

Excess Thermodynamic Properties of 1, 5-Pentanediol and Dimethyl Sulfoxide Binary Mixture At 313.15 K And 318.15 K

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Abstract

Abstract: Experimental measurements of density and viscosity of binary liquid mixture with 1, 5-Pentanediol and Dimethylsulfoxide as its components were made at T= (313.15 and 318.15) K and at atmospheric pressure for samples of different compositions. Excess thermodynamic properties namely excess molar volume (VE), viscosity deviation ($\Delta\eta$) and excess Gibbs energy of activation (GE) were computed from the experimental data. These properties were then fitted to Redlich-Kister equation for calculating coefficients and standard deviations. Variation of these properties with composition and temperature has been analyzed for the possible intermolecular interactions in the binary mixture.

Keywords: Pentanediol, Dimethylsulfoxide, excess molar volume, excess Gibbs energy of activation.

I. Introduction

The information on thermodynamic properties of fluid blends is significant in all concoction building applications, especially in the structure of different detachment types of gear. Past investigations [1-4] present the abundance properties with fluctuating creations and temperatures for (DMSO+ alkanediol) twofold blends. Broad writing study proposed that no investigation have been made at this point for volumetric, viscometric and abundance thermodynamic properties of 1,5-Pentanediol and Dimethylsulfoxide double fluid blend, in this manner this paper introduces the thickness, consistency and overabundance thermodynamic properties of 1,5-Pentanediol and Dimethyl sulfoxide (DMSO) parallel fluid blend at 313.15 K and 318.15 K.

The mixes of the parallel blend are of noteworthy mechanical significance. DMSO is an economical non-poisonous dissolvable utilized in

Nourishment, paint, medication, synthetic and petrochemical industry. 1,5-Pentanediol has tremendous application in car, flying, surface covering, pharmaceutical, oil and polymer industry.

II. RESEARCH METHODOLOGY

2.1 Chemicals utilized

1,5-Pentanediol and Dimethyl sulfoxide were AR grade synthetic concoctions acquired from Spectrochem Pvt. Ltd., Mumbai (India). The synthetic concoctions were purged by standard strategies. Table 1 shows the correlation of the deliberate thickness of the unadulterated mixes with the announced writing esteems.

2.2 Apparatus utilized

The twofold blend tests containing 1,5-Pentanediol and Dimethyl sulfoxide were readied (by mass) utilizing HR-250AZ Analytical parity (A&D Company Limited). It could quantify mass with an exactness of ± 0.0001 g.

An advanced vibrating-tube densimeter (Anton Paar DSA 5000) with an exactness of ± 0.02 K in

temperature was utilized to gauge the thickness for the unadulterated mixes and their twofold blends.

Thickness was estimated utilizing Modified Ubbelohde viscometer, the working of which has been examined before by Gill et. al. [5]. Refined benzene and cyclohexane were utilized for its adjustment.

III. CORRELATIONS USED

The excess molar volume (V^E) values of binary mixture were calculated using:

$$V^E = \frac{x_1 M_1 + x_2 M_2}{\rho_m} - \left(x_1 \frac{M_1}{\rho_1} + x_2 \frac{M_2}{\rho_2} \right) \quad (1)$$

where,

x , ρ and M are the mole fraction, density and molecular mass respectively; subscript 1 is used all over in the article for 1,5-Pentanediol, 2 for DMSO and m for the mixture sample.

Deviation in viscosity was calculated using:

$$\Delta\eta = \eta_m - (x_1 \eta_1 + x_2 \eta_2) \quad (2)$$

where,

$\Delta\eta$ is deviation in viscosity, η_m , η_1 and η_2 are viscosities of the mixture, 1,5-Pentanediol and DMSO respectively.

The excess Gibbs free energy of activation of flow was calculated using the equation:

$$\frac{G^E}{RT} = \ln(\eta V_m) - \sum_{i=1}^2 x_i \ln(\eta_i V_i) \quad (3)$$

where,

G^E is excess Gibbs energy of activation, R is universal gas constant, T is temperature in Kelvin and V_m is the molar volume of the mixture. V_1 and V_2 are the molar volumes of 1,5-Pentanediol and DMSO respectively.

