Contact angle calculation for sessile drops with data obtained from top-view measurements

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Summary

Few methods have been developed to date to calculate the contact angle of a sessile drop with the information obtained when measuring it in a top-view configuration. This work presents several different ways of calculating the contact angle based on parameters of the drop obtained from top-view configuration.

Introduction

The bibliography presents multiple, easy and direct ways to calculate the contact angle from a side-view image of a sessile drop [1]. However, if one wants to measure the drop with a device that only allows viewing the drop from the top, there are few direct options to perform the same calculation [2, 3].

This work presents several alternatives for obtaining the contact angle in a top-view configuration. As input data, these mathematical methods require several parameters of the drop that can be obtained with a non-contact profilometer.

Broadly, non-contact profilometry is used to measure a surface's profile. There are a wide range of techniques which are currently being employed, such as laser triangulation, confocal microscopy, low coherence interferometry, digital holography, etc. By means of these techniques some drop's parameters, such as its height and its apparent diameter, the coordinates of its apex, etc, can be measured.

Discussion

This work presents four different methods for the calculation of the contact angle θ of a liquid sessile drop with information obtained in a top-view configuration and explores their suitability for modelling any liquid drop with contact angles between 0° and 180°.

Each method uses an adequate set of parameters in which the volume of the deposited drop is generally included, together with other parameters which can be measured with a non-contact profilometer, like the height and the apparent diameter of the drop, or the coordinates of different surface points from the top of the drop. The volume of the drop is known and must be small enough to discard gravity effects, so the shape of the drop can be approximated with a truncated sphere.

The first presented method is based on a purely geometric calculation of the radius of the drop using its height h and its apparent diameter L. With this information it is possible to calculate the drop's radius R and subsequently, the contact angle.

As shown in figures 1 and 2, two possible situations must be taken into account, depending on the surface wettability properties. In order to distinguish between the two scenarios, a comparison between drop height and apparent diameter is required.

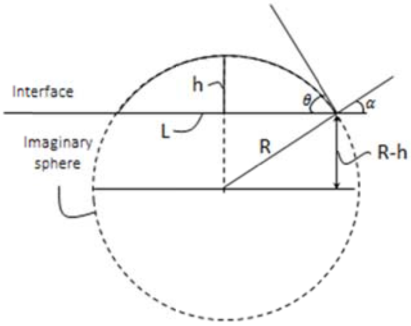

Fig. 2 Sessile drop placed on a high wettability surface

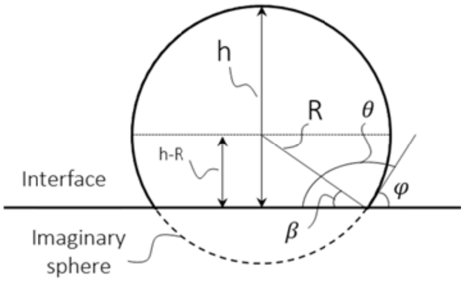

Fig. 1. Sessile drop placed on a low wettability surface

The second of the presented methods makes use of the formula that relates the volume of a spherical cap to its height and radius to calculate the drop's radius R. The main difference from the previous method is that the input parameters are the volume of the deposited drop, the drop's height h, and the value of the apparent diameter L.

The third method uses non-contact profilometry to measure the coordinates of at least three different points located along a meridian of the spherical cap. This allows the calculation of the drop's radius R by using the perpendicular bisector method.

Finally, the last method uses a fitting with a None Uniform Rational B-Splines (NURBS) surface of a spherical cap to fit a set of data points on the drop's surface which are obtained by non-contact profilometry. The value of the drop's radius is obtained by the fitting process, and subsequently the contact angle can be calculated.

Conclusions

This work addresses the problem of obtaining the contact angle of a sessile drop from top-view measurements. It presents four mathematical methods which are adequate for modeling any sessile drop with contact angles between 0° and 180°, using different parameters of the drop which can easily be measured with a non-contact profilometer.

References

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