ULTRASONIC VELOCITY, DENSITY AND VISCOSITY OF BINARY LIQUID MIXTURE OF ISOBUTYL ALCOHOL AND ISODECYL ALCOHOL WITH O-NITROTOLUNE AT 303.15 AND 313.15 K.

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Abstract
Ultrasonic velocity, density and viscosity were reported for binary mixture of isobutyl alcohol and Isodecyl alcohol with O-nitro toluene over an entire range of composition at 303.15 and 313.15 K. The experimental data were used to calculate the excess molar volume, viscosity deviation and deviation in isentropic compressibility. The result was interpreted in terms of molecular interaction studies between the components of binary mixture. The deviation in ideal mixing law in most of calculated parameters are negative. This reveals the nature and magnitude of intermolecular interaction between unlike molecules and electron donating alkyl group.
Key Words: Ultrasonic velocity, Density, Viscosity Excess molar volume, viscosity deviation, Isentropic Compressibility.

1. Introduction

The measurement of ultrasonic velocity, density and viscosity find wide applications in physic-chemical properties of liquid mixtures .It is also understanding in the molecular interaction studies of pure liquids and binary liquid mixtures[1-3]. The ultrasonic measurement can be used to provide information about physical nature and strength of molecular interactions in liquid mixtures[4-6]. The ultrasonic velocity is mainly related to binding forces between atoms or molecules.

The physico-chemical properties of pure liquids and of their binary liquid mixture at different temperature of whole composition are useful for the understanding the thermodynamics and transport properties as well as practical chemical engineering purposes The excess thermo-dynamic properties are applicable for the interaction between components of mixtures [7-10].

The study of ultrasonic velocity, density and viscosity measurement are widely used in characterising the physico- chemical properties .The alcohols are strongly self associated liquid with three dimensional network of hydrogen bond [11]. The investigation regarding the molecular association in organic binary mixture having one of the alkanol group. Since alkanol group is highly polar and can be association with any other group having some degree of polar attraction.

2. Experimental

The chemicals used Isobutyl alcohol and Isodecyl alcohol with O-nitro toluene were of analytical grade (A.R) minimum assay of 99.9% obtained from s. d. fine chemicals India which are used as such without further purification. The densities of pure components and binary mixtures were measured by using a Bi-capillary pycnometer. The purities of the above chemicals were checked density determination. The binary liquid mixtures of different known concentration were prepared in stopper measuring flask. The weight of the sample was measured using electronic digital balance with an accuracy of ± 0.1mg. The viscosity was measured using Ubbelohde viscometer (20ml) and the efflux time was determined using a

digital clock to within ± 0.015. The ultrasonic velocity (U) in liquid mixtures has been measured using an ultrasonic interferometer (Mittal type, model F-81) working at 2 MHz frequency. The accuracy of sound velocity was ±0.1 ms^{-1}

3. Theory and calculation

The molar excess volume of the binary mixture have been calculated from the value of density and mole fractions –

$$V^E = \frac{M_1X_1+M_2X_2}{\rho_{12}} - \frac{M_1X_1}{\rho_1} - \frac{M_2X_2}{\rho_2} \qquad (1)$$

The viscosity of binary mixture can be determine by –

$$ln\eta_m = X_1 ln\eta_1 + X_2 ln\eta_2 \qquad (2)$$

The measured values of viscosities of binary mixture have been evaluated the viscosity deviation –

$$\Delta\eta_m = \eta_{12} - X_1\eta_1 - X_1\,\eta_2 \qquad (3)$$

Deviation in isentropic compressibility have been calculated by following way –

$$\Delta k_S = k_S - \Phi_1 k_{S1} - \Phi_2 k_{S2} \qquad (4)$$

Where $k_{S1,}$ k_{S2} and K_S are isentropic compressibility of liquid mixtures and Φ is volume fraction of pure i^{th} component in the mixture and is defined as

$$\phi = \frac{(Xi\ Vi)}{(\Sigma\ Xi\ Vi)} \qquad (5)$$

Where x_1 and V_i are mole fraction and molar volume of i^{th} component in the mixture

4.1 Table1- Values of density (ρ) viscosity (η) ultrasonic velocity (U), Excess volume (V^E), viscosity deviations and (Δη), deviation on isentropic compressibility (Δk_S) for Binary System of Isodecyl alcohol(1) with O-nitrotolune(2) at 303.15 and 313.15 K.

