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Ultrasound Velocity, Density And Excess Parameters Of Dimethyl Sulphoxide In Alcohols

1. DR. Shiv Nandan 2. Sarita Sharma

1. Associate Professor, 2 Research Scholar, Department of Chemistry, N.D. College, Shikohabad, Firozabad (U.P.), India

Received- 04.11.2018, Revised- 06.11.2018, Accepted- 13.11.2018 E-mail:aaryvart2013@gmail.com

Abstract: Ultrasound velocity, density and viscosity in binary liquid mixtures of dimethyl sulphoxide in ethanol, Iso-propanol and butanol have been determined at 303°K over the entire composition range. From the measured parameters, isentropic compressibility. Intermolecular free length available volume and their excess values have been computed. The excess isentropic binary mixtures exhibit negative deviations while excess viscosity and available volume exhibit position deviations from ideal behaviour over the entire mole fraction.

Key Words: Ultrasound velocity, density, viscosity liquid mixtures, isentropic, binary mixtures, negative.

Ultrasound propagation parameters yield valuable information regarding the bahaviour of liquid binary systems because intermolecular and intermolecular association dipolar effect the compressibility of the system which in turn produces corresponding our of aqueous solution the results to hydrogen bonded complex formation. Rajendran [2] observed Ultrasound velocity, density and viscosity in the binary liquid mixtures of n-heptane with n - propanol, isopropanol, n - butanol and isobutanol over the entire range of mole fractions at a constant temperature of 298.15^0K. Jajoo et al. [3] have attempted a quantitative study of the ultrasound velocity in some binary mixtures on the basis of collision factor theory and free length theory.

The present investigation deals with study of the excess isentropic compressibility (β_s), excess available volume (V_a), excess intermolecular free length (L_f) and excess viscosity (η^E) for the binary mixtures of dimethyl sulphoxide $(DMSO)^+$ butanol, dimethyl sulphoxide $(DMSO)^+$ typical binary mixtures with a wide scope for complexation through hydrogen bonding.

EXPERIMENTAL DETAILS:

All the liquids used in the present study have been distilled to remove impurities following standard procedures. The purity of each sample was checked by comparing the measured densities of components with those reported in the literature [4]. Ultrasound velocities were measured using single crystal ultrasound interferometer of 2MHz frequency and the data were accurate upto 0.2%. Densities of the mixtures have been determined by using specific gravity bottle and electrical balance. The viscosities have been determined by using Ostwald viscometer. The temperature was maintained by circulating water around liquid cell form a thermostat controlled at 303°K.

The value of β_s were calculated using the relation :

$$\beta_s = p^{-1}, V^{-2}$$

Intermolecular free length (L_f) has been calculated using the formula :-

$$L_f = K(\beta_s)^{1/2}$$

where k is Jacobson's [5] constant. Available volume (V_a) and its excess values have been calculated by using the formula :

$$V_a = V_m\left(1 - \frac{V}{V_\infty}\right)$$

$$V_a^E = Va_{\exp} - \left(X_1 Va_1 + X_2 Va_2\right)$$

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where Va,Va_1, Va_2 are mean available volume of the mixture and pure components 1 and 2 respectively and X_1, X_2 are mole fraction of components 1 and 2. Excess viscosity has been calculated by using the relation

$$\eta^E = \eta_{exp} - \left(X_1\eta_1 + X_2\eta_2\right)$$

where η_1 and η_2 are the viscosity of pure liquids 1 and 2. Excess isentropic compressibility (β_s) was calculated using the relation

$$\beta_s = \beta_{exp} - \left(X_1\beta_{s1} + X_2\beta_{s2}\right)$$

where β_s, β_{s1}, β_{s2},are the isentropic compressibilities of binary mixture and the pure components 1 and 2.

Excess free length of the mixture has calculated using the equation

$$L_f^E = L_{f\,exp} - \left(X_1L_{f1} + X_2L_{f2}\right)$$

Where L_{f1} and L_{f2} are intermolecular free lengths of pure liquids 1 and 2.

RESULTS & DISCUSSION :

The values of Ultrasound velocity density, viscosity, available volume, isentropic compressibility, intermolecular free length, and their excess parameters β_s, L_f and η^E are represented in Table (1-3). The excess parameters V_a mole fraction curves are also ploted in Fig. (1-3).

Mole Fraction (X1) of Di Methyl Sulphoxide (D.M.S.O.), Density Ultrasound Velocity V, Viscosity η, Available Volume V_a Isentropic Compressibility β_s, Intermolecular free Length L_f and Excess Available Volume V_a^E for the Binary Mixtures at 303°K.

Table 1 : DMSO + Ethanol

X_1		V	η	V_a	β_s	L_f	V_a^E
0.0000	0.7826	1162	1.018	16.112	94.60	0.6137	0.0000
0.1415	0.8014	1208	1.043	15.469	85.50	0.5834	+1.0779
0.2919	0.8262	1254	1.070	14.506	76.90	0.5333	+1.3270
0.3778	0.8436	1281	1.085	13.794	72.20	0.5361	+1.4780
0.4519	0.8574	1306	1.098	12.978	68.30	0.5214	+1.4070
0.6226	0.9004	1356	1.127	11.182	60.40	0.4903	+1.3260
0.8049	0.9618	1419	1.153	8.452	51.60	0.4532	+0.4270
0.9023	1.0236	1439	1.165	7.371	47.10	0.4330	+0.3270
1.0000	1.0948	6.065	1.176	6.065	42.60	0.4118	0.0000

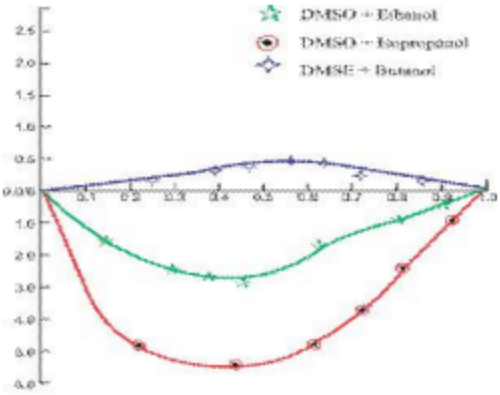

Fig.-1: Mole Fraction Vs excess isentropic compressibility.

