Theoretical ultrasonic velocities in binary liquid mixture containing aniline and anisole at different temperatures – a comparative study

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ABSTRACT

Ultrasonic velocity is measured experimentally at 3MHz frequency in the binary liquid mixture containing aniline and anisole at different temperatures over the entire composition range and theoretical values of ultrasonic velocity have been evaluated by using Nomoto's relation, Impedance relation, Van Dael ideal mixture relation. These theoretical values are compared with the experimental values. A good agreement has been found between experimental and theoretical ultrasonic velocities.

Keywords: Ultrasonic velocity, Aniline, Anisole, Binary liquid mixture.

1. INTRODUCTION

In assessing the nature of molecular interactions and investigating the physicochemical behaviour of liquid and liquid mixtures ultrasonic study has been gained much importance for the past several years.

Many researcheres [1-9] carried out ultrasonic velocity and their investigations in liquid mixtures. The experimental results of ultrasonic velocity and theoretical results of ultrasonic velocities using Nomoto [10], impedence [11] ,Van dael [12] relations are interpreted in terms of molecular interactions.

In the present study ultrasonic velocities in the binary liquid mixture containing aniline and anisole are experimentally measured at different temperatures are compared with theoretical values [16].

2. THEORETICAL

The different theoretical ultrasonic velocicy relations used in the present study are expressed as follows,

Nomoto's relation
$$U_N = [(x_1R_1+x_2R_2)/(x_1V_1+x_2V_2)]^3 \qquad (1)$$

Impedance dependent relation
$$U_{Im} = \Sigma x_iZ_i / \Sigma x_i\rho_i \qquad (2)$$

Van Dael ideal mixing relation
$$U_{imx} = [(x_1/M_1U^2_1 + x_2/M_2U^2_2)(x_1M_1+x_2M_2)]^{-1/2} \qquad (3)$$

3. EXPERIMENTAL

The chemicals used in the present study were purified by standard procedure [13]. The purity of samples was checked by comparing experimental values of density and ultrasonic velocity with the available literature [14-15] compiled in Table 1. Job's method of continuous variation was used to prepare the mixtures of required proportions.

The prepared mixtures were preserved in well-Stoppard conical flasks. After mixing the liquids thoroughly, the flasks were left undisturbed to allow them to attain thermal equilibrium.

The ultrasonic velocities were measured by using single crystal ultrasonic pulse echo interferometer (Mittal enterprises, India; Model: F-80X). It consists of a high frequency generator and a measuring cell. The measurements of ultrasonic velocities were made at a fixed frequency of 3MHz. The ultrasonic velocity has an accuracy of $\pm$ 0.5 ms^{-1}. The temperature was controlled by circulating water around the liquid cell from thermostatically controlled constant temperature water bath.

The densities of pure liquids and liquid mixtures were measured by using a specific gravity bottle with an accuracy of $\pm$ 0.5%. Weights were measured with an electronic balance (Shimadzu AUY220, Japan) capable of measuring up to 0.1mg. An average of 4-5 measurements was taken for each sample.

Table 1. Experimental and literature values of density and ultrasonic velocity of pure liquids at 303.15 K.

Liquids	$U/ (m.s^{-1})$		$\rho / (kg.m^{-3})$	
	Expt.	Lit.	Expt.	Lit.
Aniline	1629	1614.5[14]	1.0160	1.0170[14]
Anisole	1398	------	0.9849	0.9843[15]

Expt. – Experimental;   Lit. – Literature;

Table 2. Experimental and theoretical values of velocities (m·s^{-1}) in binary liquid system aniline and anisole system at different temperatures.

