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Prediction of Ultrasonic Velocities in Binary Liquid Mixtures of N,N,Dimethyl Acetamide With Certain Amines

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***Abstract*—Ultrasonic velocity and density values have been measured for the binary liquid mixtures of N,N Dimethyl Acetamide as a common component with Diethylamine, Diethanolamine and Benzylamine at 303, 308, 313 and 318K over the entire composition range. Theoretical velocity values have been evaluated by various relations viz., Nomoto, Free Length Theory (FLT), Van deal and Vangeel ideal mixing relation (IMR), Impedance Dependence Relation (IDR), and Junjie for three binary liquid mixtures. An attempt has been made to compare the merits of the relations and the relative applicability of these theories to the present systems have been checked and discussed. The results are explained in terms of intermolecular interactions occurring in these binary systems. The deviation in the variation of U^2_{exp} / U^2_{imx} from unity has also been evaluated for explaining the non-ideality in the mixtures**

***Index Terms*—ultrasonic velocity; binary liquid mixture; theoretical velocity; intermolecular interactions; non-ideality.**

I. INTRODUCTION

Now a days much interest has been shown on the study of physico-chemical properties, behaviour and molecular interactions in liquid mixtures. The analysis of thermodynamic properties of the liquid mixtures can be used to get the qualitative information about the energetic and structural effects and packing phenomena that govern the mixing process. Ultrasonic velocity studies in binary and multi component liquid mixtures which are capable to reveal the hydrogen bonding among the molecules has been carried out by many researchers [1-3].

Theoretical evaluation of ultrasonic velocity in binary liquid mixtures and its correlation to study molecular interaction has been successfully done in recent years [4-6]. Ultrasonic velocities of liquid mixtures are of considerable importance in understanding intermolecular interaction between component molecules, and they find applications in several industrial and technological processes. Several relations, semi-empirical formula and theories are available for the theoretical computation of ultrasonic velocity in liquid and

liquid mixtures.

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Using the theories available in literature, ultrasonic velocities in liquid mixtures have been calculated and compared with those obtained experimentally. The comparison of theoretical ultrasonic velocities with thoseobtained experimentally reveals the nature of interactions between the component molecules in the mixtures.

The aim of the present investigation is to compare the ultrasonic sound velocity in three binary liquid mixtures from various theoretical relations of Nomoto, Free Length Theory (FLT), Van deal and Vangeel ideal mixing relation (IMR), Impedance Dependence Relation (IDR), and Junjie. An attempt has been made to compare the merits of the relations for the binary liquid mixtures investigated at four different temperatures. The relative applicability of these theories to the present systems have been checked and discussed. The results are explained in terms of intermolecular interactions occurring in these binary systems. The deviation in the variation of U^2_{exp} / U^2_{imx} from unity has also been evaluated for explaining the non-ideality of the mixtures.

II. EXPERIMENATAL

The binary liquid mixtures under study are:
1.N,N,Dimethyl Acetamide + Diethylamine (NNDA+DEA)
2.N,N,DimethylAcetamide + Diethanolamine (NNDA +DEIA) and
3.N,N,DimethylAcetamide + Benzylamine (NNDA +BA)

All the chemicals used in the present research work are AR grade of minimum assay of 99.9% and henceused without further purification. The liquid mixtures were prepared by mixing calculated amount of pure liquids. The ultrasonic velocities in the liquid mixtures were measured using a single crystal variable path interferometer operating at a frequency of 10MHz (MITTAL ENTERPRISES, New Delhi, Model:M-84) with an overall accuracy of ± 0.1%. The temperature during the experiment was controlled by circulating water around the liquid cell from the thermostatically controlled adequately stirred water bath. The densities of pure liquids and liquid mixtures were determined from the weight measurements using 10ml specific gravity bottle by the standard procedure with an accuracy of ±0.1kg m^{-3}.

III. THEORETICAL

3.1 NOMOTO'S RELATION:

Rao found experimentally that [7], for pure liquids, the ratio of temperature coefficients of sound velocity U and molar volume remains almost constant: $$\frac{\left(\frac{1}{U}\right)\left(\frac{dU}{dT}\right)}{\left(\frac{1}{V}\right)\left(\frac{dV}{dT}\right)} = -3$$

Where T is the absolute temperature. On Integrating this equation we get

$$VU^{1/3} = cons\tan t = \frac{M}{\rho U^{1/3}} = R$$

Where M is molecular weight and ρ is density. The constant R is called the molar sound velocity or Rao's constant. It was found to be additive i.e., it can be calculated as a sum of increments from the atoms or atom groups in the molecule and from the chemical bonds.On assuming the additivity of molar sound velocity (R) and no volume change on mixing, Nomoto established the following relation for a liquid mixture

$$R = \frac{M}{\rho U^{1/3}}$$

Where U and ρ are determined experimentally and M is the mean molecular weight in a binary liquid mixture

$$M = \left(X_1 M_1 + X_2 M_2\right)$$

Where X_1 and X_2 are the mole fractions and M_1 and M_2 are molecular weights of constituent components respectively. Simple theoretical treatment gives the following relation

$$U_{Nomoto} = \left[\frac{\left(X_1 R_1 + X_2 R_2\right)}{\left(X_1 V_1 + X_2 V_2\right)}\right]^3 \quad (1)$$

