

Determination of Surface Tension and Percentage Composition

Object

Determination of surface tension of an organic liquid and determination of percentage composition of an unknown mixture.

Principle

The surface tension of the given organic liquid was determined by using a stalagmometer. When a fixed volume of a liquid was allowed to flow through the capillary of the stalagmometer, the number of drops formed was related to the surface tension and density of the liquid. The surface tension of the given liquid A was determined by comparing it with water B using the relation:

$$\frac{\gamma_A}{\gamma_B} = \frac{\rho_A n_B}{\rho_B n_A}$$

Therefore,

$$\gamma_A = \gamma_B \frac{\rho_A n_B}{\rho_B n_A}$$

where γ_A and γ_B were the surface tensions of liquid A and water B respectively,

ρ_A and ρ_B were the densities of liquid A and water B respectively, and n_A and n_B were the average numbers of drops obtained for the same fixed volume of the respective liquids.

For determining the percentage composition of the unknown mixture, standard mixtures of liquid A and water B of known compositions were prepared. The number of drops for each standard mixture

was determined. A calibration graph was plotted between the percentage composition of A and the average number of drops. The percentage composition of the unknown mixture was determined from this calibration graph.

Chemicals Required

- Water (B)
- Given organic liquid (A)
- Unknown mixture of A and B

Apparatus Required

- Stalagmometer
- Density bottle
- Electronic balance
- Beakers
- Measuring cylinder
- Pipette
- Wash bottle
- Thermometer

Preparation of Standard Mixtures

Five standard mixtures of liquid A and water B were prepared in different known proportions. The total volume of each standard mixture was kept constant. The required volumes of liquid A and water B were mixed according to the following table.

S. No.	A (Given Liquid), mL	B (Water), mL	Composition of A (%)	Composition of B (%)
1	5	95	5	95
2	10	90	10	90
3	15	85	15	85
4	20	80	20	80
5	25	75	25	75

Procedure

A. Determination of Density

The density bottle was cleaned and dried thoroughly. The empty density bottle along with its stopper was weighed and its mass was recorded. The density bottle was then filled completely with water (B),

the stopper was fitted properly and the outside surface was wiped dry. The mass of the density bottle containing water was recorded. The bottle was then emptied, cleaned and dried thoroughly. It was filled completely with the given organic liquid (A), the stopper was fitted properly and the outside surface was wiped dry. The mass of the density bottle containing liquid A was recorded. The same density bottle was used for both liquids, so the same volume of water and liquid A was taken.

B. Determination of Surface Tension

The stalagmometer was cleaned thoroughly with distilled water and was rinsed with a small quantity of the liquid under investigation. It was first filled with water (B) above the upper mark. The liquid was allowed to flow slowly through the capillary and the number of drops formed between the upper and lower marks was counted. Two readings, n_1 and n_2 , were taken and their average was calculated. The same procedure was repeated with the given organic liquid A. The temperature and the volume between the two marks were kept constant during both measurements.

C. Determination of Percentage Composition of the Unknown Mixture

The prepared standard mixtures were taken one by one. The stalagmometer was rinsed with the respective standard mixture and was then filled above the upper mark. The liquid was allowed to flow slowly through the capillary and the number of drops formed between the two marks was counted. Two readings, n_1 and n_2 , were taken for each standard mixture and their average was calculated. The same procedure was followed for the unknown mixture. The average number of drops obtained for the unknown mixture was used to determine its percentage composition from the calibration graph.

Observations

A. Determination of Density

The same volume of water (B) and the given organic liquid (A) was used in the density bottle.

S. No.	Liquid	Mass of Empty Density Bottle (g)	Mass of Density Bottle + Liquid (g)	Mass of Liquid (g)
1	B (Water)			
2	A (Given Organic Liquid)			

B. Determination of Surface Tension

S. No.	Liquid	n_1	n_2	Average Drops
1	B (Water)			
2	A (Given Organic Liquid)			

C. Standard Mixtures and Unknown Mixture

S. No.	Composition (%)		n_1	n_2	Average Drops
	A (Ethanol), mL	B (Water), mL			
1	5	95			
2	10	90			
3	15	85			
4	20	80			
5	25	75			
6	Unknown				

Calculations

A. Calculation of Density

Let the mass of the empty density bottle be W_0 , the mass of the density bottle containing water (B) be W_B , and the mass of the density bottle containing the given organic liquid (A) be W_A .

The mass of water was calculated as:

$$m_B = W_B - W_0$$

The mass of the given organic liquid A was calculated as:

$$m_A = W_A - W_0$$

Since the same volume V of both liquids was used, their densities were calculated as:

$$\rho_B = \frac{m_B}{V}$$

and

$$\rho_A = \frac{m_A}{V}$$

The relative density of liquid A with respect to water B was defined as:

$$RD = \frac{\rho_A}{\rho_B}$$

B. Calculation of Average Number of Drops

The average number of drops for each liquid and standard mixture was calculated using:

$$n = \frac{n_1 + n_2}{2}$$

C. Calculation of Surface Tension of Liquid A

The surface tension of the given organic liquid A was calculated by comparing it with water B. The densities of A and B were used directly in the equation:

$$\frac{\gamma_A}{\gamma_B} = \frac{\rho_A n_B}{\rho_B n_A}$$

Therefore,

$$\gamma_A = \gamma_B \frac{\rho_A n_B}{\rho_B n_A}$$

where γ_B was the known surface tension of water at the experimental temperature, ρ_A and ρ_B were the densities of liquid A and water B respectively, and n_A and n_B were their respective average numbers of drops.

D. Determination of Percentage Composition of Unknown Mixture

The average number of drops for each standard mixture was calculated. A calibration graph was plotted by taking the percentage composition of liquid A on the X-axis and the average number of drops on the Y-axis. The experimental points obtained for the standard mixtures were plotted and a best-fit calibration curve was drawn.

The average number of drops obtained for the unknown mixture was located on the Y-axis. A horizontal line was drawn from this point to meet the calibration curve. From the point of intersection, a perpendicular was drawn to the X-axis. The corresponding value on the X-axis gave the percentage composition of liquid A in the unknown mixture.

If the percentage composition of A obtained from the graph was $x\%$, then:

$$\%A = x$$

Therefore, the percentage composition of water B was:

$$\%B = 100 - x$$

Graph

A calibration graph was plotted between the percentage composition of liquid A (%) and the average number of drops obtained for the standard mixtures. The average number of drops of the unknown mixture was then used to determine its corresponding percentage composition from the graph.

Result

The density of water (B) was found to be _____ g mL⁻¹, and the density of the given organic liquid (A) was found to be _____ g mL⁻¹. The surface tension of the given organic liquid A was found to be _____ dyn cm⁻¹ at _____ °C. The percentage composition of liquid A in the unknown mixture was found to be _____ %, and the percentage composition of water (B) was found to be _____ %.

Precautions

1. The density bottle was cleaned and dried thoroughly before taking the readings.
2. The same density bottle was used for water and liquid A so that the same volume of both liquids was taken.
3. The density bottle was filled completely without leaving air bubbles.
4. The outside surface of the density bottle was wiped dry before weighing.
5. The stalagmometer was cleaned thoroughly before taking the observations.
6. The stalagmometer was rinsed with the liquid under investigation before taking the readings.
7. The liquid was allowed to flow slowly and uniformly through the capillary.
8. The drops were counted carefully between the same two marks.
9. The temperature was kept constant during all measurements.
10. Two readings were taken for each liquid and standard mixture, and their average was used.

11. The standard mixtures were prepared accurately and the total volume of each mixture was kept constant.