Study of molecular interactions in Binary Liquid Mixtures at Temperatures 303.15K, 308.15K, 313.15K, and 318.15K

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Abstract

Densities, Speed of sound and viscosity values are measured in binary liquid mixtures containing o-anisidine with o-cresol at temperatures 303.15.15K, 308.15, 313.15K, 318.15K over the entire mole fraction range. These values are used to measure various parameters like enthalpy, H, internal pressure, π, and by using these various excess parameters like excess enthalpy, H^E excess internal pressure, π^E excess speed of sound, u^E and excess viscosity, η^E values are calculated. The results are explained in the light of molecular interactions.

Introduction

Industry required the data of Physical and chemical properties of liquid mixtures. In the development of new models for process design, energy efficiency and in the evaluation of possible environmental impacts these data is used [1, 2]. The present investigation is concerned with the study of the binary system o-anisidine with o-cresol at temperatures 303.15K, 308.15 K, 313.15K and 318.15 K for the entire mole fraction range. o-anisidine is a yellow liquid with a melting point of -1 to 5^0C and it is used as an intermediate compound in the manufacture of dyes. O-cresol is mainly used as a precursor to other compounds.

In continuation of our research work [3,4] involving the study of excess properties of binary liquid mixtures containing o-anisidine, we report here the experimental measured values of speed of sound, viscosity and density for the binary mixtures of o-anisidine with o-cresol at 303.15K, 308.15K, 313.15K and 318.15K and atmospheric pressure. The experimental values were used to calculate enthalpy and internal pressure and their excess values. The variation of these parameters with the composition and temperature of the mixtures have been discussed in light of molecular interactions in these mixtures.

Materials And Methods

o-anisidine, o-cresol were used directly without further purification. All the liquids were kept tightly sealed in dark bottles to minimise the absorption of atmospheric moisture. The purity of the samples was checked by comparing the measured values with their corresponding literature values and presented in Table 1.

Table 1: Comparison of experimental values of speed of sound, density and viscosity with literature values at temperature 303.15 K.

Liquid	Speed of Sound, u (ms^{-1})		Density, ρ ($Kg\ m^{-3}$)		Viscosity, η (mPa s)	
	Expt.	Lit.	Expt.	Lit.	Expt.	Lit.
o-Anisidine	1597.89	1597.89[5]	1087.07	1091.70[6]	4.9123	4.9236[6]
o-Cresol	1485.26	1487.00[7]	1036.20	1036.90[7]	7.4791	4.2430[8] (313.15K)

The speeds of sound were measured by using single crystal ultrasonic pulse echo interferometer (Mittal enterprises, India; Model: F-80X). The densities of pure liquids and liquid mixtures were measured by using a specific gravity bottle with an accuracy of ± 0.5%. An electronic balance (Shimadzu AUY220, Japan), with a precision of ±0.1 mg was used for the mass measurements. Averages of 4-5 measurements were taken for each sample. Viscosities were measured at the desired temperature using Ostwald's viscometer, which is calibrated using water and benzene. Flow time has been measured, after the mixture had attained bath temperature.An electronic stop watch with a precision of 0.01s was used for the flow measurements. The viscosity is determined using the relation

$$\eta = k\rho t \qquad (1)$$

From the experimental data of speed of sound, density and viscosity various parameters are evaluated using standard equations [9].

Results and Discussion

The experimental values of speed of sound (u), density (ρ) and viscosity (η) for the binary mixtures over the entire composition range and at temperatures 303.15K, 308.15, 313.15 K and 318.15 K are given in Table 2. Plots of H^E, π^E, u^E and η^E against mole fraction of o-anisidine at different temperatures are given in Figures 1 to 4.

The results of the excess enthalpy, H^E, plotted in figure 1 are negative at all the temperatures studied. As the temperature increases the H^E values becomes more negative. According to *Fort and Moore* [10], the liquids of different molecular size usually mix with increase in volume yielding negative H^E values.

