**Practical No 35**

# ESTIMATION OF VOLUME AND RADIUS OF A SINGLE MOLECULE APLYING THE VISCOMETRIC METHOD

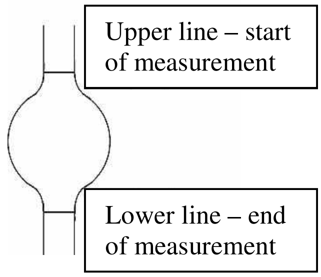


Fig. 1 Scheme of the upper part of viscometer

## Laboratory equipment

Viscometer, stop-watch, glycerol solutions.

## Course of measurements

**ATTENTION – the results of all calculations should be rounded off three decimal places!**

**ATTENTION – to obtain correct results of measurements it is necessary to keep the viscometer in a vertical position!**

1. Pour 3 ml of distilled water to the viscometer.

2. Using a syringe pump water to another branch of viscometer up to the level above the upper line, but below the sign „0,4".

3. Turn on the stop-watch at the moment while, during a laminar water flow, the lower meniscus of water is reaching the upper line – start of measurement (Fig. 1), and turn it off at the moment while the meniscus is reaching the lower line – end of measurement (Fig. 1).

4. How to remove a solution from the viscometer:

   - keep the viscometer in a vertical position, then loosen its holding screw
   - turn the viscometer gently down until the end of the branch is above the beaker to pour the solution out
   - if some solution remains inside the viscometer, push the syringe piston to "blow" it out.

5. After having finished the measurement pour the water out from the viscometer, applying the procedure described in the point 4. Pour 3 ml of glycerol solution of the **lowest** concentration into the viscometer and measure the time of flow between the upper and the lower line, such as in case of distilled water, applying the experimental protocol described in points 2-4.

6. Measure the time of flow for all other examined solutions of glycerol, applying the experimental protocol described in points 2-4.

7. Applying the formula given below:

$$\eta_{rel} = \frac{\eta}{\eta_0} = \frac{t}{t_0}\frac{\varrho}{\varrho_0}$$

where $\varrho_0^{(20\,C)}=0{,}998$ g·cm$^{-3}$ – water density (20$^0$ C), $\eta_0$ – water viscosity, $\eta$ – viscosity for each examined solution, calculate the relative viscosity for each examined solution. Densities (ϱ) of examined solutions should be read of from a plot and write down the data to the Table 1.

Then, based on the formula:

$$\eta_{spec} = \frac{\eta}{\eta_0} - 1$$

calculate its specific viscosity.

8. Write the results down to the table 1 in the final report sheet. Convert the percentage concentration into the expressed concentration g/cm$^3$.

9. Make a plot $\frac{\eta_{spec}}{c} = f(c)$ , then use the extrapolation method to estimate the limiting viscosity number ($\eta_{lim}$).

10. Knowing the limiting viscosity number ($\eta_{lim}$), calculate volume of a single molecule (v) of glycerol (in Å$^3$), applying the formula:

$$v = \frac{M\eta_{lim}}{2{,}5N_A}$$

where: M=92,1 g·mol$^{-1}$ is the molar mass of glycerol, $N_A$=6,022·10$^{23}$mol$^{-1}$ - Avogadro number.

11. Knowing the v calculate radius of a single molecule r (in Å) assuming that the molecule has a shape, which is approximately spherical.

12. Write all the results down into boxes in the final report sheet.

**Required background in theory**

1. Types of liquid flow: laminar flow, turbulent flow.
2. Internal friction during transportation of liquids.
3. Viscosity of liquids – Newton law – viscosity coefficient, viscosity units.
4. Which liquids are newtonian and which are non-newtonian ?
5. Poisseuille law for liquid transportation in a vessel
6. Einstein formula describing viscosity of a solution in relation to viscosity of a solvent, in which spherical molecules are dissolved..
7. Define a relative viscosity, specific viscosity and limiting viscosity number.
8. Method of determination of limiting viscosity number.
9. Describe the method of determination of volume and radius of a single molecule using Ostwald viscometer and Poisseuille law.

**Literature**

1. Glaser, “Biophysics”, Springer, 2001.

| Wrocław Medical University<br>Department of Biophysics<br>and Neuroscience | **Practical No 35**<br><br>**Estimation of volume and radius of a single molecule applying the viscometric method** |
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| Grade: | Tutor's signature: |

1. Measurement of time of flow.

Table 1

| Examined liquid | Concentration [%] | Concentration [g/cm$^3$] | $t_x$ [s] | $\varrho$ [g·cm$^{-3}$] | $\eta_{rel}$ | $\eta_{spec}$ | $\frac{\eta_{spec}}{c}$ [cm$^3$/g] |
|---|---|---|---|---|---|---|---|
| Water | - | - | | | - | - | - |
| Solution 1 | 6 | | | | | | |
| Solution 2 | 10 | | | | | | |
| Solution 3 | 14 | | | | | | |
| Solution 4 | 16 | | | | | | |
| Solution 5 | 20 | | | | | | |

2. Plot $\frac{\eta_{spec}}{c} = f(c)$

$\boldsymbol{\eta_{lim}}$ =

2. Volume of a single molecule of glycerol.

**v =** [Å$^3$]

4. Radius of a single molecule of glycerol.

**r =** [Å]