

Acoustic Studies on Different Binary Liquid Mixtures of LIX Reagents with Different Diluents

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ABSTRACT. Ultrasonic velocity and density measurements have been undertaken for a number of binary liquid mixtures involving different commercial solvent extractants, LIX reagents. The binary mixtures under investigation have been classified under two categories such as polar-polar, and polar-non-polar types. Different theories and relations such as Schaaff's Collision Factor Theory (CFT), Nomoto's relation (NOM), and Van Dael & Vangeel ideal mixing relation (IMR) have been used to evaluate the velocity theoretically for all these binary systems. The relative merits of afore-mentioned theories and relations compared to experimental values of velocity have been discussed in terms of percentage variations. However, the CFT and Nomoto's relation show better agreement with the experimental findings than the ideal mixing relation for all the systems under investigation.

Key words: Sound velocity, Solvent extractants, Schaaff's collision factor theory, Nomoto's relation, Van Dael & Vangeel ideal mixing relation

INTRODUCTION

Theoretical evaluation of sound velocity in liquids has been investigated by many workers employing various Factors. Schaaffs,^{1,2} on the basis of collision factor theory (CFT), developed a relation for the evaluation of sound velocity in pure liquids. The theory was extended to binary liquid mixtures by Nutsch-Kuhnkie,³ Sheshadri et al.^{4,5} Basing on the assumption of linearity of molar sound velocity, Nomoto⁶ established an empirical formula for sound velocity in binary mixtures and Bhimsenachar et al.⁷ computed the ultrasonic velocity using this relation. Besides, Van Dael and Vangeel⁸ established ideal mixing relation (IMR) for evaluating sound velocity. Review of literatures⁹⁻¹⁷ shows that many successful attempts have been made to compute ultrasonic velocity for quite a number of binary liquid systems employing the afore-said relations. But, however, the binary mixtures involving commercial extractants are scarce in literature.

Commercially available LIX reagents are the substituted acetophenone oximes^{18,19} and are widely used as extractants for the extraction of nuclear strategic metals like uranium and thorium.²⁰ Besides, TBP is also used as an effective extractant for the separation and isolation of plutonium and uranium from the fission products and other nuclides. In the chemical processing of nuclear fuels (PUREX process) and with suitable diluents and modi-

fiers, TBP has shown its utility for the extraction of various metal ions.²¹ All these binary systems can effectively be employed as the organic phase of solvent extraction during the extraction of various metals. In the present study, special efforts have been made to evaluate the sound velocity in different binary liquid mixtures involving commercial solvent extractants and diluents. Commercially available LIX reagents (Liquid Ion Exchanger) such as LIX 84, LIX 622, LIX 860 and LIX 980 have been taken with amyl alcohol, TBP and benzene for investigation at 303.15 K temperature. The binary mixtures of different LIX reagents with amyl alcohol and tri-n-butyl phosphate (TBP) fall under polar-polar category whereas LIX reagents with benzene come under the category polar – non-polar type. The theoretical values of sound velocity have been compared with the experimental values and the deviations in values may indicate the existence of molecular interactions.

EXPERIMENTAL

The LIX reagents were supplied by Henkel Corporation, Ireland and were used as received. TBP (SRL), benzene and amyl alcohol (Merk), analytical reagent grade (AR) were used. The solutions were prepared on percentage basis (v/v) by dissolving known volumes of LIX reagents in appropriate volumes of benzene, amyl alcohol and TBP, and measuring their masses on Metler-Toledo

AB 54 electronic balance.

The densities of all the mixture solutions were measured by a bicapillary pycnometer calibrated with deionised double distilled water with $0.996 \times 10^3 \text{ kg m}^{-3}$ as its density at 303.15K. The precision of density measurement was within $\pm 0.0003 \text{ kg m}^{-3}$. The ultrasonic velocity of the mixtures as well as of the pure ones were measured at 303.15K by a single crystal variable path ultrasonic interferometer operating at 5 MHz frequency supplied by Mittal Enterprise, N. Delhi. The temperature of the solution was maintained constant within $\pm 0.01\text{K}$ by circulation of water from thermostatically regulated water bath through the water-jacketed cell. The velocity measurement was precise up to $\pm 0.5 \text{ ms}^{-1}$.

