

Determination of Viscosity of and Percentage Composition

Object

Determination of viscosity of an organic liquid and determination of percentage composition of an unknown mixture by viscosity method.

Principle

The viscosity of the given organic liquid was determined by using an Ostwald viscometer. When a fixed volume of liquid was allowed to flow through the capillary of the viscometer under the influence of gravity, the time of flow was related to the viscosity and density of the liquid. The viscosity of the given liquid A was determined relative to water B by using the relation:

$$\frac{\eta_A}{\eta_B} = \frac{\rho_A t_A}{\rho_B t_B}$$

Therefore,

$$\eta_A = \eta_B \frac{\rho_A t_A}{\rho_B t_B}$$

where η_A and η_B were the viscosities of liquid A and water B respectively, ρ_A and ρ_B were their densities, and t_A and t_B were the average times of flow of 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 having known compositions were prepared. The time of flow of each standard mixture

through the viscometer was measured. A calibration graph was plotted between the percentage composition of A and the average time of flow. 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

- Ostwald viscometer
- Density bottle
- Electronic balance
- Stopwatch
- 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 Viscosity of Liquid A

The Ostwald viscometer was cleaned thoroughly and rinsed with distilled water. It was then rinsed with a small quantity of the liquid under investigation. Water (B) was introduced into the viscometer and was drawn above the upper mark using a pipette or suitable suction arrangement. The liquid was allowed to flow freely through the capillary and the time required for the liquid level to pass from the upper mark to the lower mark was measured using a stopwatch. Two readings, t_1 and t_2 , were taken and their average time was calculated. The same procedure was repeated with the given organic liquid A, keeping the temperature and the volume between the two marks constant.

C. Determination of Percentage Composition of the Unknown Mixture

The prepared standard mixtures were taken one by one. The Ostwald viscometer was rinsed with the respective standard mixture and was then filled with the mixture. The liquid was drawn above the upper mark and was allowed to flow freely through the capillary. The time required for the liquid level to pass from the upper mark to the lower mark was recorded using a stopwatch. Two readings, t_1 and t_2 , were taken for each standard mixture and their average time was calculated. The same procedure was followed for the unknown mixture. The average time 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)			

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

B. Determination of Viscosity

S. No.	Liquid	t_1 (s)	t_2 (s)	Average Time (s)
1	B (Water)			
2	A (Given Organic Liquid)			

C. Standard Mixtures and Unknown Mixture

S. No.	Composition (%)		t_1 (s)	t_2 (s)	Average Time (s)
	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:

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

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

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

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

B. Calculation of Average Time

The average time of flow for each liquid and standard mixture was calculated from the two observations using:

$$t = \frac{t_1 + t_2}{2}$$

C. Calculation of Viscosity of Liquid A

The viscosity 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:

$$\frac{\eta_A}{\eta_B} = \frac{\rho_A t_A}{\rho_B t_B}$$

Therefore,

$$\eta_A = \eta_B \frac{\rho_A t_A}{\rho_B t_B}$$

where η_B was the known viscosity of water at the experimental temperature, ρ_A and ρ_B were the densities of liquid A and water B respectively, and t_A and t_B were their respective average times of flow.

D. Determination of Percentage Composition of Unknown Mixture

The average time of flow 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 time of flow on the Y-axis. The experimental points obtained for the standard mixtures were plotted and a best-fit calibration curve was drawn.

The average time 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 time of flow obtained for the standard mixtures. The average time of flow 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 viscosity of the given organic liquid A was found to be _____ poise 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 Ostwald viscometer was cleaned thoroughly before taking the observations.
6. The viscometer was rinsed with the liquid under investigation before taking the readings.
7. The liquid was allowed to flow freely through the capillary without applying pressure during the measurement.
8. The time was measured between the same two marks for every observation.
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.