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Application note 23

Determination of low interfacial tensions with DataPhysics Spinning Drop Tensiometers

Task

Interfacial tensions of liquids can be determined by optical analysis of the drop shape with the pendant drop method, or with a tensiometer with Wilhemly plat or Du-Noüy ring. However, the measurement of low interfacial tensions becomes difficult with these methods. Because the interfacial tension of liquids is also an interest in, e.g. for the measurement of surfactant/oil interfaces, an other method is needed for this application.

Method

To determine lower interfacial tension between liquids the DataPhysics Spinning Drop Tensiometers of the SVT-series have been developed. Due to the rotation of the measurement capillary the liquids separate depending on their density. The denser liquid is going to be pushed out of the centre while the less dense liquid will form a drop at the rotation axis. The elongation of the drop is depending on the interfacial tension between the liquids. A lower interfacial tension will result in a more elongated shape of the drop, whereas a higher interfacial tension results in a more centred drop. While increasing the rotation speed the drop will become flat caused by the stronger forces on the denser liquid. Therefore the shape of the drop is results out of equilibrium depending on the existing rotational and interfacial forces.

At the beginning of each measurement the capillary has to be filled. The denser liquid gets to be filled first. After filling the capillary it is to be checked that there are no air bubbles left in the system. When the capillary is filled completely and free of air bubbles a special developed closing mechanism ensures the air bubble free closing of the capillary. Through a syringe opening within the screw tap the less dense liquid can be added. From this liquid there is a drop with just a few µl needed which is positioned in the middle of the capillary.

After a successful preparation of the capillary it can be fixated easily in the measurement cell due to a fast closing mechanism of the Spinning Drop Tensiometers SVT.

For the measurement the camera has to be focused on the rotation drop. Therefore a fitting magnification has to be chosen by the zoom lens. With the automatic and software controlled tilting of the measurement cell the drop will be hold in a stationary position. In addition the drop can be automatically held in the centre of the camera, by automatic drop shape recognition and a depending camera movement to compensate drifting effects of the drop. Due to the stable drop shape the software is able to determine the magnification factor of the system automatically by correlating a given driving distance of the camera with the change in pixels of the image.

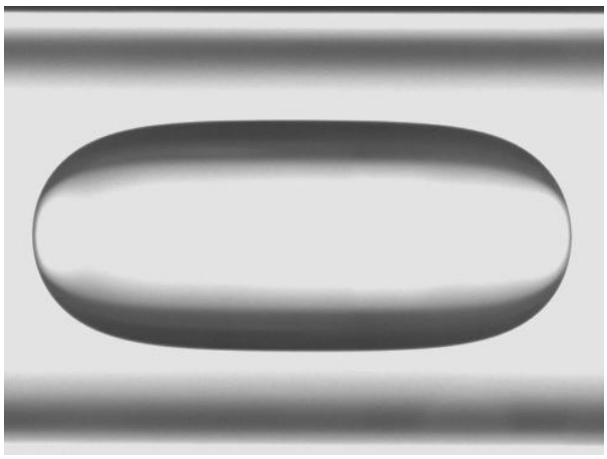

Figure 1: Oil drop at 6.000 rpm

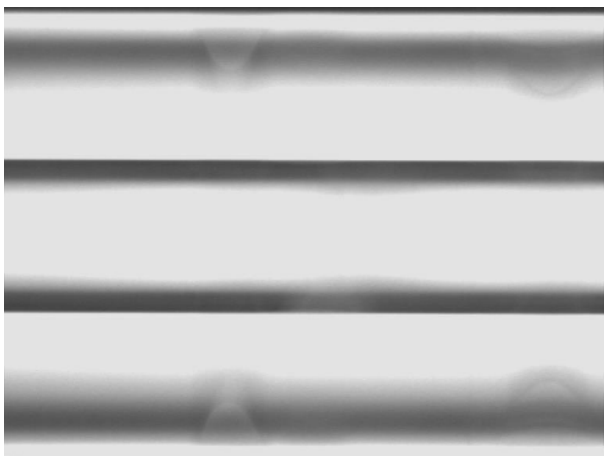

Figure 2: Image section of the above drop at 10.000 rpm

With variation of the rotational speed of the capillary the elongation of the drop can be influenced. The shape of the drop becomes more cylindrical for higher rotational speeds. Figures one and two are giving an example of this effect for a surfactant-oil system with rotational speeds of 6.000 and 10.000 rpm. The software enables the possibility to calculate the interfacial tension between the liquids form different image sections. If the elongated drop is bigger than the displayed image section it is possible to calculate the interfacial tension by determine the left or right end of the drop, or even by the cylindrical mid stage of the drop.

The rotational speed of the capillary has to be high enough so the influence of the buoyant force to the shape of the drop is negligible. Otherwise the determined interfacial tension between the liquids will deliver defective values. By knowing the rotational speed and liquid specific data like, density and refractive index the interfacial tension can be calculated through different calculation algorithms.

Results

With the DataPhysics Spinning Drop Tensiometer the interfacial tension between a surfactant solution and an organic oil has been determined. The measurement was done with 6.000 rpm and at a controlled temperature of 25°C. Therefore the drop shape was recorded 150 times and the resulting interfacial tension of the images has been calculated using algorithms by „Cayias, Schechter, Wade", „Laplace Young" and „Vonnegut". The mean values can be seen in table 1.

Table 1: Interfacial tension between surfactant and oil calculated by different methods

Interfacial tension By:	Mean Value [mN/m]	SDDV [mN/m]
Cayias, Schechter, Wade	0,8212	0,0259
Laplace Young	0,8220	0,0253
Vonnegut	0,8146	0,0258
Mean Value [mN/m]	0,8193	
SDDV [mN/m]	0,0041	

It can be seen that the interfacial tension between the liquids is almost identical for the three different calculation algorithms. The maximum difference (Laplace Young to Vonnegut) has a value of 0,0074 mN/m and is far beyond the SDDV´s of the measured interfacial tensions by each method. The calculation by Vonnegut becomes better with a more elongated drop. Measurements with high rotational speeds can just be done by using the Vonnegut calculation within the cylindrical mid stage of the drop. The determined value will become more equal to the values calculated by Laplace Young and Cayias, Schechter, Wade. The small difference of the values are showing that it is possible with devices of the DataPhysics SVT-series to determine exact interfacial tensions even at smaller rotational speeds than it is possible with comparable systems.

Conclusion

By using a DataPhysics Spinning Drop Tensiometer the interfacial tension between surfactant and oil could be determined. By calculating by different methods the interfacial tension has been determined to be about 0,82 mN/m.

The DataPhysics Spinning Drop Tensiometer is an easy possibility to determine low interfacial tension between liquids with a high reproducibility.