ISSN : 0974 - 7524 Volume 9 Issue 2

Physical CHEMISTRY
An Indian Journal

Full Paper

PCAIJ, 9(2), 2014 [57-69]

Theoretical evaluation of ultrasonic velocity and viscosity in binary mixtures of amides with anisic aldehyde

P.B.Sandhya Sri, Zareena Begum, C.Rambabu*
Department of Chemistry, Acharya Nagarjuna University – Guntur, Andhra Pradesh, (INDIA)
Email : rbchintala@gmail.com

ABSTRACT

Theoretical values of ultrasonic velocity in binary liquid mixtures of anisic aldehyde+formamide, anisic aldehyde +N,N-dimethyl formamide and anisic aldehyde+ N,N-dimethyl acetamide have been evaluated at 303.15,308.15,313.15 and 318.15K using Nomoto's relation, ideal mixing relation (IMR) impedance dependence relation(IDR), Rao's velocity method (RVM), Junjie's method (JM) and Danusso relation. The relative merit of these theoretical relations were examined by comparing the theoretical values of ultrasonic velocity with the values obtained experimentally. The validity of the theories was checked by applying the chi-square test for goodness of fit and by calculating the average percentage error (APE). The viscosity data are correlated with some of the semi - empirical viscosity models such as Grunberg and Nissan, Katti–Chaudhri, Heric and Brewer and Hind, and the results are compared with the experimental results.

KEYWORDS

Ultrasonic velocity;
Viscosity;
Anisic aldehyde;
Amides;
Chi-Square test;
Molecular interaction parameter.

INTRODUCTION

In recent years, an increasing variety of research techniques are being employed to get an insight into the molecular behaviour of liquids. In the present stage of development, ultrasonic techniques are yielding fruitful results comparable with those of other methods in the elucidation of molecular mechanisms. Measurement of sound velocity has been used for many years in connection with the determination of elastic and thermodynamic properties of gases, liquids and solids. Intimate relations between the values of sound velocity and chemical or structural characteristics of molecules of liquids or liquid mixtures have been found. This gives sound velocity the primary quantity in the molecular theory of liquids.

Theoretical evaluation of ultrasonic velocity in binary liquid mixtures and its comparison with the experimental values reflects the molecular interaction in liquid mixtures, which is very useful to build comprehensive theoretical models for liquids. Several researchers[1-9] carried out investigations on liquid mixtures and correlated the experimental results of ultrasonic velocity with the theoretical relations of Nomoto's relation[10], ideal mixing relation (IMR)[11], impedance dependence relation (IDR)[12], Rao's velocity method (RVM)[13] Junjie's method (JM)[14] and Danusso[15]. Further, the best suitable theory for the given studied system is also picked out by computing the average percentage error and Chi-Square test. The viscosity data are correlated with some

Full Paper

of the semi - empirical viscosity models such as Grunberg and Nissan, Katti–Chaudhri, Heric and Brewer and Hind, and the results are compared with the experimental results.

In the present investigation, experimentally determined ultrasonic sound velocities are compared with the theoretical relations like Nomoto, Van Dael and Vangael, Impedance Relation, Rao's specific velocity, Junji and Danusso relation at various temperatures. Anisic aldehyde is mixed with acetates (MA, EA and BA) at different mole fractions, to study the interactions between the component molecules. The results are explained and discussed in terms of molecular interactions present in the investigated systems. The deviation in the variation of U^2_{exp}/U^2_{imx}, average percentage error, (APE), Chi-square test for goodness of fit, from unity have also been evaluated to further explain the non-ideality of the system. The ratio of $U_{exp}{}^{2}/U_{imx}{}^{2}$ gives an idea of extent of interaction taking place between molecules of the mixtures, positive values of which infer strong interactions between the components. Further, the mixture viscosities were correlated using Grunberg – Nissan[16], Katti – Choudary[17], Heric and Brewer[18] and Hind[19] equations to test their relative applicability.

EXPERIMENTAL

Velocities were determined using single crystal ultrasonic pulse echo interferometer (Model M-82, Mittal enterprises, India) working at 1 M Hz. The principle used in measurement of ultrasonic velocity waves of known frequency produced by quartz crystal in measuring cell[13]. The ultrasonic interferometer has an accuracy of $\pm$ 0.5m/s.

The temperature of the solution was controlled by circulating water through the jacket of double walled cell. Measurements were made using constant temperature bath with in $\pm$ 0.01K.

THEORETICAL CONSIDERATIONS

Nomoto equation

Rao proposed the relation that the ratio of temperature coefficients of sound velocity U and molar volume V remains almost constant for pure liquids:

$$[(1/U)(dU/dT)] / [(1/V)(dV/dT)] = -3 \quad (1)$$

where T is the absolute temperature.

Integration the above equation, we get

$$VU^{1/3} = const = M/\rho U^{1/3} = R \quad (2)$$

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

$$M = (X_1M_1 + X_2M_2) \quad (3)$$

where M_1 and M_2 are molecular weights of constituent components.

Simple manipulation yields the following relation

$$U_{Nomoto} = [(X_1R_1+X_2R_2) / (X_1V_1+X_2V_2)]^3 \quad (4)$$

The van dael and vangeel equation

Van Dael obtained the relation for ultrasonic velocity in liquid mixtures as

$$1/(X_1M_1+X_2M_2)*1/U^2_{imx} = X_1/M_1U_1^2 + X_2/M_2U_2^2 \quad (5)$$

where U_{imx} is the ideal mixing ultrasonic velocity in liquid mixture. U_1 and U_2 are ultrasonic velocity in species.

The impedance relation

$$\text{Impedance relation } U = \Sigma X_i Z_i / \Sigma X_i\rho_i \quad (6)$$

where X_i mole fraction, ρ_t, is the density of the mixture and Z_i is the acoustic impedance.

The rao's specific velocity method relation

$$\text{Rao's specific velocity method}^{14}\ U = (\Sigma X_i r_i \rho)^3 \quad (7)$$

where X_i mole fraction, U_i is the ultrasonic velocity, ρ_t is the density of the mixture, r_i is the Rao's specific sound velocity = $Ui^{1/3}/\rho_i$ and Z_i is the acoustic impedance.

The Junjie equation

$$\text{Junjie equation } U_J = (X_1M_1/\rho_1+X_2M_2/\rho_2)/[\{X_1M_1+X_2M_2\}^{1/2}\{X_1M_1/\rho_1U_1^2+X_2M_2/\rho_2U_2^2)\}^{1/2}] \quad (8)$$

where M_1, M_2 are molecular weights of constituent components.. ρ_1 and ρ_2 are the densities of constituent components.

Danusso model

Danusso model of velocity of ultrasonic waves is given by

$$U_D = (1/\rho mix)\,(1/M_{eff}(X_1M_1/\rho_1{}^2U_1{}^2+X_2M_2/\rho_2{}^2U_2{}^2))^{-1/2} \quad (9)$$

Chi-square test for goodness of fit

According to Karl Pearson[20] Chi-square value is

evaluated for the binary liquid mixtures under study using the formula

$$\chi^2 = \sum_{n=1}^{n} (U_{mix(obs)} - U_{mix(cal)})^2 / U_{mix(cal)} \quad (10)$$

where n is the number of data used.

Average percentage error (APE)

The Average percentage error[21] calculated using the relation

$$APE = 1/n \Sigma (U_{mix(obs)} - U_{mix(cal)}) / U_{mix(obs)}) X100\% \quad (11)$$

where n is the number of data used, $U_{mix(obs)}$ = experimental values of ultrasonic velocities Pilar Garcia Giminez $U_{mix(cal)}$ = computed values of ultrasonic velocities

Molecular association

The degree of intermolecular interaction or molecular association is given by

$$\alpha = [U_{exp}^2 / U_{imx}^2] - 1 \quad (12)$$

Viscosity theories

Grunberg and Nissan proposed the following equation for viscosity of liquid mixtures at low temperatures,

$$\ln \eta = X_1 \ln \eta_1 + X_2 \ln \eta_2 + X_1 X_2 G_{12} \quad (13)$$

where η_1, η_2 are viscosity of components Anisic Aldehyde and methylacetate or ethyl acetate or butyl acetate respectively, G_{12} is an interaction parameter which is the function of the chemical nature of the components and temperature.

