Experiment

Determination of the percentage (%) composition by drop weight (surface tension) method

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Date: ………………. **Room Temperature: 28 ^{o}C**

Objective

To determine the percentage (%) composition of the given mixture consisting of two liquids *A* and *B* (non-interacting system) by drop weight (surface tension) method.

Requirements

(a) Apparatus and Glassware: Stalagmometer, Clamp stand, Beaker, Pipette.

(b) Chemicals:

- Cleaning mixture (Chromic acid solution)
- Liquid ***A*** (Distilled water)
- Liquid ***B*** (40 % (v/v) glycerol solution in water)

1. Principle

Surface tension is defined as the force acting per unit length of the surface of liquid perpendicular to the surface and is denoted by the symbol γ.

$$\gamma = \frac{\text{Force } (F)}{\text{Length } (l)}$$

It is measured in dynes per centimeter (dynes cm^{-1}). Surface tension of a liquid is numerically equal to the work done in enlarging the surface of the liquid by unit amount under isothermal conditions. The force of surface tension is responsible for the spherical shape of drops since for a given volume, the sphere has a minimum surface area. It is also responsible for the rise of liquid in a capillary *etc*. The value of surface tension depends on the nature of the liquid and also on the temperature. Surface tension decreases with the rise of temperature. There are several methods for the determination of surface tension but we shall discuss here the *drop weight method* using **Traube's stalagmometer.**

Drop weight method

The method is based on the principle that, when a definite volume of a liquid is allowed to drop through a fine capillary (or jet), the number of drops formed depends on the surface tension of the liquid. The apparatus used to determine surface tension of various liquids is called Traube's stalagmometer. A stalagmometer is a pipette-like apparatus with a fine capillary tube, the end of which is flattened, grounded, and polished well as shown in **Fig. 1**.

The flattened and grounded surface provides a smooth layer-dropping surface. There are two graduation marks on it. The liquid is allowed to fall from the upper mark to the lower mark. The flow of the liquid is regulated through the inflow of air from the top with the help of a pinch cock. The number of drops formed from the liquid is counted. Let the liquid of surface tension γ_1 and density d_1 produce n_1 drops whereas, the other liquid of surface tension γ_2 and density d_2 produce n_2 drops, then:

$$\frac{\gamma_1}{\gamma_2} = \frac{n_2 d_1}{n_1 d_2}$$

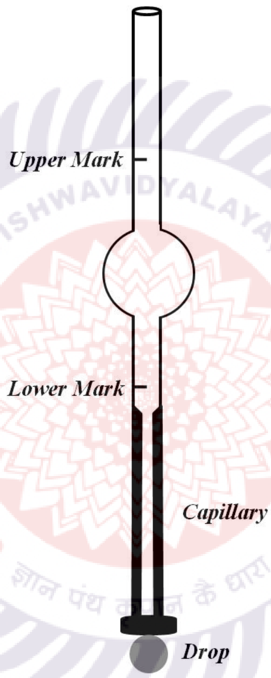

Fig. 1. Traube's stalagmometer.

2. Solution Preparation

2.1. Cleaning mixture (chromic acid solution):

Mix solid $K_2Cr_2O_7$ with 7-8 times its weight of concentrated H_2SO_4.

2.2. Liquid *B* (40 % (v/v) Glycerol solution in water)

Dissolve 40 mL of pure glycerol in a 100 mL volumetric flask and make upto the mark with distilled water.

2.3. Mixing the two liquids *A* and *B* in different proportions

By taking 40 % glycerol solution as liquid ***B***, a mixture solution of 80, 60, 40, and 20 % of liquid ***B*** in liquid ***A*** (distilled water) can be prepared as follows:

Preparation of an 80 % mixture solution of liquid ***B*** in liquid ***A*** in a total volume of 20 mL

$$N_1V_1 \text{ (liquid } \boldsymbol{B}) = N_2V_2 \text{ (80 \% liquid } \boldsymbol{B})$$

$$100 \times V_1 = 80 \times 20$$

$$V_1 = 16 \text{ mL}$$

Take 16 mL of liquid ***B*** in a beaker and add 4 mL of liquid ***A*** (distilled water). Similarly, prepare 60, 40, 20, and 0 % liquid ***B*** solutions by dilution with liquid ***A*** of corresponding higher % of liquid ***B*** solution.

3. Procedure

Prepare a number of mixture solutions by mixing the two liquids ***A*** and ***B*** in different proportions. For example, prepare the solutions of 20, 40, 60, 80, and 100 % of the liquid ***A*** by volume. Count the number of drops for each mixture solution by stalagmometer as follows.

