EXERCISE 33A	MEASUREMENT OF SURFACE TENSION: TEAR-OFF METHOD

Measurement procedure

1. List of equipment

- Torsion balance
- Metal plates
- Calliper
- Micrometre screw
- Tested liquids
- Measuring vessel

2. Goal

Determination of surface tension of several different liquids using the tear-off method.

3. Measurement setup

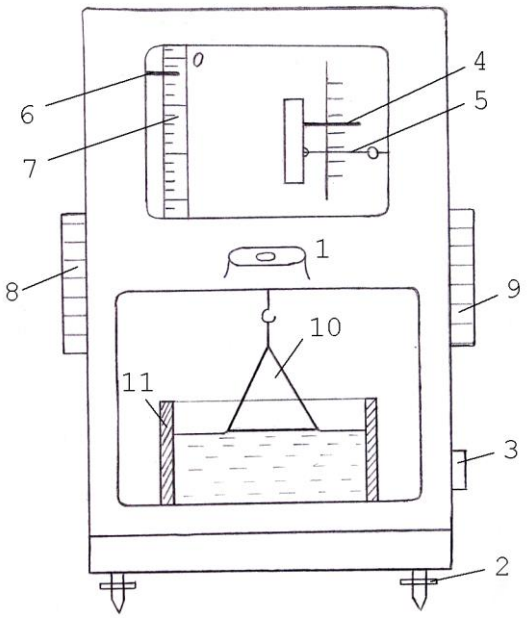

Fig. 1. Torsion balance parts description.

1. Level gauge
2. Adjusting screws
3. Protecting locking knob
4. Movable pointer
5. Red line – indicator of balance
6. Pointer
7. Movable scale
8. Knob causing rotation of the scale (7)
9. Knob causing shift of the pointer (6)
10. Metal plate
11. Measuring vessel with tested liquid

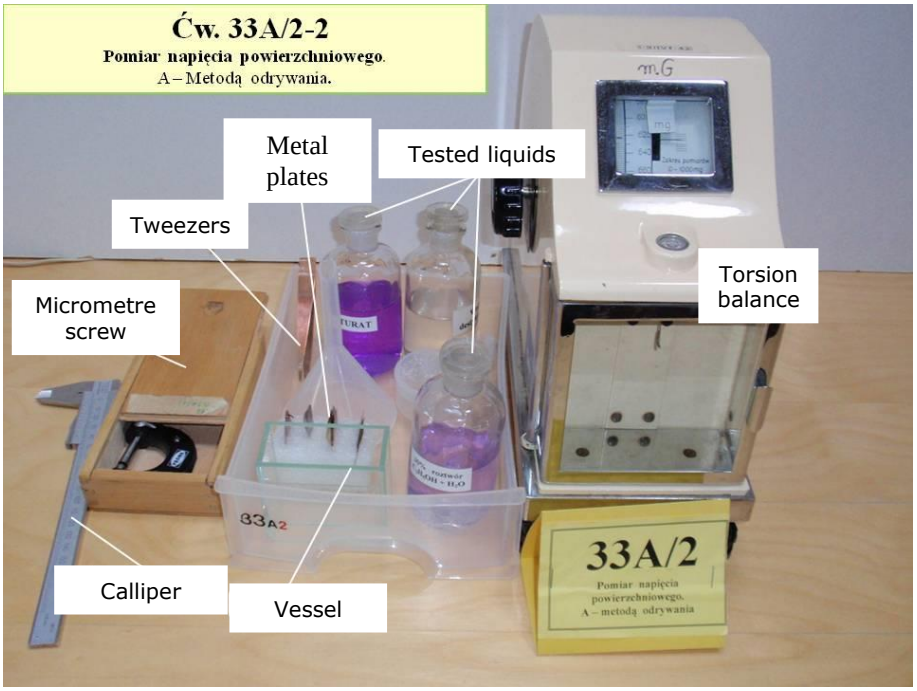

Fig. 2. Measurement setup.

4. Measurements plan

a) Prepare the torsion balance for measurements:
   i. Ensure that the balance is locked – red dot on the knob (3) indicates the „z" position.
   ii. Level the balance using adjusting screws (2).
   iii. Close the measuring chamber and unlock the balance (red dot on the knob (3) in position „0"). Next, make the scale balanced: by turning the left knob (8) rotate the scale (7) until the moving pointer (4) aligns with the red line (5). When the scale is balanced, using the knob (9) set the pointer (6) to indicate zero on the scale (7).
   iv. Lock the balance using knob (3).

b) Measure the length *l* (using calliper) and the thickness *d* (using micrometre screw) of the edge of the metal plate to be immersed in the liquid.

c) Metal plates should be thoroughly washed with soap, rinsed with distilled water and dried.

d) Hang a selected metal plate on the hook of the torsion balance. Unlock the balance. Now, balance the scale: by turning the left knob (8) rotate the movable scale (7) until the movable pointer (4) aligns with the red line (5). Then the pointer (6) indicates on the scale (7) the weight Q of the hanging metal plate expressed in units of $[mG\ ]$

e) With the balance locked, place the vessel under the metal plate and fill it with tested liquid to a level at which the lower edge of the plate almost touches the surface of the liquid.

f) Measure the force *F* required to detach the plate from the liquid. To this end, unlock the balance and make the bottom side of the plate immersed in liquid. Close the glass cover of the measuring chamber. Turn the left knob (which rotates the scale (8)) counter-clockwise until detachment of the plate from the liquid. This is accompanied by a jump of the moving pointer (4) from the bottom to the top. The liquid level in the vessel should be such that just before the detachment of the plate from the liquid the moving pointer was near the red line (5).

g) On the movable scale (7) read the force *F* indicated by the pointer (6). Repeat the measurement of the force *F* ten times and calculate the average value. Lock the balance.

h) Perform the measurements for two different plates and for two different liquids specified by the teacher.

5. Analysis of results

a) Calculate the surface tension of the liquid by means of the formula

$$\sigma = \frac{F-Q}{2(l+d))} \qquad (1)$$

where l and d denote the length and thickness of the plate immersed in the liquid.

b) Determine measurement uncertainty.

c) Compare the obtained values of the surface tension of the liquid with the values read from physical tables. Show systematic error, which is subject to the proposed method, which would justify the differences in values.

d) Collect the results of measurements and calculations in the table.

6. Additional information

$$1\,[mG] \;=\; 9{,}807 \cdot 10^{-6}\,[N]$$

During the measurement, pay attention to the level of liquid in the vessel: it should be slightly below the lower edge of the plate during the measurement of its weight.

7. Proposed tables (for approval by the teacher)

Table 1. Measurements of surface tension by tear-off method (Measurements documentation)

No.	***Liquid***	***l*** [mm]	***d*** [mm]	***Q*** [mG]	***F*** [mG]
1					
2					
3					
⋮					
n					

Table 2. Measurements of surface tension by tear-off method (Report)

No.	***Liquid***	***l*** [m]	***d*** [m]	***Q*** [N]	***F*** [N]	$\boldsymbol{\sigma}\left[\frac{\boldsymbol{N}}{\boldsymbol{m}}\right]$
1						
2						
3						
⋮						
n						
$\bar{X}$						
ΔX						
$u(X)$						
$u_c(X)$						

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