TABLE ⟹

	Concentrate of the polymer solution	Time of Flow (average)	Relative viscosity $\frac{\eta}{\eta_0} = \frac{t}{t_0}$	Specific viscosity $\eta_{sp} = \frac{\eta}{\eta_0 - 1}$	Reduced viscosity $\eta_{red} = \frac{\eta_{sp} \times 100}{C}$
	%	sec			
1)	Pure solvent	$t_0 = 55$			
2)	0.1% 0.1	$t_0 = 58$	1.055	0.055	55
3)	0.2	$t_0 = 62$	1.127	0.127	64
4)	0.3	$t_0 = 67$	1.218	0.218	73
5)	0.4	$t_0 = 72$	1.309	0.309	77
6)	0.5	$t_0 = 79$	1.440	0.440	88

CALCULATION ⟹

$$\eta_i = K(M)^{\alpha}$$

$$\therefore \log \eta_i = \log K + \alpha \cdot \log M$$

$$\text{so, } \alpha \cdot \log M = \log \eta_i - \log K$$

$$\therefore \log M = \frac{\log \eta_i - \log K}{\alpha}$$

$$\text{i.e. } M = \text{antilog}\left[\frac{(\log \eta_i - \log K)}{\alpha}\right]$$

as; $\eta_i = 51$, $K = 45.3 \times 10^{-3}$ and $\alpha = 0.64$

$$\therefore M = \text{antilog}\left[\frac{(\log 51 - \log 0.0453)}{0.64}\right]$$

$$= 58,603.$$

Date 03/06/2021

Expt. No. 6 Page No.

DETERMINATION OF MOLECULAR WEIGHT OF A POLYMER BY VISCOSITY AVERAGE METHOD.

INTRODUCTION ⟹

It is important to know that molecular weight of polymers since physical properties of macromolecular are mostly determined by their molecular weight.

There are number of methods available to calculate the molecular weight of a polymer such as:

1) Number average molecular weight.
2) Weight average molecular weight.
3) Z - average molecular weight.
4) Viscosity average molecular weight.
5) Distribution of molecular weight.

• VISCOSITY AVERAGE MOLECULAR WEIGHT (M_v):

Viscosity is due to the internal friction of molecules and increase in viscosity would decrease the flow of liquid. It would mostly depend on the nature and temperature of the liquid. There are various methods to measure the viscosity of polymer solution. The Ostwald method is convenient for the measurement of viscosity.

APPARATUS REQUIRED ⟹

Ostwald's viscometer, stopwatch, standard flasks, graduated pipette, suction bulb, etc.

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REAGENTS ⟹

1) Polymer - Polyvinyl Alcohol (PVA).
2) Water.

PRINCIPLE ⟹

Measurement of solution viscosity offers a simple and convenient method for molecular weight determination if polymer is soluble in a solvent.

In capillary viscometer (Ostwald / Ubbelhode), the viscosity of a liquid is proportional to the time taken by a known volume of liquid to flow through a capillary under a specified hydrostatic pressure at a fixed temperature.

The Staudinger - Mark - Houwink equation which relates η_i with molecular weight : $\eta_i = K(M)^{\alpha}$

where, 'M' is molecular weight of the polymer, 'η_i' is intrinsic viscosity, 'K' is an empirical parameter characteristic of a particular solute - solvent pair and 'α' is a shape parameter, which can vary from 0.5 for well coiled polymers in poor solvents to about 2 rigidly extended rod like polymers. For known values of 'K' and 'α', molecular weight can be determined.

For polyvinyl alcohol solution, $K = 45.3 \times 10^{-3}$ and $\alpha = 0.64$

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

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

- The values of η/η_0 is known as the relative viscosity 'η_{rel}'. In dilute solutions, which are often employed for molecular weight determination, 'ρ' is not much different from 'ρ_0' and hence:

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

- Specific viscosity η_{sp} is defined as:

$$\eta_{sp} = \frac{\eta - \eta_0}{\eta_0} = \frac{\eta}{\eta_0 - 1} = \eta_{rel} - 1$$

- Reduced viscosity η_{red} is equal to the ratio of the relative viscosity to concentration of the sample.

$$\eta_{red} = \frac{\eta_{sp}}{C}$$

PROCEDURE ⟹

1) Preparation of various concentrations of polymer in water (solvent). % of polymer solution in water will be supplied.
2) We need to prepare atleast 5 dilutions, (i.e. 0.1, 0.2, 0.3, 0.4 and 0.5%) polymer in water before carrying out the experiment.
3) Dilutions can be done by using volumetric expression: $V_1N_1 = V_2N_2$.