RESULTS AND DISCUSSIONS

The theoretical values of ultrasonic velocity in the present binary mixtures were calculated using Schaaff's collision factor theory (CFT), Nomoto's relation (NOM), and Van Dael and Vangeel ideal mixing relation (IMR) by the following expressions:

$$U_{CFT} = U_{\infty}(x_1S_1 + x_2S_2) \frac{x_1B_1 + x_2B_2}{V} \quad (1)$$

Here S_1 , S_2 and B_1 , B_2 are the respective collision factors and geometrical volumes of the molecules per mole of components 1 & 2 having mole fractions x_1 & x_2 . U_{∞} is taken to be 1600 ms^{-1} . Geometrical volume B can be obtained by using the equation.¹²

$$B = \frac{4\pi}{3} r^3 N \quad (2)$$

where N is the Avogadro's number and r is the molecular radius.

$$U_{NOM} = \left[\frac{x_1R_1 + x_2R_2}{x_1V_1 + x_2V_2} \right]^3 \quad (3)$$

where R_1 , R_2 and V_1 , V_2 are the molar sound velocity and molar volume of component 1 and 2, respectively

$$U_{IMR} = U_1U_2 \times \left[\frac{M_1M_2}{\{(x_1M_2U_2^2 + x_2M_1U_1^2)(x_1M_1 + x_2M_2)\}} \right]^{1/2} \quad (4)$$

where M_1 , M_2 are the molecular masses of corresponding components. Various parameters like geometrical volume, molecular radius, etc. have been calculated from the measured values of density and ultrasonic velocity for

pure liquids and which are in turn employed to find collision factor of liquid mixtures to evaluate sound velocities using collision factor theory. Experimentally observed ultrasonic velocity, U_{EXP} and theoretically computed values obtained from the afore-said relations, U_{CFT} , U_{NOM} , U_{IMR} along with their percentage variations from the experimental velocity have been summarised in Table 1 to 3. Comparison of experimentally observed ultrasonic velocities with those obtained theoretically in all the above binary systems have been displayed graphically [Figs. 1-12].

A close perusal of Table 1 for the velocities of different LIX reagents with amyl alcohol indicate that Nomoto's relation, with minimum percentage variations fits the experimental data well, followed by collision factor theory and then by ideal mixing relation, which is found to show the maximum variations from the experimental values. In the binary mixtures of LIX reagents with TBP and with benzene [in Table 2 & 3], both Nomoto's relation as well as CFT are almost equally suited with the experimental results well followed by the ideal mixing relation showing maximum percentage variations. But, however, the percentage difference obtained in U_{IMR} for these binary systems are comparatively low to those obtained for LIX reagents with amyl alcohol.

From Figures, it reveals that the experimental velocities are in a regular increase with the concentrations for all the systems under investigation. Both U_{CFT} and U_{NOM} values show approximately similar trends with U_{EXP} data, whereas those for U_{IMR} decrease first with concentration and then increase giving minima at around 0.3-0.5 mole fraction for all the binary systems, which indicates that Nomoto's relation and collision factor theory are quite satisfactory and seem to be equally good in predicting the experimental data, rather there is not any remarkable deviation between the experimental velocity values and those calculated from both the theories. But, however, the ideal mixing relation is on the other hand shown to deviate more from the experimental findings than the afore-said two theories for all the systems. The limitations and approximation incorporated in the ideal mixing theory is supposed to be responsible for such variations. According to the assumption for the formation of ideal mixing relation, the ratio of specific heats of the components is equal to the ratio of specific heats of ideal mixtures, indicating the equality in volumes.¹⁷ This implies that no interaction should be entitled here. But, on mixing of components, specially polar-polar and non-polar-polar types of components there is the probability of various types of forces like hydrogen bonding, dipole-dipole, dipole-induced-dipole, dispersion forces,

