Date 12.11.21

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DETERMINATION OF MOLECULAR WEIGHT OF A POLYMER BY VISCOSITY AVERAGE METHOD

★ **AIM:**

→ To determine the molecular weight of a polymer in solution by using a viscometer.

★ **APPARATUS REQUIRED:**

→ Ostwald's viscometer, Volumetric flask, stop watch, standard flasks.

★ **REAGENTS REQUIRED:**

→ Polymer, suitable solvents.

★ **PRINCIPLE:**

→ If a polymer is soluble in a suitable solvent, measurement of solution viscosity provides a simple and convenient method for molecular weight determination.

→ Using Poiseuille's equation it is possible to show that if t, η and ρ are the flow time, viscosity and density of a solution respectively and t_0, η_0 and ρ_0 are those of the pure solvent, then

$$\frac{\eta}{\eta_0} = \frac{\rho}{\rho_0} \cdot \frac{t}{t_0}$$

→ The value of $\frac{\eta}{\eta_0}$, is known as the relative viscosity η_{rel}.

→ In dilute solutions, which are often employed for molecular weight determinations, ρ is much different from ρ_0 and hence $\eta_{rel} = \frac{\eta}{\eta_0} = \frac{t}{t_0}$

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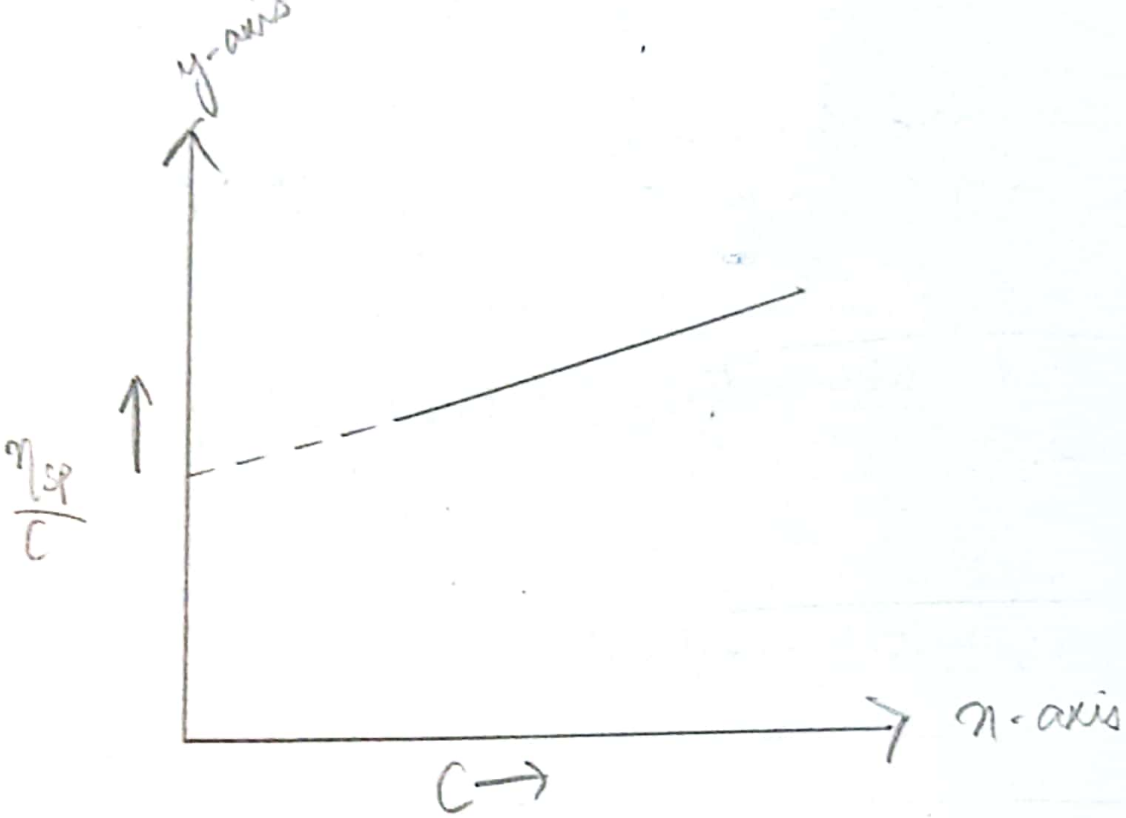

