Determination of Polymer Molecular Mass Using the Viscometry Method

VIRTUAL LAB 2(a) – UNIT 2

Determination of the molecular mass of polymer from viscosity measurements using organic solvents

Background: Viscosity is a measure of a fluid's resistance to flow. For polymer solutions, the viscosity depends on the size and shape of the polymer molecules, as well as the interaction between the polymer and the solvent. By measuring the viscosity of a polymer solution, we can infer the molecular mass of the polymer, because larger polymer molecules (i.e., those with higher molecular mass) contribute more to the solution’s viscosity.

The greater the molecular mass of the polymer, the larger the individual polymer molecules, leading to higher viscosity. Polymers in solution do not behave like small, simple molecules. Instead, they form large, flexible, and extended chains. These chains can occupy significant volumes in the solvent, and as the polymer concentration increases, the solution viscosity increases in a nonlinear fashion due to interactions between the polymer chains.

Types of Viscosity in Polymer Solutions

- **Relative Viscosity (η_r)**: This is the ratio of the viscosity of the polymer solution (η) to that of the pure solvent (η_0).

$$\boldsymbol{\eta_r} = \frac{\eta}{\eta_0} \quad \text{or} \quad \boldsymbol{\eta_r} = \frac{\boldsymbol{t_s}}{\boldsymbol{t_o}}$$

Where ts = Time flow for polymer solution

t_0 = Time flow for pure organic solvent

- **Specific viscosity(η_{sp})** : The specific viscosity η_{sp} of the solution at a different concentration(C) is

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

- **Intrinsic Viscosity[η] :** The viscosity of the solution at infinite dilution (i.e., when the concentration approaches zero)

$$[\boldsymbol{\eta}] = \lim_{n \to \infty} \frac{\eta_{sp}}{C}$$

- The molecular mass of a polymer can be determined from its intrinsic viscosity using the Mark-Houwink equation and is given by

$$[\eta] = K\, M_v^a$$

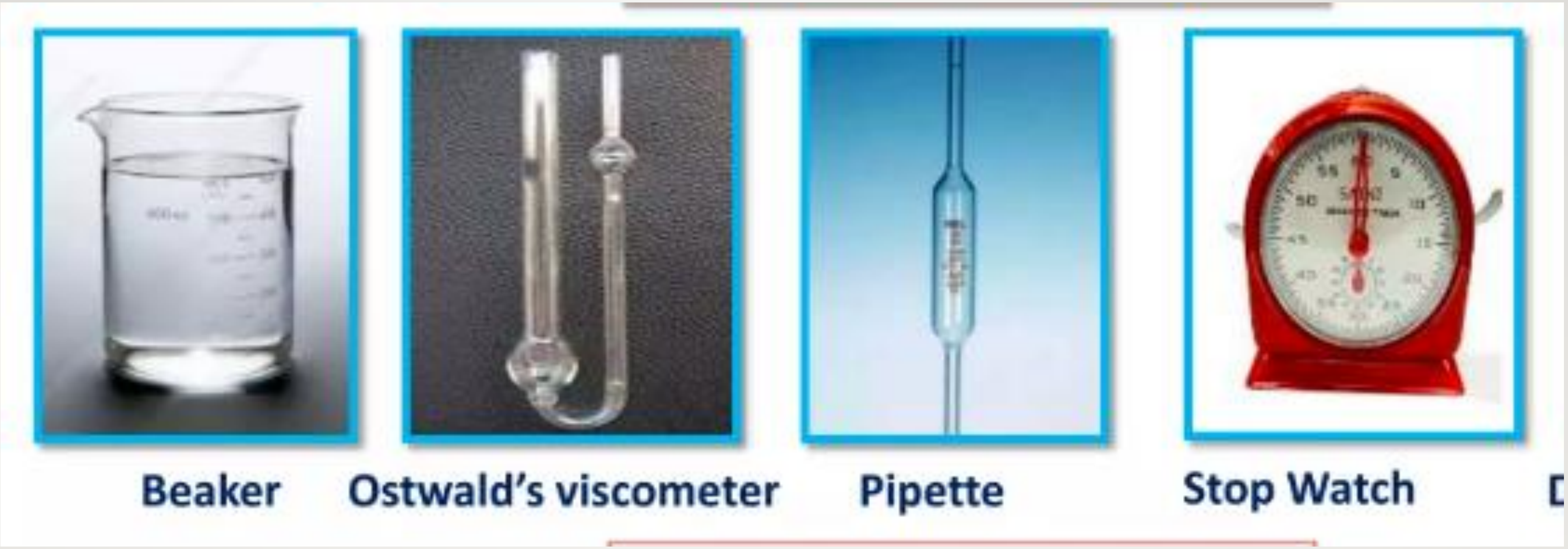
Where,

$[\eta]$ is the intrinsic viscosity, a measure of the polymer's contribution to the solution's viscosity.

