Calibration Traceability

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Users may calibrate measurements made with drop shape software in a traceable fashion. This calibration must be done at the installation laboratory using customer supplied traceable equipment. This note describes the calibration procedure.

Magnification, Aspect Ratio, and Contact Angle

The first, and most important, calibration is magnification. This must be done each time the zoom microscope is changed. Since this can be varied at any time, calibration must be done at the time of use. A spherical sapphire ball embedded in an aluminum holder is furnished with each instrument. While it is convenient the ball is spherical, the calibration does not depend on the exact degree of sphericity. The user must supply a traceable micrometer, preferably one with 1 micron accuracy; certainly 10 micron accuracy is a requisite. Ordinary calipers will not have sufficient accuracy.

1. Measure the diameter D of the ball and the height H the ball protrudes above the base with the traceable micrometer. These might be, for example, 6.000 and 3.000mm, respectively.

2. Measure the contact angle with the system in spherical mode. Use the image format (half or full) and the contrast levels normally employed. You may want to take a movie and average, say, ten frames. This will yield an angle θ', width D', and height H'. *You must have a well defined baseline for the following steps to be valid; adjust the system until it is clear.*

3. Calibrate the magnification of the system using the calibration tab and the measured D' and known D. This will yield a new value of nanometers per pixel. With this new, calibrated, magnification, reanalyze the same images in spherical contact angle mode. Call these data θ", D", and H".

4. Magnification is now traceably calibrated to the degree with which D" agrees with D. CCD cameras are linear by design but the linearity of the system can be measured by repeating the above experiment at different magnifications, so the ball occupies different portions of the image. Magnification accuracy and repeatability will be influenced by the sharpness of focus and clarity of image (neither too much nor too little contrast). In extreme situations, it will also be affected by building vibration. As a rule of thumb, magnification can be established to within 0.25%. It is much easier to obtain this accuracy in full format mode, so use full format if the absolute best accuracy must be obtained.

5. Aspect ratio is the ratio of magnification measured vertically to that measured horizontally. The D measurement made above is in the horizontal direction. The aspect ratio is 1 by design, but can be verified by comparing the H and H" values. The images used in Step 2

were calibrate against D specifically, so take a new set of images. Compare the relative accuracies of D and H (i.e., compare the measured and actual base widths and heights). If D and H have the same accuracy levels, the aspect ratio is 1. For example, both D and H might vary by 0.25%, on average. Since the aspect ratio is set by design, any variance here is likely caused by image focus or a high camera tilt (lookdown) angle.

6. The actual contact angle is given by $\theta = 2 \arctan(2H / D)$. Compute θ using the micrometer measured base and height. The contact angle accuracy of the system is given by comparing the calculated θ and the software measured θ". It should be within $\pm 1°$. If you find variance, check focus and baseline position. Again, full format will achieve higher accuracy.

Surface or Interfacial Tension

Surface tension requires an accurate magnification calibration, so the above steps must be performed first. Surface tension secondly requires knowledge of the densities of the phases. The surface tension measurement is directly proportional to the difference in densities. Densities must be measured or obtained from traceable outside sources, then entered into the calibration text boxes in the software.

Summary

There is only one variable which is truly calibrated in the system: magnification. Densities must be known but are simply transferred in. You may verify aspect ratio, but there is no mechanism for adjusting the software's concept of aspect ratio, which is 1.0. In general, what a traceable calibration process for this instrument type does is validate overall setup. Focus, image clarity, and isolation from mechanical vibration all affect accuracy, but are under the operator's control.