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THERMO-ACOUSTICAL PARAMETERS IN BINARY LIQUID MIXTURES CONTAINING PROPYLENE GLYCOL AND ETHANOL AT DIFFERENT TEMPERATURES

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ABSTRACT:
Viscosities,Ultrasonic velocities and Densities have been measured in binary liquid mixture containing propylene glycol and Ethanol over the entire molefraction range at temperatures T=(298.15,303.15,308.15,313.15 and 318.15)K. From experimentally measured data of ultrasonic velocity, density and viscosity, thermo-acoustical parameters such as adiabatic compressibility(β), intermolecular freelength(L_f) and acoustical impedance(Z) have been calculated. These results have been explained in terms of molecular interactions.

KEYWORDS: *Viscosity,Ultrasonic velocity, propylene glycol, adiabatic compressibility.*

INTRODUCTION:

Study of thermo-acoustical parameters are useful to understand different kinds of association, the molecular packing, physico-chemical behaviour and various types of intermolecular interactions in the liquid mixtures. Acoustical parameters study in binary liquid mixture has proved to be useful in elucidating the structural interactions between the components of liquid mixture[1-6].There are considerable number of recent investigations[7-9] on ultrasonic velocity and their derived parameters are available in this technology with variation of composition and temperature. The temperature dependence of the parameters give important information about the molecular interaction between the components of the mixtures.In the present paper, values of thermo-acoustical parameters and their variations with molefraction of propylene glycol in binary liquid mixtures containing propylene glycol and Ethanol at temperatures T=(303.15,308.15,313.15 and 318.15)K have been reported[10].

MATERIALS AND METHODS

The chemicals are of AnalaR grade. The chemicals are purified by standard procedure[11].The different concentrations of the liquid mixture are prepared by varying mole fractions with respect to Job's method of continuous variation. Stoppard conical flasks are used for preserving the prepared mixtures and the flasks are left undisturbed to attain thermal equilibrium. Ultrasonic pulse echo interferometer (Mittal enterprises, India) is used for ultrasonic velocities measurements and all these measurements are done at a fixed frequency of 3MHz. The temperature of the pure liquids or liquid mixtures is done by using temperature controlled water bath by circulating water around the liquid cell which is present in interferometer. Specific gravity bottle is used for the measurement of densities of pure liquids and liquid mixtures.

THEORY AND CALCULATIONS

The experimentally measured values of ultrasonic velocities, viscosities and densities, have been used to calculate thermo-acoustical parameters such as adiabatic compressibility(β), intermolecular freelength (**L_f**) and acoustical impedance(Z) by using following relations .[12-14]

(a) ADIABATIC COMPRESSIBILITY (β):

$$\beta = \frac{1}{\rho . U^2} \quad N^{-1}.m^2 \qquad \text{------(1)}$$

(b) INTERMOLECULAR FREE LENGTH (L_f)

$$L_f = k.\beta^{1/2} \quad Å \qquad \text{-------(2)}$$

(c) ACOUSTICAL IMPEDANCE (Z):

$$Z = U.\rho \quad Kg.m^{-2}.s^{-1} \qquad \text{-------(3)}$$

RESULTS AND DISCUSSION

Thermo-acoustical parameters such as adiabatic compressibility(β), intermolecular freelength(**L_f**) and acoustical impedance(Z) for the above binary liquid mixture over the entire molefraction at temperatures T=(298.15,303.15,308.15,313.15 and 318.15)K are given in the **Table-1toTable-5.**

Table-1: Ultrasonic Velocity (U), density (ρ), viscosity (η), adiabatic compressibility (β), free length (L_f) and acoustic impedance (Z) values at various mole fractions of Ethanol + propylene glycol mixtures at a temperature of 298.15K.