Temp. (K)	x_1	ρ (gm/cm^3)	$\eta 10^3$ (Nsm^{-2})	U (MS^{-1})	V^E x 10^6(m^3 $mole^{-1}$)	Φ	Δη x 10^3 ($Kg\ m^{-1}\ s^{-1}$)	Δk_S x 10^{11}($m^2\ N^1$)
	0.0000	0.84870	9.49710	1560.8	0.0000	0.0000	0.000	
	0.1142	0.78690	9.57820	1600.5	18.1567	0.0818	96.485	23.07
	0.2254	0.90780	6.96590	1603.0	-4.3815	0.1675	-78.600	-33.15
	0.3309	0.92420	5.85610	1614.2	-3.7091	0.2547	-107.850	-35.18
	0.4344	0.94750	4.34610	1617.1	-4.0726	0.3467	-178.670	-34.82
303.15	0.5355	0.98110	3.26200	1633.7	-5.8073	0.4434	-208.759	-43.89
	0.6338	1.01190	2.97930	1649.6	-6.7499	0.5446	-160.877	-49.39
	0.7291	1.03580	2.25460	1665.9	-6.5022	0.6503	-159.519	-50.86
	0.8221	1.07170	2.16370	1683.7	-7.5935	0.7615	-96.562	-55.06
	0.9128	1.14760	1.96220	1796.4	-12.7286	0.8785	-46.448	-98.89
	1.0000	1.06470	1.75020	1631.2	0.0000	1.0000	0.000	
	0.0000	0.84420	6.85430	1516.1	0.0000	0.0000	0.000	
	0.1142	0.86930	5.80330	1534.5	-0.5464	0.0766	-41.858	-11.18
	0.2254	0.90020	5.28350	1552.3	-1.8689	0.1577	-32.191	-22.11
	0.3309	0.91680	4.03950	1565.7	-0.3296	0.2414	-98.104	-21.03
	0.4344	0.93990	3.36770	1590.1	0.2130	0.3308	-107.906	-26.88
313.15	0.5355	0.97270	2.61910	1598.1	-0.5680	0.4259	-126.718	-25.67
	0.6338	1.00280	2.40600	1598.7	-0.5980	0.5269	-93.533	-17.36
	0.7291	1.02700	1.92560	1599.4	0.4116	0.6339	-88.740	-4.99
	0.8221	1.05580	1.84430	1603.8	0.9762	0.7483	-45.313	6.03
	0.9128	1.06270	1.76270	1634.0	4.3720	0.8707	-3.191	15.30
	1.0000	1.13740	1.31050	1682.4	0.0000	1.0000	0.000	

4.2 Table 2: Values of density (ρ) viscosity (η) ultrasonic velocity (U), Excess volume (V^E), viscosity deviations and ($\Delta\eta$), deviation on isentropic compressibility (Δk_S) for Binary System of Isobutyl alcohol (1) with O-Nitrotolune (2) at 303.15 and 313.15 K.

Temp. (K)	x_1	ρ (gm/cm^3)	$\eta 10^3$ (Nsm^{-2})	U (MS^{-1})	V^E x 10^6(m^3 $mole^{-1}$)	Φ	$\Delta\eta$ x 10^3 ($Kg\ m^{-1}\ s^{-1}$)	Δk_S x 10^{11} ($m^2\ N^1$)
	0.0000	0.79540	3.00030	1400.1	0.0000	0.0000	0.000	
	0.0568	0.83210	2.46730	1417.3	-1.8340	0.0768	-46.230	-21.00
	0.1192	0.84560	2.40750	1466.4	-0.8979	0.1575	-44.409	-46.04
	0.1880	0.88610	2.05180	1481.3	-2.8696	0.2424	-71.378	-57.20
	0.2651	0.91000	1.87180	1508.1	-2.8254	0.3326	-79.740	-62.34
303.15	0.3509	0.94560	2.11640	1550.1	-3.9217	0.4275	-44.554	-78.02
	0.4479	0.98290	1.80990	1598.2	-5.0199	0.5285	-63.078	-90.70
	0.5580	1.02100	1.73030	1617.2	-6.0312	0.6356	-57.275	-83.64
	0.6834	1.06850	1.67900	1648.2	-7.8592	0.7488	-46.728	-80.98
	0.8296	1.10280	1.72700	1667.2	-8.1216	0.8705	-23.652	-64.17
	1.0000	1.06470	1.75020	1631.2	0.0000	1.0000	0.000	
	0.0000	0.78730	2.34130	1366.0	0.0000	0.0000	0.000	
	0.0568	0.82350	1.91730	1383.2	-1.2956	0.0716	-36.569	-19.58
	0.1192	0.83700	1.70240	1419.5	-0.2307	0.1477	-51.626	-33.19
	0.1880	0.87620	1.74890	1499.5	-1.0045	0.2286	-39.884	-88.60
	0.2651	0.90140	1.81480	1483.7	-0.3957	0.3159	-25.347	-59.91
313.15	0.3509	0.93660	1.64840	1514.6	-0.6780	0.4090	-33.143	-63.99
	0.4479	0.97350	1.46940	1546.9	-0.8572	0.5094	-41.044	-62.98
	0.5580	1.01160	1.44320	1550.2	-0.8675	0.6177	-32.315	-40.82
	0.6834	1.05870	1.47880	1565.2	-1.5225	0.7342	-15.829	-23.50
	0.8296	1.09310	1.57600	1626.1	-0.4395	0.8617	8.962	-15.90
	1.0000	1.13740	1.31050	1682.4	0.0000	1.0000	0.000	

