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Engineering polymers- viscosity and molecular weight analysis

Expt No. 08

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Principle:

When a polymer is mixed with a solvent, the solvent enters into the polymer matrix and swelling of polymer coils takes place. This expanded polymer coil disintegrates and moves out of polymer matrix and dissolves in the solvent. The apparent volume occupied by the expanded coil is referred to as the 'hydrodynamic volume' of the polymer molecule in the solution under flow. The viscosity of a polymer solution is a direct measure of hydrodynamic volume of the polymer, which in turn is a measure of its molecular weight. The viscosity of a polymer is more in a good solvent than in a poor solvent. In a particular solvent, molecular weight of the polymer is directly proportional to viscosity of the solution. Mark-Houwink equation relates the molecular weight and intrinsic viscosity of the polymer solution as follows

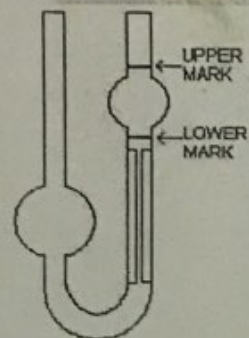
$$[\eta] = KM_v^\alpha$$

where K , α are constants (depends on the nature of polymer, solvent and temp.)

$[\eta]$ = intrinsic viscosity or the limiting viscosity number of the polymer solution

Reagents: PEG (polyethylene glycol), Distilled water

Apparatus: Ostwald viscometer, stop-clock, 50 mL standard flasks



Procedure:

Preparation of various concentrations of PEG in water

Normally, 10 g/100 mL (10%) PEG in water will be supplied.

Prepare at least four different dilutions (for instance, ranging 4 - 9% solutions) from the provided standard polymer solution.

Rinse the Ostwald viscometer with a little amount of water. Fill it with 20 mL pure water and keep it in a constant temperature thermostat maintained at 30 °C for 10 to

15 minutes so that solvent attains the temperature of water bath (30 °C). By keeping the upper mark of the small reservoir of viscometer parallel to eyes, allow the solvent to flow down to the lower mark and note down time in seconds. This is known as the E_{flux} time. Repeat the same experiment for 3 times to get the average E_{flux} time for water(t_0). Apply the same procedure to determine the flow rate for various diluted solutions of PEG in water and note down their flow time in seconds.

Plot the graph between concentrations (C g/mL) vs η_{sp}/C . The value of intercept at C = 0 will give intrinsic viscosity of the polymer solution (see Figure 1).

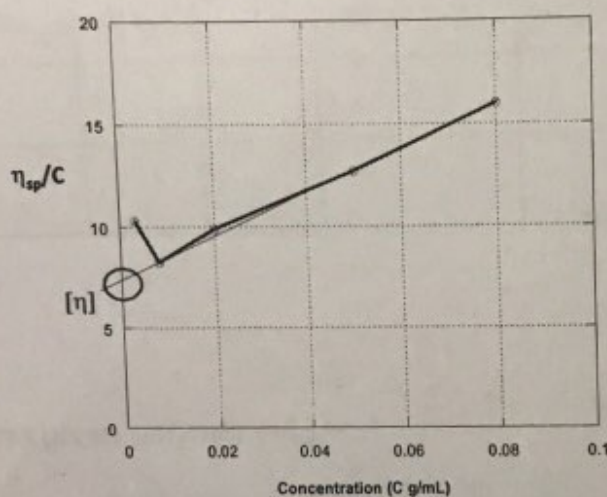


Figure 1. Concentration (C g/mL) Vs η_{sp}/C

Calculations:

$$[\eta] = KM_v^a$$

∴ Molecular weight of the given polymer (M_v) =

$$M = \text{Anti ln} \frac{\ln [\eta] - \ln K}{a}$$

Constants for PEG in water $K = 0.0428$

$$a = 0.64$$

E_{flux} time for pure water (t_0) = 77 sec.

S. No.	Concentration, C (g/mL)	E_{flux} time, t (sec)				$\eta_r = t_s/t_0$	$\eta_{sp} = \eta_r - 1$	η_{sp}/c
		t_1	t_2	t_3	$t_s = \frac{t_1 + t_2 + t_3}{3}$			
1	0.01	93	93.7		93.35	1.212	0.212	21.20
2	0.03	133	133.9		133.45	1.733	0.733	24.43
3.	0.05	177.10	177.32		177.21	2.302	1.302	26.04
4								
5								

Result:

Molecular weight of the given polymer (M_v) =

5825.499

$$M = \text{antilog} \left[\frac{\ln[\eta] - \ln[K]}{a} \right]$$

$$M = \text{antilog} \left[\frac{\ln[20] - \ln[0.0428]}{0.64} \right]$$

$$M = \text{antilog} \left[\frac{2.301 - (-3.368)}{0.64} \right]$$

$$M = \text{antilog} [8.67]$$

$$M = 5825.499341 \text{ g}$$

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Scale

Along x-axis: $1 \text{ cm} = 0.05 \text{ unit}$
 Along y-axis: $1 \text{ cm} = 2 \text{ unit}$