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Expt. No. _____ Page No. _____

RESULT ⟹

1) Volume of polymer solution used for each measurement = 12.5 ml.

2) The average molecular weight of the given polymer = 58,603 g/mol.

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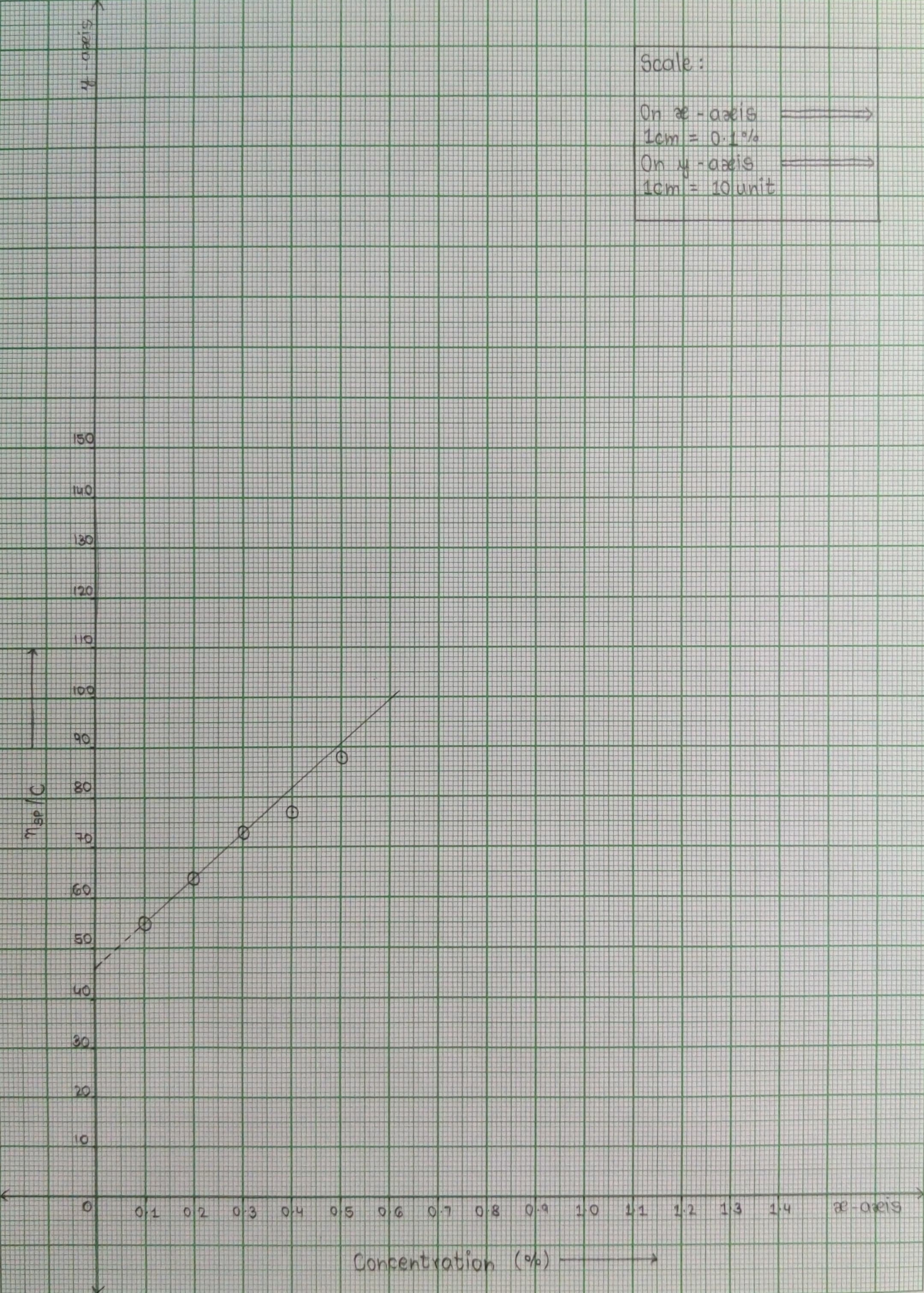
Scale:
On x-axis
1cm = 0.1%
On y-axis
1cm = 10 unit
y-axis
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
η_{sp}/C
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
x-axis
Concentration (%)