3.2 Relation based on Free Length Theory

Jacobson[8] deduce an empirical relation for ultrasonic velocity (U_{FLT}) making use of intermolecular free length (L_f) and density (ρ) as

$$U_{FLT} = \left[\frac{K}{L_{f_{mix}} \rho_{\exp}^{1/2}}\right] \quad (2)$$

Where K is temperature dependent called Jacobson's constant and the value of K at the working temperatures of the experiment were calculated (MKS units) and they are given below

Temp(^{0}K)	303	308	313	318
Value of K	2.075 $\times10^{-6}$	2.095 $\times10^{-6}$	2.115 $\times10^{-6}$	2.135 $\times10^{-6}$

3.3 Ideal Mixing Relation based on the Van Deal and Vangeel Theory

Van Deal and Vangeel[9] proposed the ideal mixing theory in the light of assumptions made by Blandamer and Wadding[10], yield the following relation for adiabatic compressibility $(\beta_{ad})_{imix}$

$$\left(\beta_{ad}\right)_{imix} = \Phi_1 \frac{\gamma_1}{\gamma_{imix}}\left(\beta_{ad}\right)_1 + \Phi_2 \frac{\gamma_2}{\gamma_{imix}}\left(\beta_{ad}\right)_2$$

Where Φ_1 and Φ_2 volume fractions of the liquids 1 and 2, γ_1 and γ_2 are the ratios of specific heats of the respective liquids. This relation holds good if the mixture is ideal and if $\gamma_1 = \gamma_2 = \gamma_{imix}$. Using the additional assumption that $V_1 = V_2$ the above equation can be transformed into a linear combination of mole fraction X_1 and X_2,

$$\left(\beta_{ad}\right)_{imix} = X_1\left(\beta_{ad}\right)_1 + X_2\left(\beta_{ad}\right)_2$$

On the basis of this equation, Van Deal and Vangeel obtained the relation for ultrasonic velocity in liquid mixtures as

$$U_{IMR} = \left[\frac{1}{X_1 M_1 + X_2 M_2}\right]^{\frac{1}{2}} \left[\frac{X_1}{M_1 U_1^2} + \frac{X_2}{M_2 U_2^2}\right]^{\frac{-1}{2}} \quad (3)$$

Where U_1 and U_2 are the ultrasonic velocities of the pure liquid components.

3.4 Impedance Dependence Relation

The ultrasonic velocity can be evaluated by the Impedance Dependence Relation [11]of the following form

$$U_{IDR} = \frac{X_1 Z_1 + X_2 Z_2}{X_1 \rho_1 + X_2 \rho_2} \quad (4)$$

where X_1 and X_2 are the mole fractions, ρ_1 and ρ_2 are the densities and Z_1 and Z_2 are the acoustic impedances of the liquid components.

3.5 Junjie's Relation

Junjie'sRelation[12] for ultrasonic velocity is given by

$$U_{Junjie} = \left[\frac{X_1 V_1 + X_2 V_2}{\left(X_1 M_1 + X_2 M_2\right)^{1/2}}\right]\left[\frac{X_1 V_1}{\rho_1 U_1^2} + \frac{X_2 V_2}{\rho_2 U_2^2}\right]^{-1/2} \quad (5)$$

Where, 1& 2 represents the first and second component of the liquid mixture and the other symbols have their usual meanings.

3.6 Percentage Deviation

The percentage deviation is calculated from the relation

$$\%\ deviation = \sum \frac{\left(U_{mix(obs)} - U_{mix(cal)}\right)}{U_{mix(obs)}} X100 \quad (6)$$

Here, $U_{mix(obs)}$ is experimental value of ultrasonic velocity and $U_{mix(cal)}$ is computed value of ultrasonic velocity. The worst-case error is the maximum value of deviation of the theoretical values from experimental values of ultrasonic velocity.

3.7 Degree of interaction, α

The deviation of the ratio U^2_{exp} / U^2_{imx} from unity is called degree of interaction, α.

IV. RESULTS AND DISCUSSION

The theoretical relations used to calculate ultrasonic velocity in all the above liquid mixtures are mentioned above at different temperatures 303, 308, 313 and 318K and the values along with the experimental values are given in the Tables from 1 to 3 Also the validity of different theoretical formulae is checked by percentage deviation for all the mixtures and at all the temperatures are shown.

