Optical Contour Analysis (OCA)

Absorption Measurements of Water Droplets on Filter Membranes

dataphysics
Understanding Interfaces

Porous absorbent materials are often characterized by absorption studies in which the maximum adsorption capacity is determined for a particular liquid. However, the absorption rate, rather than simply the maximum absorption volume, is also of great interest as this can often provide an insight into the characteristic pore size of the material. The absorption kinetics are determined, not only by the surface and inner 'volume' porosity, but also by the direction and rate of spreading on the absorbent surface and within the pores. The viscosity of the absorbent liquid is an influencing factor on absorbance rates and must be taken into consideration by any calculation routine. With the video based contact angle measuring systems of the OCA series the absorption kinetics of liquids placed on a filter membrane can be studied time dependently as we will show in the following application note.

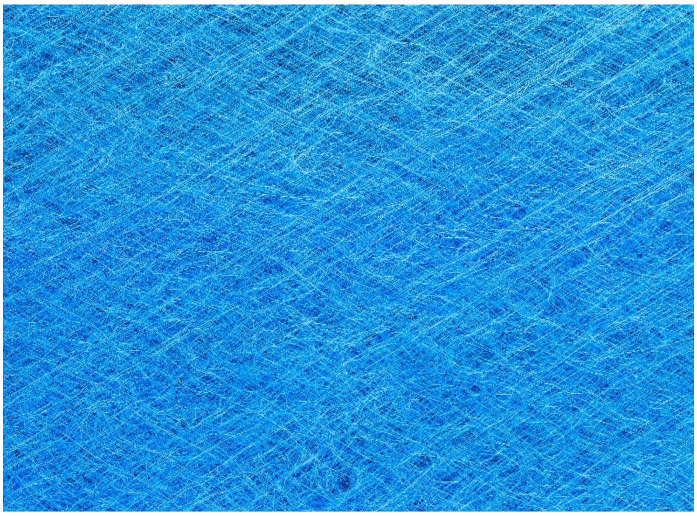

Fig. 1. Filter membrane.

Keywords: OCA ▪ High Speed Video System ▪ Absorption Measurement ▪ Filter Membrane ▪ Absorbent Material

Technique and Experiment

The optical contact angle measuring and contour analysis systems of the OCA series (Fig. 2) combine high resolution optics, exact liquid dosing and precise sample positioning into powerful and reliable measuring systems for interfacial parameters and phenomena.

Fig. 2. The contact angle measuring and drop contour analysis system OCA from DataPhysics Instruments.

In the present study, the absorption behaviour of different pre-treated filter membranes used in beverage production has been studied. The data detailed in this application note is limited to the absorption behavior of water, but the method illustrated is also applicable to any absorbent liquid that can be dispensed from a needle and syringe. 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, the drop flattens out. However, after 40 ms, the drops reach their equilibrium shape and a sessile drop profile is visible.

The video-based OCA devices and supporting software SCA 20 enable two different routines for the collection and analysis of data: (1) The collection of images and 'live' analysis of each, via an automated routine. (2) The collection of a video file and analysis of individual frames 'after the event'. The prerequisite for either method is that the collection of analyzable images takes place at a high enough rate to account for the speed of absorption. By using our high-speed video system, a movie sequence can be obtained with more than 3000 frames/second.

To enable reliable reporting of data for the contact angle, drop volume, drop base diameter and sessile drop profile during an automated measurement routine, the border (base line) between the drop and the absorbing substrate must be well defined and consistent.

Depending on the liquid and especially on the substrate the second evaluation procedure, using a recorded movie sequence and evaluating individual images after the fact, is preferable as it gives you full control and all the time needed to even evaluate difficult experimental scenarios.

Results

In Fig. 3, the absorption of a water droplet into the hydrophilic membrane is represented by a sequence of 6 pictures selected from a sequence which was recorded during the measurement. This sequence of images clearly illustrates that the drop volume, as well as the contact angle, continuously decreases over time (from top left to bottom right).