Table 1. Theoretical values of ultrasonic velocities calculated from CFT (U_{CFT}), Nomoto's (U_{NOM}) and Van Dael & Vangeel's ideal mixing relation (U_{IMR}) along with experimental values of ultrasonic velocity (U_{EXP}) and percentage difference for the binary liquid systems

x_i	U ms ⁻¹				% Variations			
	LIX s	Exp.	CFT	NOM	IMR	CFT	NOM	IMR
LIX 84 + amyl alcohol								
0.000	1210.3	1210.3	1210.3	1210.3	1210.3	0.00	0.00	0.00
0.039	1239.2	1243.7	1243.7	1238.1	1112.8	0.36	0.08	10.20
0.066	1253.2	1244.3	1244.3	1252.9	1061.3	0.71	0.02	15.31
0.099	1278.2	1250.4	1250.4	1267.5	1010.7	2.17	0.83	20.92
0.199	1306.8	1257.7	1257.7	1297.8	909.5	3.75	0.68	30.40
0.278	1313.8	1266.1	1266.1	1313.1	863.4	3.63	0.05	34.28
0.398	1338.6	1279.4	1279.4	1328.8	827.7	4.42	0.73	38.16
0.598	1355.8	1298.9	1298.9	1344.8	835.1	4.19	0.81	38.40
0.759	1356.0	1325.7	1325.7	1352.9	908.8	2.23	0.22	32.97
1.000	1361.0	1361.0	1361.0	1361.0	1361.0	0.00	0.00	0.00
LIX 622 + amyl alcohol								
0.000	1210.3	1210.3	1210.3	1210.3	1210.3	0.00	0.00	0.00
0.021	1233.6	1246.3	1246.3	1226.2	1164.5	1.03	0.60	5.60
0.046	1250.5	1248.4	1248.4	1242.3	1118.5	0.17	0.65	10.55
0.077	1268.5	1246.7	1246.7	1259.1	1071.4	1.72	0.74	15.54
0.115	1287.5	1254.5	1254.5	1276.0	1024.9	2.56	0.89	20.39
0.164	1305.2	1261.0	1261.0	1293.5	978.8	3.38	0.89	25.01
0.227	1331.6	1262.9	1262.9	1310.9	935.7	5.16	1.55	29.73
0.314	1348.0	1278.5	1278.5	1328.8	897.6	5.15	1.42	33.41
0.440	1362.0	1296.4	1296.4	1346.9	874.2	4.82	1.11	35.81
0.639	1365.0	1316.0	1316.0	1365.3	900.9	3.59	0.02	34.00
0.788	1383.7	1341.8	1341.8	1374.6	986.1	3.03	0.65	28.73
1.000	1384.1	1384.1	1384.1	1384.1	1384.1	0.00	0.00	0.00
LIX 860 + amyl alcohol								
0.000	1210.3	1210.3	1210.3	1210.3	1210.3	0.00	0.00	0.00
0.021	1243.6	1287.8	1287.8	1226.8	1164.5	3.55	1.35	6.36
0.046	1249.2	1283.5	1283.5	1243.7	1118.5	2.74	0.44	10.46
0.077	1265.8	1281.6	1281.6	1261.4	1071.5	1.25	0.35	15.35
0.115	1283.8	1282.7	1282.7	1279.4	1025.1	0.08	0.34	20.15
0.164	1306.5	1287.2	1287.2	1298.0	979.0	1.48	0.65	25.07
0.227	1318.3	1288.0	1288.0	1316.6	936.0	2.30	0.13	28.99
0.314	1330.0	1297.1	1297.1	1335.9	898.1	2.47	0.44	32.47
0.440	1351.5	1311.1	1311.1	1355.6	874.9	2.99	0.30	35.26
0.639	1361.1	1339.5	1339.5	1375.7	902.4	1.58	1.07	33.70
0.788	1375.2	1362.4	1362.4	1385.9	988.9	0.93	0.77	28.09
1.000	1396.5	1396.5	1396.5	1396.3	1396.0	0.00	0.01	0.03
LIX 984 + amyl alcohol								
0.000	1210.3	1210.3	1210.3	1210.3	1210.3	0.00	0.00	0.00
0.016	1222.0	1234.3	1234.3	1222.4	1170.1	1.07	0.03	4.25
0.042	1251.7	1347.0	1347.0	1239.2	1115.5	7.61	1.00	10.88
0.071	1264.4	1248.7	1248.7	1254.6	1065.8	1.24	0.77	15.70
0.106	1290.8	1255.7	1255.7	1269.8	1017.5	2.72	1.62	21.17
0.152	1297.7	1254.9	1254.9	1285.6	968.3	3.30	0.93	25.38
0.211	1317.8	1264.1	1264.1	1301.2	922.1	4.07	1.26	30.03
0.294	1333.0	1264.3	1264.3	1317.4	879.4	5.15	1.17	34.03
0.417	1341.8	1287.9	1287.9	1333.8	849.1	4.01	0.59	36.72
0.617	1364.6	1303.9	1303.9	1350.4	865.2	4.45	1.04	36.59
0.773	1366.5	1338.7	1338.7	1358.8	944.5	2.03	0.56	30.88
1.000	1367.3	1367.3	1367.3	1367.3	1367.3	0.00	0.00	0.00