It is observed from the tabulated values that the theoretical values of ultrasonic velocities evaluated by the above mentioned relations show deviations from the experimental values. The reason for the deviation maybe the limitations and approximations incorporated in these theories. The effect of volume change due to mixing was not considered in the Nomoto's relation. That is interaction between the molecules was not taken into account. In Free Length theory, it was assumed that the molecules are of spherical shape but it is not true at all times. In the case of Ideal mixing relation, it was assumed that, the ratio of specific heats and volumes are equal. Again no molecular interactions were considered.

Upon mixing two liquids, the interaction between the molecules of the two liquids take place because of the presence of various types of forces such as dispersion forces, charge transfer, hydrogen bonding, dipole-dipole and dipole-induced-dipole interactions. Thus, the observed deviation of theoretical values of velocity from the experimental values shows the molecular interactions between the unlike molecules in the liquid mixture [13-18]. In the present study, in the three binary mixtures esters, the velocities predicted by the Nomoto's relation are in better agreement than the otherrelations. When two liquids are mixed various types of forces play a vital role due tointeractions. Thus, the observed deviations between theoretical and experimental values ofvelocity shows that there is molecular interaction between the unlike molecules in the liquid mixture. The FLT assumes that molecules are rigid spheres with no interaction between them and it is not valid in all the cases. Hence the deviation from the experimental ultrasonic velocity values is maximum in the FLT.

4.1 NN-Dimethyalacetamide + Diethylamine

From the reported values, Table-1, it can be observed that the experimental values are very close in agreement with the computed values by Nomoto's relation, followed by the values obtained by Junjie's relation, Ideal Mixing Relation Impedance Dependence Relation and Free Length Theory. The percentage deviations are very less positive in the case of Nomoto'svalues ,where as the deviations are large for FLT relation with negative valuesat all temperatures. The Nomoto's Relation gives the best approximation for this binary mixture.

4.2 NN-Dimethyalacetamide + Diethanolamine

A perusal of Table-2 reveals that the values calculated on the basis of Nomoto's Relation are in good agreement with the experimental values and there is no significant deviation at all temperatures.

Next to that, the values obtained by Nomoto's relation are very close to that of the experimental values and a slight negative deviation is observed. The values evaluated by theJunjie's relation, Ideal Mixing Relation and IDR follows the above respectively with a little more deviations. For this mixture also the FLT gives a large deviation in evaluated ultrasonic velocity values compared to the values obtained by the other four relations.

4.3 NN-Dimethyalacetamide + Benzyalamine

A close look at Table-3 reveals that velocities determined by Nomoto's Relation give a very close approximation with the measured values and the deviation observed is almost nil. The deviation in values calculated by Junjie's relation, Impedance Dependence Relation and Ideal Mixing Relation follows the deviation of the values obtained by respectively. In this case also the observed fact is that, FLT approximated values are much higher and negative values, the percentage deviations are also high.

The positive values of α in all the system clearly indicate the existence of tendency for the formation of association in mixture through hydrogen bonded complexes [17,18].

Velocities were determined on the basis of different theories and relations are discussed by other researchers earlier[19-21] and the validity of different theoretical formulae is checked by percentage deviation at different temperatures. As per the earlier studies, the limitations and approximations incorporated in these theories are responsible for the deviations between theoretical and experimental values.

Figs 1, 2 and 3 represent the variation of U^2_{exp} / U^2_{imx} with mole fraction of NN-Dimethyalacetamide. It is observed that the curves are similar in all the three systems with maximum approximately at 0.5 mole fraction of NN-Dimethyalacetamide at all temperatures. They are increasing with increase in temperature. The trend of the curves reveals a fact that the mixtures tend move towards more non-ideality up to the middle mole fraction of NN-Dimethyalacetamide, which suggests the formation of association in liquid mixtures through dipole-dipole interactions as reported by Shukla et al[22].

Graphical representation for variation of U^2_{exp} / U^2_{imx} with mole fraction of N,N Dimethyl acetamide