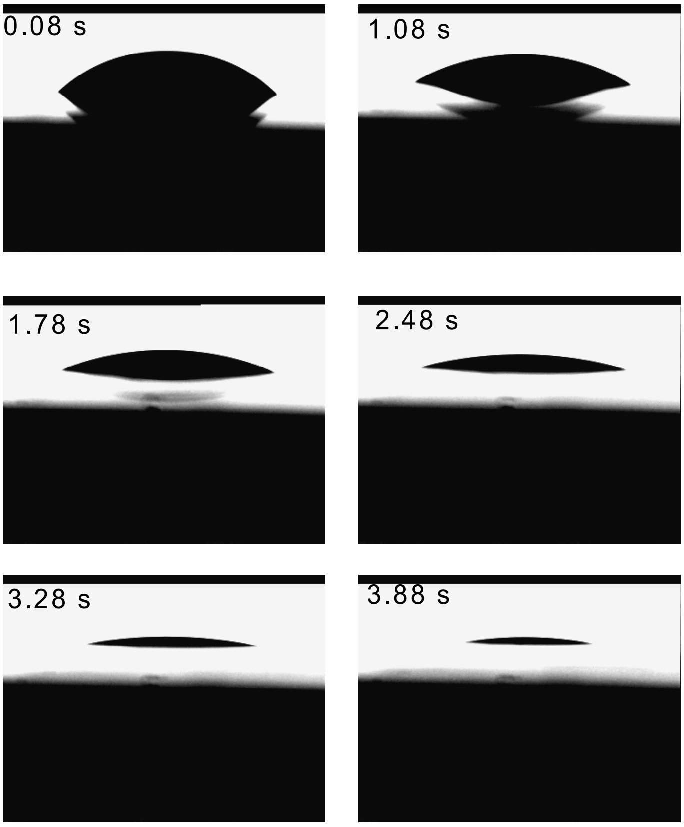

Fig. 3. Picture sequence of the absorption of a water drop on a filter membrane.

Fig. 4 shows the absorption rate (decrease in drop volume vs. time) of water on three differently pre-treated membranes. The effects of the hydrophilic and hydrophobic treatment can be easily seen. (Faster absorption rate because of hydrophilic and a much slower, absorption rate because of hydrophobic pre-treatment).

For the hydrophilic membrane (blue curve) the fastest absorbing behavior could be monitored: within t = 4 s the water droplet has been absorbed completely. The adsorption rate of the untreated and hydrophobic membrane changes during the adsorption process: An initial fast absorption is observed (comparable to the hydrophilic one) that after about 2 s changes into a much slower absorption.

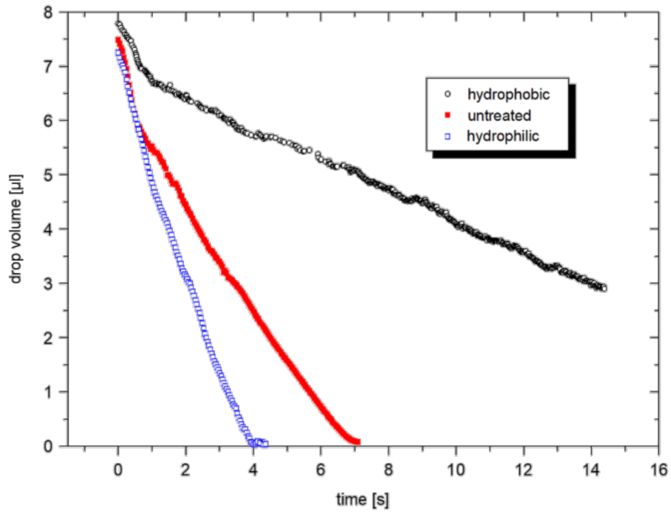

Fig. 4. Water drop volume vs. time on differently treated filter membranes

Analyzing individual frames shows that the drop diameter does not change during the absorption. Therewith it could be shown that the absorption took place vertically to the membrane level.

Theory had suggested that any flow of the water droplet 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.

Summary

The optical contact angle measuring and contour analysis systems of the OCA series with their high frame rate video systems can be used to directly and simply evaluate even the fastest absorption processes. Through the precise and accurate determination of 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 optimization.

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