Surface tension of Water

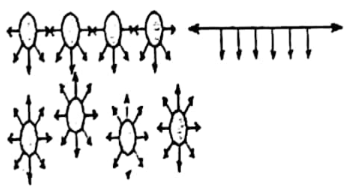
Objective:

To calculate the surface tension of water.

Theory:

A: Surface tension using balance:

A molecule in the interior of the liquid experiences attractive force due to all its neighbors which lowers its potential energy. A molecule at the surface does not have as many neighbors, and its potential energy is not so low. Consequently, the molecules at the surface arrange themselves, so that they have as many neighbors as possible. In this process, they minimize the surface area and the potential energy and produce the observed surface tension.



The force between the molecules of a liquid have a resultant effect exerted on bodies at the surface. This force is given by:

$$F = 2\gamma L$$

And the surface tension is defined as the force per unit length exerted by the liquid surface

$$\gamma = \frac{F}{2L}$$

Where

γ: is the surface tension (N/m)

L: is the length of the liquid film (m)

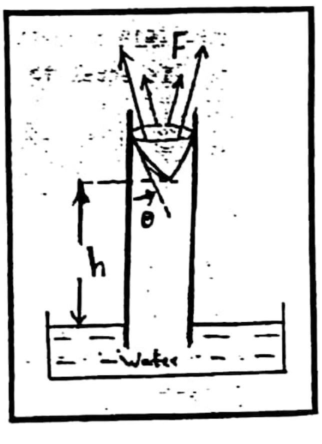
For a circular ring with radius R

$$\gamma = \frac{F}{2(2\pi R)} \quad \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

B-Surface tension using the capillary rise:

The surface of a liquid in contact with a solid surface forms an angle θ with respect to the solid surface .If θ is less than 90, the liquid will rise in narrow tubes, and if θ is grater than 90 it will be depressed. This figure shows a liquid of density ρ in a tube of radius r.

The contact angle is less than 90 .The net horizontal force = 0 but the net vertical force:



$$F_{up} = 2\pi r\gamma\cos\theta$$

In case of water θ=0

$$F_{up} = 2\pi r\gamma \quad \text{.........................(2)}$$

The volume of the liquid column up to the bottom of the curved liquid surface is :

$$V = \pi r^2 h$$

The weight of the liquid column is:

$$W = mg = \rho V g$$

$$W = \rho(\pi r^2 h)g \quad \text{..........................(3)}$$

From equations (2) and (3)

$$2\pi r\gamma = \rho\pi r^2 gh$$

Surface tension of liquid is:

$$\gamma = \frac{\rho r g h}{2}$$

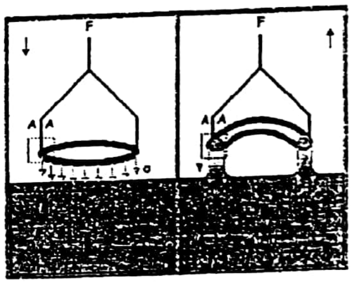
$$h = \frac{2\gamma}{\rho g}\frac{1}{r} \quad \text{..................(4)}$$

Apparatus:

Beaker, surface tension balance set, ruler, dynamometer, liquid and capillary tubes of different diameters.

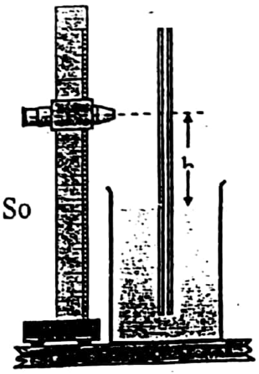
Procedure:

A: Surface tension using balance:



1. Make sure the ring is horizontal and adjust the pointer on the dynamometer scale to read zero.
2. Raise the liquid beaker to the bottom edge of the ring so that the edge touches the liquid surface.
3. Slowly and carefully turn the adjustable foot anticlockwise, thus tending to draw the ring away from liquid, at the same time carefully observing the position of the pointer on the scale. Record the final reading of the dynamometer before breaking a way from liquid.
4. Repeat the above steps three times and calculate the average of forces.

B-Surface tension using the capillary rise:



1. Use a clean capillary tube and hold it vertically in water (Figure 2).
2. Measure the height (h) of the liquid rise in the capillary tube.
3. Use capillary tubes of different radii and measure h for each radii and tabulate data.
4. Plot the graph between (1/r) as horizontal axis and h as vertical axis. So calculate (γ)

Measurements and results:

A: Surface tension using balance:

F ( )
F_1=
F_2=
F3=
$F_{avg.}$=

F=.................

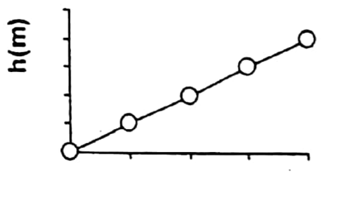
$$\gamma_1 = \frac{F}{4\pi R} = ...$$

Where R=2.95 x10^{-2} m

B-Surface tension using the capillary rise:

ρ=..........................kg/m^3 g=........................m/s^2

h ( )	D ( )	r ( )	1/r ( )



V.I = ...

Slope=.......................................

$$\gamma_2 = \frac{slope * \rho g}{2} = ...$$

* compare between γ_1 and γ_2.