Plot of η_{sp}/C vs C of Polymer solution to find out intrinsic viscosity

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→ The specific viscosity η_{sp} is defined as

$$\eta_{sp} = \eta_{rel} - 1$$

→ A plot of $\frac{\eta_{sp}}{C}$ vs C is a straight line for dilute solutions, the intercept: $\lim_{C \to 0} \frac{\eta_{sp}}{C} = \eta_{int}$ of which is known as the intrinsic viscosity η_{int}.

→ The Staudinger–Mark–Houwink equation which relates η_{int} with molecular weight: $\eta_{int} = K(M)^a$

★ **PROCEDURE:**

→ Preparation of various concentrations of polymer in water (solvent):

- 1% solution of polymer in water will be supplied. We need to prepare at least '5' dilutions viz 0.1%, 0.2%, 0.3%, 0.4% and 0.5% polymer in water before carrying out the experiment dilutions can be done by using volumetric expression.

$$V_1 N_1 = V_2 N_2$$

Eg: To prepare 100 ml of 0.2% diluted solution from a 1% solution, volume is

$$V_1 = \frac{V_2 \times N_2}{N_1} = \frac{100\,ml \times 0.2\%}{1\%} = 20\,ml$$

Similarly, any other dilutions can be prepared by the above method.

- Set up the Ostwald viscometer and measure the flow time (t_0) of a fixed volume of the pure solvent. Take an average of three readings. Rinse the viscometer thoroughly

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with the most dilution solution, measure the flow time (t_1) keeping the flow-volume the same. Repeat the procedure for other solutions.

- Calculate η_{rel} and η_{sp}. Plot η_{sp}/C vs C, extrapolate to C=0 to obtain η_{int}. From the given values of K and α, calculate the molecular weight.

★ OBSERVATIONS:

S.No.	Concentration of Polymer Sol.	Time of Flow	Relative viscosity $\frac{\eta}{\eta_0} = \frac{t}{t_0}$	Specific viscosity $\eta_{sp} = \frac{\eta}{\eta_0} - 1$	Reduced viscosity η_{sp}/C
1	Pure Solvent	$t_0 = 48$	1	0	0
2	0.1%	$t_0 = 51$	1.062	0.062	62.0
3	0.2%	$t_0 = 53$	1.104	0.104	52.0
4	0.3%	$t_0 = 57$	1.187	0.187	62.33
5	0.4%	$t_0 = 63$	1.312	0.312	78.0
6	0.5%	$t_0 = 67$	1.395	0.395	79.0

★ CALCULATIONS:

