Experiment 11: Determination of Viscosity co-efficient of the given liquid using Ostwald's viscometer

Significance of the experiment:Viscosity[1,2] gives us precisely how fast a liquid/fluid flows. Ever wondered why chocolate melts if it is not kept at cold temperature? The reason for this is the change in viscosity of the chocolate syrup with temperature. Viscosity is sensitive to temperature and in some fluids its value doubles for a mere 5 ^{o}Cincrease in temperature. A measure of viscosity is very important in the food industry to increase the consistency, quality, production efficiency, and texture in foods.[3]Similarly, viscosity is precisely maintained at specific value in paints and varnishes so that they can be evenly and smoothly applied over the surface with brush roller or a paintbrush. For easy flow of the products such as toothpaste, syrups, and lubrication oils they should have a particular value of viscosity to be useful. Viscosity coefficient is same as dynamic viscosity.[4,5]The ratio of shearing stress to the velocity gradient gives viscosity coefficient. The SI unit of dynamic viscosity is pascal second and cgs unit is poise. 1 millipoise = 1/1000 poise and 1 poise = 1/10 pascal second (Poise unit is named after Jean Poiseuille, scientist who first observed the factors that influence the flow of fluids in circular tubes and derived an equation for Viscosity). In this particular experiment you are only interested in the flow of non-turbulent (steady) and non-pulsatile (no periodic variations) fluids in circular tubes. The blood has viscosity value between 3 to 4 milli Pascal second (mPa s) or 0.3-0.4 millipoise at 37^{o}C. Similarly food/liquid items that are used in your daily life such as water at 20 ^{o}C, milk at 25 ^{o}C, honey at 20 ^{o}C, and ketchup at 20 ^{o}C have viscosity values of 0.1, 0.3, 1000, and 5000 respectively.[1]

Aim: To determine viscosity co-efficient of a given liquid using Ostwald's viscometer

Principle: Viscosity arises due to internal friction between moving layers of molecules. A liquid flowing through a cylindrical tube of uniform diameter is expected to move in the form of molecular layers. A layer close to the surface is almost stationary while that at the axis of the tube moves faster than any other intermediate layer. A slow moving layer exerts a drag or friction on its nearest moving layer backwards. This property of a liquid by which it retards or opposes motion between layers is called viscosity. The co-efficient of viscosity is the tangential force per unit area required to maintain a unit velocity gradient between any two successive layers of a liquid situated unit distance apart. The coefficient of viscosity of a liquid is given by Poiseuille's formula.

In this experiment you will be determining the viscosity by studying the flow of fluid through a circular tube. Jean Poiseuille and Gotthilf Hagen first carried out these studies independently on various fluids.By studying the various factors that influence the flow of non-turbulent (steady) and non-pulsatile (no periodic variations) fluids through circular tube they arrived at an equation (1)given below for volume flow rate $\left(\frac{v}{t}\right)$[volume (v) that flows after a specified time (t)].

Volume flow rate $\left(\frac{v}{t}\right) = \frac{\pi \Delta P r^4}{8\,\eta l}$…….(1)alternatively, $\eta = \frac{\pi \Delta P\ tr^4}{8\ vl}$

Where v = volume of the liquid, r = radius of the tube, l = length of the tube, ΔP = pressure difference between the two ends of the tube,Ƞ = co-efficient of viscosity of the liquid.

If equal volumes of two different liquids (one being water) are allowed to flow through the same tube under identical conditions, then

$$\frac{\eta 1}{\eta w} = \frac{t1d1}{twdw}$$

The time t_l taken by the given liquid to travel through a certain distance in the tube is determined. The time, t_w taken by the water to travel through the same distance is measured. Knowing the densities, d_l and d_w of the test liquid and the water and also the coefficient of viscosity of the water (η_w), coefficient of viscosity of the test liquid (η_l) can be calculated.

Procedure: Clean the given viscometer with water, rinse with acetone and dry it. Fix the viscometer vertically to a stand. Using a pipette, transfer a known volume of test liquid into the wider limb. Suck it above the upper mark of the viscometer. Allow it to flow freely through the capillary. When the level of water just crosses the upper mark, start a stop clock. Stop the stop clock when the water just crosses the lower mark. Record the time of flow in seconds. Repeat for 3 times.

Pour out the water, rinse the viscometer with acetone and dry it. Clamp it vertically to a stand and transfer the same volume of ion exchange water into the wider limb. As described above, record the time taken in seconds by the liquid to flow through tha same distance. Determine the coefficient of viscosity of liquid using the relation.

$$\frac{\eta 1}{\eta w} = \frac{t1d1}{twdw}$$

Result:

The coefficient of viscosity of the given liquid = …… millipoise

Links to the external sources of information about the topic:

1. http://physics.info/viscosity/
2. http://schoolworkhelper.net/what-is-viscosity-application-flow-factors/
3. http://www.cscscientific.com/viscosity
4. http://en.wikipedia.org/wiki/Viscosity
5. http://www.infoplease.com/encyclopedia/science/viscosity-the-velocity-gradient.html
6. http://www.engineeringtoolbox.com/dynamic-absolute-kinematic-viscosity-d_412.html

Experiment 11: Observation and calculations

	Time of flow (in seconds)			
Liquid	Trail I	Trail II	Trail III	Average
Water (t_w)				
Test liquid (t_l)				

Laboratory temperature =…….°C (T)

Density of water at ……°C = …….g/mL (will be provided to you)

Viscosity co-efficient of water at `T' °C = …… millipoise (will be provided to you)

Density of the given liquid at `T' °C = ……..g/mL (will be provided to you)

Viscosity co-efficient of the given liquid,

$$\eta_l = \eta_w \text{ x } \frac{t1\ d1}{twdw}$$

Where,

η_l= coefficient of viscosity of the test liquid.

η_w= coefficient of viscosity of the water.

t_w= time taken (in seconds) by the water to flow from point A to B.

t_l= time taken (in seconds) by the liquid to flow from point A to B.

d_l= density of the given liquid.

d_w= density of water.

Result:

The coefficient of viscosity of the given liquid = …… millipoise