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Original Research Article

"Ultrasonic Study And Thermodynamic Properties Of A Binary Mixture Of Methanol + Aniline And 1-Propanol + Aniline"

J. S. Lad

Government College of Arts and Science, Aurangabad.

Abstract :

Ultrasonic waves are sound waves, which have frequency more than audible limit. The value of ultrasonic velocity (?) with composition (c) in a binary mixture of Methanol + Aniline and 1-Propanol + Aniline shows that ultrasonic velocity (?) increases progressively as composition of Methanol increases in the mixture. Adiabatic compressibility (?a) of Methanol + Aniline show decrease wave like with increases of Methanol in the mixture and this nature is exactly in reciprocate nature of velocity composition curve.

This curve is wave like changing in nature showing a molecular interaction between the Methanol and Aniline mixture is weak interaction. This interaction between the molecules may be due to the functional groups of Methanol and Aniline binary mixture.

Keywords: *Binary mixture, Curve, Methanol, Ultrasonic velocity,*

Introduction :

Ultrasonic waves are sound waves, which have frequency more than audible limit. The audible range of normal ear is 20Hz to 20kHz. The sound which have frequencies less than the limit i.e. 20Hz are called Infrasonic while the sound waves having frequencies above the audible limit i.e. 20 kHz are called ultrasonic waves. Ultrasonic waves can be used to detect flaws in metal. When ultrasonic waves passed through a metal having some blow hole, or crack inside it, there will be an appreciable reflection or absorption due the sudden change in the medium.[1] Molecular behaviour is explained by ultrasonic velocity. Material is in general composed of atoms and molecules. Attractive forces between them hold these atoms and molecules together. These shape and size of molecules in liquid phase make the molecules to give response to external stimuli. Thus various properties of liquids and their interaction in the mixtures have important role in building a life on earth planet [2]. Keeping this view in mind, the binary mixture of Methanol + Aniline organic liquid systems has been considered for their ultrasonic velocity measurements in pure and various compositions. Most materials are ultrasonically trans-parent1-3 and allow the analysis of a broad variety of sample types, chemical reactions and processes. Ultrasonic analysis can now be easily performed in chemistry, Physics, biotechnology, Pharmaceuticals, food, agriculture, environmental Control, medicine oil petroleum and gas industries. [2-3]

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AMIERJ Aarhat Multidisciplinary International Education Research Journal

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Materials and Methods :

To determine thermodynamic parameters, an accurate ultrasonic velocity is required. Ultrasonic velocities were measured on 1 MHz ultrasonic interferometer supplied by Mittal New Delhi, which is direct and simple device for measuring sound velocity in liquids. Densities of pure liquids and liquid mixtures were measured with a calibrated Class-A certified density bottle (25m1) in a water bath thermostat whose temperature was kept within the range of $\pm 0.10^{C}$. Different composition of the one component with other in the range 0 to 1 mole fractions were prepared by volume and then converted to mole fractions[4]. Acoustical study such as, ultrasonic velocity, adiabatic compressibility, molecular free length and acoustic impedance have been calculated at four temperatures 25^0, 30^0, 35^0 and 40^0 C respectively. Excess parameters are better measure of intermolecular interactions as compared to derived ones [5,6]. The magnitude values of υE, βaE, LfE and ZE indicate interaction of strength between the components [7]. Weak molecular interactions cannot be resolved from the spectroscopic spectra [8]. Ultrasonic technique on other hand provides its useful wavelength range and moreover ultrasonic parameters are directly related to a large number of molecular and thermodynamic parameters[9].

The chemical and structural units of liquid systems, rates and formation of complex can also be studied by ultrasonic measurement. In addition, the ultrasonic velocity and density of the liquids can be employed to calculate various thermodynamic parameters of the liquids such as adiabatic compressibility (βa), intermolecular length (Lf) and acoustic impedance (Z).

Ultrasonic measurements of (Methanol + Aniline)

Methanol and Aniline have been considered in the plan of work, because these two compounds have different functional groups and different dipole moments10. The two functional group - OH and —NH_2 may form hydrogen bonding when they were mixed in stichometric ratio. To get a perfect combination of two components, we have prepared seven different combinations of these two to get total volume of 40 cc of the mixture system. Hence, the seven binary mixtures were prepared and kept in airtight 100 ml glass flask. Density (ρ) of each mixture was measured at four different temperatures using a class - A certified density bottles 25 ml and single pan sensitive balance. [10]

Ultrasonic measurements of (1-Propanol + Aniline)

1-Propanol and Aniline have been considered in the plan of work, because these two compounds have different functional groups and different dipole moments10. The two functional group - OH and —NH_2 may form hydrogen bonding when they were mixed in stichometric ratio. To get a perfect combination of two components, we have prepared seven different combinations of these two to get total volume of 40 cc of the mixture system. Hence, the seven binary mixtures were prepared and kept in airtight 100 ml glass flask. Density (ρ) of each mixture was measured at four different temperatures using a class - A certified density bottles 25 ml and single pan sensitive balance. [11]

