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Research Paper

Acoustical Parameters of Some Binary Liquid Mixtures Containing Heterocyclic Aromatic Compound with Methylphenols at Different Temperatures

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***Abstract** – Ultrasonic velocity (u), density (ρ) and viscosity (η) values have been measured in the three binary mixrures containing heterocyclic aromatic compound such as quinoline with 2,3,4-methylphenols such as o-cresol, m-cresol, p-cresol respectively at 303.15K, 308.15K, 313.15K and 318.15K. From this data, acoustical parameters such as adiabatic compressibility (β), free length (L_f), free volume (V_f) and internal pressure (π) have been estimated using standard relations.These parameters are useful for explaining the molecular association between the components of liquid mixtures.*

Key Words: Adiabatic compressibility, binary mixtures, free length, quinoline, methylphenol,cresol.

Introduction

Ultrasonic wave propagation affects the physical properties of the medium and hence, can furnish information on the physics of the liquid and liquid mixtures. Molecular interaction in liquid mixtures has been extensively studied using ultrasonic technique by many workers [1], because mixed solvents find practical applications in many chemical, biological and industrial processes.On the basis of todays progressive and ongoing research [2] on thermodynamic and acoustic properties of binary liquid mixtures, we report here the results of study on binary mixtures of heterocyclic aromatic compound such as quinoline with 2,3,4-methyl phenols such as o-cresol, m-cresol and p-cresol respectively over the entire range of composition at T= 303.15K, 308.15K, 313.15K and 318.15K. Using the experimental values of ultrasonic velocity (u), density (ρ) and viscosity (η), acoustical parameters such as adiabatic compressibility, free length, free volume and internal pressure have been estimated using standard relations. These derived parameters offer a convenient method for the study of thermodynamic properties of liquid mixtures not easily obtainable by other means. The results are interpreted in terms of molecular association between the components of the liquid mixtures.

The binary liquid systems taken up for present study at T=303.15K,308.15K,313.15K and 318.15K are

**System-I : ** Heterocyclic aromatic compound(Quinoline) + 2-methylphenol (o-cresol)

System-II: Heterocyclic aromatic compound (Quinoline) + 3-methylphenol (m-cresol)

System-III: Heterocyclic aromatic compound (Quinoline) + 4-methylphenol (p-cresol)

Material and Methods

The mass fraction of the liquids (Obtained from Merck) was as follows: o-cresol (0.990), m-cresol (0.990), and p-cresol (0.980) and the purity of the liquid (obtained from SRL Chemicals) Quinoline (0.950). All the liquids used were further purified by standard procedure [3]. Job's method of continuous variation was used to prepare the mixtures in the required proportions. The mixtures were preserved in well-Stoppered conical flasks. After the through mixing of the liquids, the flasks were left undisturbed to allow them to attain thermal equilibrium.In all the mixtures the mole fraction of 1st compound quinoline has been increased from 0 to 1. The ultrasonic velocity in liquid mixtures have been measured using an ultrasonic interferometer (Mittal Enterprises, Model F-80X) working at 3MHz frequency with an accuracy ± 0.5 $m.s^{-1}$. The densities (ρ) of these liquids were measured using 10ml specific gravity bottle in an electronic balance (Shimadzu AUY220, Japan) precisely with in ±0.1mg accuracy. Ostwald viscometer is used to measure viscosities of the liquids. The accuracy of the apparatus is ±0.002cP.In all the above apparatus the temperature was maintained constant at 303.15K, 308.15K, 313.15K and 318.15K using proportional temperature controller of accuracy ± 0.01K.From the experimentally measured values of ultrasonic velocity (u), density (ρ) and viscosity (η), various acoustic parameters are calculated. They have been dealt elsewhere in detail [4].

Results and Discussion

The experimentally determined values of density, viscosity and ultrasonic velocity for all the three systems over the entire range of composition and at temperatures 303.15K, 308.15K, 313.15K and 318.15K are given in Table 1. Acoustical parameters such as adiabatic compressibility, free length, free volume and internal pressure have been estimated using standard relations.From the Table 1 that the ultrasonic velocity increases with increase in mole fraction of quinoline. This may be due to association of a very strong dipole-induced dipole interaction between the component molecules.

Here with the increase of temperature due to thermal agitation of component molecules the interaction becomes weak[5] and this is indicated by decrease in ultrasonic velocity values in all the three systems.