Table 2. Theoretical values of ultrasonic velocities calculated from CFT(U_{CFT}), Nomoto's (U_{NOM}) and Van Dael & Vangeel's ideal mixing relation (U_{IMR}) along with experimental values of ultrasonic velocity (U_{EXP}) and percentage difference for the binary liquid systems

x_i	U ms ⁻¹				% Variations			
	LIX s	Exp.	CFT	NOM	IMR	CFT	NOM	IMR
LIX 84 + TBP								
0.0000	1252.8	1252.8	1252.8	1252.8	1252.8	0.00	0.00	0.00
0.0440	1254.1	1269.5	1262.9	1262.9	1237.0	1.23	0.70	1.36
0.1515	1264.8	1290.6	1283.7	1283.7	1207.7	2.04	1.49	4.51
0.2172	1281.0	1295.0	1294.3	1294.3	1195.6	1.09	1.03	6.66
0.2941	1290.5	1301.2	1305.1	1305.1	1186.3	0.83	1.13	8.07
0.3847	1301.0	1309.5	1315.9	1315.9	1181.8	0.65	1.14	9.16
0.4929	1314.0	1318.1	1327.0	1327.0	1185.1	0.31	0.99	9.81
0.6250	1326.0	1331.0	1338.2	1338.2	1202.5	0.37	0.92	9.31
0.7895	1348.5	1334.4	1349.5	1349.5	1248.0	1.04	0.07	7.45
1.0000	1361.0	1361.0	1361.0	1361.0	1361.0	0.00	0.00	0.00
LIX 622 + TBP								
0.0000	1252.8	1252.8	1252.8	1252.8	1252.8	0.00	0.00	0.00
0.0521	1258.3	1270.0	1265.1	1265.1	1242.7	0.93	0.50	1.24
0.1748	1269.0	1301.2	1290.2	1290.2	1226.5	2.54	1.64	3.35
0.2478	1303.0	1306.5	1302.1	1302.1	1221.4	0.27	0.02	6.26
0.3307	1324.1	1316.2	1316.1	1316.1	1219.5	0.59	0.63	7.90
0.4257	1342.7	1326.1	1329.3	1329.3	1222.5	1.23	1.01	8.95
0.5355	1355.2	1342.8	1342.7	1342.7	1232.9	0.91	0.94	9.02
0.6641	1365.1	1344.3	1356.3	1356.3	1255.3	1.52	0.66	8.04
0.8164	1377.5	1357.3	1370.0	1370.0	1298.8	1.46	0.55	5.71
1.0000	1384.0	1384.0	1384.0	1384.0	1384.0	0.00	0.00	0.00
LIX 860 + TBP								
0.0000	1252.8	1252.8	1252.8	1252.8	1252.8	0.00	0.00	0.00
0.0521	1274.3	1263.9	1265.9	1265.9	1245.2	0.81	0.65	2.28
0.1748	1296.0	1297.2	1293.5	1293.5	1227.4	0.09	0.19	5.29
0.2478	1300.7	1308.8	1307.7	1307.7	1222.7	0.62	0.54	5.99
0.3307	1321.1	1324.6	1321.9	1321.9	1221.4	0.26	0.06	7.54
0.4257	1332.8	1337.1	1336.4	1336.4	1225.1	0.32	0.27	8.08
0.5355	1348.2	1344.9	1351.0	1351.0	1236.4	0.24	0.21	8.29
0.6641	1361.4	1365.6	1365.8	1365.8	1260.3	0.31	0.32	7.42
0.8164	1379.5	1384.8	1380.8	1380.8	1306.1	0.38	0.09	5.32
1.0000	1396.0	1396.0	1396.0	1396.0	1396.0	0.00	0.00	0.00
LIX 984 + TBP								
0.0000	1252.8	1252.8	1252.8	1252.8	1252.8	0.00	0.00	0.00
0.0477	1255.4	1263.2	1263.1	1263.1	1239.6	0.62	0.61	1.26
0.1618	1282.6	1298.2	1285.0	1285.0	1216.4	1.21	0.19	5.16
0.2309	1290.5	1305.9	1296.3	1296.3	1207.5	1.19	0.45	6.43
0.3102	1312.0	1310.8	1307.7	1307.7	1201.6	0.09	0.33	8.41
0.4032	1326.0	1320.0	1319.3	1319.3	1200.5	0.45	0.50	9.46
0.5124	1336.2	1325.5	1331.1	1331.1	1206.9	0.80	0.38	9.67
0.6431	1349.5	1338.9	1343.0	1343.0	1226.4	0.78	0.48	9.12
0.8021	1363.5	1346.9	1355.0	1355.0	1270.7	1.21	0.62	6.80
1.0000	1367.3	1367.3	1367.3	1367.3	1367.3	0.00	0.00	0.00