5. Figures

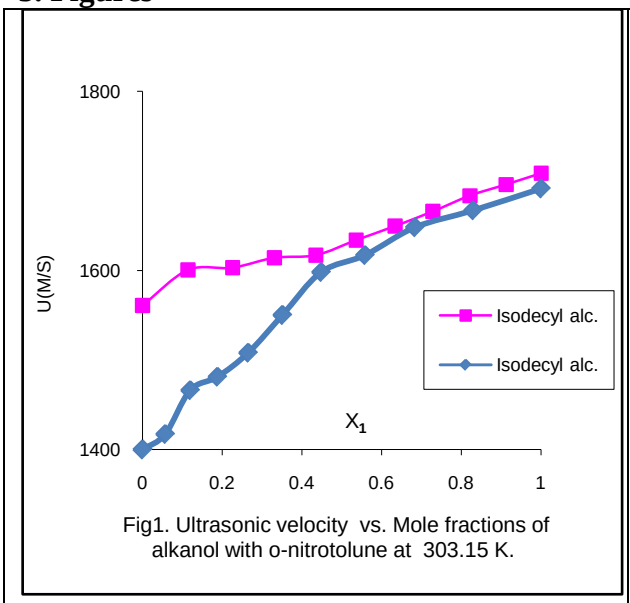

Fig1. Ultrasonic velocity vs. Mole fractions of alkanol with o-nitrotolune at 303.15 K.

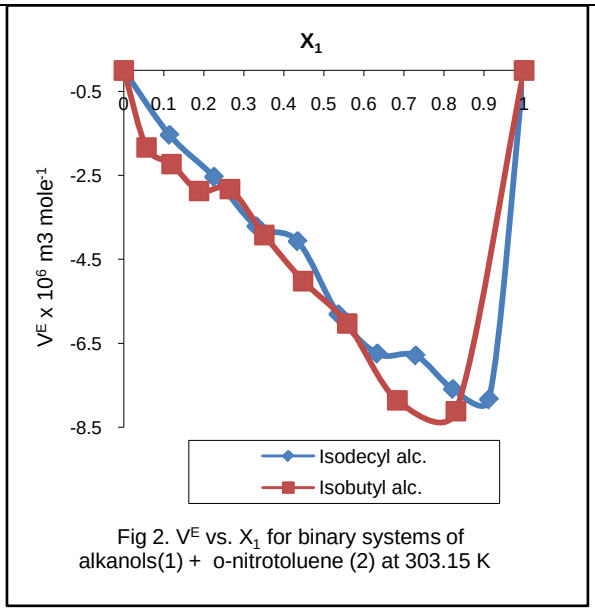

Fig 2. V^E vs. X_1 for binary systems of alkanols(1) + o-nitrotoluene (2) at 303.15 K

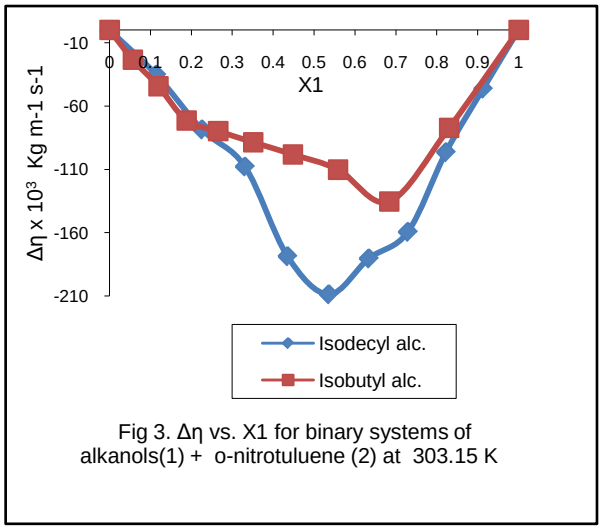

Fig 3. Δη vs. X1 for binary systems of alkanols(1) + o-nitrotuluene (2) at 303.15 K