From the Plot of adiabatic compressibility versus mole fraction of quinoline for the three mixtures which are shown in Figure 1 (a to c), It can be observed that the compressibility decreases with increase in mole fraction of quinoline in all the three mixtures taken up for study. As adiabatic compressibility is inversely proportional to ultrasonic velocity, since ultrasonic velocity increases with mole fraction (Table 1) so that adiabatic compressibility decreases with mole fraction of quinoline.

From Figure 1 (a to c) and Figure 2 (a to c) it is also observed that, the values of L_f and β increases with increase in temperatures, it clearly reveals that interaction become weaker at higher temperatures [6].

Table 1
Values of density (ρ), viscosity (η) and ultrasonic velocity (u) for the binary mixtures of quinoline + cresols at T = 303.15K, 308.15K, 313.15K and 318.15K

X1	T=303.15K			T=308.15K			T=313.15K			T=318.15K		
	ρ kgm^{-3}	η$X10^{-3}$ Nsm^{-2}	u ms^{-1}	ρ kgm^{-3}	η $X10^{-3}$ Nsm^{-2}	u ms^{-1}	ρ kgm^{-3}	η $X10^{-3}$ Nsm^{-2}	u ms^{-1}	ρ kgm^{-3}	η $X10^{-3}$ Nsm^{-2}	u ms^{-1}
System-I												
0.0000	1036.20	7.479	1485	1031.00	5.963	1467	1026.00	4.238	1452	1021.10	2.125	1437
0.0888	1048.32	13.382	1500	1044.34	12.507	1494	1041.76	11.459	1487	1038.39	11.185	1481
0.1798	1055.14	13.432	1509	1052.57	12.512	1506	1049.98	11.469	1503	1047.71	11.218	1494
0.2732	1063.07	13.437	1515	1060.08	12.519	1513	1056.07	11.475	1508	1054.91	11.240	1500
0.3690	1070.40	13.377	1525	1066.17	12.448	1519	1063.07	11.499	1509	1059.78	11.467	1503
0.4672	1075.08	13.016	1532	1071.76	12.179	1522	1069.57	11.204	1514	1066.17	11.082	1506
0.5681	1078.84	9.322	1534	1073.80	8.670	1529	1072.90	7.950	1516	1069.00	7.921	1509
0.6717	1080.77	6.585	1538	1076.13	6.051	1534	1074.35	5.422	1520	1071.04	5.303	1516
0.7782	1081.18	4.639	1544	1078.43	4.262	1540	1076.61	3.950	1525	1069.62	3.799	1520
0.8876	1084.33	3.795	1551	1081.20	3.448	1546	1077.28	3.103	1536	1073.37	2.927	1528
1.0000	1085.45	2.932	1554	1082.11	2.707	1551	1078.60	2.447	1548	1074.99	2.430	1541
System-II												
0.0000	1025.80	8.929	1464	1021.50	7.412	1456	1017.00	6.116	1444	1013.50	5.019	1433
0.0896	1043.54	19.344	1488	1040.68	18.111	1484	1035.77	16.614	1481	1031.28	16.294	1475
0.1813	1047.10	18.546	1496	1043.32	17.354	1487	1039.33	15.925	1484	1034.63	15.729	1478
0.2752	1056.46	17.706	1509	1052.76	16.437	1494	1049.58	15.122	1491	1044.77	15.039	1481
0.3713	1061.45	16.364	1519	1057.94	15.303	1500	1055.06	14.091	1497	1051.16	14.049	1487
0.4697	1068.06	12.925	1528	1065.46	12.037	1513	1062.97	11.029	1503	1059.43	10.891	1497
0.5706	1075.49	9.257	1532	1072.38	8.669	1522	1069.16	7.957	1516	1065.36	7.806	1506
0.6740	1077.82	6.715	1544	1075.21	6.211	1539	1073.53	5.579	1521	1070.53	5.463	1514
0.7799	1079.88	4.841	1547	1076.43	4.456	1540	1074.24	4.029	1528	1071.45	3.854	1519
0.8886	1083.86	3.534	1549	1081.40	3.263	1544	1078.30	2.864	1538	1073.78	2.656	1532
1.0000	1085.45	2.932	1552	1082.11	2.707	1550	1078.60	2.447	1546	1074.99	2.403	1540
System-III												
0.0000	1026.50	9.540	1461	1022.00	8.119	1449	1018.10	6.741	1436	1013.90	5.469	1424
0.0896	1038.15	25.040	1472	1034.49	23.431	1458	1031.92	21.767	1446	1026.31	23.899	1440
0.1812	1046.69	21.706	1491	1043.33	20.325	1470	1040.14	18.821	1462	1035.44	18.905	1456
0.2751	1058.49	18.790	1500	1054.60	17.519	1486	1050.90	16.227	1476	1046.39	16.221	1472
0.3711	1065.72	16.696	1505	1061.70	15.641	1500	1058.20	14.449	1494	1053.69	14.472	1484
0.4696	1072.43	13.636	1514	1067.70	12.680	1506	1063.68	11.763	1500	1060.39	11.741	1494
0.5704	1076.81	9.272	1522	1073.38	8.596	1516	1068.76	7.928	1506	1065.16	7.852	1497
0.6738	1079.86	6.879	1533	1076.13	6.234	1528	1072.61	5.701	1516	1068.70	5.649	1512
0.7798	1080.88	4.672	1541	1077.34	4.280	1535	1073.63	3.879	1525	1069.41	3.788	1517
0.8885	1084.94	3.500	1547	1081.91	3.249	1541	1077.18	2.890	1535	1072.84	2.872	1528
1.0000	1085.45	2.932	1550	1082.11	2.707	1549	1078.60	2.447	1545	1074.99	2.430	1538

