SURFACE TENSION

EXPERIMENT:

Measuring the surface tension using the ‘break-away’ method.

OBJECTIVE:

1. Creating a liquid layer between the edge of a metal ring and the surface of the liquid.
2. Measuring the tensile force acting on the metal ring just before the liquid layer breaks away.
3. Determining the surface tension from the measured tensile force

PRINCIPLES:

The surface tension is due to the fact that a molecule on the surface of a liquid is acted upon by attractive forces from adjacent molecules towards one side only (see Fig.1). The resultant force acting on the molecule points into the liquid and is perpendicular to the surface. In order to enlarge the surface, i.e, to take more molecules to the surface, energy has to be supplied. The ratio of the energy ΔE supplied at a constant temperature and the change the surface ΔA is called surface energy or surface tension of the liquid:

$$\sigma = \Delta E/\Delta A$$

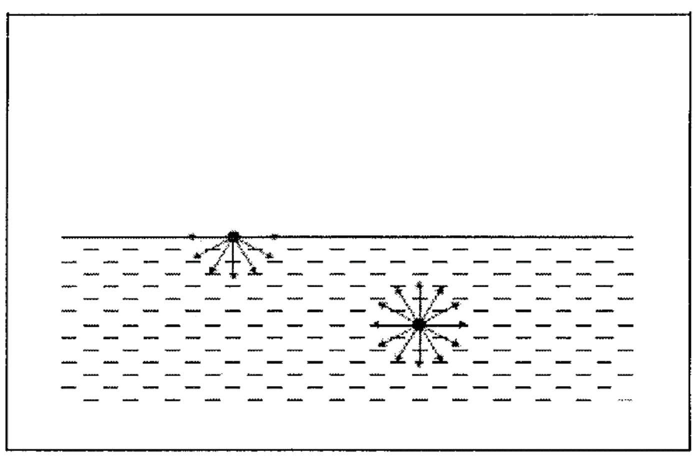

Fig.1: Forces exerted by adjacent molecules on molecules on the surface of a liquid and inside the liquid

The surface tension can be measured, e.g, by means of metal ring with a sharp edge which at first is immersed in the liquid so that it is completely wetted. If the ring is slowly taken out of the liquid, a thin liquid layer is pulled up (see Fig. 2). The outside and inside surface of the liquid changed is

$$\Delta A = 4\pi R\Delta x$$

R: radius of the metal ring. When the metal ring is lifted by Δx. Pulling up the ring requires the force

$F = \Delta E/\Delta x$ to be applied. If this force is exceeded, the liquid layer breaks away. Now the surface tension is

$$\sigma = \Delta E / \Delta A = F/4 \pi R$$

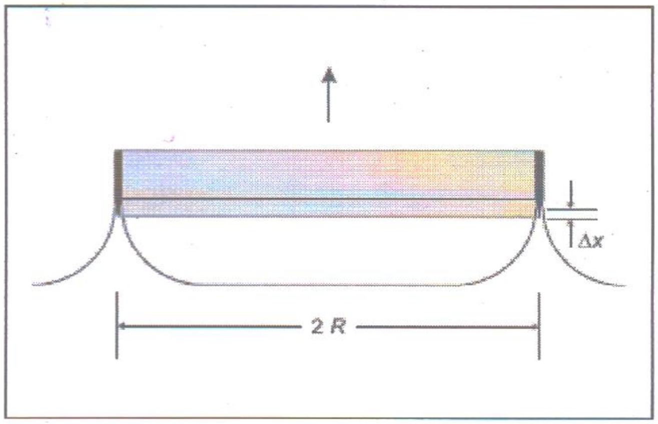

Fig. 2

CONTENTS:

1. Metal ring for measuring surface tension.
2. Precision dynamometer 0.1N.
3. Vernier caliper
4. Crystallization dish
5. Laboratory Jack
6. Stand base, A-shape
7. Stand rod, 75 cm
8. Clamp with hook

Additionally required:

Distilled water, ethanol

SETUP PROCEDURE:

The experimental setup is illustrated in Fig.3.

1. Carefully clean the crystallization dish.
2. Carefully remove fat from the metal ring, e.g. with ethanol, and suspend it from the dynamometer. Suspend the dynamometer from the clamp with hook so that the ring hangs over the crystallization dish.
3. Set the laboratory stand to a height of approx.10cm.

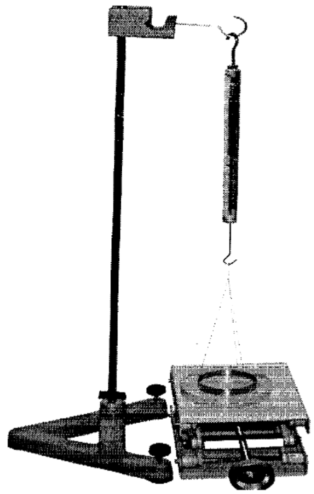

Fig. 3 Experimental setup

EXPERIMENT PROCEDURE:

1. Determine the diameter of the metal ring.
2. Make the zero adjustment at the dynamometer using the movable tube.
3. Fill distilled water into the crystallization dish.
4. Lower the clamp with hook until the metal ring is completely immersed.
5. Cautiously lower the laboratory stand, always observing the tensile force at the dynamometer. As soon as the edge of the metal ring emerges from the liquid, the liquid layer is formed. When the tensile force does no longer increase although the laboratory stand is further lowered, the layer is just before breaking away.
6. Read the tensile force just before the layer breaks away, and take it down.
7. Pour the distilled water out, and dry the crystallization dish and the metal ring.
8. Repeat the measurement with ethanol.

MEASUREMENT:

Weight of the ring = 0.037N

Force when the metal ring is completely immersed F_1 = 0.029N

Tensile force just before the layer breaks away F_2 = 0.057N

Actual Tensile force with water $F = F_2 - F_1$ = 0.028N

Diameter of the metal ring: 2R = 61.5mm

Surface Tension (σ) = $F/2\pi R = 0.028/(2x3.14x61.5x10^{-3})$

$= 7.249x10^{-2}$N/m = 72.49 mN/m

EVALUATION:

Measuring result for water: σ =72.49 mN/m

Literature value for water at 25^0C: σ =72 mN/m

Literature value for ethanol: σ =22 mN/m

RESULT:

Compared with other liquids, water distinguishes itself by a particularly high surface tension.