charge transfer etc. operating in them, which may result in violating the assumption. The deviations in the ideal mixing relation is therefore, supposed to indicate as the presence of inter-molecular interaction in these binary mixtures

and this interaction may result in treating the component molecules to be elastic spheres, which is, in fact the basic concept for collision factor theory, corroborated from the similar trends of U_{CFT} and U_{EXP} in all the Figures. On the

Table 3. Theoretical values of ultrasonic velocities calculated from CFT(U_{CFT}), Nomoto's (U_{NOM}) and Van Dael & Vangeel's ideal mixing relation (U_{IMR}) along with experimental values of ultrasonic velocity (U_{EXP}) and percentage difference for the binary liquid systems

x_i	U ms ⁻¹				% Variations			
	LIX s	Exp.	CFT	NOM	IMR	CFT	NOM	IMR
LIX 84 + benzene								
0.0000	1257.2	1257.2	1257.2	1257.2	1257.2	0.00	0.00	0.00
0.0071	1266.8	1263.2	1262.1	1262.1	1232.5	0.28	0.37	2.70
0.0327	1272.6	1262.6	1277.1	1277.1	1156.7	0.78	0.35	9.11
0.1193	1278.1	1270.0	1307.8	1307.8	993.6	0.63	2.32	22.25
0.1689	1295.8	1273.9	1318.2	1318.2	936.7	1.69	1.73	27.71
0.2472	1304.3	1282.1	1329.5	1329.5	876.1	1.70	1.93	32.82
0.5496	1355.5	1311.2	1350.1	1350.1	815.5	3.26	0.39	39.83
0.6431	1359.4	1320.9	1353.3	1353.3	836.9	2.83	0.44	38.43
0.7263	1361.5	1329.3	1355.6	1355.6	875.1	2.36	0.43	35.72
0.8642	1363.8	1342.9	1358.7	1358.7	1005.2	1.53	0.37	26.29
1.0000	1361.0	1361.0	1361.0	1361.0	1361.0	0.00	0.00	0.00
LIX 622 + benzene								
0.0000	1257.2	1257.2	1257.2	1257.2	1257.2	0.00	0.00	0.00
0.0083	1267.0	1261.5	1263.2	1263.2	1234.0	0.43	0.30	2.60
0.0275	1274.0	1264.6	1275.3	1275.3	1186.1	0.74	0.10	6.89
0.0698	1277.3	1275.4	1296.1	1296.1	1102.8	0.15	1.47	13.66
0.1384	1294.8	1278.4	1318.9	1318.9	1010.3	1.26	1.86	21.97
0.2727	1321.3	1294.3	1344.6	1344.6	910.8	2.04	1.76	31.07
0.3912	1343.8	1308.8	1357.6	1357.6	872.6	2.60	1.02	35.06
0.5913	1362.4	1333.8	1370.8	1370.8	876.4	2.10	0.61	35.67
0.6812	1368.7	1344.5	1374.8	1374.8	906.3	1.77	0.44	33.78
0.8870	1377.0	1370.7	1381.4	1381.4	1091.6	0.46	0.32	20.72
1.0000	1384.1	1384.1	1384.1	1384.1	1384.1	0.00	0.00	0.00
LIX 860 + benzene								
0.0000	1257.2	1257.2	1257.2	1257.2	1257.2	0.00	0.00	0.00
0.0175	1268.6	1262.9	1270.3	1270.3	1210.0	0.45	0.13	4.62
0.0386	1279.0	1264.7	1283.6	1283.6	1161.5	1.12	0.36	9.18
0.0644	1283.0	1267.3	1279.1	1279.1	1112.0	1.22	0.30	13.33
0.1384	1293.8	1275.6	1324.5	1324.5	1010.4	1.40	2.37	21.90
0.2727	1315.4	1293.1	1352.6	1352.6	911.1	1.69	2.83	30.73
0.3912	1325.0	1307.4	1366.9	1366.9	873.1	1.32	3.16	34.10
0.5913	1333.5	1333.4	1381.4	1381.4	877.5	0.01	3.59	34.19
0.6810	1336.5	1344.9	1385.7	1385.7	907.8	0.63	3.68	32.07
0.8870	1341.9	1372.7	1393.0	1393.0	1096.2	2.29	3.80	18.31
1.0000	1396.0	1396.0	1396.0	1396.0	1396.0	0.00	0.00	0.00
LIX 984 + benzene								
0.0000	1257.2	1257.2	1257.2	1257.2	1257.2	0.00	0.00	0.00
0.0076	1260.0	1259.5	1232.4	1232.4	1233.3	0.04	2.19	2.12
0.016	1267.6	1263.4	1267.7	1267.7	1208.8	0.33	0.01	4.64
0.0353	1272.0	1263.7	1278.3	1278.3	1159.2	0.65	0.49	8.87
0.059	1275.0	1265.0	1389.0	1389.0	1108.1	0.78	8.94	13.09
0.1277	1288.9	1273.4	1310.8	1310.8	1001.9	1.20	1.70	22.27
0.2547	1316.0	1287.2	1333.0	1333.0	894.9	2.18	1.29	32.00
0.5687	1343.0	1323.0	1355.8	1355.8	843.6	1.49	0.95	37.18
0.6600	1349.2	1330.8	1359.2	1359.2	868.5	0.36	0.74	35.63
0.8770	1361.8	1354.1	1365.0	1365.0	1047.7	0.56	0.23	23.06
1.0000	1367.3	1367.3	1367.3	1367.3	1367.3	0.00	0.00	0.00