X	U_{exp}	U_N	U_{Im}	U_{imx}
303.15 K				
0.0000	1629	1629.0000	1629.000	1491.865
0.0853	1605	1604.7181	1609.849	1455.214
0.1733	1584	1580.7396	1589.986	1419.418
0.2644	1569	1556.9924	1569.310	1384.333
0.3587	1539	1533.4918	1547.785	1349.953
0.4559	1524	1510.3462	1525.466	1316.403
0.5571	1506	1487.3357	1502.085	1283.339
0.6619	1482	1464.5997	1477.716	1250.935
0.7707	1458	1442.0942	1452.248	1219.106
0.8829	1434	1419.9786	1425.801	1188.052
1.0000	1398	1398.0000	1398.000	1157.395
308.15 K				
0.0000	1611	1611.0000	1611.000	1475.381
0.0853	1584	1586.4735	1591.519	1438.451
0.1733	1569	1562.2369	1571.331	1402.427
0.2644	1551	1538.2180	1550.332	1367.162
0.3587	1527	1514.4327	1528.489	1332.645
0.4559	1509	1490.9915	1505.859	1298.999
0.5571	1494	1467.6723	1482.175	1265.874
0.6619	1458	1444.6168	1457.512	1233.446
0.7707	1440	1421.7811	1431.763	1201.623
0.8829	1404	1399.3275	1405.051	1170.603
1.0000	1377	1377.0000	1377.000	1140.009
313.15 K				
0.0000	1602	1602.0000	1602.000	1467.138
0.0853	1569	1576.7373	1582.075	1429.503
0.1733	1554	1551.7973	1561.416	1392.853
0.2644	1533	1527.1054	1539.916	1357.034
0.3587	1506	1502.6774	1517.539	1322.028
0.4559	1491	1478.6259	1494.343	1287.956
0.5571	1479	1454.7226	1470.051	1254.460
0.6619	1440	1431.1123	1444.741	1221.711
0.7707	1422	1407.7495	1418.297	1189.616
0.8829	1392	1384.7995	1390.847	1158.371
1.0000	1362	1362.0000	1362.000	1127.591
318.15 K				
0.0000	1578	1578.0000	1578.000	1445.159
0.0853	1554	1553.3336	1558.612	1408.389
0.1733	1536	1528.9907	1538.502	1372.561
0.2644	1515	1504.8979	1517.565	1337.526
0.3587	1491	1481.0704	1495.766	1303.269
0.4559	1476	1457.6179	1473.161	1269.909
0.5571	1461	1434.3171	1449.476	1237.098
0.6619	1425	1411.3091	1424.787	1205.004
0.7707	1404	1388.5492	1398.981	1173.538
0.8829	1374	1366.1981	1372.179	1142.891
1.0000	1344	1344.0000	1344.000	1112.689
323.15 K				
0.0000	1557	1557.9000	1557.900	1426.751
0.0853	1536	1532.6929	1538.263	1389.583
0.1733	1509	1507.8459	1517.880	1353.428
0.2644	1491	1483.2832	1496.644	1318.128
0.3587	1470	1459.0198	1474.517	1283.664
0.4559	1458	1435.1659	1451.553	1250.152
0.5571	1440	1411.4939	1427.474	1217.236
0.6619	1407	1388.1465	1402.354	1185.082
0.7707	1383	1365.0774	1376.072	1153.596
0.8829	1356	1342.4485	1348.752	1122.968
1.0000	1320	1320.0000	1320.000	1092.820

4. RESULTS AND DISCUSSION

The theoretical evaluation of sound velocity based on different models in liquid mixture has been used to correlate with the experimental findings. The theoretical values of ultrasonic velocities calculated by using the equations (1-3) along with the experimental values for the liquid mixture at different temperatures of (303.15, 308.15, 313.15, 318.15 and 323.15) K are given in Tables 2. From Table 2 it is observed that the theoretical values of ultrasonic velocity calculated by using various theories show deviation from experimental values.

The limitations and approximation incorporated in these theories are responsible for the deviations of theoretical values from experimental values. In Nomoto's theory, it is supposed that the volume does not change on mixing. But on mixing two liquids, the interaction between the molecules of the two liquids takes place because of the presence of various types of forces such as hydrogen bonding, dipole-dipole, dispersive forces, charge transfer and dipole-induced dipole interactions.

The deviations of experimental values from theoretical values calculated using Van Dael Ideal mixture relation might be due to the compressibility of the component liquids in the present mixtures. The deviations of experimental values and values calculated from impedance relation imply non-additivity of acoustic impedance in the liquid mixtures. Thus, the observed deviation of theoretical values of velocity from the experimental values shows that weak molecular interactions are taking place between the component molecules.

5. CONCLUSION

Ultrasonic velocities in the binary liquid mixture containing aniline and anisole at different temperatures are determined, and the validity of different theories is checked. Over all the observations it is cleared that in all the theories Nomoto's relation gives best results followed by Impedance theory.

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