Table 2: Speed of sound, density and viscosity values of binary mixture o-anisidine + o-cresol at 303.15K, 308.15K, 313.15K, and 318.15 K temperatures.

x_1	Speed of Sound, u (ms^{-1})				Density, ρ ($Kg\ m^{-3}$)				Viscosity, η (mPa s)			
	303.15 K	308.15 K	313.15 K	318.15 K	303.15 K	308.15 K	313.15 K	318.15 K	303.15 K	308.15 K	313.15 K	318.15 K
0.0000	1485.26	1466.84	1452.11	1437.06	1036.20	1030.00	1026.00	1021.10	7.4791	5.9629	4.2380	2.2150
0.0929	1492.10	1474.52	1460.89	1446.31	1042.60	1038.82	1031.21	1025.81	7.2206	5.7480	4.0683	2.1108
0.1872	1500.00	1482.36	1469.26	1455.31	1048.86	1042.72	1036.94	1030.73	6.9519	5.5125	3.8834	2.0160
0.2831	1509.47	1491.63	1478.21	1464.73	1055.23	1048.70	1042.57	1035.89	6.6766	5.3058	3.7396	1.9578
0.3805	1521.42	1503.05	1489.42	1475.89	1061.17	1054.48	1048.33	1041.35	6.4257	5.1248	3.6209	1.9305
0.4795	1527.36	1509.36	1495.57	1481.52	1066.97	1059.62	1052.79	1045.58	6.1821	4.9440	3.5050	1.9074
0.5802	1542.00	1522.84	1508.36	1494.21	1073.04	1065.89	1058.65	1051.45	5.9329	4.7599	3.3905	1.8908
0.6825	1552.46	1533.05	1517.36	1502.45	1076.71	1690.67	1063.50	1055.70	5.6802	4.5715	3.2708	1.8709
0.7865	1564.21	1543.84	1527.84	1512.84	1080.78	1073.70	1067.82	1060.06	5.4256	4.3826	3.1583	1.8589
0.8924	1579.47	1539.31	1543.47	1527.90	1084.73	1077.22	1071.55	1063.60	5.1666	4.1953	3.0432	1.8437
1.0000	1597.89	1575.78	1557.84	1541.05	1087.07	1080.01	1074.59	1066.53	4.9123	4.0145	2.9344	1.8401

From figure 2 it is observed that π^E values are negative for the entire mole fraction range, for the two temperatures studied. The negative values of H^E and π^E for these binary mixtures may be dispersion forces dominate over formation of complexes between unlike molecules [11].

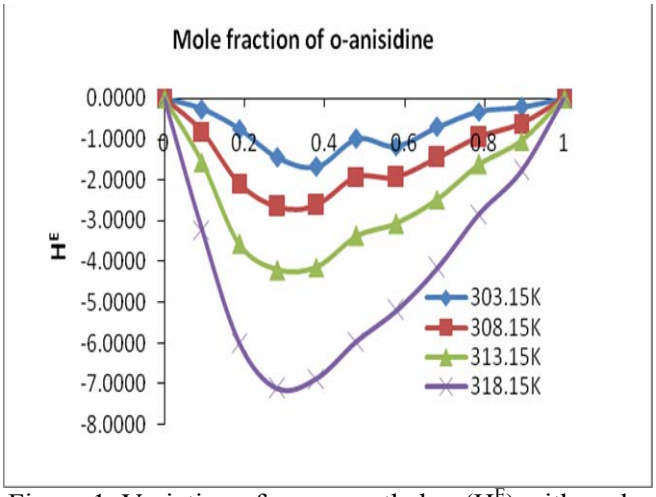

Figure 1. Variation of excess enthalpy (H^E) with mole fraction of o-anisidine at different temperatures

