

Determination of Percentage Composition by Surface Tension Method

Object

Determination of percentage composition by surface tension method.

Principle

The surface tension of a liquid is a measure of the cohesive force acting between its molecules. When two completely miscible liquids are mixed, the surface tension of the resulting mixture depends upon the composition of the mixture. Therefore, the percentage composition of a mixture can be determined by measuring its surface tension and comparing the measured value with those obtained for mixtures of known composition.

In the stalagmometer method, a fixed volume of liquid is allowed to flow through the capillary of the stalagmometer and the number of drops formed between two fixed marks is counted. For the same stalagmometer and under identical experimental conditions, the number of drops is related to the surface tension of the liquid. Hence, standard ethanol-water mixtures of known composition are used to establish a relationship between composition and number of drops. The number of drops obtained for the unknown mixture is then compared with this relationship to determine its percentage composition.

Chemicals Required

- Ethanol
- Distilled water
- Unknown ethanol-water mixture

Apparatus Required

- Stalagmometer
- Stand and clamp
- Beakers
- Measuring cylinder
- Pipette
- Rubber tube or suction arrangement
- Thermometer
- Wash bottle
- Glass rod

Preparation of Standard Solutions

Standard ethanol-water mixtures of different known compositions are prepared by mixing the required volumes of ethanol and distilled water. In each case, the total volume of the mixture is kept at 100 mL. The standard mixtures are prepared as 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.

Procedure

1. The stalagmometer 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 stalagmometer is fixed vertically on a stand with the help of a clamp. It should remain perfectly vertical throughout the experiment so that the drops are formed regularly at the tip of the capillary.
3. The temperature of the laboratory and the liquid is noted. The measurements for all the standard solutions and the unknown solution are carried out under approximately the same temperature conditions.
4. The first standard solution containing 5 mL ethanol and 95 mL distilled water is taken in a clean beaker.
5. A small quantity of the standard solution is introduced into the stalagmometer for rinsing. The rinsing liquid is discarded and the stalagmometer is filled with the same solution.
6. The liquid is drawn above the upper mark of the stalagmometer using the suction arrangement. The suction is then stopped and the liquid is allowed to flow freely through the capillary.
7. The number of drops falling between the two fixed marks is counted carefully. Two observations are taken and recorded as n_1 and n_2 .
8. The average number of drops is calculated from the two observations using the relation: $N = (n_1 + n_2)/2$.
9. The same procedure is repeated for the standard solutions containing 10%, 15%, 20% and 25% ethanol. The values of n_1 , n_2 and the corresponding average number of drops are recorded.
10. After completing the observations for the standard solutions, the stalagmometer is thoroughly rinsed and filled with the unknown ethanol-water mixture.
11. The number of drops for the unknown mixture is determined in exactly the same manner and two readings, n_1 and n_2 , are recorded. The average number of drops is then calculated.
12. A calibration graph is plotted by taking the percentage composition of ethanol on the X-axis and the corresponding average number of drops on the Y-axis.
13. The average number of drops obtained for the unknown solution is located on the Y-axis and a horizontal line is drawn to meet the calibration curve. From the point of intersection, a perpendicular is drawn to the X-axis.
14. The value obtained on the X-axis gives the percentage composition of ethanol in the unknown mixture. The percentage of water is obtained by subtracting the percentage of ethanol from 100.

Observation Table

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		—	—	—

Calculation

For each solution, the average number of drops is calculated from the two experimental observations using the following relation:

$$N = (n_1 + n_2) / 2$$

where N is the average number of drops, n₁ is the first observation and n₂ is the second observation.

The average number of drops obtained for the standard solutions is used to construct the calibration curve. The average number of drops obtained for the unknown solution is then used to determine its percentage composition from the calibration curve.

Graph

A graph is plotted between the percentage composition of ethanol and the average number of drops obtained for the standard ethanol-water mixtures.

X-axis: Percentage of ethanol (%)

Y-axis: Average number of drops

The point corresponding to the average number of drops of the unknown solution is located on the calibration curve. Its corresponding value on the X-axis gives the percentage of ethanol present in the unknown mixture.

Result

The percentage composition of the given unknown mixture is determined by the surface tension method.

Percentage of ethanol in the unknown mixture = _____ %

Percentage of water in the unknown mixture = _____ %

Precautions

- The stalagmometer should be thoroughly clean and free from grease and dust.
- The stalagmometer must be kept perfectly vertical during the experiment.
- The same stalagmometer should be used for all the measurements.
- The temperature should be kept as constant as possible throughout the experiment.
- The liquid should flow slowly and the drops should be formed regularly.
- The liquid level should be raised above the upper mark before each measurement.
- The drops should be counted only between the two specified marks.
- The stalagmometer should be rinsed with the solution before taking its reading.
- The formation of drops should not be disturbed while counting.
- All readings should be taken under identical experimental conditions.