The value of G_{12}, obtained from Eq. (14) using experimental viscosity.

The Katti–Chaudhri (KC) equation is given by:

$$\ln (\eta V) = X_1 \ln (\eta_1 V_1) + X_1 \ln (\eta_1 V_1) + X_1 X_1 W_{visc}/RT \quad (14)$$

where W_{vis} is the interaction energy for activation of viscous flow

The three parameter Heric and Brewer model is of the following form:

$$\ln \eta = X_1 \ln \eta_1 + X_2 \ln \eta_2 + X_1 \ln M_1 + X_2 \ln M_2 - (\ln X_1 M_1 + \ln X_2 M_2) X_1 X_2 \Delta_{12} \quad (15)$$

The two parameter Heric equation is of the following form:

$$\eta = X_1^2 \eta_1 + X_2^2 \eta_2 + 2 X_1 X_2 H_{12} \quad (16)$$

where H_{12} is an interaction parameter

DISCUSSION

Anisic Aldehyde, also known as para methoxy benzaldehyde is slightly polar (CH=O group). Oxygen is more electronegative than carbon so it has a tendency to pull electrons in a carbon-oxygen bond towards itself. Formamide molecules are highly polar (μ = 3.77 D at 298.15 K) and are strongly self associated through extensive three - dimensional net work of hydrogen bonds, through its three hydrogen bond donors (3H – atoms) and three acceptors (two lone pairs of electrons at oxygen and one on nitrogen atom)[22,23]. On the other hand NNDMF to some extent is associated by means of dipole-dipole interactions. Significant structural effects are absent due to the lack of hydrogen bonds. Therefore it acts as an aprotic protophilic solvent[24]. NNDMAc is dipolar aprotic solvent and is moderately structured[25]. The NN- dialkyl amides have no significant intermolecular hydrogen bonding capability but are highly polar with high percentage of ionic character, making oxygen of C = O group strongly negative[26].

The experimental values of ultrasonic velocity for the system along with theoretical values and percentage deviations for Nomoto's Relation (U_{NR}), Vandeal Vangael Ideal Mixing Relation (U_{imx}), Impedance Dependence Relation (U_I), Rao's specific velocity method (U_{Rao}) Junjie's relation (U_J) and Danusso (U_D) are compared for all the three binaries.

TABLE 1, denotes the evaluated velocity values from various theories adopted under study along with experimental values. From the data it is observed that the velocities computed from Nomoto relation(,U_{NR}) exhibit more satisfactory agreement with the experimental values in the temperature range 303.15K-318.15K than other approaches in the binary systems. The agreement between theoretical velocities of Nomoto's relation in all the three binary systems suggests that R is additive property in all the three systems. It is observed that the experimental values show deviation with the theoretical values of ultrasonic velocities which confirms the existence of molecular interactions.

TABLES 1, 2, and 3 show the values of ultrasonic velocity computed by various theories along with experimental values (U). There are variations between the evaluated and experimental values. From the observed values of all three systems, there is a good agreement between theoretical and experimental values through Impedance relation followed by Nomoto Relation for

Full Paper

TABLE 1 : Experimental velocities (U/m.sec^{-1}), theoretical velocities ((Ux/m.sec^{-1}) for the system anisic aldehyde (AA) +Formamide (FA)

X_1	U_{exp} ms^{-1}	U_{NR} ms^{-1}	U_{imx} ms^{-1}	U_{IR} ms^{-1}	U_R ms^{-1}	U_j ms^{-1}	U_D ms^{-1}
			303.15K				
0.0000	1588.00	1588.00	1588.00	1588.00	1588.00	1588.00	1588.00
0.0353	1588.90	1583.53	1552.04	1586.44	1605.88	1583.36	1576.57
0.0761	1589.04	1579.05	1516.23	1584.63	1618.43	1578.76	1566.99
0.1238	1589.08	1574.57	1480.93	1582.51	1626.59	1574.21	1558.86
0.1802	1589.33	1570.11	1446.81	1580.01	1630.46	1569.70	1552.09
0.2479	1589.26	1565.65	1414.93	1577.00	1629.81	1565.23	1546.71
0.3309	1587.91	1561.21	1387.24	1573.31	1623.40	1560.81	1543.06
0.4348	1583.99	1556.77	1367.51	1568.69	1611.00	1556.42	1541.16
0.5687	1577.00	1552.34	1363.86	1562.73	1592.41	1552.07	1541.04
0.7479	1564.70	1547.92	1397.29	1554.75	1569.78	1547.77	1541.93
1.0000	1543.50	1543.50	1543.50	1543.50	1543.48	1543.50	1543.50
			308.15K				
0.0000	1578.00	1578.00	1578.00	1578.00	1578.02	1578.00	1578.00
0.0353	1579.00	1571.82	1542.05	1575.85	1602.36	1571.52	1562.27
0.0761	1578.98	1565.65	1506.21	1573.38	1612.74	1565.14	1551.26
0.1238	1578.36	1559.51	1470.84	1570.48	1619.78	1558.84	1541.38
0.1802	1577.52	1553.38	1436.56	1567.06	1621.61	1552.62	1533.17
0.2479	1575.66	1547.27	1404.40	1562.94	1618.61	1546.49	1526.44
0.3309	1572.57	1541.18	1376.25	1557.89	1609.61	1540.43	1521.50
0.4348	1567.23	1535.11	1355.70	1551.56	1594.90	1534.46	1518.20
0.5687	1558.11	1529.06	1350.53	1543.39	1574.59	1528.57	1516.44
0.7479	1542.98	1523.02	1380.69	1532.44	1549.00	1522.75	1516.00
1.0000	1517.00	1517.00	1517.00	1517.00	1517.01	1517.00	1517.00
			313.15K				
0.0000	1566.00	1566.00	1566.00	1566.00	1565.98	1566.00	1566.00
0.0353	1566.19	1560.26	1530.38	1564.01	1595.24	1559.98	1548.91
0.0761	1565.85	1554.54	1494.87	1561.72	1608.15	1554.05	1537.37
0.1238	1565.65	1548.83	1459.84	1559.04	1613.64	1548.20	1528.31
0.1802	1565.28	1543.14	1425.90	1555.87	1613.88	1542.43	1520.94
0.2479	1563.96	1537.47	1394.11	1552.05	1609.37	1536.73	1515.09
0.3309	1561.44	1531.82	1366.32	1547.37	1599.41	1531.12	1510.93
0.4348	1556.62	1526.19	1346.15	1541.50	1584.93	1525.58	1508.15
0.5687	1548.08	1520.57	1341.38	1533.92	1565.82	1520.11	1506.75
0.7479	1533.88	1514.98	1372.03	1523.75	1541.09	1514.72	1507.02
1.0000	1509.40	1509.40	1509.40	1509.397	1509.42	1509.40	1509.29
			318.15K				
0.0000	1554.00	1554.00	1554.00	1554.00	1554.01	1554.00	1554.00
0.0353	1554.52	1547.68	1518.57	1551.83	1588.21	1547.34	1534.40
0.0761	1555.24	1541.39	1483.25	1549.33	1599.80	1540.79	1522.43
0.1238	1554.64	1535.13	1448.38	1546.40	1605.08	1534.35	1512.61
0.1802	1553.48	1528.89	1414.57	1542.92	1603.67	1528.01	1504.98
0.2479	1551.85	1522.68	1382.85	1538.75	1597.01	1521.77	1499.05
0.3309	1548.65	1516.50	1355.05	1533.63	1586.36	1515.63	1494.39
0.4348	1543.32	1510.34	1334.71	1527.20	1571.09	1509.58	1491.20
0.5687	1534.03	1504.20	1329.44	1518.90	1551.98	1503.63	1489.21
0.7479	1518.41	1498.09	1358.79	1507.75	1526.35	1497.77	1489.26
1.0000	1492.00	1492.00	1492.00	1491.99	1492.01	1492.00	1492.06

