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Application Note 2

Absorption measurements with the DataPhysics Optical Contact Angle range of instruments.

Quantitative determination of the absorption behaviour of filter membranes

The Problem

In order to characterise the properties of porous absorbent materials, within both industrial and research environments, physical and chemical measurement methods are employed. The most commonly undertaken absorption studies provide only a single measurement of maximum adsorption capacity of a particular liquid. As advancements are made in the development and optimization of modern substrates it can be the absorption rate, rather than simply the max. absorption volume, that is the parameter of greater interest, as this can often provide an insight into the characteristic pore size of the material, for a particular application field. The absorption kinetics are determined, not only by the surface and inner 'volume' porosity, but also by the direction and rate of spread, over and within. The viscosity of the absorbent liquid is an influencing factor on absorbance rates and must be taken into consideration by any calculation routine.

Using the example of filter membranes (in this case, those used within the brewing industry) we will show how the video based contact angle measuring system, OCA xx, and chosen optics/camera can be used to provide an exact quantitative illustration of the absorption kinetics of water when placed on such filter membranes.

Method

The data detailed in this application note is limited to the absorption behavior of water, but the method illustrated is applicable to any absorbent liquid that can be dispensed from a needle and syringe, combination in a software controlled electronic syringe drive unit, ES.

A defined liquid volume is dispensed; the shape of the formed drop being dependent on the surface tension of the water and the diameter of the needle. Allowing the drop to fall a short distance onto the absorbing substrate provides for more robust data, than placing it on the surface, as the influence of the needle on the initial drop shape is eliminated.

Immediately after the impact of the drop, on the surface under study, the drop flattens out.

However, after some 40 ms the drops internal networking reaction reaches its equilibrium and a

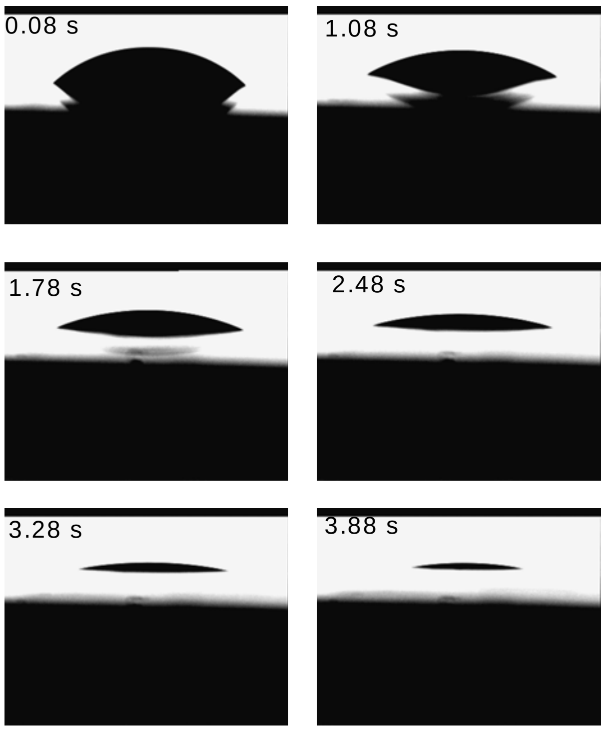

Figure 1 Picture sequence of the absorption of a water drop on a filter membrane.

regular, sessile drop profile is discernable.

The video based OCA devices and supporting software enable two quite different routines for the collection/analysis of the subsequent data. (1) The collection of images and 'live' analysis of each, via a automated routine. (2) The collection of a video file and analysis of individual frames 'after the event'. The prerequisite for this method is that the collection of analyzable images takes place at a high enough rate to account for the speed of absorption. By using the specially developed high speed video system, a movie sequenced can be obtained with in excess of 3000 frames/second.

In order to enable reliable reporting of data such as contact angle, drop volume, drop base diameter and sessile drop profile, during an automated measurement routine, the boarder (base line) between the drop and the absorbing substrate must be defined and consistent. Unfortunately, as a consequence of the very process that we are seeking to understand here, the base line can rise, due to swelling of the substrate, and frustrate the automated measurement routine.

In situations where the potential error introduced by the above effect might be significant or where the absorption rate is such that the limitation placed of speed of image capture, by the automated routine, may mean that that some crucial data is missed, the recording of a movie for subsequent, off line, a analysis is a method of choice. Having recorded a movie sequence of this type individual images can be selected and analysed (with manual placement of base line) at your leisure.

Results

In figure 1 the absorption, of a water droplet, into a hydrophilic filter membrane is represented by a sequence of 6 pictures (selected from a series of over 100, collected during the measurement).

This sequence of images clearly illustrates that the drop volume, as well as the contact angle, continuously decreases during the time scale of this measurement routine.

Figure 2 illustrates the absorption rate (decrease in drop volume vs. time) of water on three different membranes. The effect of pre-treatment, to induce hydrophilic and hydrophobic nature, can be easily seen. (A faster, overall, absorption rate as a consequence of hydrophilic pre-treatment and a much slower, overall, absorption rate as a consequence of hydrophobic pre-treatment).

A step change in absorption rate occurs in both the untreated and hydrophobic cases. (illustrated by the steeper initial gradient of the data, compared with a lesser gradient after about 3 seconds). The

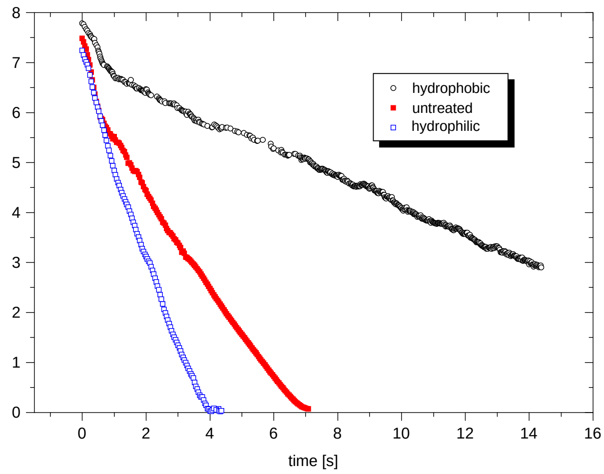

Figure 2. Visible (unabsorbed) drop volume, as a function of time, on different pretreated filter membranes.

hydrophilic data set does not exhibit such a step change in gradient.

This more rapid absorption during the first few seconds (compared with that a little later in the process) is a behavior theoretically predicted, but unproven (unseen) before advances in technology provided for the possibility of this evaluation.

Theory had suggested that any movement of the drop into and within the membrane would be accompanied by an inefficient creation of new surfaces between water and the air contained within the membrane. This process slows down the rate of liquid 'up take' in the cases of the untreated and hydrophobic membranes, but is not an influence in the case of hydrophilic pre-treatment, where the absorption rate is consistent throughout the entire process.

As this process is also influenced by the porosity of the upper and lower sides of the membrane surface, conclusions can be drawn, from the difference of the absorption gradients (rates at which the water is able to move into and then within the air filled voids) about the properties of the membrane surface in addition to the structure within.

With each saved image further data sets are calculated. eg. contact angle, drop height and drop diameter. These data sets are then available for analysis and graphical representation at any time.

Conclusion

The video based optical contact angle measurement range of instruments, OCA xx, along with the latest video image capture/analysis technology can be used to directly and simply evaluate even the fastest absorption processes.

Through the precise and accurate determination of, for example, the decrease in volume of a drop moving into an absorbent surface, the details of the influences on the on-going absorption process can be deduced. This new found knowledge can be used to monitor the effect of membrane treatments/modifications and modified material properties optimised.