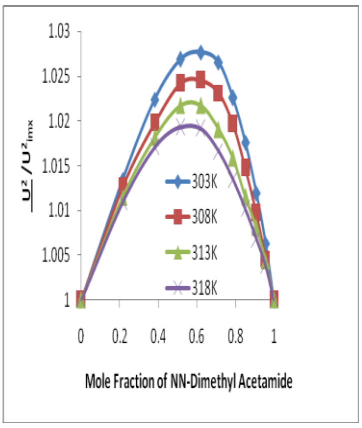

Fig.1 for NNDA+DEA

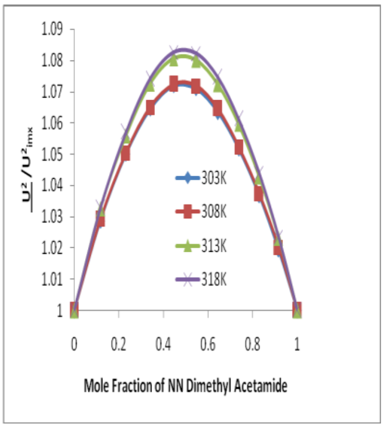

Fig.2 for NNDA +DElA

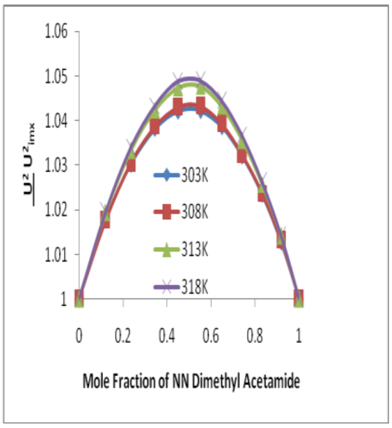

Fig.3 for NNDA +BA

Table 1.Experimental and Theoretical values of Ultrasonic velocity and Percentage of Deviation atdifferent temperatures for the binary liquid mixture- I (NN-Dimethyalacetamide + Diethylamine).

Mole Fracti -on of NNDA	**Exp. Velocity**	**Theoretical Velocities**					**Percentage Deviation**					$\frac{U^2}{U^2_{imx}}$
X_1	U_{exp}	U_{Nom}	U_{FLT}	U_{IMR}	U_{IDR}	U_{JUNJ}	U_{Nom}	U_{FLT}	U_{IMR}	U_{IDR}	U_{JUNJ}	
303K												
0.0000	1084.8	1084.8	1084.8	1084.8	1084.8	1084.8	0.00	0.00	0.00	0.00	0.00	1.0000
0.2149	1139.0	1154.0	997.2	1132.0	1176.5	1123.9	1.30	-14.22	-0.62	3.19	-1.34	1.0124
0.3811	1189.0	1210.4	932.1	1177.1	1241.4	1163.3	1.77	-27.56	-1.01	4.22	-2.21	1.0203
0.5135	1234.0	1257.3	892.8	1219.5	1289.7	1202.1	1.86	-38.21	-1.19	4.32	-2.65	1.0239
0.6215	1274.0	1296.9	879.2	1259.1	1327.1	1240.0	1.77	-44.91	-1.18	4.00	-2.74	1.0238
0.7112	1311.1	1330.7	883.7	1296.0	1356.9	1277.0	1.47	-48.37	-1.17	3.37	-2.67	1.0235
0.7870	1345.2	1359.9	906.0	1330.3	1381.1	1312.8	1.08	-48.48	-1.12	2.60	-2.47	1.0226
0.8518	1374.1	1385.4	964.5	1362.2	1401.3	1347.5	0.82	-42.46	-0.88	1.94	-1.97	1.0176
0.9079	1400.2	1407.8	1057.7	1391.9	1418.3	1381.2	0.54	-32.38	-0.60	1.28	-1.37	1.0120
0.9568	1424.1	1427.7	1200.8	1419.6	1432.9	1413.9	0.25	-18.60	-0.32	0.61	-0.72	1.0064
1.0000	1445.5	1445.5	1445.5	1445.5	1445.5	1445.5	0.00	0.00	0.00	0.00	0.00	1.0000
308K												
0.0000	1069.8	1069.8	1069.8	1069.8	1069.8	1069.8	0.00	0.00	0.00	0.00	0.00	1.0000
0.2149	1121.7	1134.7	977.9	1116.3	1164.4	1101.5	1.15	-14.70	-0.48	3.66	-1.83	1.0097
0.3811	1170.5	1188.8	911.1	1160.8	1229.5	1135.9	1.54	-28.48	-0.84	4.80	-3.04	1.0168
0.5135	1213.5	1234.5	876.7	1202.6	1277.1	1171.6	1.70	-38.42	-0.90	4.98	-3.57	1.0182
0.6215	1253.1	1273.7	862.8	1241.7	1313.3	1208.0	1.61	-45.24	-0.92	4.59	-3.74	1.0185
0.7112	1290.8	1307.5	863.8	1278.0	1341.9	1244.5	1.28	-49.42	-1.00	3.81	-3.72	1.0201
0.7870	1324.6	1337.1	886.0	1311.8	1365.0	1281.1	0.93	-49.51	-0.98	2.96	-3.40	1.0196
