually porous systems using porosity, hydrophilicity and sometimes even additives like surfactants to guide liquids from where they are into the tissue or to some other place. This paper will present three different strategies to yield the surface parameters describing the paper's properties in contact with other phases.

Sorption of water into tissue material

Tissue-materials used for diapers, cosmetic tissues, toilet-, household- or blotting-papers are selected and modified for maximum sorptive rate and capacity for water-based fluids.

The most obvious way to measure these properties is to measure the contact angle versus time of a droplet being placed onto the material. In the past these high-speed measurements were simply not possible due to lack of low-cost high-speed video-equipment. But now with the DSA10 HS-option up to 360 values (one value every 2.7ms) are possible. Figure 1 shows such measurement comparing two tissues for diapers. One has got a hydrophobic, one has got a hydrophilic surfactant coating.

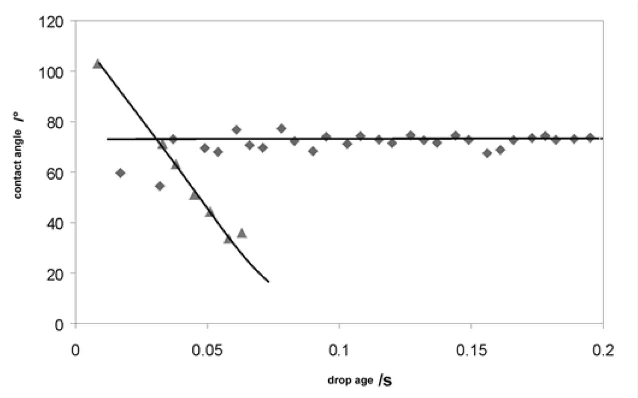


Fig. 1: Contact angles versus drop age of two differently treated paper tissues

Figure 2 shows selected images from the video-sequence of water on the hydrophilic tissue.

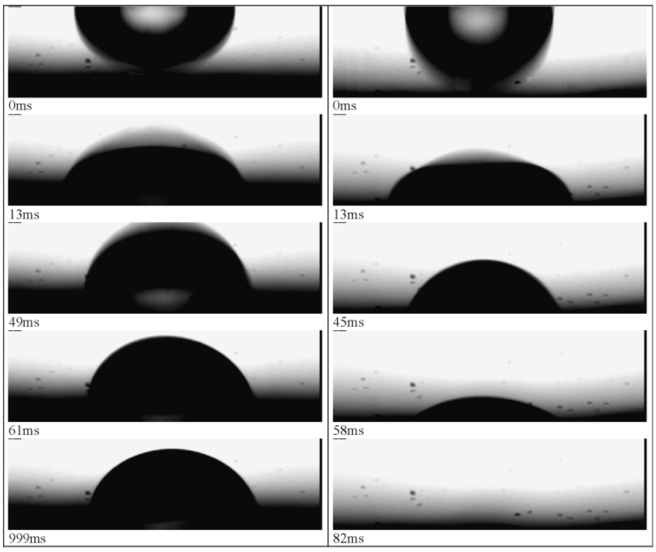


Fig. 2: Selected images from the video-sequence of water on the hydrophobic (left hand side) and the hydrophilic (right hand side) tissue

This technique is especially useful, when the direction of sorption and comparison of extremely different materials with the same liquid are necessary.

Sorption rate and contact angles of porously coated paper

For some papers special coatings are necessary to adjust liquid penetration on one side, e.g. labels. These can be special pigments like carbonates mixed with a low amount of polymeric latex. In general liquid penetration into porous materials is governed by two major properties of the system. The geometry ("capillarity/porosity") and the energy ("contact angle"). Both in total yield sorptive behavior. To judge whether geometry or energy changed in different products, Washburn-measurements were performed, measuring the capillarity with the completely wetting liquid n-hexane and the capillary rise velocity as well as contact angles with water. The samples were prepared by sticking the sides that were non-sorptive onto double sided adhesive tape.

Figure 3 shows the measurement data of n-Hexane on the samples.