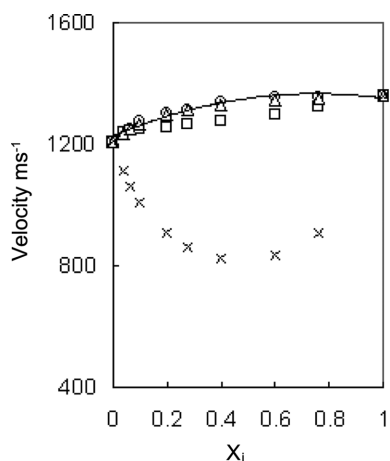


Fig. 1. Variation of ultrasonic velocities as a function of mole fraction of LIX 84 in the mixture LIX 84 + amyl alcohol [-○- EXP, □□ CFT, △△ NOM, ×× IMR].

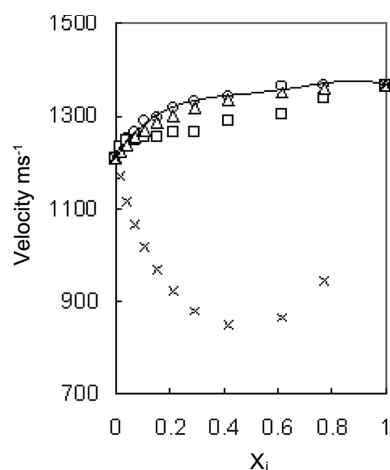


Fig. 4. Variation of ultrasonic velocities as a function of mole fraction of LIX 860 in the mixture LIX 860 + amyl alcohol [-○- EXP, □□ CFT, △△ NOM, ×× IMR].

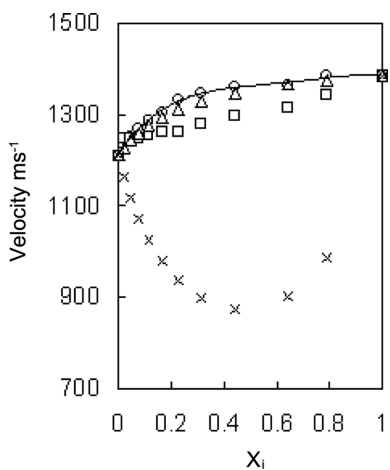


Fig. 2. Variation of ultrasonic velocities as a function of mole fraction of LIX 622 in the mixture LIX 622 + amyl alcohol [-○- EXP, □□ CFT, △△ NOM, ×× IMR].