Mole fraction X_1	**U** ms^{-1}	**ρ** 10^{-3} Kg m^{-3}	**η** 10^{-3} Nsm^{-2}	**β** 10^{-11} m^2N^{-1}	**L_f** A^o	**Z** $Kgm^{-2}s^{-1}$
0.0000	1544.77	997.53	0.7654	42.01	0.1285	1.540
0.1227	1521.13	973.48	0.8228	44.40	0.1321	1.480
0.2393	1493.58	951.81	0.8658	47.10	0.1361	1.420
0.3503	1468.03	932.94	0.9088	49.74	0.1398	1.360
0.4562	1441.48	911.63	0.9418	52.79	0.1441	1.310
0.5572	1418.93	890.64	0.9848	55.77	0.1481	1.260
0.6537	1391.38	870.83	1.0278	59.32	0.1527	1.210
0.7459	1359.83	849.74	1.0608	63.64	0.1582	1.150
0.8342	1316.28	829.76	1.0838	69.56	0.1654	1.090
0.9189	1249.73	809.33	1.1068	79.11	0.1764	1.010
1.0000	1174.76	789.46	1.1198	91.78	0.1900	0.920

Table-2: Ultrasonic Velocity (U), density (ρ), viscosity (η), adiabatic compressibility (β), free length (L_f) and acoustic impedance (Z) values at various mole fractions of Ethanol + propylene glycol mixtures at a temperature of 303.15K.

Mole fraction X_1	**U** ms^{-1}	ρ 10^{-3} Kg m^{-3}	η 10^{-3} Nsm^{-2}	β 10^{-11} m^2N^{-1}	**L_f** A°	**Z** $Kgm^{-2}s^{-1}$
0.0000	1510.25	991.38	0.7455	44.22	0.1319	1.500
0.1227	1487.22	967.31	0.8031	46.74	0.1356	1.440
0.2393	1458.60	945.58	0.8459	49.71	0.1398	1.380
0.3503	1433.51	926.96	0.8895	52.50	0.1437	1.330
0.4562	1406.96	905.64	0.9219	55.78	0.1481	1.270
0.5572	1384.41	884.51	0.9649	58.99	0.1523	1.220
0.6537	1358.86	864.72	1.0079	62.63	0.1569	1.180
0.7459	1325.91	842.82	1.0417	67.49	0.1629	1.120
0.8342	1281.26	823.77	1.0642	73.95	0.1705	1.060
0.9189	1216.21	802.97	1.0869	84.19	0.1819	0.980
1.0000	1140.24	783.34	1.0999	98.19	0.1965	0.890

Table-3: Ultrasonic Velocity (U), density (ρ), viscosity (η), adiabatic compressibility (β), free length (L_f) and acoustic impedance (Z) values at various mole fractions of Ethanol + propylene glycol mixtures at a temperature of T= 308.15K.

Mole fraction X_1	**U** ms^{-1}	ρ 10^{-3} Kg m^{-3}	η 10^{-3} Nsm^{-2}	β 10^{-11} m^2N^{-1}	**L_f** A°	**Z** $Kgm^{-2}s^{-1}$
0.0000	1478.29	983.15	0.7236	46.54	0.1362	1.450
0.1227	1455.46	959.34	0.7797	49.21	0.1401	1.400
0.2393	1426.64	937.02	0.8240	52.44	0.1446	1.340
0.3503	1401.55	918.98	0.8684	55.40	0.1486	1.290
0.4562	1375.98	897.53	0.8996	58.85	0.1532	1.230
0.5572	1352.45	876.12	0.9430	62.40	0.1578	1.180
0.6537	1326.82	856.73	0.9858	66.30	0.1626	1.140
0.7459	1293.90	834.93	1.0198	71.54	0.1689	1.080
0.8342	1249.95	815.36	1.0427	78.50	0.1769	1.020
0.9189	1185.22	794.42	1.0656	89.61	0.1890	0.940
1.0000	1108.28	775.02	1.0780	105.1	0.2047	0.860

Table-4: Ultrasonic Velocity (U), density (ρ), viscosity (η), adiabatic compressibility (β), free length (L_f) and acoustic impedance (Z) values at various mole fractions of Ethanol + propylene glycol mixtures at a temperature of 313.15K.