AA +FA and Nomoto's relation followed by impedance relation. There are higher variations in some intermediate concentration range suggesting the existence of strong tendency of association between component molecules as a result of hydrogen bonding.[27]

Nomoto's theory proposes that the volume does

TABLE 2 : Experimental velocities (U/m.sec^{-1}), theoretical velocities ((Ux /m.sec^{-1}) for the system anisaldehyde (AA) + N,N – di methyl formamide (DMF)

X_1	U_{exp} ms^{-1}	U_{NR} ms^{-1}	U_{imx} ms^{-1}	U_{IR} ms^{-1}	U_R ms^{-1}	U_j ms^{-1}	U_D ms^{-1}
			303.15K				
0.0000	1439.00	1439.00	1439.00	1439.00	1438.99	1439.00	1439.00
0.0664	1449.14	1449.23	1424.93	1447.17	1496.15	1445.07	1440.22
0.1380	1459.40	1459.51	1413.31	1455.75	1545.41	1451.99	1443.69
0.2153	1470.64	1469.84	1404.60	1464.76	1589.20	1459.79	1448.29
0.2991	1482.26	1480.22	1399.43	1474.25	1623.50	1468.52	1454.91
0.3903	1494.43	1490.64	1398.70	1484.24	1647.95	1478.22	1463.29
0.4899	1506.62	1501.12	1403.71	1494.79	1660.64	1488.95	1473.64
0.5990	1516.93	1511.64	1416.39	1505.93	1656.42	1500.76	1487.14
0.7192	1526.66	1522.21	1439.82	1517.72	1636.25	1513.73	1503.20
0.8521	1534.65	1532.83	1479.10	1530.23	1599.07	1527.95	1521.91
1.0000	1543.50	1543.50	1543.50	1543.50	1543.48	1543.50	1543.50
			308.15K				
0.0000	1420.00	1420.00	1420.00	1420.00	1420.02	1420.00	1420.00
0.0664	1431.85	1429.52	1405.93	1427.58	1478.90	1425.58	1419.85
0.1380	1441.84	1439.07	1394.26	1435.54	1528.54	1431.96	1422.39
0.2153	1452.05	1448.67	1385.42	1443.90	1571.55	1439.19	1426.39
0.2991	1462.96	1458.30	1380.03	1452.70	1605.14	1447.28	1432.33
0.3903	1474.25	1467.98	1378.95	1461.98	1628.80	1456.29	1440.01
0.4899	1485.74	1477.70	1383.44	1471.77	1640.05	1466.26	1449.79
0.5990	1496.51	1487.47	1395.38	1482.11	1635.33	1477.25	1462.39
0.7192	1505.99	1497.27	1417.69	1493.06	1614.39	1489.32	1477.58
0.8521	1513.94	1507.11	1455.28	1504.67	1575.20	1502.54	1495.75
1.0000	1517.00	1517.00	1517.00	1517.00	1517.01	1517.00	1517.00
			313.15K				
0.0000	1399.00	1399.00	1399.00	1399.00	1399.01	1399.00	1399.00
0.0664	1412.05	1409.81	1385.58	1407.61	1461.24	1405.60	1398.76
0.1380	1423.48	1420.68	1374.58	1416.66	1513.22	1413.06	1401.69
0.2153	1434.53	1431.59	1366.46	1426.17	1556.31	1421.41	1406.92
0.2991	1446.06	1442.56	1361.85	1436.18	1590.09	1430.69	1414.20
0.3903	1458.40	1453.57	1361.65	1446.73	1614.40	1440.95	1423.23
0.4899	1471.53	1464.64	1367.15	1457.87	1626.08	1452.26	1434.60
0.5990	1484.90	1475.75	1380.32	1469.64	1623.63	1464.68	1448.46
0.7192	1496.80	1486.92	1404.25	1482.11	1605.08	1478.28	1465.11
0.8521	1504.60	1498.13	1444.12	1495.34	1568.01	1493.15	1485.08
1.0000	1509.40	1509.40	1509.40	1509.40	1509.42	1509.40	1509.29
			318.15K				
0.0000	1390.00	1390.00	1390.00	1390.00	1390.02	1390.00	1390.00
0.0664	1404.37	1400.01	1376.44	1397.95	1454.87	1396.07	1388.10
0.1380	1415.40	1410.07	1365.25	1406.30	1507.46	1402.94	1390.03
0.2153	1425.72	1420.17	1356.88	1415.08	1549.60	1410.65	1394.67
0.2991	1436.41	1430.31	1351.94	1424.32	1581.82	1419.23	1401.46
0.3903	1447.73	1440.49	1351.30	1434.07	1604.66	1428.73	1409.91
0.4899	1460.12	1450.71	1356.21	1444.36	1615.33	1439.19	1420.50
0.5990	1473.13	1460.97	1368.56	1455.24	1612.03	1450.68	1433.43
0.7192	1484.73	1471.27	1391.33	1466.77	1592.55	1463.26	1449.10
0.8521	1491.75	1481.62	1429.47	1479.00	1554.03	1477.01	1468.17
1.0000	1492.00	1492.00	1492.00	1492.00	1492.01	1492.00	1492.06

not change upon mixing. Therefore, no interaction between the components of liquid mixtures has been taken into account. Similarly, the assumption for the formation of ideal mixing relation is that, the ratios of specific heats of ideal mixtures and the volumes are also equal. Again no molecular interactions are taken into account.

Full Paper

TABLE 3 : Experimental velocities (U/m.sec^{-1}), theoretical velocities (Ux/m.sec^{-1}) for the system Anisic aldehyde (AA) + N,N – di methyl acetamide (DMA)

