First Ten Ångstroms **ApplicationNotes**

Basic Contact Angle Measurements on Paper

October 16, 1997

Contact angle and absorbency measure-ments are easily performed with the FTÅ200. The system has several features designed specifically for these measurements:

- fast image acquisition: 60 images/second
- long movies: typically up to 200 images
- flexible image timing: linear/non-linear
- synchronization: fiber optic drop sensor

Fast image acquisition does two things: it allows the instrument to capture extremely rapid absorptions, such as acetone and other solvents, into the sample, and it permits one to accurately determine when the drop settled on the specimen and began absorbing. Long movies, a unique feature of the FTÅ200, permit the entire process to be captured with-out sacrificing the details at the beginning.

The instrument has another unique feature: non-linear capture timing. This means the spacing between captured images can be varied on an image-by-image basis. Many phenomena happen rapidly at first and then slow down to a long "steady-state" con-clusion. Non-linear timing (often called "log timing") stretches the time between the later images compared to the early ones. This is having your cake and eating it too: fast timing at the start to capture the initial drop contact and then slow capture during the final absorption.

The fiber optic drop detector is an independent sensor for the presence of the pendant drop on the dispense needle. It tells the acquisition board when the drop can no longer be seen and this serves as a "trigger" for the movie capture. Image capture is like a "transient recorder" which means that a preset number of images will be constantly held, so when the trigger actually occurs the previously saved images can be stored away. In this fashion, one can take a movie of events before the trigger, and not just after. For example, you can take high speed movies of the drop detaching and falling, even though there is no ***a priori*** knowledge of when the drop will detach.

The following example was run on a sample of lightly coated paper with water as the test fluid. The paper was very thin, so it could not absorb much directly under the drop, but water would spread well beyond the drop area once it had entered the paper. The specimen was supported over air, so there was no second solid interface to trap fluid.

Figure 1 shows the instant the droplet detached from the dispensing needle (seen in the upper center) and contacted the paper.

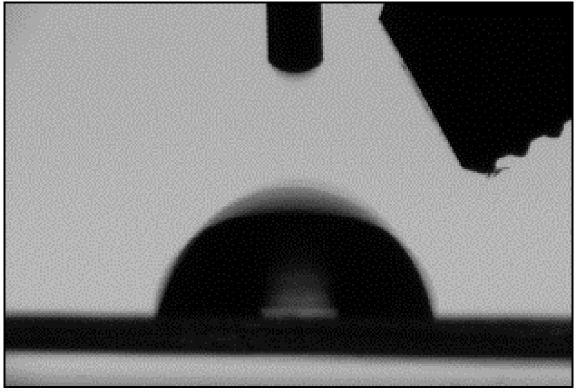

Figure 1. Initial contact of droplet on paper.

To give some scale to the image, the diameter of the dispensing needle is 0.710mm (.028"). The volume of the droplet is essentially 10µl. The paper appears thicker than it actually is because it does not lie absolutely square to the camera; the actual thickness is .05mm (.002"). Images were captured over the next 130s as the water absorbed. The droplet at the end of this time is shown in Figure 2.

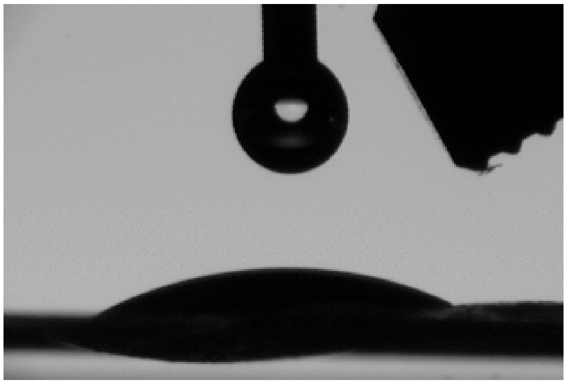

Figure 2. After 130 seconds.

The instrument analyzed all images in the movie automatically. The data is graphed in various ways below. Figure 3 shows the contact angle as a function of time and Figure 4 shows the base area of the droplet as it spreads.

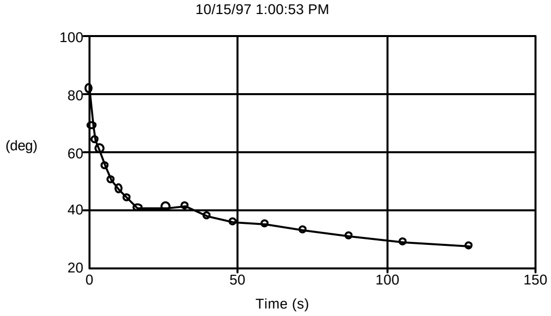

Figure 3. Contact Angle of Water on Paper.

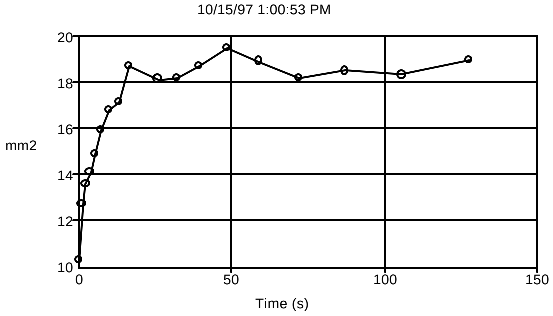

Figure 4. Area of Spreading Drop.

Notice the drop spreads rapidly in the first 20s, then stops as it absorbs. At this point the contact angle is low enough that it will not spread further. Since the paper swells after the spreading stops, the exact base area is difficult to measure and there is some variance in the data.

Figure 5 shows the standing drop volume as a time function and Figure 6 shows the "flow" of water into the specimen.

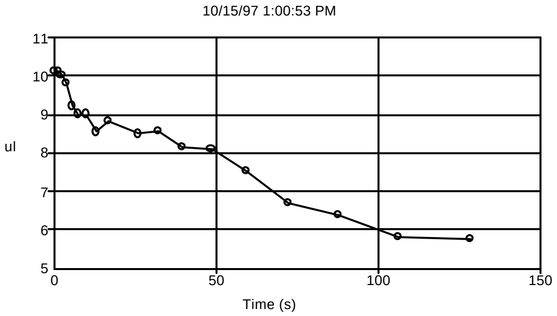

Figure 5. Droplet volume during absorption.

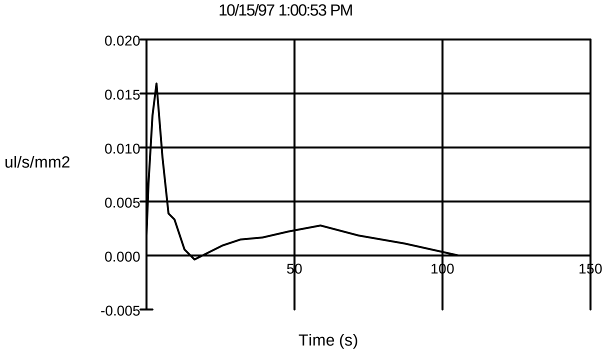

Figure 6. Rate of change in volume ("flow").

The last figure illustrates a common phenomena: high initial flow until the media directly under the drop is saturated, then a slower horizontal flow of fluid through the paper. Of course this second path to "dry" material is much longer, so it proceeds more slowly. Other time functions appear when sizing is present: there will be a slow period while the sizing is dissolved, then a rapid absorption. See, for example, movie demo_6.mdb provided with the FTÅ200 software.

This note was prepared entirely electronically. Images and graphs from the FTÅ software were transferred directly into the manuscript, which was then sent to the printer via e-mail.