

Determination of Percentage Composition by Viscosity Method

Object

Determination of percentage composition by viscosity method.

Principle

Viscosity is the internal resistance offered by a liquid to its flow. When two completely miscible liquids such as ethanol and water are mixed, the viscosity of the resulting mixture changes with its composition. Therefore, the percentage composition of an unknown ethanol-water mixture can be determined by comparing its flow time with those of mixtures of known composition.

In this experiment, an Ostwald viscometer is used to determine the flow time of ethanol-water mixtures. A fixed volume of the liquid is allowed to flow through the capillary between two fixed marks under the action of gravity, and the time required for the meniscus to pass between these marks is measured with a stopwatch. Standard mixtures of known composition are used to establish a calibration curve between percentage composition and average flow time. The flow time of the unknown mixture is then determined under the same conditions and its percentage composition is obtained from the calibration curve.

Chemicals Required

- Ethanol
- Distilled water
- Unknown ethanol-water mixture

Apparatus Required

- Ostwald viscometer
- Stand and clamp
- Stopwatch
- Beakers
- Measuring cylinder
- Pipette
- Thermometer
- Rubber tube or suction arrangement
- Wash bottle

Preparation of Standard Solutions

Standard ethanol-water mixtures of known composition are prepared by mixing the required volumes of ethanol and distilled water. The same compositions are used as in the surface tension method. The standard mixtures consist of 5 mL ethanol + 95 mL water, 10 mL ethanol + 90 mL water, 15 mL ethanol + 85 mL water, 20 mL ethanol + 80 mL water, and 25 mL ethanol + 75 mL water. The total volume of each standard mixture is 100 mL.

Procedure

1. The Ostwald viscometer is thoroughly cleaned with distilled water to remove dust, grease and other impurities. It is then rinsed with a small quantity of the solution to be examined.
2. The viscometer is fixed vertically on a stand with the help of a clamp. It should remain perfectly vertical throughout the experiment.
3. The first standard mixture containing 5 mL ethanol and 95 mL distilled water is introduced into the viscometer.
4. The liquid is drawn above the upper mark of the viscometer with the help of a rubber tube or suitable suction arrangement.
5. The liquid is then allowed to flow freely through the capillary under the action of gravity. The stopwatch is started when the meniscus crosses the upper mark and stopped when it crosses the lower mark.
6. The time taken by the liquid to flow between the two marks is recorded as t_1 . The measurement is repeated under the same conditions and the second reading is recorded as t_2 .
7. The average flow time is calculated using the relation:

$$t_{\text{avg}} = \frac{t_1 + t_2}{2}$$

8. The viscometer is rinsed with the next standard solution and the same procedure is repeated for the mixtures containing 10 mL ethanol + 90 mL water, 15 mL ethanol + 85 mL water, 20 mL ethanol + 80 mL water and 25 mL ethanol + 75 mL water.
9. After completing the observations for all the standard solutions, the viscometer is thoroughly rinsed with the unknown ethanol-water mixture.
10. The unknown mixture is introduced into the viscometer and its flow time is determined in exactly the same manner. Two readings, t_1 and t_2 , are taken and the average flow

time is calculated.

11. A calibration graph is plotted between the percentage composition of ethanol and the corresponding average flow time of the standard solutions.
12. The average flow time obtained for the unknown solution is located on the calibration curve and the corresponding percentage composition of ethanol is determined.
13. The percentage of water present in the unknown mixture is calculated by subtracting the percentage of ethanol from 100.

Observation Table

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		—	—	—

Calculation

For each standard solution and the unknown solution, the average flow time is calculated from the two experimental readings using the following relation:

$$t_{\text{avg}} = \frac{t_1 + t_2}{2}$$

where t_{avg} is the average flow time in seconds, t_1 is the first observed flow time and t_2 is the second observed flow time.

For an Ostwald viscometer, the coefficient of viscosity is related to the flow time and density of the liquid. For two liquids, the relative viscosity can be expressed as:

$$\frac{\eta_1}{\eta_2} = \frac{\rho_1 t_1}{\rho_2 t_2}$$

where η_1 and η_2 are the coefficients of viscosity, ρ_1 and ρ_2 are the densities, and t_1 and t_2 are the corresponding flow times of the two liquids.

In the present experiment, the calibration-curve method is used. The average flow time obtained for each standard ethanol-water mixture is plotted against its known percentage composition. The average flow time of the unknown mixture is then used to determine its corresponding ethanol percentage from the calibration curve.

Graph

A calibration graph is plotted between the percentage composition of ethanol and the average flow time of the standard ethanol-water mixtures.

X-axis: Percentage of ethanol (%)

Y-axis: Average flow time (s)

The average flow time of the unknown solution is located on the calibration curve. The corresponding value on the X-axis gives the percentage of ethanol present in the unknown mixture.

Result

The percentage composition of the given unknown ethanol-water mixture is determined by the viscosity method.

Percentage of ethanol = _____%

Percentage of water = _____%

Precautions

- The Ostwald viscometer should be thoroughly clean and free from grease and dust.
- The viscometer should be kept perfectly vertical during the experiment.

- The same viscometer should be used for all standard and unknown solutions.
- The temperature should be kept constant throughout the experiment because viscosity is highly dependent on temperature.
- The viscometer should be rinsed with the solution before taking its reading.
- No air bubbles should be present in the capillary while taking the readings.
- The liquid should be allowed to flow freely under gravity without applying pressure during measurement.
- The stopwatch should be started exactly when the meniscus crosses the upper mark and stopped exactly when it crosses the lower mark.
- Two or more concordant readings should be taken for each solution.
- All standard solutions and the unknown solution should be measured under identical experimental conditions.