0.8518	1355.1	1363.1	933.8	1343.2	1384.1	1317.5	0.59	-45.11	-0.88	2.09	-2.85	1.0177
0.9079	1381.2	1386.2	1024.7	1372.5	1400.1	1353.7	0.36	-34.79	-0.63	1.35	-2.03	1.0127
0.9568	1404.5	1406.9	1177.3	1399.9	1413.7	1389.7	0.17	-19.30	-0.33	0.65	-1.06	1.0066
1.0000	1425.4	1425.4	1425.4	1425.4	1425.4	1425.4	0.00	0.00	0.00	0.00	0.00	1.0000
313K												
0.0000	1047.0	1047.0	1047.0	1047.0	1047.0	1047.0	0.00	0.00	0.00	0.00	0.00	1.0000
0.2149	1095.7	1106.4	958.6	1091.6	1141.2	1071.4	0.97	-14.30	-0.37	3.99	-2.27	1.0075
0.3811	1140.6	1156.8	902.3	1134.3	1204.5	1100.3	1.40	-26.41	-0.56	5.30	-3.66	1.0112
0.5135	1181.2	1200.1	874.7	1174.3	1249.9	1132.0	1.57	-35.03	-0.58	5.49	-4.34	1.0117
0.6215	1218.2	1237.5	867.7	1211.7	1284.1	1165.6	1.56	-40.40	-0.53	5.13	-4.51	1.0107
0.7112	1254.6	1270.3	869.8	1246.5	1310.7	1200.6	1.24	-44.24	-0.65	4.28	-4.50	1.0131
0.7870	1287.6	1299.2	892.4	1278.8	1332.1	1236.6	0.89	-44.29	-0.69	3.34	-4.13	1.0138
0.8518	1317.0	1324.9	941.0	1308.8	1349.6	1273.3	0.60	-39.96	-0.62	2.41	-3.43	1.0125
0.9079	1344.2	1347.9	1019.3	1336.8	1364.2	1310.7	0.27	-31.88	-0.55	1.47	-2.55	1.0111
0.9568	1366.5	1368.5	1162.7	1362.9	1376.6	1348.7	0.15	-17.52	-0.27	0.73	-1.32	1.0053
1.0000	1387.2	1387.2	1387.2	1387.2	1387.2	1387.2	0.00	0.00	0.00	0.00	0.00	1.0000
318K												
0.0000	1029.4	1029.4	1029.4	1029.4	1029.4	1029.4	0.0	0.0	0.0	0.0	0.0	1.0000
0.2149	1077.2	1087.2	942.0	1074.0	1126.3	1050.0	0.9	-14.4	-0.3	4.4	-2.6	1.0059
0.3811	1121.2	1136.7	887.9	1116.7	1190.2	1076.2	1.4	-26.3	-0.4	5.8	-4.2	1.0081
0.5135	1161.6	1179.7	861.0	1156.8	1235.6	1106.2	1.5	-34.9	-0.4	6.0	-5.0	1.0083
0.6215	1199.1	1217.3	853.1	1194.3	1269.5	1138.9	1.5	-40.6	-0.4	5.5	-5.3	1.0081
0.7112	1235.0	1250.4	857.0	1229.1	1295.8	1173.7	1.2	-44.1	-0.5	4.7	-5.2	1.0096
0.7870	1268.7	1279.8	876.5	1261.5	1316.8	1210.2	0.9	-44.7	-0.6	3.6	-4.8	1.0114
0.8518	1299.5	1306.1	921.3	1291.7	1333.9	1248.3	0.5	-41.1	-0.6	2.6	-4.1	1.0122
0.9079	1327.5	1329.7	994.1	1319.7	1348.1	1287.7	0.2	-33.5	-0.6	1.5	-3.1	1.0118
0.9568	1350.5	1351.0	1125.0	1345.9	1360.1	1328.4	0.0	-20.0	-0.3	0.7	-1.7	1.0068
1.0000	1370.4	1370.4	1370.4	1370.4	1370.4	1370.4	0.0	0.0	0.0	0.0	0.0	1.0000

