Experiment 10

Liquid Properties : Viscosity

Purpose :

To measure relative viscosity of liquids and determine the viscosity-composition curve for a two-component liquid system.

Principle :

The absolute viscosity of a liquid is defined as the force required to move a plane of unit area at unit velocity with respect to another parallel plane separated by unit distance, the space between the planes being filled with the liquid under observation. Absolute viscosity (η) may be measured by observing the rate of flow through capillary tubes, and applying **Poiseuille's** law:

$$\eta = \frac{\Delta P g \pi r^4}{8 \nu l} = \frac{\Delta P g \pi r^4 t}{8 V l} \qquad (1)$$

where

ΔP	is the pressure drop across the tube in g/cm^2,
g	the acceleration due to gravity in cm/sec^2,
r	the radius of the tube in *cm*,
ν	the volume delivered in unit time in ml/sec,
V	he volume delivered in *ml*,
l	the length of the tube in *cm*.

To obtain the relative viscosity of a liquid at a given temperature, it is necessary to measure its time of flow at that temperature and the corresponding time of flow for the same volume of water in the same viscometer at the same temperature. Since the pressure of a liquid in a viscometer of the type used is proportional to its density, and since the terms *r*, *V*, and *l* in Eq. (1) are the same for both liquids, it follows that the ratio of the viscosities is given by the following equation:

$$\frac{\eta_1}{\eta_2} = \frac{d_1 t_1}{d_2 t_2} \qquad (2)$$

If substance *2* is the reference liquid, we arbitrarily assign to η_2, the value of unity. Then η_1 is calculated by substitution of the densities and the flow times in Eq. (2). We can also use Eq. (2) to obtain the viscosity of water at a given temperature relative to the viscosity of water at $25\ ^{\circ}C$.

Apparatus and Chemicals :

Ostwald viscometer; *10-ml* pycnometer; two *25-ml* pipettes; two *10-ml* pipettes; two safety bulbs; four *100-ml* beakers; rubber bulb.

Acetone.

Procedures :

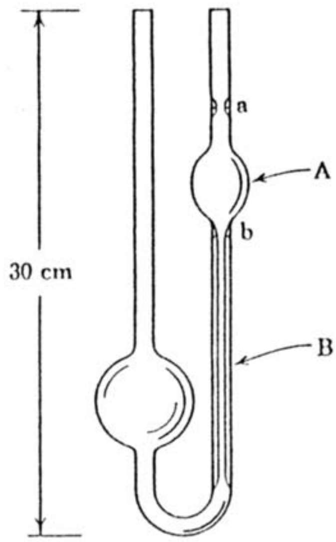

Fig. 10 Ostwald viscometer

(1) After the viscometer (see **Fig. 10**) has been thoroughly cleaned with warm soap solution, it is thoroughly rinsed by distilled water through it, followed by acetone, and finally is dried by aspirating clean air through it.

(2) Clamp the viscometer vertically in such a position that it can be viewed easily.

(3) Pipette exactly *10 ml* of distilled water into the left arm of the viscometer and suck the liquid up into the right arm above the mark ***a*** by attaching a piece of rubber tubing.

(4) Allow the liquid to flow down several times to be sure that no air bubbles remain on the wall of the capillary.

(5) Again suck the liquid up into the right arm above ***a*** and, using a stopwatch, determine the time it takes the liquid to pass between marks ***a*** and ***b***. Repeat this procedure so that at least three readings are obtained. The observations should not deviate more than ±*0.2 sec* among themselves.

(6) Make determinations on the solutions which have the following composition: *20*, *40*, *60*, *80*, and *100 mole* percent acetone in water. Prepare the above solutions with total volume *30 ml* previously.

(7) The density of each liquid must also be measured at room temperature by using pycnometer.

Calculations :

(1) Get the absolute viscosity of water at room temperature from literature and calculate the absolute viscosity of each liquid and solution.

(2) Plot the viscosity-composition diagram for the acetone-water system.

References :

(1) P. W. Atkins and J. de Paula, "*Physical Chemistry*," 9th ed., pp. 686-688, 754-758, Oxford University Press, U.S.A (2010).

(2) P. W. Atkins and J. de Paula, "*Physical Chemistry*," 8th ed., pp. 756-760, Oxford University Press, U.S.A (2006).

(3) A. W. Davison and others, "*Laboratory Manual of Physical Chemistry*," 4th ed., pp. 27-28, John Wiley & Sons, Inc., U.S.A. (1956).

(4) H. D. Crockford and **J. W. Nowell**, "*Laboratory Manual of Physical. Chemistry*," pp. 55-58,.John Wiley & Sons, Inc., U.S.A. (1956).

(5) O. F. Steinbach and **C. V. King**, "*Experiments in Physical Chemistry*," pp. 55-60, American book company, U.S.A. (1950).