From Figure 2 (a to c) it is observed that, the intermolecular free length L_f decreases with increase in mole fraction of quinoline which shows that the dipole-induced dipole interaction becomes stronger which makes the system less compressible as evident from the values of adiabatic compressibility.The observed increase in ultrasonic velocity and corresponding decrease in L_f with molefreaction of quinoline in all the mixtures is in accordance with the proposed by Eyring and kincard [7].

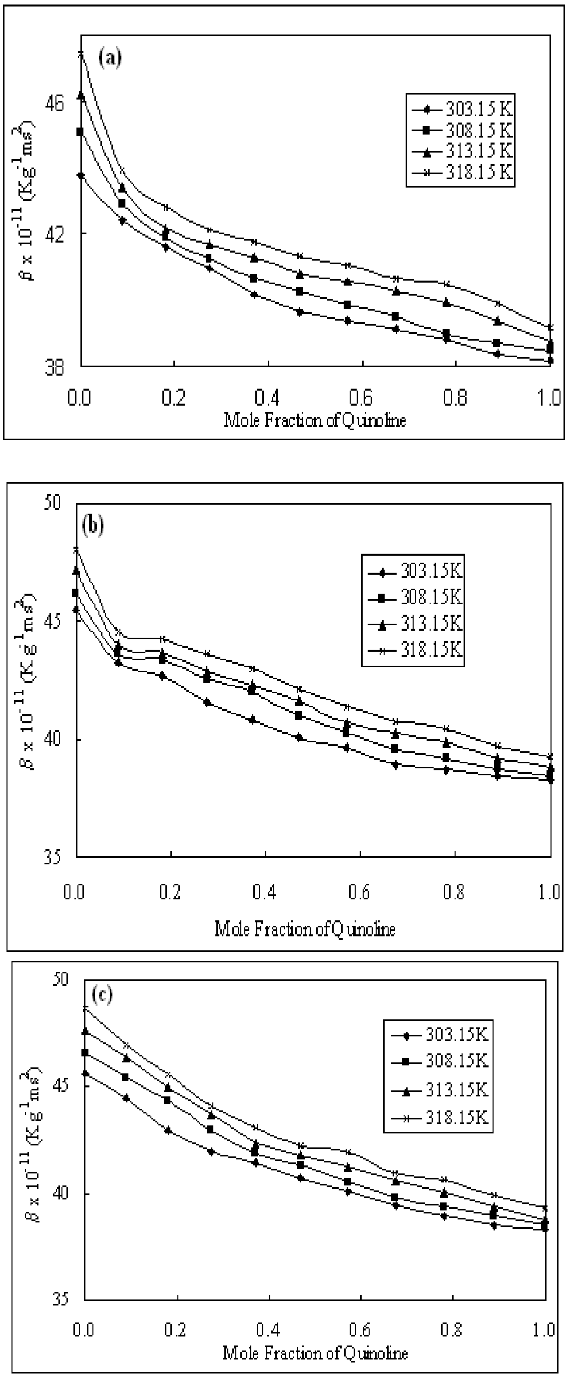

Figure 1: Adiabatic compressibility (β) as a function of mole fraction of Quinoline (x_1) for (a) System-I (b) System-II (c) System-III.