X_1	U_{exp} ms^{-1}	U_{NR} ms^{-1}	U_{imx} ms^{-1}	U_{IR} ms^{-1}	U_R ms^{-1}	U_j ms^{-1}	U_D ms^{-1}
			303.15K				
0.0000	1436.00	1436.00	1423.00	1436.00	1436.00	1436.00	1436.00
0.0548	1446.38	1446.52	1398.60	1443.00	1515.74	1442.02	1433.23
0.1154	1455.13	1457.09	1376.64	1450.57	1586.34	1448.96	1433.50
0.1827	1463.61	1467.71	1357.68	1458.78	1645.51	1456.85	1436.79
0.2581	1473.10	1478.38	1342.53	1467.70	1694.51	1465.73	1442.08
0.3429	1483.41	1489.10	1332.42	1477.44	1730.25	1475.66	1449.61
0.4390	1495.04	1499.88	1329.29	1488.12	1748.23	1486.70	1459.95
0.5490	1508.25	1510.71	1336.39	1499.87	1736.75	1498.92	1475.64
0.6761	1522.11	1521.59	1359.56	1512.87	1699.62	1512.40	1495.00
0.8244	1533.81	1532.52	1410.52	1527.33	1636.14	1527.22	1517.57
1.0000	1543.50	1543.50	1517.00	1543.50	1543.50	1543.50	1543.50
			308.15K				
0.0000	1423.00	1423.00	1423.00	1423.00	1423.01	1423.00	1423.00
0.0548	1436.80	1432.23	1398.60	1429.12	1504.97	1428.12	1418.23
0.1154	1444.10	1441.50	1376.64	1435.73	1577.33	1434.08	1416.64
0.1827	1452.24	1450.80	1357.68	1442.90	1637.02	1440.91	1418.38
0.2581	1460.15	1460.14	1342.53	1450.70	1685.06	1448.65	1422.45
0.3429	1469.06	1469.52	1332.42	1459.22	1717.30	1457.34	1429.32
0.4390	1479.25	1478.94	1329.29	1468.55	1730.73	1467.03	1439.13
0.5490	1490.39	1488.40	1336.39	1478.83	1718.94	1477.77	1452.96
0.6761	1501.73	1497.89	1359.56	1490.20	1680.68	1489.63	1470.50
0.8244	1511.97	1507.43	1410.52	1502.85	1614.56	1502.68	1491.54
1.0000	1517.00	1517.00	1517.00	1517.00	1515.68	1517.00	1517.00
			313.15K				
0.0000	1406.00	1406.01	1406.00	1406.00	1406.01	1406.00	1406.00
0.0548	1420.98	1416.15	1382.10	1412.73	1491.79	1411.86	1400.62
0.1154	1430.14	1426.34	1360.64	1419.99	1566.14	1418.60	1399.17
0.1827	1437.50	1436.57	1342.19	1427.87	1626.79	1426.23	1401.48
0.2581	1445.67	1446.84	1327.57	1436.44	1673.85	1434.82	1406.76
0.3429	1455.30	1457.16	1318.02	1445.80	1706.65	1444.39	1414.53
0.4390	1467.00	1467.52	1315.51	1456.06	1719.47	1455.02	1425.71
0.5490	1479.39	1477.93	1323.35	1467.37	1709.57	1466.75	1440.40
0.6761	1492.61	1488.37	1347.48	1479.88	1673.44	1479.67	1458.95
0.8244	1504.86	1498.87	1399.93	1493.81	1609.21	1493.85	1481.33
1.0000	1509.40	1509.40	1509.40	1509.40	1509.42	1509.40	1509.40
			318.15K				
0.0000	1386.00	1386.00	1386.00	1386.00	1386.10	1386.00	1386.00
0.0548	1403.23	1396.41	1362.52	1392.88	1479.29	1392.13	1378.28
0.1154	1411.80	1406.86	1341.46	1400.31	1552.79	1399.13	1377.22
0.1827	1418.59	1417.35	1323.38	1408.38	1612.78	1407.02	1379.87
0.2581	1426.74	1427.89	1309.10	1417.16	1658.08	1415.86	1385.81
0.3429	1436.32	1438.47	1299.85	1426.75	1688.97	1425.70	1394.34
0.4390	1448.51	1449.09	1297.60	1437.27	1701.45	1436.58	1405.90
0.5490	1462.28	1459.75	1305.64	1448.86	1692.91	1448.57	1420.60
0.6761	1476.60	1470.46	1329.91	1461.70	1658.36	1461.74	1439.21
0.8244	1488.54	1481.21	1382.42	1475.99	1595.45	1476.19	1461.86
1.0000	1492.00	1492.00	1492.00	1491.9964	1492.01	1492.00	1492.06

But upon mixing, interactions between the molecules occur 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

TABLE 4 : Percentage deviations and interaction parameters (α) for the system anisic aldehyde (AA) +Formamide (FA)

X_1	% U_{NR}	% U_{imx}	% U_{IR}	% U_R	% U_J	% U_D	U^2/U^2_{imx}	α
				303.15K				
0.0000	0.0000	0.0000	-0.0001	0.0010	0.0000	0.0000	1.0000	0.0000
0.0353	-0.4549	-2.3399	-0.1992	1.4796	-0.4734	-1.0597	1.0481	0.0485
0.0761	-0.8437	-4.6085	-0.3546	2.1381	-0.8764	-1.7554	1.0983	0.0990
0.1238	-1.1942	-6.8121	-0.4989	2.6242	-1.2368	-2.3427	1.1514	0.1515
0.1802	-1.5303	-8.9360	-0.6635	2.7949	-1.5786	-2.8117	1.2067	0.2059
0.2479	-1.8014	-10.8688	-0.8073	2.7260	-1.8513	-3.1238	1.2616	0.2588
0.3309	-1.9960	-12.4842	-0.9336	2.3553	-2.0436	-3.2478	1.3102	0.3056
0.4348	-2.0497	-13.4972	-1.0002	1.7650	-2.0912	-3.1287	1.3417	0.3364
0.5687	-1.8650	-13.3225	-0.9451	1.0577	-1.8965	-2.6747	1.3370	0.3310
0.7479	-1.2937	-10.5180	-0.6832	0.3903	-1.3114	-1.7487	1.2540	0.2489
1.0000	0.0001	0.0000	0.0001	0.0004	0.0000	0.0000	1.0000	0.0000
				308.15K				
0.0000	0.0000	0.0000	-0.0003	-0.0005	0.0000	0.0000	1.0000	0.0000
0.0353	-0.4549	-2.3399	-1.6180	1.0305	-2.8005	-3.1417	1.0485	0.1048
0.0761	-0.8437	-4.6085	-2.2076	2.4222	-4.3764	-4.9237	1.0990	0.1893
0.1238	-1.1942	-6.8121	-2.3165	3.6863	-5.2787	-5.9304	1.1515	0.2596
0.1802	-1.5303	-8.9360	-2.2509	4.5480	-5.7946	-6.4742	1.2059	0.3179
0.2479	-1.8014	-10.8688	-2.1168	4.9386	-6.0017	-6.6570	1.2588	0.3618
0.3309	-1.9960	-12.4842	-1.7904	5.0202	-5.7444	-6.3425	1.3056	0.3805
0.4348	-2.0497	-13.4972	-1.3401	4.7046	-5.0355	-5.5483	1.3364	0.3668
0.5687	-1.8650	-13.3225	-0.7685	3.9183	-3.8018	-4.1893	1.3310	0.3081
0.7479	-1.2937	-10.5180	-0.6031	2.0275	-2.4498	-2.6511	1.2489	0.2010
1.0000	0.0001	0.0000	0.0000	0.0014	0.0000	0.0090	1.0000	0.0000
				313.15K				
0.0000	0.0000	0.0000	-0.0002	-0.0013	0.0000	0.0000	1.0000	0.0000
0.0353	-0.3782	-2.2863	-0.1387	1.8550	-0.3961	-1.1032	1.0473	0.0473
0.0761	-0.7228	-4.5335	-0.2641	2.7010	-0.7540	-1.8188	1.0972	0.0972
0.1238	-1.0742	-6.7582	-0.4220	3.0655	-1.1145	-2.3849	1.1502	0.1502
0.1802	-1.4148	-8.9046	-0.6017	3.1048	-1.4603	-2.8326	1.2051	0.2051
0.2479	-1.6939	-10.8606	-0.7617	2.9036	-1.7409	-3.1249	1.2585	0.2585
0.3309	-1.8970	-12.4962	-0.9010	2.4320	-1.9418	-3.2348	1.3060	0.3060
0.4348	-1.9554	-13.5212	-0.9715	1.8185	-1.9943	-3.1142	1.3372	0.3372
0.5687	-1.7770	-13.3518	-0.9148	1.1461	-1.8065	-2.6697	1.3319	0.3319
0.7479	-1.2325	-10.5516	-0.6605	0.4697	-1.2491	-1.7514	1.2498	0.2498
1.0000	0.0001	0.0000	-0.0002	0.0014	0.0000	-0.0073	1.0000	0.0000
				318.15K				
0.0000	0.0000	0.0000	0.0001	0.0005	0.0000	0.0000	1.0000	0.0000
0.0353	-0.4396	-2.3121	-0.1727	2.1677	-0.4616	-1.2943	1.0479	0.0479
0.0761	-0.8905	-4.6294	-0.3805	2.8652	-0.9292	-2.1096	1.0994	0.0994
0.1238	-1.2545	-6.8349	-0.5301	3.2449	-1.3049	-2.7030	1.1521	0.1521
0.1802	-1.5825	-8.9416	-0.6794	3.2306	-1.6396	-3.1218	1.2060	0.2060
0.2479	-1.8795	-10.8900	-0.8443	2.9099	-1.9384	-3.4027	1.2594	0.2594
0.3309	-2.0761	-12.5009	-0.9699	2.4352	-2.1322	-3.5037	1.3062	0.3062
0.4348	-2.1370	-13.5167	-1.0442	1.7998	-2.1857	-3.3771	1.3370	0.3370
0.5687	-1.9444	-13.3364	-0.9863	1.1704	-1.9814	-2.9215	1.3315	0.3315
0.7479	-1.3385	-10.5125	-0.7022	0.5231	-1.3593	-1.9197	1.2488	0.2488
1.0000	0.0000	0.0000	-0.0002	0.0005	0.0000	0.0040	1.0000	0.0000

that the molecular interactions are taking place between the unlike molecules[1]