Table 2. Experimental and Theoretical values of Ultrasonic velocity and Percentage of Deviation atdifferent temperatures for the binary liquid mixture- II (NN-Dimethyalacetamide + Diethanolamine).

Mole Fracti -on of NNDA	Exp. Velocity	Theoretical Velocities					Percentage Deviation					$\frac{U^2}{U^2_{imx}}$
X_1	U_{exp}	U_{Nom}	U_{FLT}	U_{IMR}	U_{IDR}	U_{JUNJ}	U_{Nom}	U_{FLT}	U_{IMR}	U_{IDR}	U_{JUNJ}	
303K												
0.0000	1719.2	1719.2	1719.2	1719.2	1719.2	1719.2	0.0	0.0	0.0	0.0	0.0	1.0000
0.1181	1690.8	1685.1	1984.9	1667.0	1689.9	1670.7	-0.3	14.8	-1.4	-0.1	-1.2	1.0287
0.2316	1663.0	1652.4	2678.3	1622.9	1660.7	1629.1	-0.6	37.9	-2.5	-0.1	-2.1	1.0501
0.3407	1635.6	1621.2	1097.6	1585.3	1631.8	1593.0	-0.9	85.1	-3.2	-0.2	-2.7	1.0645
0.4456	1608.0	1591.3	-747.9	1553.1	1603.1	1561.6	-1.1	315.0	-3.5	-0.3	-3.0	1.0719
0.5466	1578.7	1562.6	409.4	1525.5	1574.7	1533.9	-1.0	-285.6	-3.5	-0.3	-2.9	1.0709
0.6440	1548.7	1535.1	789.4	1501.8	1546.4	1509.5	-0.9	-96.2	-3.1	-0.1	-2.6	1.0634
0.7378	1519.2	1508.7	1007.2	1481.3	1518.4	1487.8	-0.7	-50.8	-2.6	-0.1	-2.1	1.0518
0.8283	1490.4	1483.3	1178.2	1463.7	1490.5	1468.4	-0.5	-26.5	-1.8	0.0	-1.5	1.0368
0.9156	1462.5	1459.0	1314.9	1448.5	1462.9	1451.1	-0.2	-11.2	-1.0	0.0	-0.8	1.0194
1.0000	1435.5	1435.5	1435.5	1435.5	1435.5	1435.5	0.0	0.0	0.0	0.0	0.0	1.0000
308K												
0.0000	1698.8	1698.8	1698.8	1698.8	1698.8	1698.8	0.0	0.0	0.0	0.0	0.0	1.0000
0.1181	1672.4	1665.6	2085.3	1648.5	1670.9	1650.9	-0.4	19.8	-1.4	-0.1	-1.3	1.0292
0.2316	1646.0	1633.9	3658.0	1606.0	1643.1	1610.1	-0.7	55.0	-2.5	-0.2	-2.2	1.0505
0.3407	1620.0	1603.6	2729.0	1569.7	1615.4	1575.0	-1.0	159.4	-3.2	-0.3	-2.9	1.0651
0.4456	1593.4	1574.7	153.1	1538.7	1587.8	1544.6	-1.2	-940.9	-3.6	-0.3	-3.2	1.0723
0.5466	1565.5	1547.1	649.5	1512.1	1560.4	1518.1	-1.2	-141.0	-3.5	-0.3	-3.1	1.0719
0.6440	1536.5	1520.6	884.5	1489.2	1533.2	1494.8	-1.0	-73.7	-3.2	-0.2	-2.8	1.0645
0.7378	1507.5	1495.3	1046.4	1469.5	1506.0	1474.2	-0.8	-44.1	-2.6	-0.1	-2.3	1.0524
0.8283	1479.5	1471.0	1185.9	1452.5	1479.0	1456.0	-0.6	-24.8	-1.9	0.0	-1.6	1.0375
0.9156	1452.4	1447.8	1302.2	1437.9	1452.1	1439.8	-0.3	-11.5	-1.0	0.0	-0.9	1.0202
1.0000	1425.4	1425.4	1425.4	1425.4	1425.4	1425.4	0.0	0.0	0.0	0.0	0.0	1.0000
313K												
0.0000	1687.0	1687.0	1687.0	1687.0	1687.0	1687.0	0.0	0.0	0.0	0.0	0.0	1.0000
0.1181	1658.1	1650.2	2319.0	1631.7	1656.5	1633.0	-0.5	28.5	-1.6	-0.1	-1.5	1.0326
0.2316	1628.8	1615.3	2659.7	1585.0	1626.0	1587.6	-0.8	93.9	-2.8	-0.2	-2.6	1.0560
0.3407	1600.4	1581.9	180.1	1545.4	1595.7	1548.8	-1.2	988.6	-3.6	-0.3	-3.3	1.0725
0.4456	1571.2	1550.2	548.3	1511.5	1565.6	1515.6	-1.4	-186.5	-3.9	-0.4	-3.7	1.0806
0.5466	1540.6	1519.9	806.9	1482.4	1535.5	1486.7	-1.4	-90.9	-3.9	-0.3	-3.6	1.0800
0.6440	1509.2	1490.9	959.6	1457.4	1505.6	1461.5	-1.2	-57.3	-3.6	-0.2	-3.3	1.0724
0.7378	1478.0	1463.3	1075.9	1435.8	1475.8	1439.4	-1.0	-37.4	-2.9	-0.1	-2.7	1.0596
0.8283	1447.2	1436.8	1184.1	1417.2	1446.2	1419.9	-0.7	-22.2	-2.1	-0.1	-1.9	1.0428
0.9156	1417.2	1411.5	1279.4	1401.1	1416.6	1402.6	-0.4	-10.8	-1.2	0.0	-1.0	1.0232
1.0000	1387.2	1387.2	1387.2	1387.2	1387.2	1387.2	0.0	0.0	0.0	0.0	0.0	1.0000
318K												
0.0000	1667.4	1667.4	1667.4	1667.4	1667.4	1667.4	0.0	0.0	0.0	0.0	0.0	1.0000
0.1181	1639.2	1631.1	3003.4	1613.0	1637.5	1613.8	-0.5	45.4	-1.6	-0.1	-1.6	1.0327
0.2316	1611.2	1596.6	1155.6	1567.1	1607.6	1568.8	-0.9	239.4	-2.8	-0.2	-2.7	1.0571
0.3407	1583.6	1563.7	403.1	1528.1	1577.9	1530.6	-1.3	-292.8	-3.6	-0.4	-3.5	1.0740
0.4456	1555.2	1532.5	728.6	1494.7	1548.2	1497.8	-1.5	-113.4	-4.0	-0.4	-3.8	1.0826
0.5466	1525.2	1502.7	888.1	1466.1	1518.7	1469.5	-1.5	-71.7	-4.0	-0.4	-3.8	1.0823
0.6440	1494.2	1474.2	999.1	1441.5	1489.2	1444.8	-1.4	-49.6	-3.7	-0.3	-3.4	1.0745
0.7378	1463.1	1447.0	1094.0	1420.2	1459.9	1423.2	-1.1	-33.7	-3.0	-0.2	-2.8	1.0613
0.8283	1432.3	1421.1	1186.7	1401.9	1430.6	1404.1	-0.8	-20.7	-2.2	-0.1	-2.0	1.0439
0.9156	1402.2	1396.2	1275.7	1386.0	1401.5	1387.3	-0.4	-9.9	-1.2	-0.1	-1.1	1.0234
1.0000	1372.4	1372.4	1372.4	1372.4	1372.4	1372.4	0.0	0.0	0.0	0.0	0.0	1.0000