- Cleaning the stalagmometer – The stalagmometer is cleaned with the chromic acid solution and then with distilled water. It is rinsed with alcohol and ether then dried.
- Wash a rubber tube internally to remove any dust particles and then connect it to the upper end of the stalagmometer. Attach a pinch cock with a rubber tube to regulate the flow of liquid and then clamp it vertically accurately.
- Immerse the lower end of the stalagmometer in a beaker containing a liquid (mixture solution) and suck up the liquid until it raises the upper mark. Now control the rate of flow of liquid by adjusting the pinch cock so that the flow of drops should be 12–18 drops per minute. Start counting drops when the liquid meniscus just passes the upper mark and stop when it just crosses the lower mark. Repeat the above process three to four times to determine the mean value of the number of drops.
- Count the number of drops by the same procedure as mentioned above for all the solutions prepared by mixing the two liquids ***A*** and ***B*** and also given an unknown mixture solution.

- Determine the composition of the given unknown mixture solution by comparison with values on a reference curve obtained from different known compositions of mixture solutions of liquids ***A*** and ***B***.

4. Observation Table

Room Temperature: 28 °C

S. No.	Percentage (%) of Compounds		Number of Drops
	A (H_2O)	*B* (Glycerol sol.)	
1	0	100	47
2	20	80	45
3	40	60	44
4	60	40	43
5	80	20	42
6	100	0	41
7	Unknown solution		43

5. Calculation

Plot a graph by taking **the concentrations of one of the components say *B* along the X-axis (abscissa) and the corresponding number of drops along the Y-axis (ordinate)**. Such a plot gives a straight line as shown in **Fig. 2.**

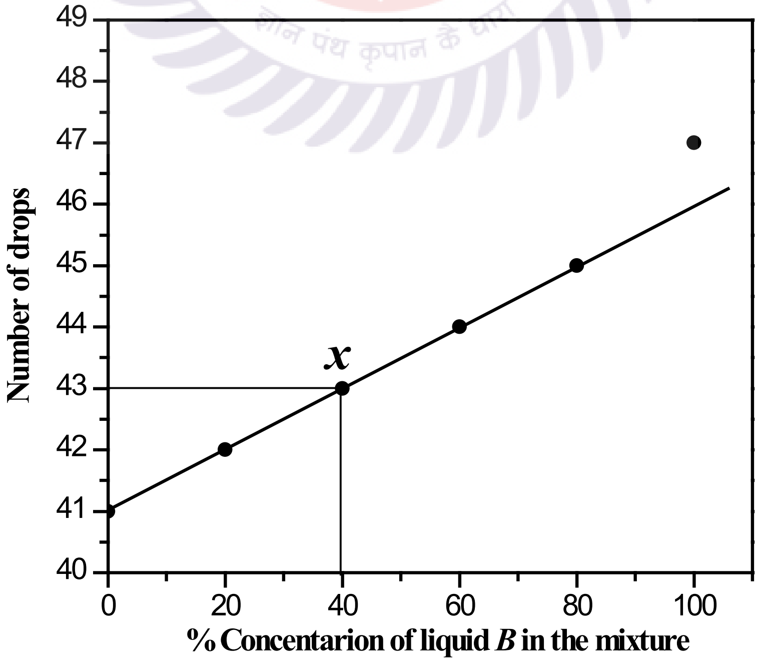

Fig. 2. Plot of percentage (%) of the component *B* versus number of drops.

The composition of the unknown mixture solution can be calculated by marking the point on the straight line corresponding to its time of flow. The ***x*** mark represents the point corresponding to the unknown solution. A perpendicular drawn from this point on the concentration axis gives the percentage (%) of ***B*** in the unknown solution.

Hence, percentage (%) of ***A*** = 100 – Percentage (%) of ***B***

6. Results

The percentage (%) composition of the given unknown mixture solution is found to be 60 % of liquid ***A*** and 40 % of liquid ***B***.

7. Precautions

- **(i)** The stalagmometer should be absolutely clean from any greasy matter.
- **(ii)** The stalagmometer should be held vertically.
- **(iii)** The drops should be allowed to fall from the stalagmometer tip under their own weight.
- **(iv)** The tip of the stalagmometer should not come in contact with your hand, desk, or some other things.
- **(v)** The rate of flow of liquid should be 12–18 drops per minute.

8. Further Reading

- J. Elias, *A Collection of Interesting General Chemistry Experiments*, Revised Ed., University Press, **2007**.
- C. W. Garland, J. W. Nibler and D. P. Shoemaker, *Experiments in Physical Chemistry*, 8th Ed., McGraw-Hill, **2003**.
- A. M. Halern and G. C. McBane, *Experimental Physical Chemistry: A Laboratory Textbook*, 3rd Ed., W. H. Freeman and Company, **2006**.
- *University Practical Chemistry*, P. C. Comboj, Vishal Publishing Co. Jalandhar.
- *Practical Chemistry* (Vol.-I), F. Bahadur, Vishal Publishing Co. Jalandhar.

APPENDIX

1. **Surface tension of water = 71.18 dynes cm^{-1} at 30 ºC.**
2. **Surface tension of glycerol (air) = 63.00 dynes cm^{-1} at 20 ºC.**