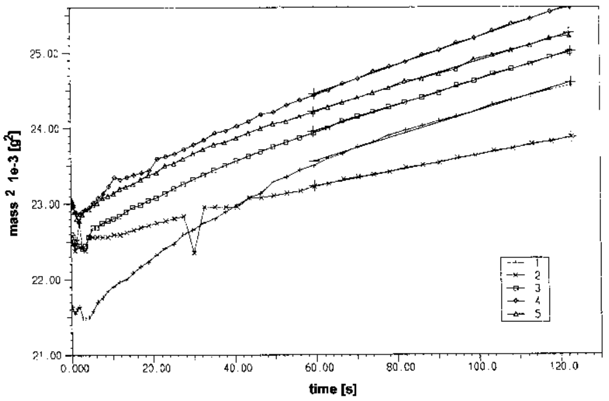


Fig. 3: Sorption of n-Hexane into the coated paper samples

Table 1 compares the results of differently coated papers.

Sample	capillary constant 10^{-7}[cm^5]	water contact angle [°]	water capillary rise velocity 10^{-7}[g^2/s]
1	6.8	52	301
2	4.1	89	3
3	6.9	35	410
4	7.7	86	41
5	6.7	70	171

Table 1: Capillary constants, water contact angle and water capillary rise velocity of differently coated papers measured with the Washburn-Method

The capillary rise velocity of water as a result of capillarity and contact angle shows, that both together influence the flow velocity of liquids in porous media. Sample 2 makes clear that a low capillary constant and a high contact angle hinder the penetration of liquid. Sample 4 shows that a high capillary constant is worth nothing, if the contact angle is high, liquid will not absorb into the solid quickly. Sample 3 is a good example of a highly sorptive coating, having a high capillary constant and a low contact angle, yielding a high capillary flow velocity with water.

Surface free energies of coated papers

When the printability or adhesion of a coated, non-porous paper should be judged the wettability and surface tension of the coated paper are the data in question. Surface free energy ("surface tension") and especially polarity of the surface govern the behavior of the paper in contact to another phase e.g. printing inks, polymer films, lacquers. Is the paper (at least on the side in question) non-porous, advancing angles of liquids can be measured by the Wilhelmy Plate-Method or the Sessile Drop-Method. Both are valuable tools to yield surface free energies of solids.
Figure 4 shows an example of a dynamic Wilhelmy Plate measurement.

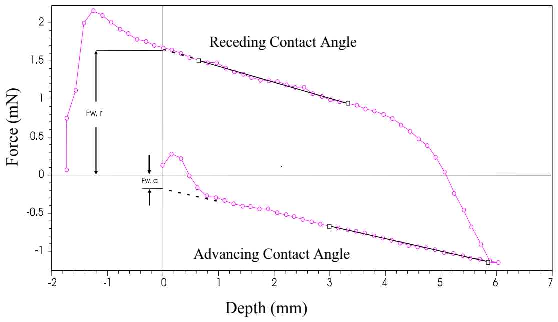


Fig. 4: Dynamic Wilhelmy Plate measurement (example)

Table 2 summarizes the contact angle data (advancing) of water and diiodomethane on printing paper.

Sample	water advancing CA [°]	diiodomethane advancing CA [°]
1	68	48
2	74	48
3	73	51
4	70	47
5	80	57

Table 2: contact angle data (advancing) of water and diiodomethane on printing paper

These data already reveal that sample 5 is the most hydrophobic, sample 1 the most hydrophilic one. This hydrophilic behavior is especially of interest if the paper is used for offset printing (take up of the fountain solution is an undesired feature). Not only the behavior versus water can be foreseen with the surface free energy data calculated from contact angles. Table 3 reveals the fact that only slight changes in coating composition (surfactant/wetting agent, polymer composition in the binder) can have a dramatic effect on the paper's surface energy and especially the polar part. This will govern wetting and adhesive behavior. When combining this set of data with the same data of the phase in contact with the paper (printing inks, polymer films, lacquers) interfacial tensions, works of adhesion are accessible.

Sample	σ [mN/m]	σ^D [mN/m]	σ^P [mN/m]
1	40	29	11
2	37	30	7
3	37	28	9
4	39	30	9
5	32	26	6

Table 3: Surface free energies (incl. dispersive and polar parts) calculated from contact angles (see table 2) according to Owens/Wendt/Rabel/Kaelble on printing papers

Literature

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