Surface tension by the pull-out method with PC interface

LEP 1.4.06

Related topics

Surface energy, surface tension, surface adhesion, bounding surface, use of an interface.

Objective of Experiment

The force exerted on a measuring ring shortly before the liquid film is torn away is determined with a force meter. The surface tension is calculated from the diameter of the ring and the tearing force.

Equipment

Surface tension measuring ring	17547.00	1
COBRA-interface 2	12100.93	1
PC COBRA data cable RS 232, 2 m	12100.01	1
Measuring module Newton	12110.00	1
Newton sensor	12110.01	1
Softw.COBRA Force (Win)	14290.61	1
Basic Softw. f. PHYWE Windows prog.	14099.61	1
Right angle clamp -PASS-	02040.55	1
Tripod base -PASS-	02002.55	1
Support rod -PASS-, square, l 250 mm	02025.55	1
Lab jack, 160×130 mm	02074.00	1
Petri dish, d 200 mm, glass	64796.00	1

The PHYWE WINDOWS® Basic Software (14099.61) must be installed on the computer being used in order to run the software.

Problems

Determination of the surface tension of water and other liquids.

Set-up

— As shown in Fig. 1. Plug the force measuring module into the MODUL 1 input of the interface.

Procedure

— COBRA: Depending on whether COBRA is connected to COM 1 or COM 2 of the computer, start the program F(t)_COM 1 or F(t)_COM 2 by double clicking on the icon.

— Fill the petri dish with water about halfway and hang the measuring ring on the hook of the force meter. Do not immerse the measuring ring into the liquid yet.

Fig. 1: Experimental set-up: Surface tension by the pull-out method with PC interface.

— As soon as the <Start> button is pressed, the system performs a tare, this takes about 5 seconds. The force meter must not be moved or jarred during taring. If it is jarred, the system may briefly display the message “Overflow” accompanied by a beep. After incorrect taring, the message “Tara Error?” is displayed on the monitor. In this case, you can restart taring by pressing the <Tara> button once the yellow highlighting has gone out. Should the “Tara Error?” message not disappear even after several taring attempts, then either there are too many vibrations in the room or the set sample time <Delta t/ms> is too small. If you are using a slow computer, the set sample times should be greater than 300 ms.

— You can set the sample rate by adjusting the scroll bar beneath <Delta t/ms>. Each connected computer has its own maximum sample rate. If the sample rate is too high, there are data communications errors evidenced by irregular advancement of the F-t recorder.

— The measuring range <0,04 N> is recommended for measuring the surface tension. This range has a resolution of 0.1 mN. If the measuring interval (± 0.04 N) is exceeded, the message “Overflow” appears accompanied by a warning tone. Generally, however, it is possible to exceed or fall short of the set measuring interval by a factor of almost 2 without a loss in precision.

— If there are large deviations in the measured force values during measurement, you can reduce the effect of interference by adjusting the <Average> slide bar to take the average of the displayed number of measurements. The greater the number is for <Average>, the „steadier“ the F(t) curve will be. However, this does lead to a slow response-time, i.e. if there is a sudden change in mass, it takes a few seconds before the correct value is attained. It is recommended that you use an <Average> value between 10 and 25 for taring.