The experimentally measured values of density and viscosity for the binary mixture of 1,5-Pentanediol (1) and Dimethylsulfoxide (2) at 313.15 K and 318.15 K are presented in Table II. Table III displays the calculated values of excess thermodynamic properties i.e. Excess molar

volume, deviation in Viscosity and excess Gibbs energy of activation for the binary mixture of 1,5-Pentanediol (1) and Dimethylsulfoxide (2) at 313.15 K and 318.15 K respectively. The excess molar volume (V^E), excess Gibbs energy of activation (G^E) and deviation in viscosity ($\Delta\eta$) were fitted to Redlich-Kister type equation:

$$A = x_1 x_2 \sum_{j=1}^n A_{j-1} (x_1 - x_2)^{j-1} \quad (4)$$

where,

n represents the polynomial degree, A is the property under consideration and A_{j-1} is the polynomial coefficient.

Well-known mathematical formula was used to calculate the standard deviation for the three excess properties at 313.15 K and 318.15 K.

$$\sigma(X) = \left[\frac{\sum (X_{\text{exp}} - X_{\text{cal}})^2}{N - n} \right]^{1/2} \quad (5)$$

where,

X is the property getting looked at; n is the quantity of coefficients; N are the quantity of information focuses. 'exp' and 'cal' terms in subscript signifies the trial and determined qualities individually. Table IV shows the coefficients (A_0, A_1, A_2, A_3) of the Redlich-Kister Equation and Standard Deviation (σ) for overabundance properties contemplated for example Overabundance molar volume, deviation in Viscosity and abundance Gibbs vitality of actuation for the paired blend of 1,5-Pentanediol (1) and Dimethyl sulfoxide (2) at 313.15 K and 318.15 K.

Table I

Experimental values of density and literature values of density for the pure compounds at 313.15 and 318.15 K.

| Component | T (K) | ρ (g.cm ⁻³) | |
|-----------------|--------|------------------------------|------------|
| | | Exp. | Lit. |
| 1,5-Pentanediol | 313.15 | 0.9774 | 0.9773 [6] |
| | 318.15 | 0.9748 | 0.9744 [6] |

| | | | |
|-------------------|--------|--------|----------------------------|
| Dimethylsulfoxide | 313.15 | 1.0804 | 1.08043 [7] 1.08077 [8] |
| | 318.15 | 1.0759 | 1.0751 [9] |

Table II

Experimental values of density and viscosity for 1,5-Pentanediol (1) and Dimethylsulfoxide (2) binary mixture at 313.15 K and 318.15 K.

| x_1 | ρ (g.cm ⁻³) | | η (cP) | |
|--------|------------------------------|----------|-------------|----------|
| | 313.15 K | 318.15 K | 313.15 K | 318.15 K |
| 0.0000 | 1.0804 | 1.0759 | 1.490 | 1.380 |
| 0.0492 | 1.0726 | 1.0682 | 1.743 | 1.601 |
| 0.0734 | 1.0689 | 1.0646 | 1.878 | 1.711 |
| 0.1575 | 1.0572 | 1.053 | 2.421 | 2.200 |
| 0.2139 | 1.0499 | 1.0459 | 2.832 | 2.583 |
| 0.2756 | 1.0424 | 1.0385 | 3.324 | 3.032 |
| 0.3340 | 1.0357 | 1.0319 | 3.898 | 3.550 |

| | | | | |
|--------|--------|--------|--------|--------|
| 0.3876 | 1.0298 | 1.0262 | 4.495 | 4.101 |
| 0.4157 | 1.0269 | 1.0233 | 4.934 | 4.413 |
| 0.4913 | 1.0192 | 1.0157 | 6.201 | 5.542 |
| 0.5346 | 1.015 | 1.0117 | 7.219 | 6.421 |
| 0.5825 | 1.0105 | 1.0073 | 8.602 | 7.576 |
| 0.6234 | 1.0068 | 1.0036 | 10.000 | 8.800 |
| 0.6812 | 1.0018 | 0.9987 | 12.800 | 10.959 |
| 0.7452 | 0.9965 | 0.9935 | 16.552 | 13.867 |
| 0.7713 | 0.9944 | 0.9914 | 18.301 | 15.251 |
| 0.8014 | 0.992 | 0.9891 | 20.693 | 17.152 |
| 0.8693 | 0.9868 | 0.984 | 27.011 | 21.856 |
| 0.9111 | 0.9837 | 0.9809 | 31.471 | 25.247 |
| 0.9753 | 0.9791 | 0.9764 | 39.649 | 31.345 |
| 1.0000 | 0.9774 | 0.9748 | 43.200 | 34.100 |