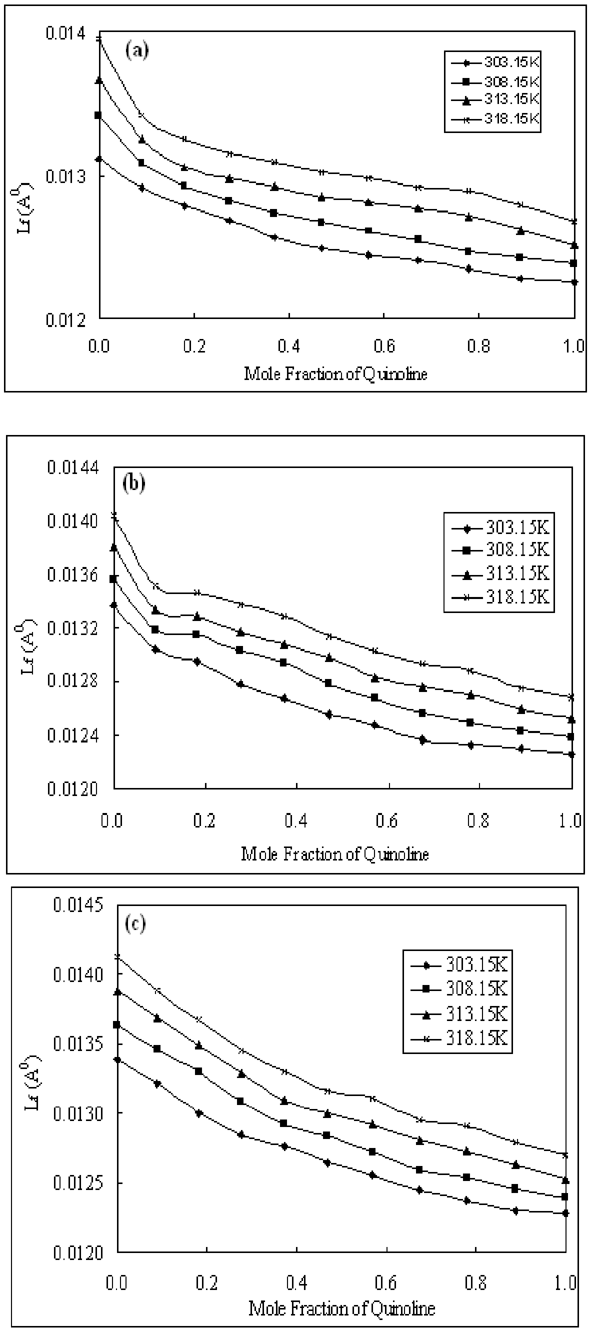

Figure 2: Intermolecular free length (L_f) as a function of mole fraction of Quinoline (x_1) for (a) System-I (b) System-II (c) System-III

The internal pressure (π) in binary mixtures can be used to access the intermolecular attraction between the components. It is observed from (Figure 4 (a to c)) that the internal pressure values in different systems are in the order System-III > System-II > System-I. The changes in internal pressure values in different systems may be due to the change in position of OH groups. The decrease in internal pressure with mole fraction at all the temperatures indicates that there exist some sort of solute-solute interactions, but at some mole fractions solute-solvent interactions are also present.

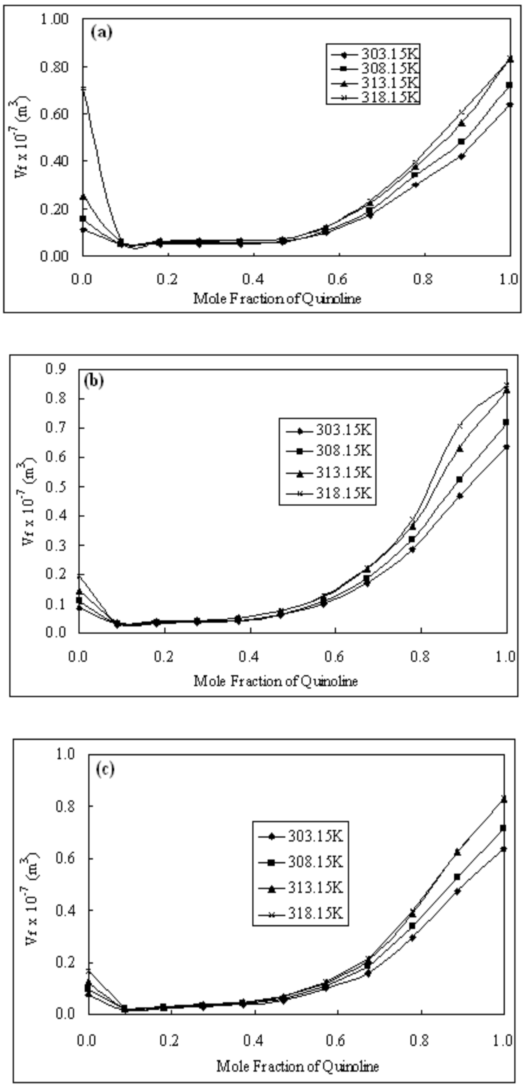

Figure 3: Free volume (V_f) as a function of mole fraction of Quinoline (x_1) for (a) System-I (b) System-II (c) System-III.

