Technical note

EZ-Pi / Aqua-Pi: Sensitivity: Detecting small changes in surface tension

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June 24, 2003

Overview

The purpose of this technical note is to study the sensitivity, *i.e.* the detection limit of changes in surface tension, of the EZ-Pi / Aqua-Pi instrument. For this purpose the surface tension of water was measured as a function of added DMSO.

Experimental

Surface tension measurements were carried out on a Aqua-Pi tensiometer (Kibron Inc, Helsinki). The only difference between the Aqua-Pi and EZ-Pi instruments is that the AquaPi is also battery operated. The key component in the instruments is a microbalance adapted for measuring small forces. The resolution of the balance is 0.1 mN/m. While the surface tension measurement is based on the Du Nouy method, our approach utilizes small needles (probes) instead of a Du Nouy ring. The probes have a diameter of 0.5 mm and the measurement solutions are assumed to completely wet the surface of the probe. The maximum force exerted by the surface tension is recorded as the probes are withdrawn from the solution. One measurement, *i.e.* the recording of one surface tension value, takes approximately 25 s.

The instrument was calibrated by adjusting the measurement scale so that the surface tension of water (MQ, Millipore) corresponded to 72.8 mN/m (standard calibration routine). Dimethylsulfoxide (DMSO) (P.A.) was obtained from Merck. 3 ml of water dispensed into a disposable plastic (PS) cuvette and 10 surface tension readings were recorded.

Table 1: Added volume of DMSO (V_{DMSO} /μl), mole fraction (x_{DMSO}), mean surface tension and standard deviation (SD) of the surface tension data are shown.

V_{DMSO} /μl	x_{DMSO} /%	γ /mN/m	SD/ mN/m
0	0.00	72.9	0.07
10	0.08	72.7	0.03
20	0.17	72.5	0.00
30	0.25	72.3	0.06
40	0.34	72.0	0.05
50	0.42	71.9	0.05
60	0.50	71.7	0.05
90	0.75	71.1	0.04
120	1.00	70.6	0.05

10 μl of DMSO was added to the cuvette, the contents were mixed and 10 surface tension readings were recorded. The measurement procedure was repeated for the following mixtures of 3 ml water and 10, 20, 30, 40, 50, 60, 90, and 120 μl DMSO.

Results and discussion

The experimental results are collected in Table 1. The standard deviation of <0.1 mN/m is a direct measure of the precision of the instrument.

Figure 1 shows how the surface tension depends on the molar fraction of DMSO. It is interesting to note the linear relation between the data points and the line. If we consider the surface phase as a two-

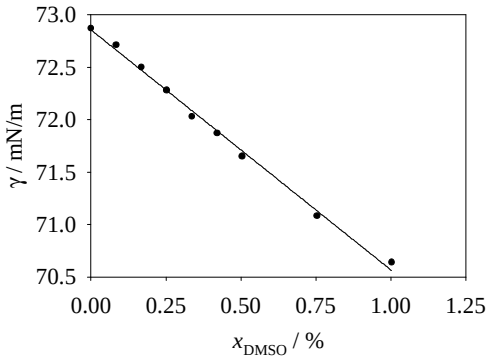

Figure 1: Surface tension of water/DMSO as a function of mole fraction of DMSO.

dimensional ideal gas, described by

$$\gamma = \gamma_0 - RT\Gamma = \gamma_0 - RTKx_{\mathrm{DMSO}} \qquad (1)$$

where γ is the surface tension, γ_0 is the surface tension of pure water and Γ is the surface concentration of DMSO. In the latter equality, K is a partitioning coefficient relating the surface concentration to the bulk mole fraction x_{DMSO}. This analysis gives $K = 0.23$ mol/m^2.

The smallest change in surface tension observed here is 0.16 mN/m. However, as seen in the graph the measured data points all fit well on a line, indicating that the points are not shifted by poor resolution. Thus, it can be concluded that the true sensitivity of the instrument is readily smaller than 0.16 mN/m.

Concluding remarks

The above results show that the Aqua-Pi / EZ-Pi instrument provides an excellent means for detecting small forces with very high precision. The impact of added DMSO on the surface tension of water proved the low detection limit of the microtensiometer.