Experiment No.: **Date:**

Aim: To determine the surface tension of a given unknown liquid with respect to water, at laboratory temperature, by stalagmometer.

Requirements: Stalagmometer (Traube's), rubber tube with screw pinch cock, relative density (R.D.) bottle, stand, balance, weighing box, beaker, unknown liquid, distilled water.

Theory: The measurement of surface tension by stalagmometer is based on the fact that drop of a liquid (at end of the stalagmometer /capillary tube) falls when weight of the drop just equal to the surface tension of the liquid.

Thus, the weight of the drop (due to force of the gravity) which pulls the drop downward is equal to **vdg**, where, **g** is the gravitational force, **v** is volume of the drop and **d** is the density of the liquid (i.e., **mg** = **vdg**).

On the other hand, the force tending to uphold the drop = **$2\pi r\gamma$;** where **$2\pi r$** is the circumference of a circular surface, γ is the surface tension of the liquid. Unit of surface tension are dyne/cm (CGS system) and Newton/meter (SI system) where, *1dyne/cm = 1mN/m*

At equilibrium, (i.e. when two forces are balanced): $2\pi r\gamma = vdg$ (i)
If **n** is the number of drops in volume **V** of the liquid, the volume of each drop will be $v = \frac{V}{n}$

Then, from equation (i) we have, $2\pi r\gamma = \frac{Vdg}{n}$ (ii)

If $\mathbf{n_1}$ and $\mathbf{n_2}$ are the number of drops counted for the same volume of two liquids (**1** & **2**) of densities $\mathbf{d_1}$ and $\mathbf{d_2}$, using the same stalagmometer, then

$$2\pi r\gamma_1 = \frac{Vd_1g}{n_1} \quad \text{(iii)}$$

$$2\pi r\gamma_2 = \frac{Vd_2g}{n_2} \quad \text{(iv)}$$

Dividing equation (iii) by (iv); $\frac{\gamma_1}{\gamma_2} = \frac{n_2d_1}{n_1d_2}$

Therefore, surface tension of the liquid (**1**) $\boldsymbol{\gamma_1}$, with respect to liquid (**2**) $\boldsymbol{\gamma_2}$ can be expressed as: $\gamma_1 = \frac{n_2d_1}{n_1d_2}\gamma_2$

In case, the second liquid is the pure water (w), then surface tension of liquid (l) with respect to water can be expressed by: $\gamma_l = \frac{n_w d_l}{n_l d_w}\gamma_w$

Procedure:

1. Note the laboratory temperature.

2. Wash the R.D.bottle with distilled water and dry.

3. Take the weight of the empty & filled (with distilled) R.D. bottle (with stopper). Then, weigh the R.D. bottle filled with unknown given liquid.

4. Clean the stalagmometer properly with distilled water. Now fix the stalagmometer on the stand & adjust the number of falling drops in between 15-20 per minute by the help of the screw pinch cock (this adjustment is essential otherwise proper drop will not form).

5. Immerse the lower end of stalagmometer in a beaker containing distilled water, in order to suck water till the upper mark of the stalagmometer.

6. Start counting the number of drops when the water level just reaches the upper mark & stop when the level just passes the lower mark. Take 3 to 4 readings.

7. Repeat the same procedure for the given unknown liquid.

Observations:

1. Laboratory temperature=…. $^{\circ}$C

2. Density measurement:

Weight of empty R.D.bottle (w_1) =…g.

Weight of R.D.bottle with water (w_2) =…g.

Weight of R.D. bottle with liquid (w_3) =…g.

So, weight of water (w_w) = (w_2-w_1) =…g.

& weight of liquid w_l = (w_3- w_1) =…g.

3. **Table**: Counting the no of drops:

S.No.	For water(w)		For unknown liquid(l)	
	No. of drops	Mean(n_w)	No. of drops	Mean(n_l)
1. 2. 3.				

Calculations:

1. Determination of the density of the liquid (d_l):

$$\frac{\text{Density of liquid } (d_l)}{\text{Density of water } (d_w)} = \frac{\text{Weight of liquid } (w_l)}{\text{Weight of water } (w_w)}$$

$$\text{Density of liquid } (d_l) = \frac{w_l}{w_w} d_w$$ (Take density of water =1.0g/ml at 25 ˚C)

2. Determination of the surface tension of the liquid (γ_l)

$$\text{Surface tension of liquid } (\gamma_l) = \frac{n_w d_l}{n_l d_w} \gamma_w$$

(Surface tension of water (γ_w) =71.97dyne/cm at 25˚C)

Precautions:

1. Drops should be properly formed.
2. The stalagmometer should be kept in vertical position while measuring.
3. Same stalagmometer should be used for water and liquid.
4. Observe carefully when the water and liquid are just passing the upper and lower marks of the stalagmometer.

Result: The Surface tension of the given liquid with respect to water at laboratory temperature was found to be ……..dyne/cm.

Sample questions:

1. Define surface tension? What are its units?
2. What is the reason of the origin of surface tension?
3. What are the factors on which surface tension of a liquid depend?
4. What is the influence of temperature on surface tension?
5. What are the examples of surface tension in daily life?
6. Define the surface energy and what are its units?
7. Can you determine surface tension by any other methods?

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