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Table 2 : DMSO + Isopropanol

X_1		V	η	V_ϕ	β_s	L_f	V_ϕ^o
0.0000	0.7810	1116	1.428	23.277	102.80	0.6397	0.0000
0.2125	0.8092	1204	1.398	19.550	85.20	0.5854	-0.0730
0.4185	0.8450	1281	1.342	19.957	72.10	0.5357	-0.1200
0.5189	0.8688	1339	1.312	14.157	62.90	0.5004	-0.1710
0.6180	0.8986	1350	1.285	12.387	61.00	0.4928	-0.2530
0.7142	0.9370	1380	1.254	10.708	56.00	0.4721	-0.2750
0.8115	0.9730	1418	1.229	8.976	51.40	0.4523	-0.3270
0.9228	1.0250	1453	1.197	6.877	46.20	0.4288	-0.5150
1.0000	1.0948	1464	1.176	6.065	42.60	0.4118	0.0000

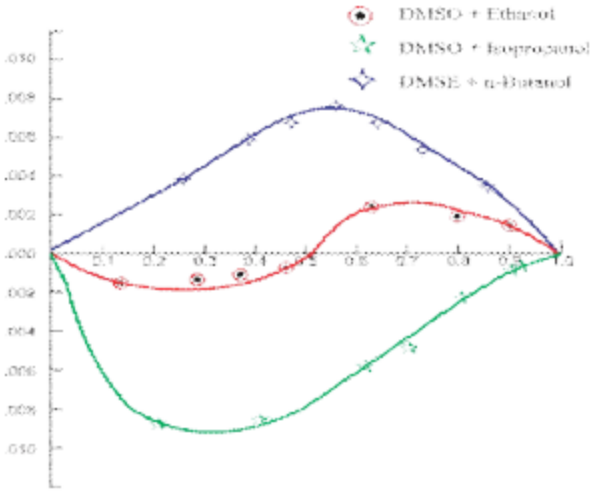

Fig.-2: Mole fraction Vs excess intramolecular free length.

Table 3 : DMSO + n – Butanol

X_1		V	η	V_ϕ	β_s	L_f	V_ϕ^o
0.0000	0.8028	1263	3.025	19.444	78.800	0.5572	0.0000
0.2540	0.8296	1334	2.617	19.695	78.800	0.5309	-0.0190
0.3927	0.8618	1342	2.256	14.162	64.406	0.5063	-0.0270
0.4736	0.8796	1358	2.105	13.072	61.600	0.4952	-0.0350
0.5640	0.9024	1376	1.943	11.849	58.500	0.4826	-0.0490
0.6358	0.9268	1389	1.816	10.921	55.900	0.4717	-0.0160
0.7212	0.9508	1412	1.665	9.516	52.700	0.4880	-0.0278
0.8662	1.0312	1430	1.410	7.855	47.400	0.4344	-1.1390
1.0000	1.0948	1464	1.176	6.065	42.200	0.4118	0.0000

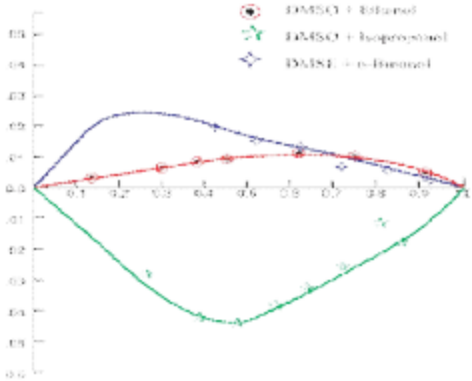

Fig.-3: Mole Fraction Vs excess viscosity.

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As it can be seen from the tables that ultrasound velocity increases with increasing mole fraction of dimethyl sulphoxide. The density also increases on increasing mole fraction of dimethyl sulphoxide. It is obivious that the moles of dimethyl sulphoxide are so dense that their density is more in comparable to alcohol.

The occurrence of peaks of curves of the excess values at mole fraction 0.5640 predicts the more interaction between sulphoxide and alcoholic group of the alcohols through complex formation [6-9] either by Hydrogen bond or by vander waal interaction forces. The existence of structurally different species in solution is also reflected in the physical and thermodynamic parameters as well.

The variation on β_s with composition of ethanol, isopropanol and n - butanol is shown in Fig. 1 at 303^0K. When the system tends to attain a closer packing at around 0.5640 mole fraction of dimethyl sulphoxide in the different mixtures. The structural change is maximum, hence peaks show maxima at this mole fraction. Similarly the positive deviation in intermolecular free length also support the least interaction in n - butanol with mole interaction in ethanol and isopropanol.

Fig. 3 shows the variation of η^E drawn as a mole fraction of dimethyl sulphoxide at 303^0K. The new structural species in solution formed by the intermolecular forces causes the solution to possess less flow capability and hence increase in viscosity. Less thick slight alcohols like ethanol and lesser proportion of isopropanol show the positive deviation hence more interaction while group alcohol (butanol) less interaction.

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