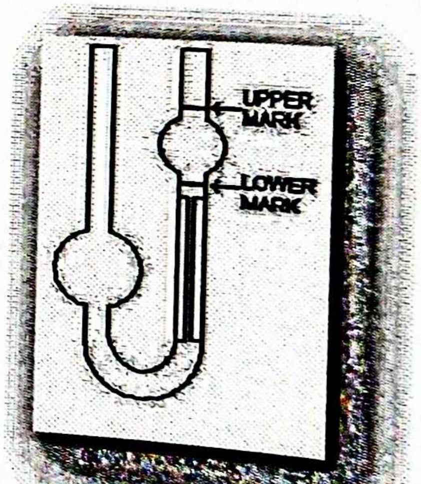
Expt. No.: 6

Date: 4.02.2020

Experiment	**Polymer Characterization: Determination of Viscosity of Different Natural Polymer/Synthetic Polymers**
Problem definition	Viscosity is the measure of resistance of a fluid to flow. Longer the polymer chains, the more entanglements between the chains and therefore the higher the viscosity. Molecular weight of polymer (M) can be derived from intrinsic viscosity data of a polymer solution.
Methodology	Determination of intrinsic viscosity using Ostwald viscometer. In a particular solvent, concentration of the polymer is directly proportional to viscosity of the solution.
Solution	Determination of intrinsic viscosity and molecular weight of the given polymer sample.
Student learning outcomes	Students will learn to determine intrinsic viscosity and molecular weight of the given polymer solution.

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. 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. Viscosity of a polymer is more in a good solvent than in a poor solvent.



Reagents: PEG (polyethylene glycol) solution of different concentrations, Distilled water.

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

Procedure:

Prepare at least 3 different diluted concentrations of PEG (1 to 5%) in water using 10% PEG stock solution (10 g/100 mL). Initially, rinse the Ostwald viscometer with a little amount of water. Fill it with 20 mL pure water and use a rubber filler to suck the water above the upper mark. 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 2 times to get the average E_{flux} time for water (t_0). Apply the same procedure to determine the flow rate for remaining 2 diluted solutions and note down their flow time in seconds. Calculate relative viscosity, specific viscosity and reduced viscosity as shown in **Table 1.** Plot the graph between polymer concentrations (C g/mL) *vs* η_{red}. The value of intercept at C = 0 will give intrinsic viscosity of the polymer solution (see **Fig. 1**).

t_o = 8.7 secs

Table 1: Viscosity measurement data

S. No.	Concentration, C (g/mL)	E_{flux} time, t (sec)			$\eta_r = t_s/t_o$	$\eta_{sp} = \eta_r - 1$	$\eta_{red} = \eta_{sp}/c$
		t_1	t_2	$t_s = t_1 + t_2/2$			
1	0.01	98	99	98.5	1.132	0.132	13.20
2	0.03	123	122	122.5	1.408	0.408	13.60
3	0.05	161	160	160.5	1.844	0.844	16.88

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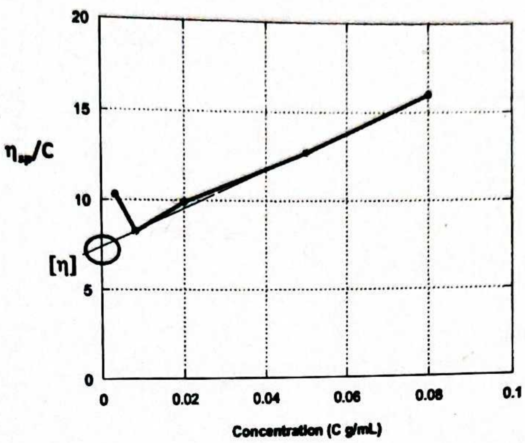

Fig. 1. Concentration (C g/mL) Vs η_{sp}/C

Calculations:

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

$\therefore$ 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 and a = 0.64

ln [9.1] = 2.208

ln [0.0428] = −3.151

a = 0.64

$M = \text{antilog}\left(\frac{2.208 + 3.151}{0.64}\right)$

= antilog (8.37)

= 4315.63

Result:

(a) E_{flux} time for pure water (t_0) = 87 sec.