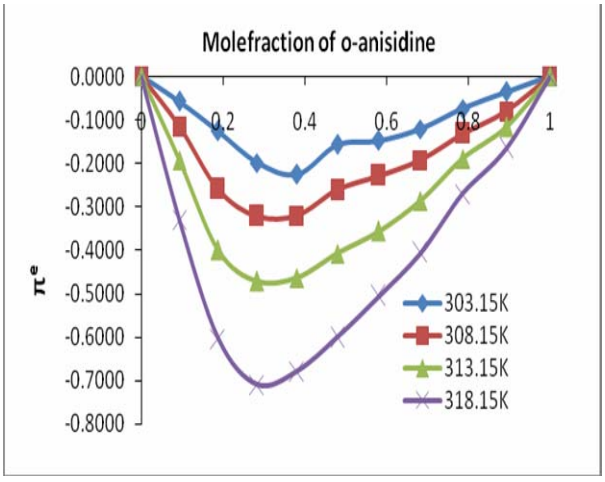

Figure 2. Variation of excess internal pressure (π^E) with mole fraction of o-anisidineat different temp.

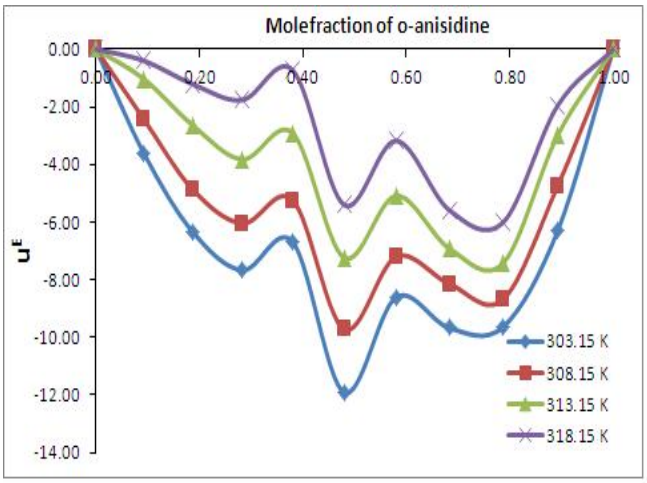

Figure 3. Variation of excess speed of sound (u^E) with mole fraction of o-anisidine at different temperatures

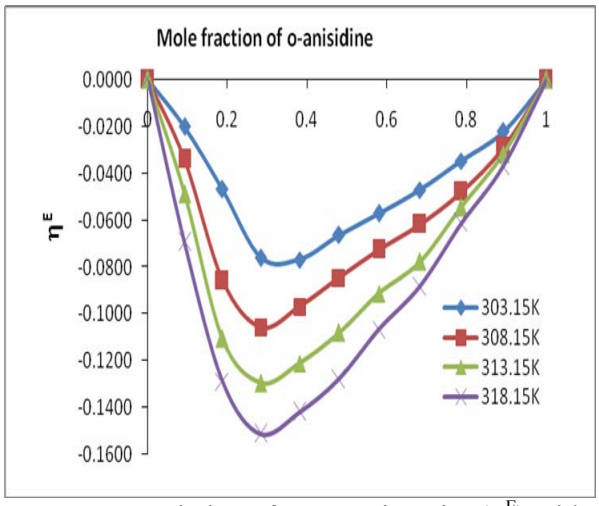

Figure 4. Variation of excess viscosity (η^E) with mole fraction of o-anisidine at different temp.

The intermolecular interaction occurring in the liquid mixtures might result in the increase of the inter space between molecules and this might lead to increase in intermolecular free length producing positive values of the excess intermolecular free length. The increase of intermolecular free length results in increase of compressibility and a decrease of velocity. The results of the excess ultrasonic velocity u^E plotted in figure 3 are negative for the mixtures at all the temperatures studied. The negative values of u^E decrease with increase in temperature which indicates the decrease in strength of interaction with temperature in the mixtures [12].

In the present investigation η^E values (figure 4) are negative over the entire composition range and for the four temperatures studied. The negative excess values of η^E clearly suggest that there exist some molecular interactions between the molecules of the mixtures [13].

Conclusions

From the data of density, viscosity and speed of sound, some thermo acoustical parameters and their excess parameters for the binary liquid mixtures of o-anisidine with o-cresol at T = (303.15K, 308.15K 313.15K, and 318.15K) are calculated for the entire composition range. The values of H^E, π^E, u^E and η^E are negative over the entire range of composition. The observed results suggests the presence of molecular interaction between the unlike molecules in the mixtures.

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