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**The Parallel between Boiling Point Elevation and Limit of Superheat for
Polymer Solutions****John H Jennings**

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DOI: <https://doi.org/10.62225/2583049X.2024.4.2.2612>Corresponding Author: **John H Jennings****Abstract**

The derivation for boiling point elevation (BPE) for polymer solutions goes back to mathematics of the Clausius-Clapeyron equation combined with Raoult's Law or the Gibbs-Helmholtz equation combined with Raoult's Law. BPE can be used to measure polymer molecular weight and is effective when the concentration of polymer approaches zero. The limit of superheat for polymer solutions formula

(LSPS) was derived by (Jennings, 2012) ^[1], a complicated derivation involving the surface tension in particular. (Jennings and Middleman, 1985) ^[2] Published data that agrees with Jennings' formula. BPE and LSPS have various uses that will be discussed as will the parallel between the two equations.

Keywords: Limit of Superheat, Boiling Point Elevation, Polymer Solutions, Molecular Weight Polymer, Surface Tension**Introduction**

BPE is used as an important property of numerous industrial solutions (Ge and Wang, 2009) ^[3] and has implications in cooking with salt and molar mass boiling point, and identification of solids (Halford, 1931) ^[4]. One drawback of BPE is that the temperature rise is of the order of millidegrees and a special thermometer has to be used. The one who successfully collected data on limit of superheat rise with addition of polymer and derivation of the formula (Jennings and Middleman, 1985; Jennings 2012, 2014, 2020a) ^[2, 1, 5, 6] proved that LSPS is better for estimating molecular weight as the temperature rise is of the order of 10 – 15 degrees Centigrade for molecular weight 500 – 5000 daltons (Jennings, 2024) ^[7]. When the molecular weight is more than 10,000, the formula predicts a near zero rise in temperature.

Results

For BPE, one uses 1) the Gibbs-Helmholtz equation or 2) Clausius-Clapeyron relation with Raoult's Law. Here I'll show the second as (1). Raoult's Law is (2). P is vapor pressure of the solution and P_o is vapor pressure of pure solvent. x₂ is mole fraction of solute.

$$d \ln P / d (1/T) = - \Delta H_{\text{vap}} / R \quad (1)$$

$$P = P_o (1 - x_2) \quad (2)$$

(Bovey and Winslow, 1979) ^[8] say these combine to get.

$$\lim_{c \rightarrow 0} \Delta T_b / c = R T^2 / \rho \Delta H_v M \quad (3)$$

For LSPS, (Jennings 2020b) ^[9], has.

$$\lim_{c \rightarrow 0} (dT/dc)_s, \text{ polymer} = (3 k T_s^2 MW1) / (\rho_1 \sigma_1 a MW2(p)) \quad (4)$$

M is identified with MW2(p) and T and T_s are the limit of superheat of the solvent. c is the concentration of polymer and ρ and ρ₁ is the density of the solvent. ΔH_v and ΔH_{vap} are the latent heat of vaporization of the solvent. ΔT_b is the boiling point

elevation. $R = N_0 k$ is the universal gas constant. a is surface area of the solvent molecule and T . k is Boltzmann constant and N_0 is Avogadro's number.

Eqs. (3) and (4) are in parallel by inspection. It is interesting that these two formulae for phase change correspond in this way especially that the absolute temperature T is squared in each and the molecular weight of polymer is in the denominator.

Discussion

There are different ways to measure the molecular weight of a polymer. It has been shown that Einstein's viscosity law (Grubisic, *et al.*, 1967) ^[10] can be used effectively in characterizing high molecular weight polymer, but (Jennings, 2024) ^[7] showed that his (Jennings, 2012) ^[11] equation can be employed for polymer molecular weight between 500 and 5000 daltons. Water (H₂O) is 18 daltons. (Bovey and Winslow, 1979) ^[8] say that with modern instrumentation a temperature difference of 10^{-3} °C can be measured with precision for BPE.

Conclusion

The Virgin Mary is the one people turn to for help. Never was it known that anyone who prayed to her was left unaided. Even though the Mideast is in turmoil, we have to trust in the Virgin's prayers.

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