The evaluated interaction parameters are positive for all the systems, indicating stronger interactions between the mixing molecules, which high for FA. This suggests somewhat stronger interaction of Anisic Aldehyde with FA in comparison to other amides[28]. The negative values indicate the dominance of dispersion

Full Paper

TABLE 5 : Percentage deviations and interaction parameters (α) for the system anisic aldehyde (AA) + N,N-Di Methyl Formamide (DMF)

X_1	% U_{NR}	% U_{imx}	% U_{IR}	% U_R	% U_J	% U_D	U^2/U^2_{imx}	α
				303.15K				
0.0000	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000	1.0000	0.0000
0.0664	0.0065	-1.6706	-0.1358	3.2440	-0.2808	-2.9658	1.0343	0.0343
0.1380	0.0080	-3.1579	-0.2500	5.8935	-0.5077	-5.1497	1.0663	0.0663
0.2153	-0.0542	-4.4905	-0.3995	8.0622	-0.7376	-6.7292	1.0962	0.0962
0.2991	-0.1377	-5.5879	-0.5404	9.5288	-0.9270	-7.6748	1.1219	0.1219
0.3903	-0.2533	-6.4055	-0.6816	10.2732	-1.0847	-8.0252	1.1416	0.1416
0.4899	-0.3654	-6.8308	-0.7855	10.2230	-1.1733	-7.6527	1.1520	0.1520
0.5990	-0.3489	-6.6277	-0.7253	9.1951	-1.0661	-6.7845	1.1470	0.1470
0.7192	-0.2917	-5.6886	-0.5857	7.1778	-0.8470	-5.2797	1.1243	0.1243
0.8521	-0.1182	-3.6197	-0.2880	4.1982	-0.4363	-3.1276	1.0765	0.0765
1.0000	0.0000	0.0000	0.0000	-0.0000	0.0000	-0.0000	1.0000	0.0000
				308.15K				
0.0000	0.0002	0.0000	-0.0003	0.0012	0.0000	0.0000	1.0000	0.0000
0.0664	-0.1632	-1.8102	-0.2987	3.2854	-0.4382	-0.8380	1.0372	0.0372
0.1380	-0.1918	-3.2999	-0.4370	6.0136	-0.6848	-1.3486	1.0694	0.0694
0.2153	-0.2329	-4.5887	-0.5612	8.2300	-0.8859	-1.7672	1.0985	0.0985
0.2991	-0.3181	-5.6686	-0.7010	9.7188	-1.0716	-2.0933	1.1238	0.1238
0.3903	-0.4250	-6.4640	-0.8323	10.4834	-1.2182	-2.3225	1.1430	0.1430
0.4899	-0.5409	-6.8851	-0.9405	10.3858	-1.3111	-2.4194	1.1534	0.1534
0.5990	-0.6045	-6.7580	-0.9622	9.2764	-1.2871	-2.2803	1.1502	0.1502
0.7192	-0.5789	-5.8629	-0.8583	7.1981	-1.1067	-1.8863	1.1284	0.1284
0.8521	-0.4511	-3.8746	-0.6125	4.0461	-0.7531	-1.2018	1.0822	0.0822
1.0000	0.0001	0.0000	0.0001	0.0004	0.0000	0.0000	1.0000	0.0000
				313.15K				
0.0000	0.0000	0.0000	-0.0003	0.0007	0.0000	0.0000	1.0000	0.0000
0.0664	-0.1584	-0.3143	-0.4575	3.4838	-0.4567	-0.9416	1.0386	0.0386
0.1380	-0.1971	-0.4796	-0.6553	6.3036	-0.7324	-1.5307	1.0724	0.0724
0.2153	-0.2049	-0.5830	-0.8182	8.4890	-0.9149	-1.9245	1.1021	0.1021
0.2991	-0.2423	-0.6834	-0.8615	9.9599	-1.0630	-2.2032	1.1275	0.1275
0.3903	-0.3312	-0.8003	-0.9226	10.6966	-1.1963	-2.4119	1.1472	0.1472
0.4899	-0.4683	-0.9282	-0.6994	10.5033	-1.3091	-2.5092	1.1585	0.1585
0.5990	-0.6160	-1.0272	-0.5287	9.3430	-1.3616	-2.4538	1.1573	0.1573
0.7192	-0.6603	-0.9811	-0.4628	7.2341	-1.2372	-2.1173	1.1362	0.1362
0.8521	-0.4298	-0.6153	-0.2988	4.2141	-0.7607	-1.2971	1.0855	0.0855
1.0000	0.0000	-0.0002	-0.0001	0.0014	0.0000	-0.0073	1.0000	0.0000
				318.15K				
0.0000	0.0000	0.0000	0.0003	0.0011	0.0000	0.0000	1.0000	0.0000
0.0664	-0.3104	-1.9889	-0.4572	3.5956	-0.5914	-1.1584	1.0410	0.0410
0.1380	-0.3763	-3.5429	-0.6428	6.5044	-0.8804	-1.7925	1.0748	0.0748
0.2153	-0.3894	-4.8287	-0.7466	8.6883	-1.0576	-2.1780	1.1040	0.1040
0.2991	-0.4242	-5.8804	-0.8412	10.1237	-1.1959	-2.4325	1.1289	0.1289
0.3903	-0.4998	-6.6609	-0.9435	10.8399	-1.3125	-2.6120	1.1478	0.1478
0.4899	-0.6445	-7.1169	-1.0797	10.6295	-1.4335	-2.7139	1.1591	0.1591
0.5990	-0.8250	-7.0981	-1.2141	9.4289	-1.5235	-2.6944	1.1586	0.1586
0.7192	-0.9059	-6.2905	-1.2095	7.2626	-1.4456	-2.3996	1.1388	0.1388
0.8521	-0.6793	-4.1750	-0.8550	4.1748	-0.9884	-1.5808	1.0890	0.0890
1.0000	0.0000	0.0000	-0.0002	0.0005	0.0000	0.0040	1.0000	0.0000

forces arising from the breakage of hydrogen bonds in the associates[29]

A positive value of α in all the system clearly indicates the existence of strong tendency for the formation of association in mixture through dipole-dipole interactions higher values of percentage deviation indicates maximum departure of the particular theory from experiment at that particular concentration and mag-

TABLE 6 : Percentage deviations and interaction parameters (α) for the system anisic aldehyde (AA) +N,N – Di Methyl Acetamide