Table 3. Experimental and Theoretical values of Ultrasonic velocity and Percentage of Deviation at different temperatures for the binary liquid mixture- II (NN-Dimethyalacetamide + Benzyalamine).

Mole Fracti -on of NNDA	**Exp. Velocity**	**Theoretical Velocities**					**Percentage Deviation**					$\frac{U^2}{U^2_{imx}}$
X_1	U_{exp}	U_{Nom}	U_{FLT}	U_{IMR}	U_{IDR}	U_{JUNJ}	U_{Nom}	U_{FLT}	U_{IMR}	U_{IDR}	U_{JUNJ}	
303K												
0.0000	1719.2	1719.2	1719.2	1719.2	1719.2	1719.2	0.0	0.0	0.0	0.0	0.0	1.0000
0.1181	1690.8	1685.1	1984.9	1667.0	1689.9	1670.7	-0.3	14.8	-1.4	-0.1	-1.2	1.0287
0.2316	1663.0	1652.4	2678.3	1622.9	1660.7	1629.1	-0.6	37.9	-2.5	-0.1	-2.1	1.0501
0.3407	1635.6	1621.2	1097.6	1585.3	1631.8	1593.0	-0.9	85.1	-3.2	-0.2	-2.7	1.0645
0.4456	1608.0	1591.3	-747.9	1553.1	1603.1	1561.6	-1.1	315.0	-3.5	-0.3	-3.0	1.0719
0.5466	1578.7	1562.6	409.4	1525.5	1574.7	1533.9	-1.0	-285.6	-3.5	-0.3	-2.9	1.0709
0.6440	1548.7	1535.1	789.4	1501.8	1546.4	1509.5	-0.9	-96.2	-3.1	-0.1	-2.6	1.0634
0.7378	1519.2	1508.7	1007.2	1481.3	1518.4	1487.8	-0.7	-50.8	-2.6	-0.1	-2.1	1.0518
0.8283	1490.4	1483.3	1178.2	1463.7	1490.5	1468.4	-0.5	-26.5	-1.8	0.0	-1.5	1.0368
0.9156	1462.5	1459.0	1314.9	1448.5	1462.9	1451.1	-0.2	-11.2	-1.0	0.0	-0.8	1.0194
1.0000	1435.5	1435.5	1435.5	1435.5	1435.5	1435.5	0.0	0.0	0.0	0.0	0.0	1.0000
308K												
0.0000	1698.8	1698.8	1698.8	1698.8	1698.8	1698.8	0.0	0.0	0.0	0.0	0.0	1.0000
0.1181	1672.4	1665.6	2085.3	1648.5	1670.9	1650.9	-0.4	19.8	-1.4	-0.1	-1.3	1.0292
0.2316	1646.0	1633.9	3658.0	1606.0	1643.1	1610.1	-0.7	55.0	-2.5	-0.2	-2.2	1.0505
0.3407	1620.0	1603.6	2729.0	1569.7	1615.4	1575.0	-1.0	159.4	-3.2	-0.3	-2.9	1.0651
0.4456	1593.4	1574.7	153.1	1538.7	1587.8	1544.6	-1.2	-940.9	-3.6	-0.3	-3.2	1.0723
0.5466	1565.5	1547.1	649.5	1512.1	1560.4	1518.1	-1.2	-141.0	-3.5	-0.3	-3.1	1.0719
0.6440	1536.5	1520.6	884.5	1489.2	1533.2	1494.8	-1.0	-73.7	-3.2	-0.2	-2.8	1.0645
0.7378	1507.5	1495.3	1046.4	1469.5	1506.0	1474.2	-0.8	-44.1	-2.6	-0.1	-2.3	1.0524
0.8283	1479.5	1471.0	1185.9	1452.5	1479.0	1456.0	-0.6	-24.8	-1.9	0.0	-1.6	1.0375
0.9156	1452.4	1447.8	1302.2	1437.9	1452.1	1439.8	-0.3	-11.5	-1.0	0.0	-0.9	1.0202
1.0000	1425.4	1425.4	1425.4	1425.4	1425.4	1425.4	0.0	0.0	0.0	0.0	0.0	1.0000
313K												
0.0000	1687.0	1687.0	1687.0	1687.0	1687.0	1687.0	0.0	0.0	0.0	0.0	0.0	1.0000
0.1181	1658.1	1650.2	2319.0	1631.7	1656.5	1633.0	-0.5	28.5	-1.6	-0.1	-1.5	1.0326