Table III Excess molar volume, deviation in Viscosity and excess Gibbs energy of activation for the binary mixture of 1,5-Pentanediol (1) and Dimethylsulfoxide (2) at 313.15 K and 318.15 K.

| x_1 | V^E (cm ³ .mol ⁻¹) | | $\Delta\eta$ (cP) | | G^E (kJ.mol ⁻¹) | |
|--------|---|----------|-------------------|----------|-------------------------------|----------|
| | 313.15 K | 318.15 K | 313.15 K | 318.15 K | 313.15 K | 318.15 K |
| 0.0000 | 0.0000 | 0.0000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 0.0492 | 0.0347 | 0.0381 | -1.799 | -1.389 | -0.011 | -0.012 |
| 0.0734 | 0.0514 | 0.0527 | -2.674 | -2.070 | -0.024 | -0.037 |
| 0.1575 | 0.0702 | 0.0809 | -5.639 | -4.333 | -0.087 | -0.071 |
| 0.2139 | 0.0775 | 0.0838 | -7.579 | -5.795 | -0.165 | -0.118 |
| 0.2756 | 0.0785 | 0.0884 | -9.661 | -7.366 | -0.283 | -0.212 |
| 0.3340 | 0.0753 | 0.0876 | -11.524 | -8.758 | -0.377 | -0.286 |
| 0.3876 | 0.0745 | 0.0796 | -13.161 | -9.962 | -0.473 | -0.357 |

| | | | | | | |
|--------|--------|--------|---------|---------|--------|--------|
| 0.4157 | 0.0662 | 0.0760 | -13.895 | -10.568 | -0.477 | -0.401 |
| 0.4913 | 0.0619 | 0.0758 | -15.781 | -11.914 | -0.544 | -0.439 |
| 0.5346 | 0.0583 | 0.0614 | -16.569 | -12.451 | -0.529 | -0.418 |
| 0.5825 | 0.0553 | 0.0568 | -17.184 | -12.863 | -0.494 | -0.389 |
| 0.6234 | 0.0511 | 0.0588 | -17.492 | -12.977 | -0.463 | -0.342 |
| 0.6812 | 0.0409 | 0.0479 | -17.102 | -12.710 | -0.331 | -0.256 |
| 0.7452 | 0.0294 | 0.0360 | -16.020 | -11.896 | -0.228 | -0.182 |
| 0.7713 | 0.0253 | 0.0357 | -15.360 | -11.366 | -0.199 | -0.155 |
| 0.8014 | 0.0230 | 0.0277 | -14.223 | -10.450 | -0.146 | -0.103 |
| 0.8693 | 0.0141 | 0.0181 | -10.738 | -7.968 | -0.056 | -0.047 |
| 0.9111 | 0.0102 | 0.0199 | -8.021 | -5.944 | -0.031 | -0.026 |
| 0.9753 | 0.0044 | 0.0120 | -2.521 | -1.947 | -0.003 | -0.009 |
| 1.0000 | 0.0000 | 0.0000 | 0.000 | 0.000 | 0.000 | 0.000 |

Table IV Coefficients (A_0 , A_1 , A_2 and A_3) of the Redlich-Kister Equation and Standard Deviations (σ) for excess molar volume, deviation in Viscosity and excess Gibbs energy of activation for the binary mixture of 1,5-Pentanediol (1) and Dimethylsulfoxide (2) at 313.15 K and 318.15 K

| Excess property | T/K | A_0 | A_1 | A_2 | A_3 | σ |
|--|--------|---------|---------|--------|--------|----------|
| V^E ($\text{cm}^3 \cdot \text{mol}^{-1}$) | 313.15 | 0.242 | -0.210 | 0.226 | -0.186 | 0.0025 |
| | 318.15 | 0.267 | -0.270 | 0.310 | -0.035 | 0.0042 |
| $\Delta\eta$ (cP) | 313.15 | -63.883 | -39.435 | -7.988 | 5.358 | 0.0441 |
| | 318.15 | -47.961 | -27.455 | -6.014 | 1.966 | 0.0452 |
| G^E ($\text{kJ} \cdot \text{mol}^{-1}$) | 313.15 | -2.035 | 0.044 | 2.687 | 0.004 | 0.0229 |
| | 318.15 | -1.578 | 0.030 | 2.014 | 0.050 | 0.0248 |