X_1	% U_{NR}	% U_{imx}	% U_{IR}	% U_R	% U_J	% U_D	U^2/U^2_{imx}	α
				303.15K				
0.0000	0.0000	0.0000	-0.0001	-0.0003	0.0000	0.0000	1.0000	0.0000
0.1087	0.0098	-2.4028	-0.2331	4.7959	-0.3009	-0.9089	1.0498	0.0498
0.2152	0.1342	-4.4930	-0.3133	9.0170	-0.4243	-1.4868	1.0963	0.0963
0.3198	0.2801	-6.3299	-0.3299	12.4286	-0.4620	-1.8323	1.1397	0.1397
0.4224	0.3582	-7.9433	-0.3667	15.0300	-0.5005	-2.1061	1.1800	0.1800
0.5231	0.3841	-9.2349	-0.4019	16.6403	-0.5220	-2.2782	1.2138	0.2138
0.6220	0.3237	-10.1056	-0.4629	16.9351	-0.5577	-2.3471	1.2375	0.2375
0.7191	0.1628	-10.3529	-0.5556	15.1496	-0.6187	-2.1620	1.2443	0.2443
0.8144	-0.0342	-9.5350	-0.6068	11.6622	-0.6381	-1.7808	1.2219	0.2219
0.9080	-0.0845	-6.7084	-0.4229	6.6714	-0.4299	-1.0588	1.1490	0.1490
1.0000	0.0000	0.0000	0.0002	-0.0011	0.0000	0.0000	1.0000	0.0000
				308.15K				
0.0000	0.0003	0.0000	-0.0003	0.0010	0.0000	0.0000	1.0000	0.0000
0.1087	-0.3180	-2.6589	-0.5347	4.7448	-0.6041	-1.2926	1.0554	0.0554
0.2152	-0.1801	-4.6712	-0.5791	9.2262	-0.6935	-1.9013	1.1004	0.1004
0.3198	-0.0995	-6.5115	-0.6430	12.7238	-0.7802	-2.3315	1.1442	0.1442
0.4224	-0.0010	-8.0557	-0.6472	15.4026	-0.7877	-2.5824	1.1829	0.1829
0.5231	0.0312	-9.3015	-0.6699	16.8979	-0.7977	-2.7054	1.2156	0.2156
0.6220	-0.0208	-10.1374	-0.7228	17.0005	-0.8259	-2.7118	1.2383	0.2383
0.7191	-0.1339	-10.3329	-0.7757	15.3344	-0.8469	-2.5117	1.2438	0.2438
0.8144	-0.2554	-9.4666	-0.7676	11.9164	-0.8058	-2.0794	1.2201	0.2201
0.9080	-0.3001	-6.7093	-0.6030	6.7853	-0.6144	-1.3509	1.1490	0.1490
1.0000	0.0000	0.0000	0.0001	-0.0868	0.0000	0.0000	1.0000	0.0000
				313.15K				
0.0000	0.0000	0.0000	0.0003	0.0006	0.0000	0.0000	1.0000	0.0000
0.1087	-0.3398	-2.7364	-0.5809	4.9829	-0.6416	-1.4330	1.0571	0.0571
0.2152	-0.2660	-4.8597	-0.7098	9.5094	-0.8074	-2.1658	1.1048	0.1048
0.3198	-0.0647	-6.6299	-0.6699	13.1679	-0.7837	-2.5059	1.1471	0.1471
0.4224	0.0810	-8.1691	-0.6385	15.7833	-0.7508	-2.6917	1.1858	0.1858
0.5231	0.1278	-9.4330	-0.6527	17.2716	-0.7495	-2.8016	1.2192	0.2192
0.6220	0.0355	-10.3263	-0.7454	17.2100	-0.8169	-2.8144	1.2436	0.2436
0.7191	-0.0987	-10.5476	-0.8122	15.5591	-0.8540	-2.6352	1.2497	0.2497
0.8144	-0.2837	-9.7231	-0.8526	12.1149	-0.8669	-2.2550	1.2270	0.2270
0.9080	-0.3987	-6.9731	-0.7348	6.9336	-0.7317	-1.5640	1.1555	0.1555
1.0000	0.0000	0.0000	-0.0002	0.0014	0.0000	0.0000	1.0000	0.0000
				318.15K				

nitude of the chi-square value finally determines the overall validity of the theory[30]. The chi square values along with average percentage error are given in TABLE 7.

On the whole, all the theoretical models fairly predicted ultrasonic velocities, are reasonably close to the experimental values for and the three binary mixtures reported in this work, thus showing the validity of studied theoretical models for binary mixtures. The predictive abilities of various ultrasonic theories discussed above, depend upon the strength interaction prevailing in a system; these theories generally fail to predict accurately the ultrasonic velocities where strong interactions are supposed to exist and the average absolute percentage relative deviation is small in systems where the interactions are less or nil[28].

The experimental and theoretical values of viscosity of the liquid mixtures calculated using Eqs. (13)–(16) are presented in TABLE 8 and the interaction parameters derived by all above equations are presented in TABLE 9 along with standard deviation, σ, values. TABLE 9 shows that, out of all four different equations used to correlate experimental data of mixture viscosity standard deviation calculated using Hind et.al is lowest than any other equations. Hence, Hind equation is more convenient and fits well.

TABLE 7 : Values of Chi Square Test and Average Percentage Error for studied binary mixtures at different temperatures

	T/K	Nomoto		Imx		IR		Rao's		Junjie		Danusso	
		χ^2	APE	χ^2	APE	χ^2	APE	χ^2	APE	χ^2	APE	χ^2	APE
AA+FA	303.15K	0.2072	0.0188	13.1923	1.1993	0.0606	0.0055	0.4665	0.0424	0.2136	0.0194	0.5967	0.0542
	308.15K	0.3033	0.0276	12.7761	0.1278	0.0675	0.0061	0.5560	0.0505	0.3181	0.0289	0.8267	0.0752
	313.15K	0.2660	0.0242	12.6876	1.1534	0.0599	0.0054	0.6960	0.0633	0.2789	0.0254	0.8272	0.0752
	318.15K	0.3236	0.0294	12.6103	1.1464	0.0719	0.0065	0.7500	0.0682	0.3415	0.0310	0.4370	0.0397
AA+DMF	303.15K	0.0061	0.0006	3.2936	0.2994	0.0351	0.0032	7.6841	0.6986	0.0864	0.0079	0.3173	0.0288
	308.15K	0.0216	0.0020	3.3895	0.3081	0.0634	0.0058	7.8001	0.7091	0.1245	0.0113	0.4232	0.0385
	313.15K	0.0216	0.0020	3.3895	0.3081	0.3888	0.0353	6.2589	0.5690	0.5219	0.0474	1.0899	0.0991
	318.15K	0.0426	0.0039	3.6672	0.3334	0.1010	0.0092	8.2113	0.7465	0.1701	0.0155	0.5936	0.0540
AA+DMA	303.15K	0.0069	0.0006	7.6143	0.6922	0.0222	0.0020	19.7401	1.7946	0.0311	0.0028	0.4126	0.0375
	308.15K	0.0043	0.0004	7.6263	0.6933	0.0534	0.0049	20.1556	1.8323	0.0688	0.0063	1.2505	0.1137
	313.15K	0.0062	0.0032	7.8988	0.7181	0.0613	0.0056	20.8380	1.8944	0.0729	0.0066	0.6701	0.0609
	318.15K	0.0111	0.0010	8.0345	0.7304	0.0762	0.0069	21.5761	1.9615	0.0851	0.0077	0.7832	0.0712

TABLE 8 : Experimental and calculated values of viscosity (η)for the binary mixtures of Anisaldehyde and studied Acetates (FA+DMF+DMA) at temperatures 303.15K,308.15 K,313.15 K and 318.15 K.