0.2316	1628.8	1615.3	2659.7	1585.0	1626.0	1587.6	-0.8	93.9	-2.8	-0.2	-2.6	1.0560
0.3407	1600.4	1581.9	180.1	1545.4	1595.7	1548.8	-1.2	988.6	-3.6	-0.3	-3.3	1.0725
0.4456	1571.2	1550.2	548.3	1511.5	1565.6	1515.6	-1.4	-186.5	-3.9	-0.4	-3.7	1.0806
0.5466	1540.6	1519.9	806.9	1482.4	1535.5	1486.7	-1.4	-90.9	-3.9	-0.3	-3.6	1.0800
0.6440	1509.2	1490.9	959.6	1457.4	1505.6	1461.5	-1.2	-57.3	-3.6	-0.2	-3.3	1.0724
0.7378	1478.0	1463.3	1075.9	1435.8	1475.8	1439.4	-1.0	-37.4	-2.9	-0.1	-2.7	1.0596
0.8283	1447.2	1436.8	1184.1	1417.2	1446.2	1419.9	-0.7	-22.2	-2.1	-0.1	-1.9	1.0428
0.9156	1417.2	1411.5	1279.4	1401.1	1416.6	1402.6	-0.4	-10.8	-1.2	0.0	-1.0	1.0232
1.0000	1387.2	1387.2	1387.2	1387.2	1387.2	1387.2	0.0	0.0	0.0	0.0	0.0	1.0000
318K												
0.0000	1667.4	1667.4	1667.4	1667.4	1667.4	1667.4	0.0	0.0	0.0	0.0	0.0	1.0000
0.1181	1639.2	1631.1	3003.4	1613.0	1637.5	1613.8	-0.5	45.4	-1.6	-0.1	-1.6	1.0327
0.2316	1611.2	1596.6	1155.6	1567.1	1607.6	1568.8	-0.9	239.4	-2.8	-0.2	-2.7	1.0571
0.3407	1583.6	1563.7	403.1	1528.1	1577.9	1530.6	-1.3	-292.8	-3.6	-0.4	-3.5	1.0740
0.4456	1555.2	1532.5	728.6	1494.7	1548.2	1497.8	-1.5	-113.4	-4.0	-0.4	-3.8	1.0826
0.5466	1525.2	1502.7	888.1	1466.1	1518.7	1469.5	-1.5	-71.7	-4.0	-0.4	-3.8	1.0823
0.6440	1494.2	1474.2	999.1	1441.5	1489.2	1444.8	-1.4	-49.6	-3.7	-0.3	-3.4	1.0745
0.7378	1463.1	1447.0	1094.0	1420.2	1459.9	1423.2	-1.1	-33.7	-3.0	-0.2	-2.8	1.0613
0.8283	1432.3	1421.1	1186.7	1401.9	1430.6	1404.1	-0.8	-20.7	-2.2	-0.1	-2.0	1.0439
0.9156	1402.2	1396.2	1275.7	1386.0	1401.5	1387.3	-0.4	-9.9	-1.2	-0.1	-1.1	1.0234
1.0000	1372.4	1372.4	1372.4	1372.4	1372.4	1372.4	0.0	0.0	0.0	0.0	0.0	1.0000

V. CONCLUSION

In the binary liquid mixtures, N,N Dimethyl acetamide + Diethylamine, N,N Dimethyl acetamide + Diethanolamine, N,N Dimethyl acetamide+ Benzylamineit is observed that there is a close agreement between experimental and theoretical values calculated by Nomoto's relation, followed by Junjie's, Ideal Mixing Relation and Impedance Dependence Relation. It may be concluded that out of the five theories and relations discussed above, the Nomoto's relation, Junjie's relation, Ideal Mixing Relation and Impedance Dependence Relation are good for estimation of velocities, as the values obtained show good agreement with the respective measured values of ultrasonic velocity.

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