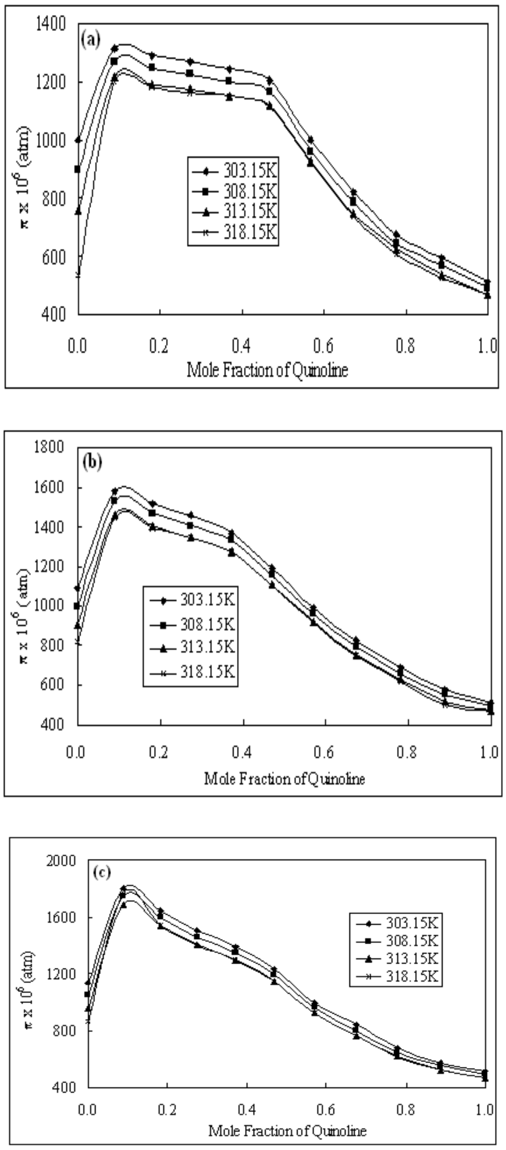

Figure 4: Internal Pressure (π) as a function of mole fraction of Quinoline (x_1) for (a) System-I (b) System-II (c) System-III

Conclusion

From the observed experimental values of ultrasonic velocity, density and viscosity and related acoustical parameters values for the binary liquid mixtures of heterocyclic aromatic compound such as quinoline with 2,3,4-methylphenols such as o-cresol,m-creol,p-cresol respectively at 303.15K,308.15K, 313.15K and 318.15K , it is very obvious that there exists a strong molecular association between the components of the liquid mixtures.

References

1. Kannappan V., Xavier Jesu Raja S. and Jaya Santhi R., Ultrasonic studies on molecular interaction of certain carbonyl compounds in n-hexane and chloroform solution, *Indian J. Pure Appl. Phys*., **41,** 690 **(2003)**

2. Narendra K., Srinivasu Ch., Fakruddin Sk. and Narayana Murthy P., Excess parameters of binary mixtures of anisaldehyde with o-cresol, m-cresol and p-cresol at T = (303.15, 308.15, 313.15, and 318.15) K, *J. Chem. Thermodyn*., **43,** 1604 **(2011)**

3. Perrin D. D. and Armarego W. L. F., Purification of Lab. Chem., 3rd ed., Pergamon Press, Oxford, **(1980)**

4. Narendra K., Srinivasu Ch., Kalpana Ch. and Narayanamurthy P., Excess thermo dynamical parameters of binary mixtures of toluene and mesitylene with anisaldehyde using ultrasonic technique at different temperatures, J. Therm. Anal. Calorim., **107,** 25 **(2012)**

5. Thitumaran S. and Deepesh George., Ultrasonic study of intermolecular association through hydrogen bonding in ternary liquid mixtures, *ARPN J. Engg. Appl. Sciences*. **4(4)**, 1 **(2009)**

6. Kumar R., Jayakumar S. and Kannappan V., Study of molecular interactions in binary mixtures, *Indian J. Pure Appl. Phys*., **46**, 169 **(2008)**

7. Eyring H. and Kincaid J.F., Free volume and free angle ratios of molecules in liquids, J. Chem. Phys., **6**, 620 **(1938).**