X_1	η Expt	η GN	η KC	η HB	η H	η Expt	η GN	η KC	η HB	η H
					AA +FA					
			303.15 K					308.15 K		
0.0000	2.967	2.967	2.967	2.967	2.967	2.654	2.654	2.654	2.654	2.654
0.0353	3.026	3.022	3.010	3.004	3.023	2.693	2.695	2.688	2.680	2.696
0.0761	3.096	3.083	3.063	3.056	3.086	2.746	2.741	2.724	2.716	2.742
0.1238	3.168	3.152	3.129	3.123	3.154	2.801	2.792	2.771	2.765	2.793
0.1802	3.250	3.230	3.211	3.209	3.229	2.867	2.848	2.829	2.829	2.848
0.2479	3.337	3.315	3.311	3.316	3.310	2.937	2.909	2.901	2.909	2.906
0.3309	3.417	3.408	3.431	3.445	3.397	3.001	2.974	2.987	3.005	2.967
0.4348	3.466	3.505	3.565	3.592	3.486	3.028	3.039	3.083	3.113	3.027
0.5687	3.502	3.593	3.694	3.731	3.567	3.036	3.093	3.172	3.211	3.078
0.7479	3.538	3.644	3.757	3.792	3.618	3.035	3.113	3.203	3.238	3.098
1.0000	3.578	3.578	3.578	3.578	3.578	3.035	3.035	3.035	3.035	3.035
			313.15 K					318.15 K		
0.0000	2.404	2.404	2.404	2.404	2.404	2.219	2.219	2.219	2.219	2.219
0.0353	2.433	2.436	2.430	2.421	2.436	2.239	2.243	2.240	2.229	2.243
0.0761	2.471	2.470	2.457	2.448	2.471	2.264	2.268	2.257	2.247	2.269
0.1238	2.513	2.508	2.490	2.484	2.509	2.298	2.296	2.279	2.274	2.296
0.1802	2.564	2.550	2.532	2.533	2.550	2.338	2.326	2.308	2.310	2.326
0.2479	2.622	2.595	2.585	2.595	2.593	2.382	2.358	2.346	2.357	2.356
0.3309	2.673	2.642	2.649	2.669	2.637	2.420	2.390	2.392	2.414	2.387
0.4348	2.688	2.687	2.720	2.752	2.680	2.427	2.418	2.444	2.476	2.413
0.5687	2.682	2.722	2.786	2.825	2.712	2.409	2.435	2.488	2.526	2.429
0.7479	2.666	2.726	2.801	2.835	2.717	2.380	2.423	2.487	2.520	2.418
1.0000	2.649	2.649	2.649	2.649	2.649	2.340	2.340	2.340	2.340	2.340
					AA +DMF					
			303.15 K					303.15 K		
0.0000	0.776	0.776	0.776	0.776	0.776	0.733	0.733	0.733	0.733	0.733
0.0664	1.024	0.969	0.969	0.967	1.033	0.944	0.901	0.901	0.899	0.955
0.1380	1.282	1.208	1.207	1.204	1.299	1.168	1.106	1.106	1.103	1.183
0.2153	1.566	1.498	1.498	1.494	1.573	1.404	1.351	1.351	1.348	1.416
0.2991	1.865	1.844	1.842	1.840	1.855	1.658	1.639	1.637	1.636	1.654
0.3903	2.178	2.239	2.238	2.239	2.143	1.921	1.964	1.962	1.963	1.896

X_1	η Expt	η GN	η KC	η HB	η H	η Expt	η GN	η KC	η HB	η H
					AA +DMF					
			303.15 K					303.15 K		
0.4899	2.494	2.669	2.669	2.673	2.436	2.179	2.312	2.310	2.316	2.138
0.5990	2.758	3.094	3.094	3.105	2.731	2.410	2.652	2.651	2.662	2.379
0.7192	3.016	3.452	3.451	3.468	3.023	2.622	2.936	2.935	2.950	2.613
0.8521	3.286	3.648	3.647	3.662	3.308	2.822	3.090	3.090	3.103	2.835
1.0000	3.578	3.578	3.578	3.578	3.578	3.035	3.035	3.035	3.035	3.035
			303.15 K					303.15 K		
0.0000	0.695	0.695	0.695	0.695	0.695	0.653	0.653	0.653	0.653	0.653
0.0664	0.896	0.852	0.852	0.850	0.900	0.825	0.791	0.791	0.789	0.831
0.1380	1.104	1.041	1.041	1.038	1.109	1.008	0.955	0.956	0.952	1.012
0.2153	1.318	1.266	1.265	1.262	1.321	1.193	1.149	1.148	1.145	1.196
0.2991	1.538	1.526	1.524	1.523	1.534	1.386	1.371	1.369	1.368	1.381
0.3903	1.757	1.817	1.814	1.816	1.747	1.578	1.617	1.614	1.617	1.565
0.4899	1.970	2.122	2.119	2.126	1.956	1.767	1.874	1.870	1.877	1.745
0.5990	2.168	2.412	2.409	2.421	2.158	1.936	2.118	2.114	2.126	1.919
0.7192	2.349	2.640	2.638	2.652	2.346	2.082	2.313	2.310	2.324	2.081
0.8521	2.508	2.742	2.741	2.753	2.513	2.212	2.405	2.404	2.415	2.225
1.0000	2.649	2.649	2.649	2.649	2.649	2.340	2.340	2.340	2.340	2.340
					AA+ DMA					
			303.15 K					303.15 K		
0.0000	0.876	0.876	0.876	0.876	0.876	0.818	0.818	0.818	0.818	0.818
0.0548	1.464	1.246	1.245	1.240	1.485	1.280	1.135	1.135	1.130	1.336
0.1154	2.108	1.772	1.770	1.760	2.097	1.844	1.575	1.575	1.565	1.855
0.1827	2.830	2.502	2.497	2.485	2.700	2.493	2.173	2.169	2.159	2.366
0.2581	3.600	3.480	3.472	3.463	3.279	3.180	2.954	2.948	2.940	2.856
0.3429	4.303	4.693	4.682	4.687	3.810	3.778	3.901	3.892	3.898	3.302
0.4390	4.502	6.005	5.996	6.025	4.256	3.921	4.907	4.896	4.927	3.676
0.5490	4.389	7.059	7.047	7.119	4.565	3.795	5.706	5.693	5.758	3.930
0.6761	4.153	7.253	7.241	7.339	4.654	3.587	5.852	5.842	5.926	3.993
0.8244	3.894	6.026	6.021	6.092	4.393	3.306	4.927	4.922	4.983	3.753
1.0000	3.578	3.578	3.578	3.578	3.578	3.035	3.035	3.035	3.035	3.035
			303.15 K					303.15 K		
0.0000	0.773	0.773	0.773	0.773	0.773	0.728	0.728	0.728	0.728	0.728
0.0548	1.175	1.051	1.052	1.047	1.212	1.121	0.986	0.986	0.981	1.123
0.1154	1.653	1.430	1.430	1.421	1.652	1.542	1.334	1.336	1.326	1.518
0.1827	2.193	1.934	1.931	1.921	2.085	2.010	1.795	1.794	1.783	1.906
0.2581	2.766	2.580	2.573	2.568	2.501	2.504	2.382	2.376	2.371	2.276
0.3429	3.321	3.350	3.339	3.347	2.880	2.953	3.074	3.063	3.071	2.613
0.4390	3.432	4.155	4.140	4.172	3.196	3.023	3.789	3.771	3.803	2.892
0.5490	3.277	4.787	4.770	4.830	3.411	2.901	4.335	4.313	4.373	3.077
0.6761	3.058	4.903	4.889	4.965	3.464	2.738	4.406	4.391	4.460	3.113
0.8244	2.836	4.173	4.167	4.220	3.260	2.551	3.719	3.714	3.760	2.913
1.0000	2.649	2.649	2.649	2.649	2.649	2.340	2.340	2.340	2.340	2.340

TABLE 9 : Interaction parameters calculated from Eqs. and the corresponding standard deviations(σ) for the binary mixtures of Anisaldehyde and acetates under study (FA,DMF,DMA) at temperatures 303.15 K, 308.15 K 313.15 K, and 318.15 K.