(b) Intrinsic viscosity of the polymer (η) = 9.1

(c) Molecular weight of the given polymer (M_v) = 4315.63

Evaluation of Result:

Sample number	Skill value M_v	Calculated M_v	Error %	Marks awarded
				9/10.

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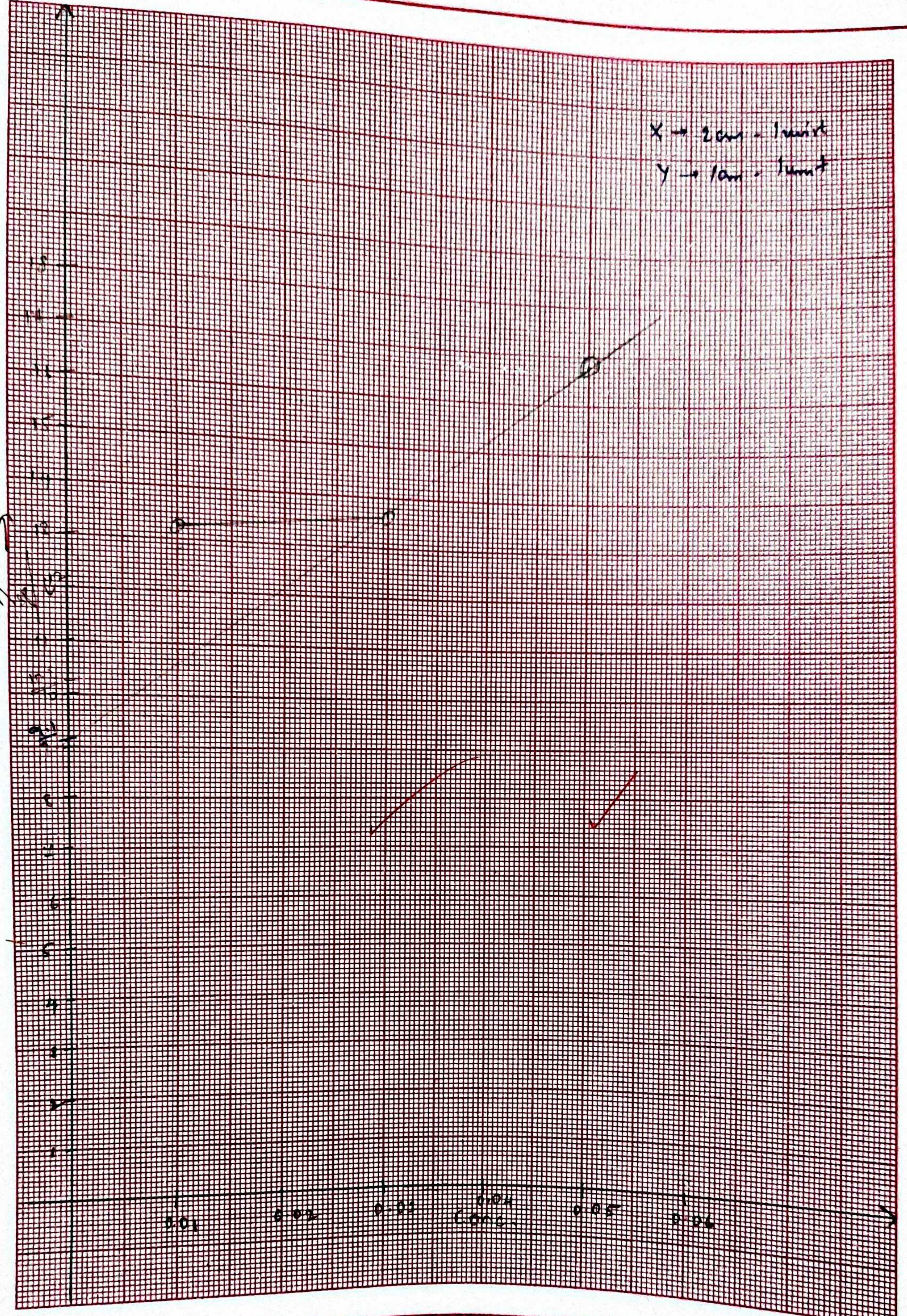

X → 2cm - 1unit
Y → 1cm - 1unit
0.01
0.02
0.03
0.04
Conc.
0.05
0.06