M_v is the weight-average molecular mass of the polymer.

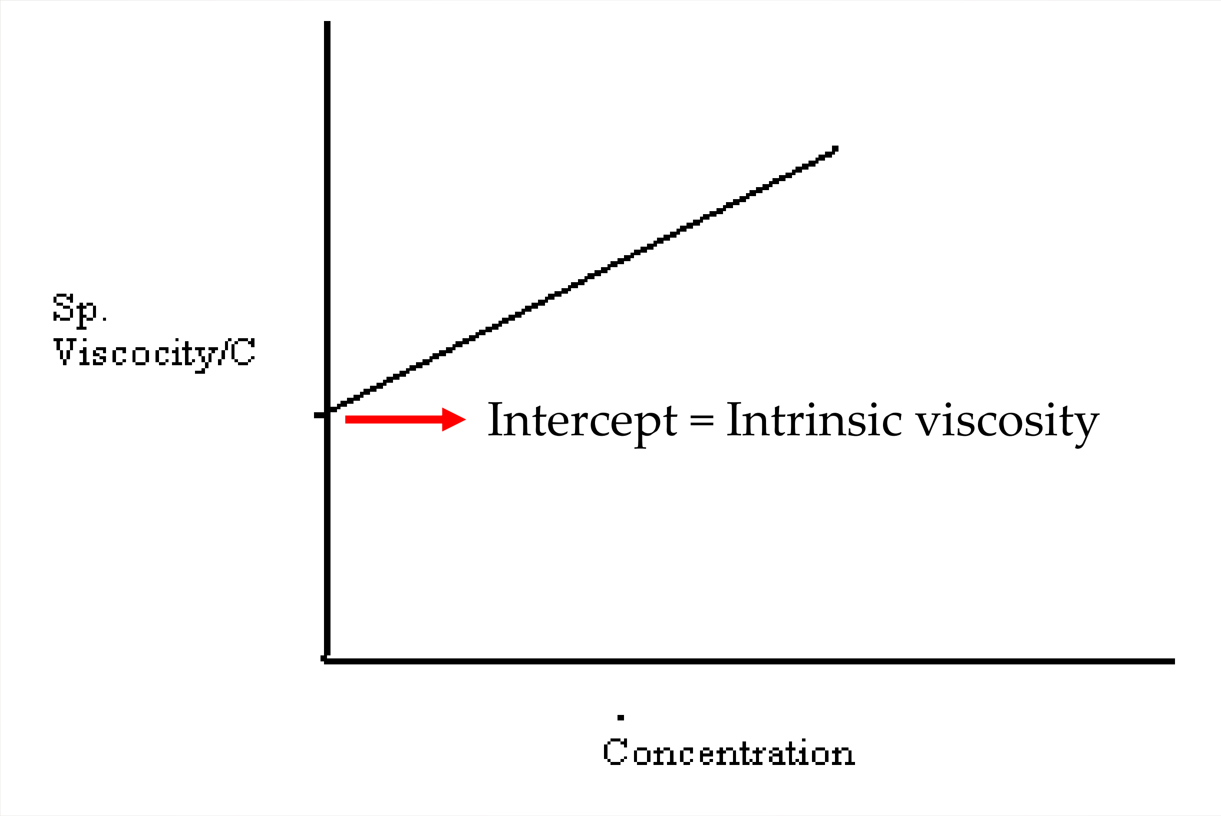
K and a are constants specific to the polymer-solvent system and temperature.

Materials Required



Procedure: Weigh approximately 1 g of polymer into a beaker and add 50 mL of organic solvent. Stir the mixture and allow it to stand until the polymer is completely dissolved. Transfer the solution to a 50 mL volumetric flask and top it up to the mark with organic solvent. Pipette 15 mL of pure solvent into a viscometer and measure the flow time. Prepare a series of dilutions from the stock polymer solution and measure the flow time of each. Use the data to determine the Intrinsic viscosity and calculate the molecular mass of Polymer.

Note: The viscosity of the polymer solution and pure solvent depends on the time flow of the liquid.


Sp.
Viscocity/C
Intercept = Intrinsic viscosity
Concentration

Viscometry

Aim of the experiment:
To determine the coefficient of viscosity of a given organic liquid using Ostwald viscometer