T/K	G12		Wvis/RT		Δ12		H12	
	I.P	σ	I.P	σ	I.P	σ	I.P	σ
				AA+FA				
303.15K	0.347	0.047	0.990	0.100	1.057	0.118	3.787	0.036
308.15K	0.314	0.034	0.946	0.074	1.023	0.092	3.267	0.029

Full Paper

T/K	G12		Wvis/RT		Δ12		H12	
	I.P	σ	I.P	σ	I.P	σ	I.P	σ
				AA+FA				
313.15K	0.282	0.026	0.904	0.058	0.989	0.075	2.871	0.024
318.15K	0.256	0.021	0.870	0.046	0.962	0.062	2.567	0.020
				AA+DMF				
303.15K	1.947	0.219	2.004	0.219	2.145	0.227	2.752	0.025
308.15K	1.811	0.160	1.863	0.160	2.009	0.167	2.440	0.020
313.15K	1.843	0.153	1.889	0.152	2.042	0.159	2.280	0.007
318.15K	1.717	0.120	1.756	0.118	1.915	0.125	2.028	0.011
				AA+DMA				
303.15K	5.308	1.548	5.441	1.542	5.672	1.588	6.681	0.309
308.15K	4.938	1.125	5.064	1.119	5.305	1.159	5.753	0.282
313.15K	4.633	0.904	4.751	0.896	5.000	0.932	4.958	0.264
318.15K	4.617	0.832	4.726	0.823	4.982	0.857	4.491	0.223

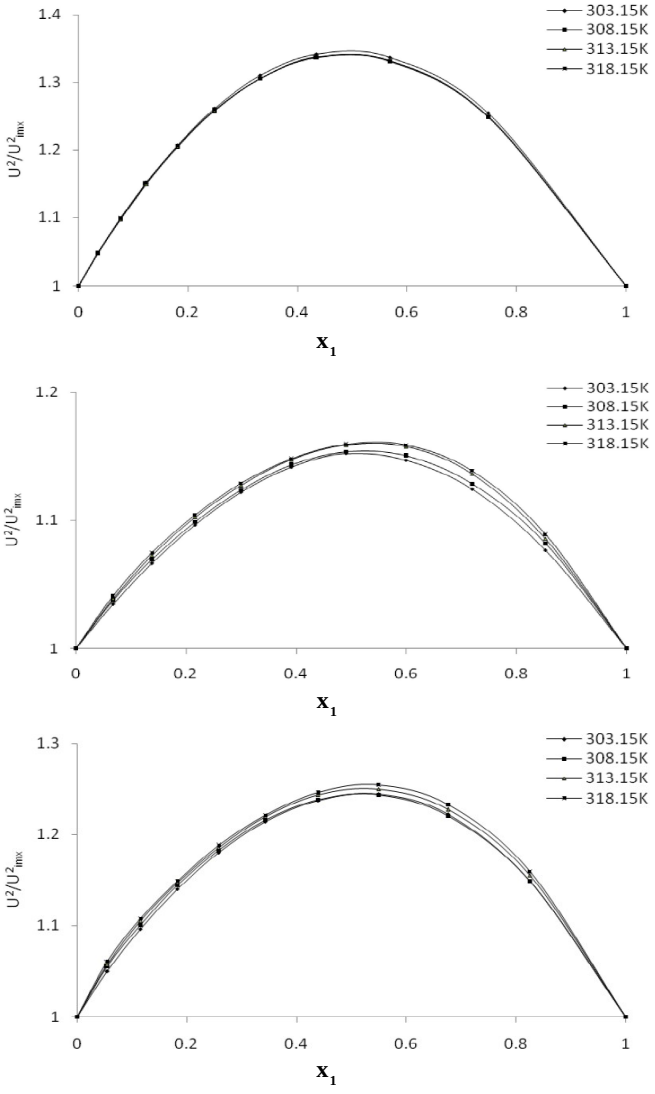

Figure 1 : Variation of (U_2/U^2_{imix}) for the system AA + DMA at temperature 303.15K,308.15K,313.15K and 318.15K against mole fraction of AA (X_1)

REFERENCES

[1] C.Rambabu, P.B.Sandhya Sri. Zareena Begum; International Scholarly Research Network ISRN Physical Chemistry Volume, Article ID 943429, 12 **(2012)**.

[2] C.Rambabu, G.V.Rama Rao, A.Viswanatha Sarma, J.Siva Rama Krishna; Indian Journal of Pure & Applied Physics May, **43**, 345 **(2005)**.

[3] N.Santhi, P.L.Sabarathinam, M.Emayavaramban, C.Gopi, C.Manivannan; E.J.of Chemistry, **7(2)**, 648 **(2010)**.

[4] A.Ali, A.K.Nain; Pramana – J. of Physics April, **58(4)**, 695 **(2002)**.

[5] K.Raju, K.Karpagavalli; J.of Convergence in Engineering and Technology and Science, December, **1**, 32 **(2009)**.

[6] Prabhakar, K.Raja Gopal; J.of Pure & Applied Ultrasonics, **27**, 41 **(2005)**.

[7] Yuva Rani, S.Sunitha; E.J.of Chemistry, **6(SI)**, S235 **(2009)**.

[8] S.Ravi Chandran, K.Rama Nathan; Aug–Oct, **1(2)**, 695-702 **(2010)**.

[9] J.D.Pandeym, A.K.Singh, Rajan Pandey Pramana; J.of Physics, January, **64(1)**, 135 **(2005)**.

[10] (a) O.Nomoto; J.Phys.Soc., Japan, **4**, 280 **(1949)**; **(b) 13**, 1528 **(1958)**; **(c)** J.Chem.Phys., **21**, 950 **(1953)**.

[11] W.Van Dael, E.Vangael; Pro Int Conf on Calori metric and Thermodynamics, Warsaw, 555 **(1955)**.

[12] Shipra Baluja, P.H.Parsania; Asian.J.Chem., **7**, 417 **(1995)**.

[13] V.D.Gokhale, N.N Bhagavat; J.Pure Appl.

Ultrason., **11**, 21 **(1989)**.
[14] Z.Junjie; J.China Univ.Sci.Techn., **14**, 298 **(1984)**.
[15] Suhasini Ernest, P.Kavitha; Chemical Environmental and Pharmaceutical Researchm, **2**, 92 **(2011)**.
[16] L.Grunberg, A.H.Nissan; Mixture law for viscosity, Nature, **164**, 799 **(1949)**.
[17] P.K.Katti, M.M.Chaudhri; J.Chem.Eng.Data, **9**, 442 **(1964)**.
[18] E.L.Heric, J.G.Brewer; J.Chem.Eng.Data, **12** 574 **(1967)**.
[19] R.K.Hind, E.McLaughlin, A.R.Ubbelohde; Trans.Faraday Soc., **56**, 328 **(1960)**.
[20] K.Pearson; Fundamentals of Mathematical Statistics, S.G.Gupta, V.K.Kapoor, S.Chand, Company, (Eds.); New Delhi, India, 903 **(1973)**.
[21] Jyh-Shing, Roger Jang; IEEE Trans Syst Man.Cybern., **23(4)**, 665 **(1993)**.
[22] Y.Marcus; Introduction to Liquid state chemistry, wiley interscience, New York, (**1977)**.
[23] G.A.Krestov; Thermodynamics of salvation, Ellis-Horwood Ltd, England, **(1991)**.
[24] M.M.H.Bhuiyan, M.H.Uddin; J.Mol.Liq., 138-139 **(2008)**.
[25] P.J.Victor, D.Das, D.K.Hazra; J.Indian.Chem.Soc., **81**, 1045 **(2004)**.
[26] Rakesh Kumar Bhardwaj, Amalendu Pal; J.Mol.Liq., **118**, 37 **(2005)**.
[27] C.Rambabu, G.V.Rama Rao, A.Viswanatha Sarma, J.Siva Rama Krishna;. Indian Journal of Pure & Applied Physics, May, **43**, 345 **(2005)**.
[28] N.Santhi, P.L.Sabarathinam, M.Emayavaramban, C.Gopi, C.Manivannan; E.J. of Chemistry, **7(2)**, 648-654 **(2010)**.
[29] W.Schaaffs; Molekutarakustik chapter XI and XII,Springer-verlag-Berlin-Gottingen-Heidelberg, **(1963)**.
[30] K.Meenakhshi, R.Palani; Indian Journal of Chemistry, **46A**, 252 **(2007)**.