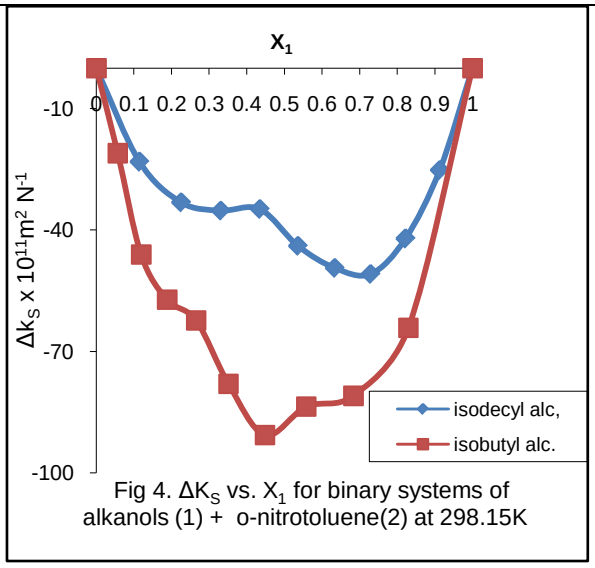

Fig 4. ΔK_S vs. X_1 for binary systems of alkanols (1) + o-nitrotoluene(2) at 298.15K

6. Result and Discussion

Determination of ultrasonic velocity and viscosity of alkanols with O-Nitro toluene gives reliable information about molecular interaction. In pure state alkanol get it associated. The association of alkanols decreases with increase in chain length of alkanols .When alcohols are mixed with O-nitro toluene then there is interaction between individual functional groups .The presence of electron withdrawing nitro group deceases the electron densities. The polarity of alcohol is less hence degree of self association is less.

The experimental values of density (ρ) viscosity (η) ultrasonic velocity (U), Excess volume (V^E), viscosity deviations and (Δη), deviation on isentropic compressibility (Δk_S) for binary Systems of Isodecyl alcohol and Isobutyl alcohol(1) with o-nitro toluene(2) at 303.15 and 313.15 K are reported in Tables1 and 2 respectively. The variation of excess parameters with mole fraction of alkanols at 303.15 and 313.15K are plotted in Figure 1-4. Fig:2-4 shows that curve for excess molar volume ,viscosity deviation and deviation isentropic compressibility are negative over entire mole fraction of alkanols at given temperature. In studied work the excess molar volume (V^E) values have been observed negative which attributed strong molecular interaction between the unlike molecules. Generally when two solvents are mixed the molecular interaction held will be depend upon the type and nature of molecules. The positive excess volumes attribute structure breaking

interactions while negative excess volumes attribute structure making interactions [13].

The observed V^E values may be analysed in terms of several effects which may be categorised as physical, chemical and geometrical contributions[12]. The physical interactions compromise mainly dispersion forces and non specific physical interaction giving positive contribution. The chemical interaction involves the charge transfer complexes, resulting in contraction of volume, geometrical or structural contribution arising from the geometrical fitting of one component into other[8]. The negative viscosity deviation and deviation in isentropic compressibility may be attributed to existence of dispersion dipole forces between unlike molecules and related to the difference in size and shape of molecules [14]. Increase of temperature disturbs hetero and homo association of molecules which increase the fluidity of the liquid. The values of viscosity deviation are more negative for Isodecyl alcohol which provides additional evidences for existence of interaction of weak magnitude like dipole –induced dipole type between components of liquid[15]. The magnitude of viscosity deviation and deviation isentropic compressibility the sign and extent of deviation of these properties from idealist depends upon the strength of interaction between unlike molecules. According to fort et. al. the excess viscosity gives the molecular interaction between interacting molecules. For the system where dispersion, induction and dipolar forces which are operated by values of excess viscosity are found to be negative, the large negative values of excess viscosity for the system can be attributed to the presence of dispersion, induction and dipolar forces between the components. The positive isentropic compressibility which indicates loosely packed molecules in the binary system. The Isodecyl alcohol has more negative viscosity deviation but less negative isentropic compressibility values this is due to structural differences in these two alcohol molecules.

7. Conclusion

The experimental data of density, viscosity and ultrasonic velocity are reported for binary mixtures of Isobutyl alcohol and Isodecyl alcohol with O-nitro toluene over entire range of mole fractions at 298.15K and 308.15K. Calculated, viscosity deviation, excess molar volume and deviation in isentropic compressibility shows large negative deviations for most investigated binary system. This reveals the existence of molecular interaction in binary system. The present investigation shows that greater molecular interaction exist in isodecyl and O-nitrotolune binary mixture which may be due to presence of more carbon – carbon linkage than iso butyl alcohol.

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