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Application note 12

Determination of contact angles by different methods of dropshape analysis

Problem

The contact angle of a drop on a solid surface is often applied to determine the surface free energy. The detection of the contact angle can be conducted by using different calculation options. With the DataPhysics SCA 20 software module, four different evaluation modes are offered:

1.) Circle-Fitting (evaluation of the outline by fitting a circle)

2.) Ellipse-Fitting (evaluation of the outline by fitting an ellipse)

3.) Tangent-Fitting (evaluation of the outline by fitting a tangent)

4.) Young-Laplace (evaluation of the outline by using the Young-Laplace algorithm)

Depending on the contact angle, one of the methods cannot detect a realistic contact angle anymore, because the algorithm hidden behind the calculation process does not correspond with the outline. This phenomenon can be explained by the fact that bigger drops become more flat because of a rising gravitation rate. Therefore, the use of the circle-fitting mode is leading to calculation errors.

The present application note shall point out some application examples of the different methods and shall show the limits of the different evaluation modes, too.

Method

Using the optical contact angle measuring devices DataPhysics OCA xx, several standards of different drop shapes were measured and saved as picture (.bmp). The camera and the standard were calibrated without distortion. The contact angle was determined of each drop shape and with each of the four methods showing differences and best appropriate modes depending on the angles size. The base and contour lines were kept.

For this purpose, five contact angles standards of 60°, 30°, 15°, 120° and 170° were used.

Results

In table 1-5 the results of the standards are listed. The errors are presented in percent to the deviation of a perfect drop shape.

Tab. 1: Averaged contact angle of the 60° standard

Method	Contact angle[°]	Error [pixel]
Circle	60.0	0.99
Ellipse	60.0	0.64
Tangent	60.0	NA
Young-Laplace	59.7	0.22

Tab. 2: Averaged contact angle of the 30° standard

Method	Contact angle [°]	Error [pixel]
Circle	29,8	1,02
Ellipse	30.0	0.65
Tangent	26.4	NA
Young-Laplace	29.9	0.16

Tab. 3: Averaged contact angle of the 15° standard

Method	Contact angle [°]	Error [pixel]
Circle	15.0	1.19
Ellipse	15.8	1.66
Tangent	13.7	NA
Young-Laplace	15.0	0.24

Tab. 4: Averaged contact angle of the 120° standard

Method	Contact angle [°]	Error [pixel]
Circle	97.9	146.71
Ellipse	113.5	11.11
Tangent	117.9	NA
Young-Laplace	119.6	0.29

Tab. 5: Averaged contact angle of the 170° standard

Method	Contact angle [°]	Error [pixel]
Circle	125.7	173.82
Ellipse	142.1	48.44
Tangent	155.1	NA
Young-Laplace	170.9	0.32

The results show that using a contact angle of 60°, all evaluation methods resulting in valid values. At 30° the tangent-fit shows clear deviations already compared to the other methods (-3.6°). Below 30° the ellipse-fitting mode becomes less accurate, as the outline approximation is getting less accurate because the shape is not an elliptic one anymore. This occurs because the shape is not similar to an ellipse anymore (Fig. 1). Above an angle of 60° the values of using the circle-fitting mode become more invalid due to a flat drop shape. Also the

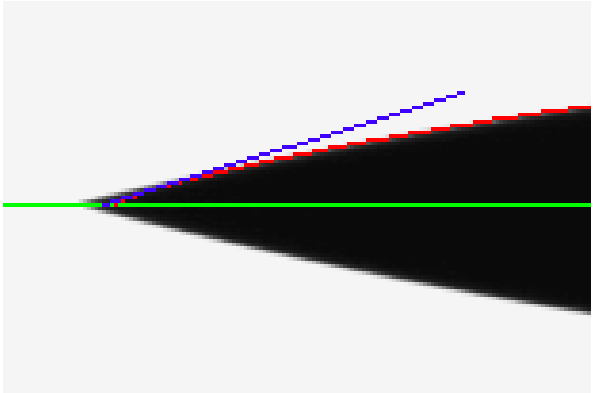

Fig. 1: Drop shape of the standards at 15° with lines of the helping tool (CA = 15.7°)

ellipse-fitting shows a high deviation to the standard value above 90° (see 120°). In case of contact angles bigger than 150°, no methods could replace the method of Young-Laplace.

It was shown that using the method of Young-Laplace all contact angles were calculated best. But if so, why is this method not always the favourite one? The answer is given by the calculation of the contact angle during dynamic processes.

Calculating a dynamic contact angle with up to 50 pictures per second, it will take a long time for determining the contact angle using the method of Young-Laplace. Although the pictures are written into the main storage place at the beginning, no more data can be saved when the limit is reached during the calculation. So, only each fifth or sixth image can be saved as result. Similar can be observed using the evaluation mode of movie files (.flm).

Nevertheless, the algorithms of the other calculation methods are working fast enough, so that all images can be evaluated in time. It's recommended using the circle-fit for calculating contact angles smaller than 30°. Between 30° and 100° the ellipse-fitting offers a good approximation for assessing the drop shape. Above 100° the evaluation should be done only with the method of tangent-fitting.

Generally, extreme contact angles above 150° have no tendency to spread or show other dynamic development. Those contact angles can be calculated statically by the method of Young-Laplace.

Conclusion

To evaluate contact angles statically, the method of Young-Laplace can be used for all sized of angles resulting in valid values. For dynamic evaluations it is recommended to use a different mode being useful in regards to the contact angle values.