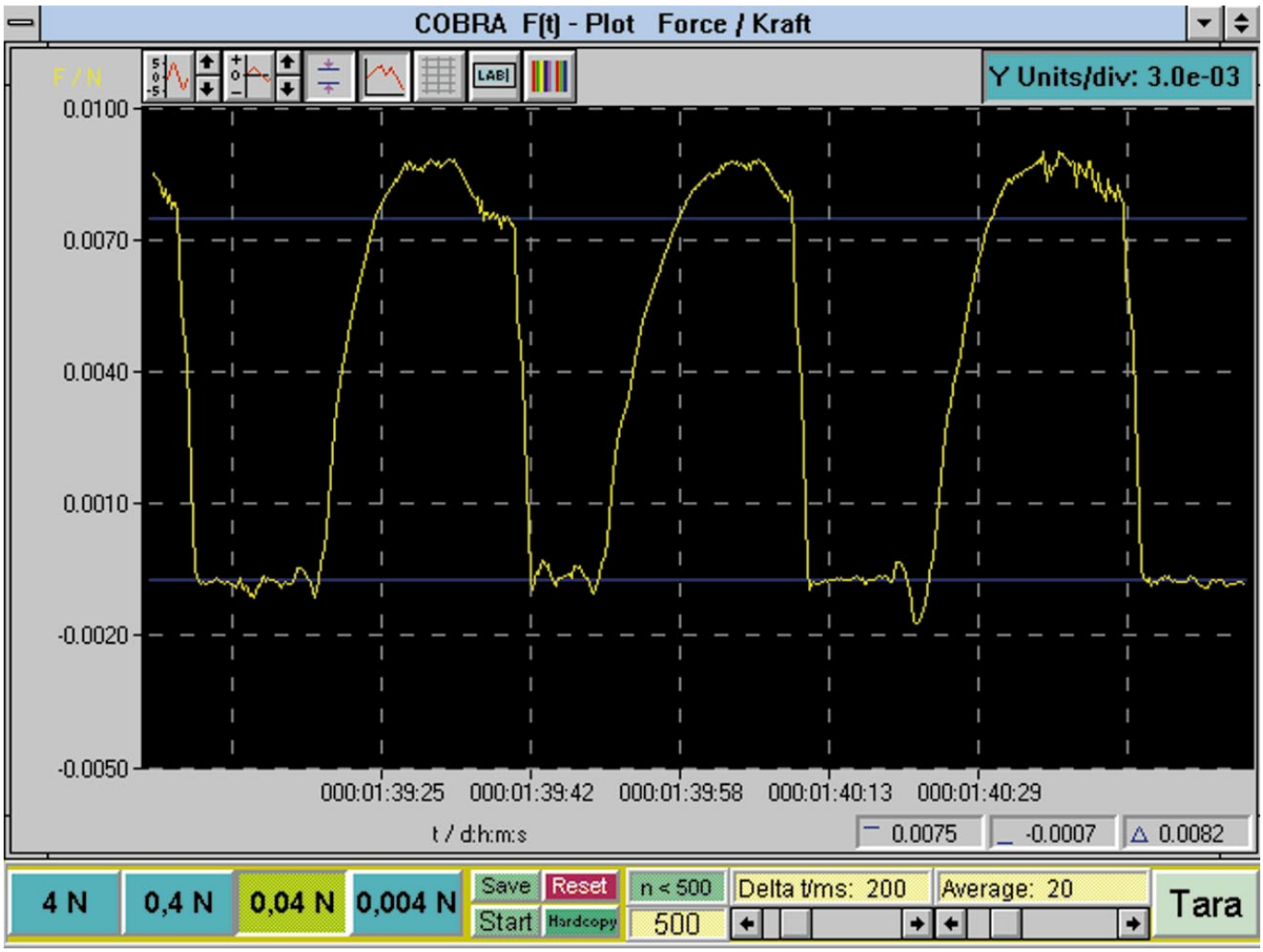
— Measuring surface tension:

  — Raise the lab lifting apparatus until the measuring ring is fully immersed in the water.

  — Being careful not to shake the set-up, lower the lab lifting apparatus by turning the knob evenly until the water film on the measuring ring breaks.

  — Repeat this procedure several times and observe the measurement curves on the monitor.

Fig. 2



Results

Forces from the surrounding molecules act on a molecule inside a liquid from all sides; the pressure ρ is isotropic. The resulting force acting on a molecule at the boundary layer on the surface of the liquid is not zero, but points into the liquid. To increase the are of the surface by ΔA, work ΔE must be performed.

$$\varepsilon = \frac{\Delta E}{\Delta A}$$

is the specific surface energy and is identical with the surface tension:

$$\gamma = \frac{F}{l}$$

where the force F acts at the edge of length l, tangentially to the surface in order to maintain the liquid film. When using a measuring ring of radius r, the length of the edge is $l = 2 \pi r$. The diameter of the measuring ring used is $2r$ = 19.5 mm, i.e. l =122.52 mm. The length l is twice the size of the ring since a water film forms on each side of the ring.

With the program F(t)_COM 1 (and/or F(t)_COM 2), it is possible to measure the force difference between the breaking point and the weight of the ring directly using the adjustable cursor line (see Fig. 2). To do this, place a cursor line at half position of the force exerted by just the ring when it is not immersed in the liquid, and place the other cursor line at the breaking point. When the measurement is performed several times, there are usually several different breaking points. These are the result of vibrations which cause the water film to break too soon. Therefore, always take the smallest breaking edge for evaluation. The force maximum, which is attained before breaking, can be reproduced quite well and comes from the weight of the raised liquid film which changes its shape and mass when the ring is pulled out. Surface tension is then calculated according to the formula

$$\gamma = \frac{F}{l} = \frac{0.0082\ \text{N}}{0.12252\ \text{m}}$$

$$= 0.067\ \frac{\text{N}}{\text{m}}\ .$$

Notes

— The surface tension can also be measured as a function of temperature. Furthermore, solutions (e. g. ethanol/water) with different concentrations can also be used for this experiment.
See also University Laboratory Experiments, Experiment 1.4.05 “Determination of surface tension by the ring method (Du Nouy method)” (21405).

— If you can not get a constant display in the 0.04 N measuring range, then you should cushion the measuring module from vibrations and shield it from drafts.