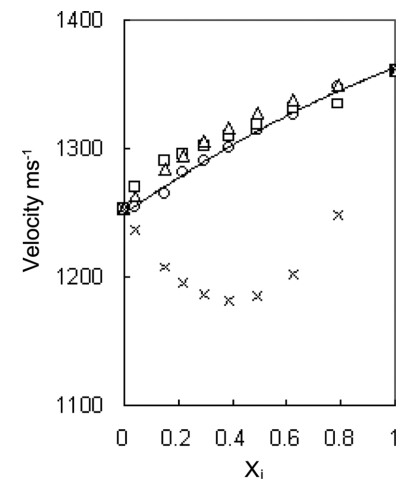


Fig. 5. Variation of ultrasonic velocities as a function of mole fraction of LIX 84 in the mixture LIX 84 + TBP [-○- EXP, □□ CFT, △△ NOM, ×× IMR].

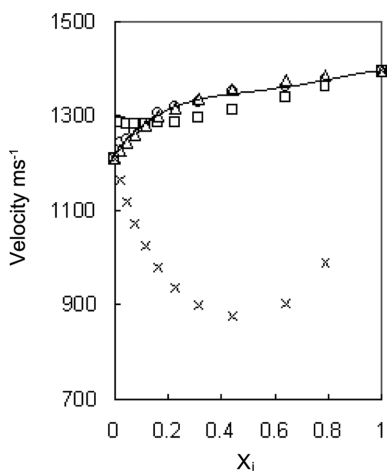


Fig. 3. Variation of ultrasonic velocities as a function of mole fraction of LIX 984 in the mixture LIX 984 + amyl alcohol [-○- EXP, □□ CFT, △△ NOM, ×× IMR].

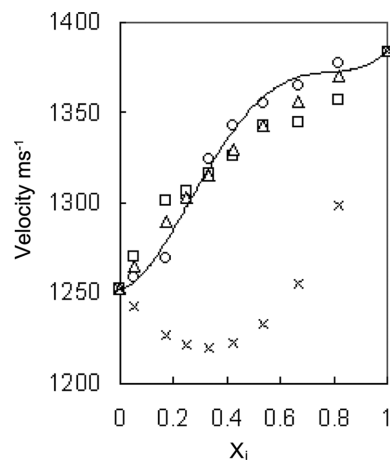


Fig. 6. Variation of ultrasonic velocities as a function of mole fraction of LIX 622 in the mixture LIX 622 + TBP [-○- EXP, □□ CFT, △△ NOM, ×× IMR].

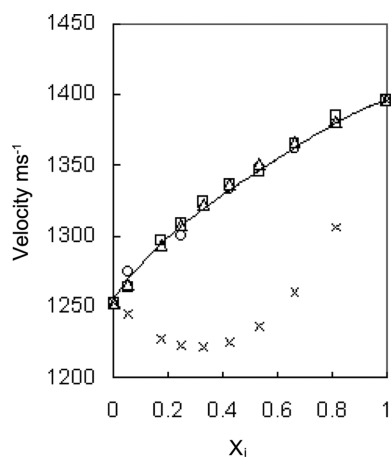


Fig. 7. Variation of ultrasonic velocities as a function of mole fraction of LIX 860 in the mixture LIX 860 + TBP [-○- EXP, □□ CFT, △△ NOM, ×× IMR].

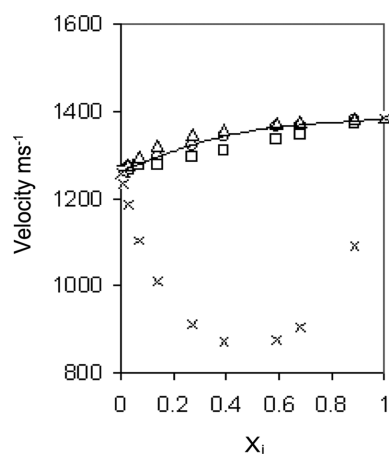


Fig. 10. Variation of ultrasonic velocities as a function of mole fraction of LIX 622 in the mixture LIX 622 + benzene [-○- EXP, □□ CFT, △△ NOM, ×× IMR].