Mole fraction X_1	**U** ms^{-1}	ρ 10^{-3} Kg m^{-3}	η 10^{-3} Nsm^{-2}	β 10^{-11} m^2N^{-1}	**L_f** A°	**Z** $Kgm^{-2}s^{-1}$
0.0000	1442.70	975.96	0.6943	49.23	0.1411	1.410
0.1227	1419.37	952.02	0.7499	52.14	0.1452	1.350
0.2393	1391.05	930.03	0.7949	55.57	0.1499	1.290
0.3503	1365.96	911.71	0.8393	58.79	0.1542	1.250
0.4562	1340.39	890.29	0.8704	62.52	0.1590	1.190
0.5572	1316.86	868.68	0.9134	66.38	0.1639	1.140
0.6537	1291.90	848.86	0.9567	70.58	0.1690	1.100
0.7459	1258.91	827.55	0.9892	76.25	0.1756	1.040
0.8342	1214.04	807.35	1.0126	84.04	0.1844	0.980
0.9189	1149.26	787.21	1.0359	96.18	0.1972	0.900
1.0000	1072.69	767.88	1.0489	113.2	0.2140	0.820

Table-5: Ultrasonic Velocity (U), density (ρ), viscosity (η), adiabatic compressibility (β), free length (L_f) and acoustic impedance (Z) values at various mole fractions of Ethanol + propylene glycol mixtures at a temperature of 318.15K.

Mole fraction X_1	**U** ms^{-1}	ρ 10^{-3} Kg m^{-3}	η 10^{-3} Nsm^{-2}	β 10^{-11} m^2N^{-1}	L_f A^o	**Z** $Kgm^{-2}s^{-1}$
0.0000	1413.31	968.94	0.6733	51.67	0.1456	1.370
0.1227	1389.36	945.03	0.7287	54.82	0.1500	1.310
0.2393	1361.66	923.14	0.7738	58.42	0.1548	1.260
0.3503	1336.57	905.15	0.8170	61.84	0.1593	1.210
0.4562	1311.00	883.88	0.8483	65.83	0.1643	1.160
0.5572	1287.47	862.25	0.8920	69.97	0.1694	1.110
0.6537	1260.89	842.37	0.9351	74.67	0.1750	1.060
0.7459	1228.57	820.59	0.9679	80.74	0.1820	1.010
0.8342	1184.65	800.34	0.9907	89.03	0.1911	0.950
0.9189	1119.25	780.73	1.0140	102.3	0.2048	0.870
1.0000	1043.30	761.47	1.0275	120.7	0.2225	0.790

It is observed from **Table-1 to Table-5** is that adiabatic compressibility value increases with the increase of molefraction and temperature in the present binary liquid mixture. Similar observations are made by Ali and Nain[15-18] in their binary mixtures and reported that the there exist strong interactions between the component molecules of liquid mixture and interactions become weak with increase of temperature.

The observations from **Table-1 to Table-5** suggest the variation of freelength of a system and it is a measure of intermolecular attraction between the components in binary mixtures. It is observed that as temperature increases the free length values increase. Further at a temperature, the free length values increase with increase in concentration of ethanol. The increase in compressibility increases the molecular distance, resulting in a increase of intermolecular free length. The increase in the values of free length and adiabatic compressibility with increase in temperature clearly reveals that the interaction becomes weaker at higher temperatures. According to a model proposed by *Eyring Kincaid*, ultrasonic velocity should decrease if the free length increases as a result of mixing components and it is also supported by Ali and Nain[15-18].

It is important to measure acoustic impedance, because acoustic impedance exhibits a non linear variation with increasing mole fraction of solute. From **Table-1 to Table-5**, it is noticed that at a temperature, as ethanol concentration increases the values of Z and found to be decreased non-linearly. This supports the molecular interactions of lesser magnitude as suggested by Garcia *et al. and* Oswal *et al*. When an acoustic wave travels in a medium, there is a variation of pressure and instantaneous velocity from particle to particle. This is governed by the inertial and elastic properties of the medium and it is also supported by Ali and Nain[15-18].

CONCLUSIONS

Ultrasonic velocity,density and viscosity values are measured in the binary liquid mixture containing propylene glycol and Ethanol at temperatures T=(303.15,308.15,313.15 and 318.15)K. By using these values, thermo-acoustical parameters such as adiabatic compressibility(β), intermolecular freelength(L_f) and acoustical impedance(Z) have been calculated over the entire molefraction range of ethanol. An analysis of these results suggests the presence of strong intermolecular interactions between the components of liquid mixture.

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