IV. RESULTS AND DISCUSSION

4.1 Excess Molar Volume: Figure 1 shows that the excess molar extent, V^E values are wonderful for the binary mixtures for all taken into consideration samples at both temperatures. Positive V^E values indicate that there's growth in extent on mixing.

The extra molar quantity increases with boom in temperature, for all of the samples protecting the whole composition range.

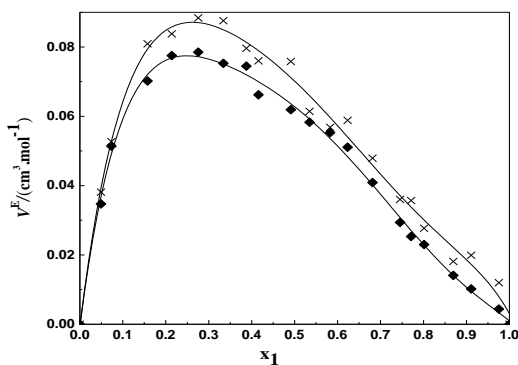


Fig. 1: Excess Molar Volume (V^E) vs. mole fraction of 1,5-Pentanediol(x_1) at 313.15 K (■) and 318.15 K (×).

4.2 Deviation in viscosity: It was observed that deviation in viscosity, $\Delta\eta$ values are negative for the binary mixture at 313.15 K and 318.15 K for samples of all compositions. There is increase in $\Delta\eta$ as temperature increases from 313.15 K to 318.15 K (Fig. 2).

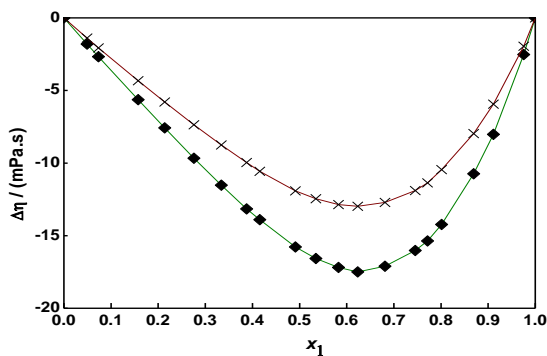


Fig. 2: Deviation in Viscosity ($\Delta\eta$) vs. mole fraction of 1,5-Pentanediol (x_1) at 313.15 K (■) and 318.15 K (×).

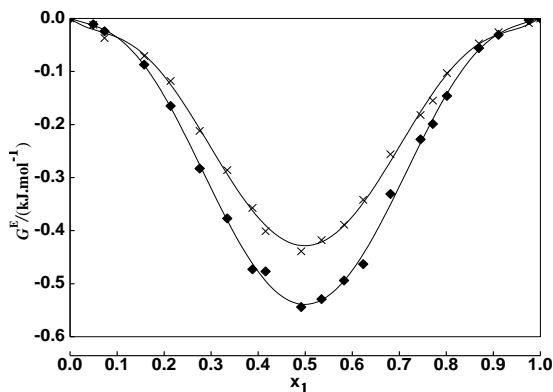


Fig. 3: Excess Gibbs Energy of Activation (G^E) vs. mole fraction of 1,5-Pentanediol(x_1) at 313.15 K (■) and 318.15 K (×).

4.3 Excess Gibbs Energy of Activation: Fig. 3 Proposes that abundance Gibbs strength of actuation, GE esteems are negative over the entire introduction run for the double aggregate at 313.15 k and 318.15 ok. It increments with increment in temperature for tests all topics considered.

V. CONCLUSION

Thickness and consistency data for 1,5-Pentanediol and Dimethylsulfoxide (DMSO) fluid combination at 313.15 okay and 318.15 ok have been accounted for. Tremendous VE, terrible $\Delta\eta$ and GE esteems showcase that powerless establishments show up amongst 1, five-Pentanediol and DMSO atoms.

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