Measurement of Surface Tension by paediatric Medicine Dropper

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Abstract

The role of surface tension in the formation of drops is described. Surface tension can be measured by using a paediatric medicine Dropper and dripping a liquid from it. A measurements made with simple apparatus are found to agree well with the literature data.

Index words: Surface tension, paediatric medicine dropper, digital weighing machine.

Introduction:

The molecules of a liquid interact through forces of cohesion. Which become weaker with distance and at distances of around 0.1 µm they are effectively zero. Therefore a molecule of a liquid interacts only with molecules that are within its field of cohesion. When the molecule is in a liquid the cohesion the cohesive force is zero, because the surrounding molecules are symmetrically distributed in relation to it. However, a molecule on the free surface of liquid is subject to the prevailing attraction of the underlying molecules of the liquid (see fig no 1) .So that the surface acts as a membrane that tends to compress the liquid.

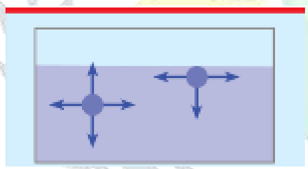

Fig 1: Model of the forces of cohesion acting on an internal molecule and surface molecule.

The free surface of a liquid is the centre of a system of forces directed both downwards and tangential to the surface in order to keep it interact .We can state that 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 =I.dx .Where the contour of the surface is labelled L (see figure 2)

This can be written as

$$T= F\,dx /ds = F\,dx / L\,dx =F /L \qquad (2)$$

That is the surface tension represents the force per metre acting on the edge of the surface.

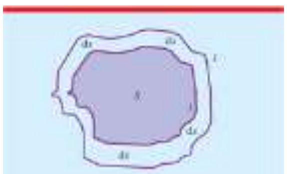

Fig: 2 Increase in a free surface S from forces perpendicular to the contour l

The strength of surface tension of a liquid depends on the impurities presents in liquid and temperature. Surface tension decreases with increasing temperature.as shown in table (1) Surface tension plays a fundamental role in the formation of drops .or example as a slow moving liquid flows through the opening of a pipe; a drop begins to form and grows in size. Surface tension represents the force per metre needed to sustain the newly formed drop. Two forces act, fundamentally, in the drop (see figure 3):

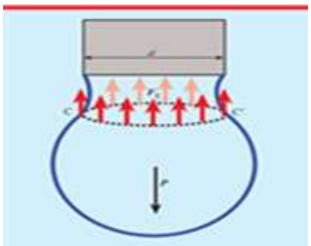

Fig: 3 Model of a drop of liquid in equilibrium due to the action of the resultant of

Surface tension forces and its weight, an instant before the drip detaches. The weight P of the drop.

$$P = mg \qquad (3)$$

Which tends to make it detach itself from the edge of the capillary, and the general force of surface tension F_T keeps the drop attached to the rest of the liquid.

$$F_T = l_{CC}T \qquad (4)$$

Where m and g stand for the drop and the acceleration of gravity, while l_{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

$$E_T = P \qquad (5)$$

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:

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

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 drip 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)

The surface tension of water at different temperatures.

S.NO	temperature	surface
1..	10	74.01
2.	15	73.26
3.	20	72.53
4.	25	71.78
5.	30	71.03

Experimental Procedure:

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

1. Sample of the liquid (tap water and demineralised water) is withdrawn using the paediatric medicine dropper as shown in figure (1) and total mass (M_i) of the dropper plus liquid is determined.
2. Setting the dropper in vertical position a number (N) of drops are produced.
3. Later the measurement of the total mass of the dropper (M_f) is determined and repeated in order to determine the mass of the N drops. The mass of the dropper as well as the liquid can be 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:

$$T = (M_I - M_f)\, g / \pi\, d\, N \qquad (7)$$

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

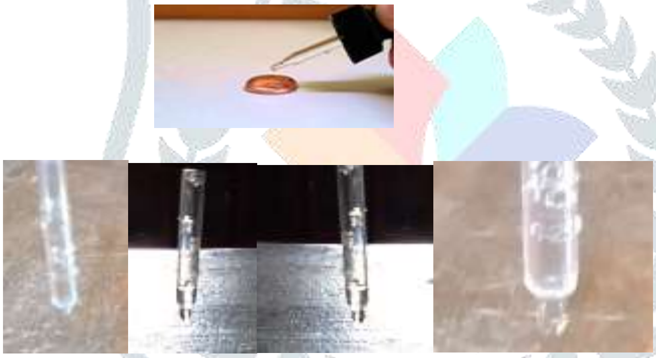

Fig 4 simulation of the formation of a drop from a dropper of diameter 0.252 cm. as the water drop detaches it can split into smaller secondary drops.

Figure: 5 the dropper prepared for the measurement

Results and discussions:

Different liquids (i.e. tap water and demineralised water) were analysed as shown in table (2) 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 dropper (see in fig no 4.) .The dimensions of the circumference of separation was undoubtedly less than the external dimensions of the dropper and it could be approximately equal to the inside edge of the dropper. The values of the coefficient of surface tension obtained by this method are reported in table (2) along with the values given in the literature. Comparing the results of the surface tension obtained experimentally with those in the literature reveals an equivalent correlation and at least to two significant figures.

Table No (2) values of the surface tension deduced experimentally to two significant figures together with values in the literature(4,5)

S.No	Number of drops	M_i	M_f	Mass of N drops	Surface tension	
					measured	literature
1.	12	5.1	4.4	0.058	72.28	72
2.	11	5.0	4.4	0.054	72.50	73

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