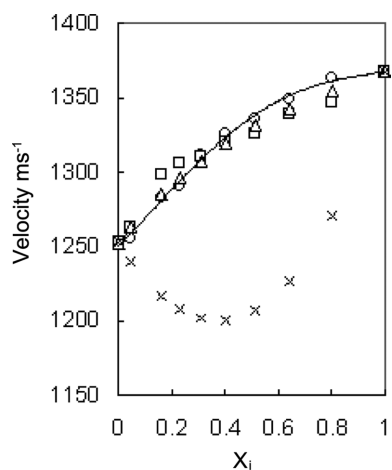


Fig. 8. Variation of ultrasonic velocities as a function of mole fraction of LIX 984 in the mixture LIX 984 + TBP [-○- EXP, □□ CFT, △△ NOM, ×× IMR].

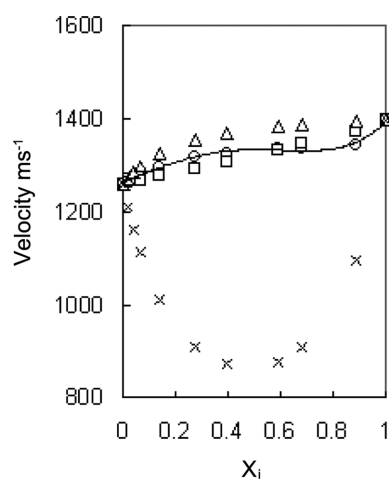


Fig. 11. Variation of ultrasonic velocities as a function of mole fraction of LIX 860 in the mixture LIX 860 + benzene [-○- EXP, □□ CFT, △△ NOM, ×× IMR].

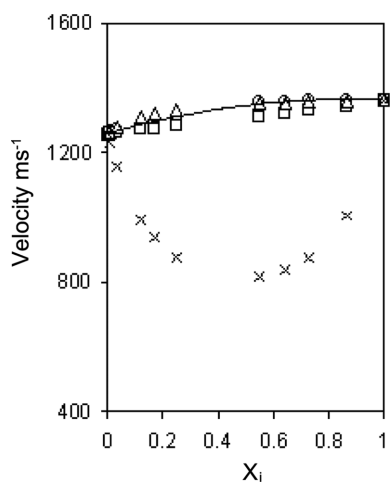


Fig. 9. Variation of ultrasonic velocities as a function of mole fraction of LIX 84 in the mixture LIX 84 + benzene [-○- EXP, □□ CFT, △△ NOM, ×× IMR].

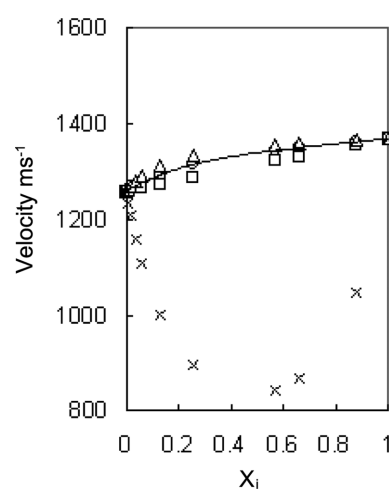


Fig. 12. Variation of ultrasonic velocities as a function of mole fraction of LIX 984 in the mixture LIX 984 + benzene [-○- EXP, □□ CFT, △△ NOM, ×× IMR].

other hand the ultrasonic velocities obtained from Nomoto's relation are better fitted to the experimental values having minimum percentage of variations. Thus, the linearity of molar sound velocity as suggested by Nomoto⁶ in deriving the empirical relation is rather more appropriate for the binary liquid mixtures studied.

It is, however, concluded that there is inter-molecular interaction present in all the binary mixtures under investigations and the interaction is supposed to be more in case of LIX reagents with amyl alcohol and benzene relative to TBP (%Variations of U_{IMR} from Tables 1-3). This investigation may further be extended by measuring other parameters like density, viscosity, refractive indices, surface tension etc., of these binary systems to study the type and strength of interactions present and accordingly it can be correlated with the extraction behaviours of these systems.

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