(PM1-3) Surface Tension Using Capillary Tubes for Different Liquids

Aim of experiment

Determination of the coefficient of surface tension of a water at room temperature.

Apparatus

Capillary Tubes of Different Radii, Liquid in a Beaker, Ruler

Theory of experiment

Consider a liquid, such as water, is placed in a vessel as shown in *figure 1.* For a molecule inside the liquid the net force acting on it equal zero. For a molecule on the liquid surface the net force acting on it tends to pull the molecule inside the liquid, so the surface of liquid acts as elastic tension membrane. This phenomenon is known as *surface tension.*

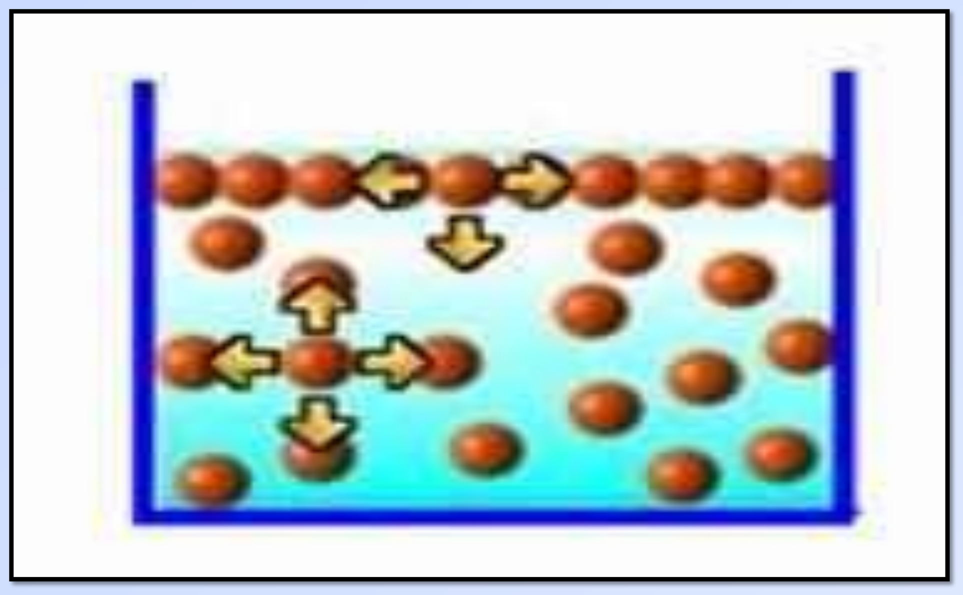

Figure 1. Force acting on liquids molecules

Coefficient of surface tension is the tangent force per unit length acting on the surface of liquid.

Consider a capillary tube with inner radius r=d/2 is dipped vertically in a liquid with density ρ and surface tension σ, *figure 2.*

The liquid will rise up until certain height h, at which equilibrium between the following two forces takes place.

1- A force acting upward due to surface tension .

$$F = \sigma\,(2\pi r)\cos\theta$$

2- A force acting downward due to gravity

$$w = \pi r^2 h\,\rho\, g$$

At equilibrium

$$\sigma\,(2\,\pi\, r)\cos\theta = \pi r^2 h\,\rho\, g$$

$$2\,\sigma\cos\theta = r\,h\,\rho\, g$$

$$h = 2\,\sigma\cos\theta\,/\,\rho\, r\, g$$

This equation represents the relation between the height of liquid in a capillary tube and its surface tension. For water θ=0 and cosθ=1.

Procedures

1. Measure the internal radii of the given capillary tubes, at least three for each radius, using a traveling microscope.
2. Insert a capillary tube of radius, r, in the water tank.
3. Measure the height of the water in the capillary tube.
4. Record the results in a table.
5. Repeat steps 2 to 4 for tubes of same radii.
6. Repeat steps 2 to 5 for tubes of different radii.
7. Draw a graph between the average height of water in the capillary tube, h_{av}, and the reciprocal of its radius $1/r$.

8-From this graph find the value of the surface tension of water from the relation $\sigma = slope \times \rho g/2$

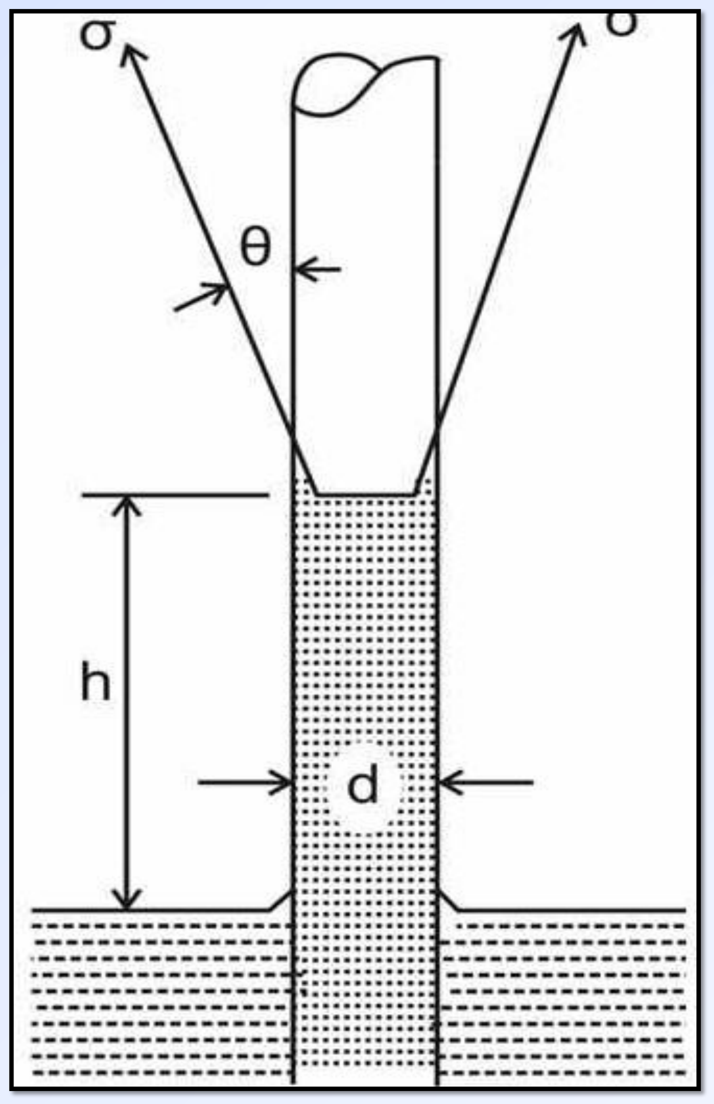

Figure 2 A capillary tube immersed in a liquid

Results

r(cm)	$1/r$ (cm^{-1})	h_1 (cm)	h_2 (cm)	h_3 (cm)	h_{av} (cm)

σ = *dyne/cm*