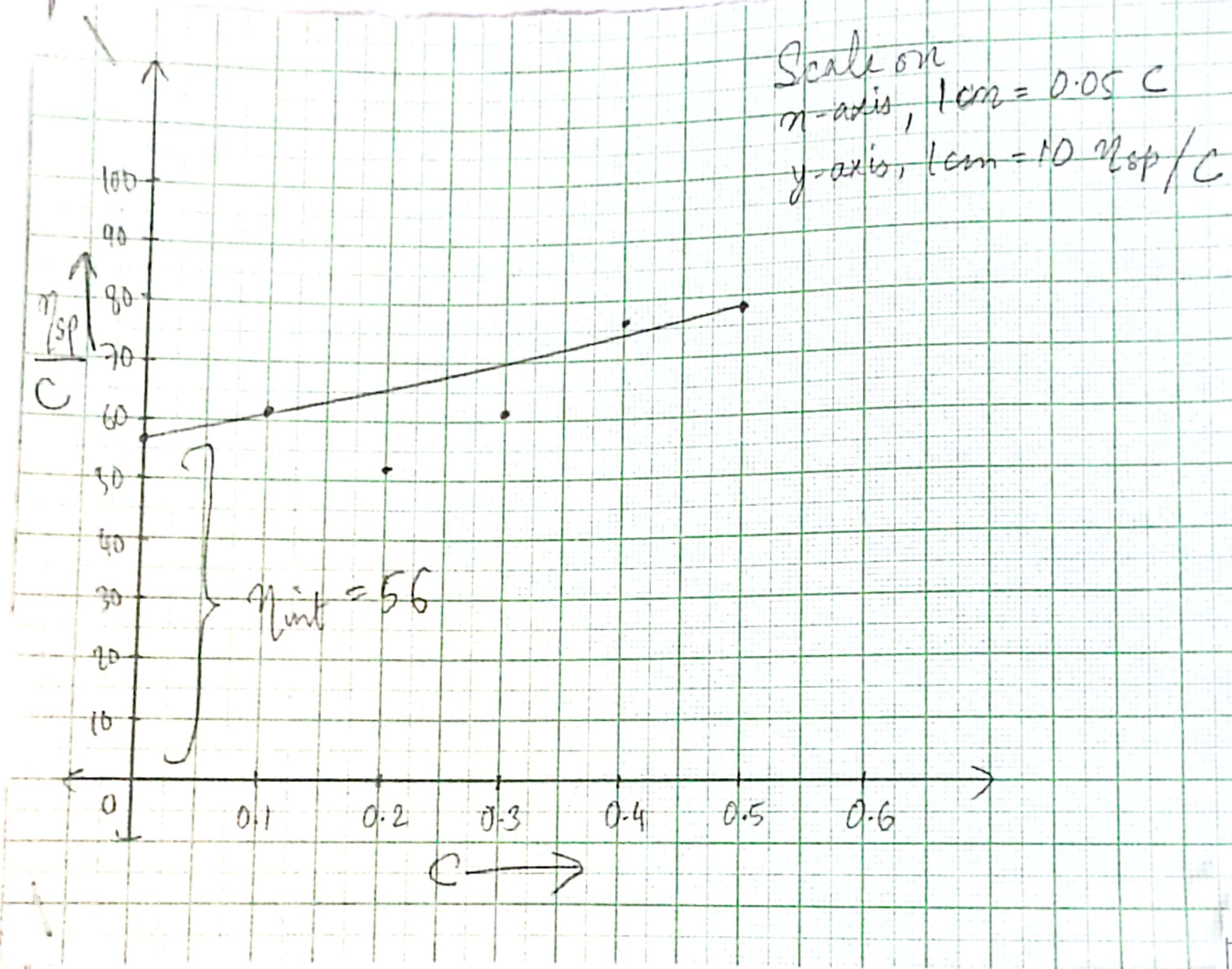
→ Solvent used water

$$\eta_{int} = K \times M^{\alpha}$$

$$\Rightarrow \log \eta_{int} = \log K + \alpha \log M$$

$$\Rightarrow \alpha \log M = \log \eta_{int} - \log K$$

★ GRAPH :



Scale on
x-axis, 1cm = 0.05 C
y-axis, 1cm = 10 ηsp/C
100
90
80
70
60
50
40
30
20
10
0
ηsp/C
0.1
0.2
0.3
0.4
0.5
0.6
C
ηint = 56

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$$\Rightarrow M = \text{antilog} \frac{\log(\eta_{int}) - \log(k)}{\alpha} = \text{antilog}\left(\frac{\log \eta_{int} - \log k}{\alpha}\right)$$

$$\Rightarrow M = \text{antilog}\left(\frac{\log(56) - \log(45.3\times10^{-3})}{0.64}\right)$$

$$\Rightarrow M = \text{antilog}\left[\frac{1.748 + 1.343}{0.64}\right] = \text{antilog}\left(\frac{3.091}{0.64}\right)$$

$$\Rightarrow M = \text{antilog}(4.829)$$

$$\Rightarrow M = 67452.802 \ g\,mol^{-1}$$

* RESULT :

→ Volume of Polymer liquid to be used for each measurement is 12.5 ml.

→ Molecular weight of given polymer is 67452.802 $g\,mol^{-1}$.

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