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Determination of Surface Tension of Mercury, Aniline, and Phenol by Ink Pillar

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Abstract: Surface tension has played an important role in finding the shape of a liquid.Determining the surface tension in the formation of drops is described.It influences by measurement methods, and measuring instruments. Modern measuring instruments are the fruits of science and technology. Which can provide new instruments for the study of nature and these studies in turn produced new discoveries like pre-size accurate measurement of physical, chemical parameters, and plays unrevealing mysteries of nature.Hence in the present study an attempt is made to measure the surface tension by ink pillar. In such a scenario the presently choosed instrument helps to know the surface tension within native. A measurements made with simple apparatus are found to agree well with the literature data.

Keywords: Surface tension, ink pillar, digital weighing machine.

Introduction:

The liquidmolecule experiences only inward cohesive forces with other molecules in all directions and interact through forces of cohesion at a distances of around 0.1 µm and they are effectively zero. However, a molecule on the free surface of liquid is subject to the prevailing attraction of the underlying molecules of the liquid, the surface acts as a membrane that tends to compress the liquid.(See fig no (1)

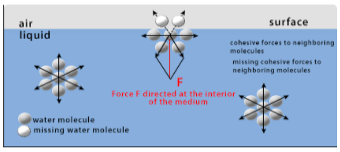


Fig 1: Model of the forces of cohesion acting on an internal molecule and surface molecule

The free surface of a liquid is the centre of a system of forces directed both downwards and tangential to the surface to keep it interacts. In order to increase the free surface of a liquid by an infinitesimal amount ds, Keeping the general volume constant and operating isothermally. It is necessary to complete an infinitesimal amount of work equal to dl, in order to constantly balance the system of tangential forces that tends to maintain the same united surface tension (T).

dS =L.dx .

Where the contour of the surface is labelled L (see figure 2)

The expression is as follows

T= F dx /ds = F dx / L dx =F /L ----------------------- (2).

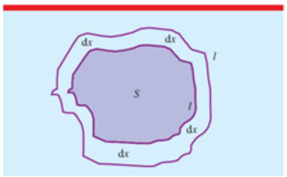


Fig: 2 Increase in a free surface S from forces perpendicular to the contour L

Thesurface tension decreases with increasing temperature.as shown in table (1) when slow moving liquid flows through the pipe a drop begins to grow in size. Force and its weight will act on a drop fundamentally. (See figure 3): P is the weight of the drop and makes detaches itself the drop from the edge of the capillary.. The force $F_T$keeps the drop to the rest of the liquid.

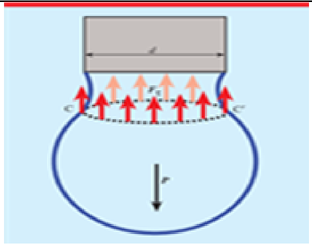


Fig: 3 Model of a drop of liquid in equilibrium

The weight P of the drop is expressed as.

$P = mg$ ------------------------ (3)

The general force of surface tension F_T is expressed as

$F_T = I_{CC}T$ --------------------- (4)

Where m and g stand for the mass of the drop and the acceleration due to gravity, I_{CC} represents the length of the circumference of separation CC' and T is just the surface tension of the liquid. The drop will fall off the pipe is balanced by the general force of the surface tension

$E_T = P$ ----------------------- (5)

And as it follows that

$\Pi dT = mg$

Where the d is approximately the external diameter of the capillary tube. This gives the analytical expression of Tate's Law:

$T = mg / \pi d$ ------------------ (6)

This states that the weight of the drop is directly proportional to the diameter of the pipe and the coefficient of surface tension. Usually when the linear dimensions of the pillar is ofthe order of 10 mm the drop will tends to shrink, straining to detach itself and very often fragments into a large drop with much smaller secondary drops, as shown in the simulation in figure(4).

(Table No:1)

The surface tension of mercury at different temperatures.

S.NO	Temperature	surface tension
1..	12.5	438.4
2.	20	425.41
3.	67	423.9

(Table No:2)

The surface tension of Aniline at different temperatures.

S.No	Temperature	Surface tension
1.	10	44
2.	22	43.40
3.	29	42.40
4.	180	24.4

(Table No: 3)

The surface tension of Phenol at different temperatures.

S.No	Temperature	Surface tension
1.	26	71.96
2.	30	71.32
3.	40	69.65
4.	50	68

Experimental Procedure:

The complexity of taking measurements can be reduced by producing slow drop formation by using aink pillar. The end of the pillar has some diameter and the other end has a rubbercork. The hole of the pillar has a circular edge and the diameter of the pillar can be determined by using the travelling microscope. Taking measurements are very simple.

1. Sample of the liquid (Mercury, Aniline, Phenol) is withdrawn using the ink pillar is as shown in figure (1) and total mass (M_i) of the pillar plus liquid is determined.

2. Setting the pillar in vertical position a number (N) of drops are produced.

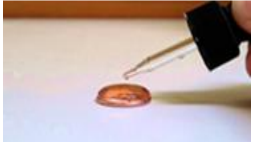
3. Later the measurement of the total mass of the pillar (M_f)is determined and repeated in order to determine the mass of the N drops. The mass of the pillar as well as the liquid is measured with the help of digital weighing machine. The average mass of the single drop will be equal to the

$$m = (M_I - M_f)/N$$

And therefore the equation (5) will be written as follows:

$$T = (M_I - M_f)\, g / \pi d N \quad \text{--------------} \ (7)$$

An experimental uncertainty arises, essentially from the measurement of the pillar diameter and drop masses. The surface tension will depend on temperature hence it has to be measured while performing the experiment. The experiment was carried out at 27 ^{o} c temperature region.



Fig(4 a)

Fig (4 b) Mercury

fig (4c) Phenol

fig (4 d) Aniline

Fig(4 a),simulation of the formation of a drop from aink pillar.

Figure: 5 the pillar prepared for the measurement

Results and discussions:

Different liquids at different temperatures (Mercury, Phenol, and Aniline) were analysed and tabulated in tables (1),(2), and(3) and the formation of the drops were recorded with the help of digital camera. We noticed that the liquids examined, the formation of the drop started from the outside of the hole of the ink pillar (seein figs no 4a, 4b, 4c, and 4d.) .The dimensions of the circumference of separation was undoubtedly less than the external dimensions of the ink pillar and it could be approximately equal to the inside edge of the ink pillar. The values of the coefficient of surface tension obtained by this method are reported in table (4) along with the values given in the literature. Comparing the results obtained experimentally with those in the literature reveals an equivalent correlation and at least to two significant figures. The surface tension of Mercury is high when compared to aniline and Phenol.

Table No (4) indicatesvalues deduced experimentally to two significant figures together with values in the literature

(Table No:4)

S.No	liquid	Number of drops	M_i	M_f	Mass of N drops	Surface tension	
						measured	literature
1.	Mercury	15	10.3	4.4	0.393	487.52	484.4
2.	Phenol	13	5.14	4.4	0.056	71.49	71.18
3	Aniline	23	5.22	4.4	0.035	42.31	42

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