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Volume-XI, Issue No.–I
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OPEN ACCESS Original Research Article

Ultrasonic velocity of each binary mixture at four different temperatures 25, 30, 35 and 40°C were measured by circulating hot water from a thermostat. The same procedure of ultrasonic velocity measurement was adopted, which was described in experimental part in Chapter III. Mittal's ultrasonic interferometer working at 1 MHz frequency was used in the measurement of the velocity. The ultrasonic velocity (υ) and density (ρ) data of (Methanol + Aniline) and (1-Propanol + Aniline) at each temperature was used in the calculation of thermodynamic parameters such as adiabatic compressibility (βa), molecular free length (Lf) and acoustical impedance (Z). Density (ρ), ultrasonic velocity (υ), adiabatic compressibility (βa), molecular free length (Lf) and acoustical impedance (Z) of seven different compositions of 1-Propanol and Aniline at four different temperatures 25, 30, 35 and 40°C were also studied [12,13] At first the Mittal make ultrasonic interferometer working at 1 MHz was standardized by using the well-known systems like double distilled water and benzene at four different temperatures. The densities of water and benzene were measureexperimentally with class A-certified density bottle (25 ml) on sensitive K-Roys single pan balance. The density values were verified from literature values.[14,15]

Result and discussion :

Ultrasonic and thermodynamic properties of Methanol + Aniline :

The experimental values of ultrasonic velocity and density of Methanol + Aniline binary mixture along with thermodynamic parameters as a function of temperature are recorded. These ultrasonic velocity and thermodynamic parameters such as adiabatic compressibility, molecular free length and acoustical impedance are plotted as a function of composition at various temperatures Fig. 1 (a) and (b). The value of ultrasonic velocity (υ) with composition (c) in a binary mixture of Methanol + Aniline shows that ultrasonic velocity (υ) increases progressively as composition of Methanol increases in the mixture. The increasing nature of the curve indicates a weak molecular interaction between the components of the mixture. Adiabatic compressibility (βa) of Methanol + Aniline show decrease wave like with increases of Methanol in the mixture and this nature is exactly in reciprocate nature of velocity composition curve (Fig. 1 (a). This curve is wave like changing in nature showing a molecular interaction between the Methanol and Aniline mixture is weak interaction. Fig. 1(b) shows a decrease wave like in free length (Lf) and increase in impedance (Z) with concentration. These both curves (Fig.1 b) of wave like decrease nature in impedance and free length indicating that there is strong molecular interaction between the components of the mixture. This interaction between the molecules may be due to the functional groups of Methanol and Aniline binary mixture.

Ultrasonic and thermodynamic properties of 1-Propanol + Aniline:

The experimental values of ultrasonic velocity and density of 1-Propanol + Aniline binary mixture along with thermodynamic parameters as a function of temperature are recorded in Tables 2 (a) and (b). These ultrasonic velocity and thermodynamic parameters such as adiabatic compressibility, molecular free length and acoustical impedance are plotted as a function of composition at various temperatures Fig. 2 (a) and (b). The value of ultrasonic velocity (υ) with composition (c) in a binary mixture of 1-Propanol and Aniline shows that ultrasonic velocity (υ)

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Volume–XI, Issue No.–I
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OPEN ACCESS

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increases wave like as composition of 1-Propanol increases in the mixture. The increasing nature of the curve indicates a weak molecular interaction between the components of the mixture. Adiabatic compressibility (βa) of 1-Propanol and ethyl acetate show decrease as wave like with composition increases of 1-Propanol and this nature is exactly in reciprocate nature of velocity composition curve (Fig. 2 a). This curve is wave like changing in nature showing a strong molecular interaction between the 1-Propanol and aniline mixture. (Fig. 2 b) shows an increase and decrease in nature of free length (Lf) and impedance (Z) with concentration. These both curves (Fig.2 b) of increase decrease nature in impedance and free length indicating that there is strong molecular interaction between the components of the mixture. This interaction between the molecules may be due to the functional groups of 1-Propanol and Aniline binary mixture.

The results are discussed from the graphs of ultrasonic velocity (v), adiabatic compressibility (βa) and molecular free length (Lf) and acoustic impedance (Z) with composition of the binary component in the mixture. The nature of the curves for all the plots of thermodynamic function show nonlinear, and wave like changes. This type of behavior indicating that there is interaction between the components after forming the binary mixture. In this work it finds that for all the binary systems, there is intermolecular interaction in solutions as well as in pure binary mixtures.

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AMIERJ Aarhat Multidisciplinary International Education Research Journal

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Jan – Feb 2022

OPEN ACCESS

Original Research Article

Table 1(a). Ultrasonic Velocity and other thermodynamic parameters for **Methanol + Aniline** at different temperatures.

Temp. °K	Mole Fraction c.	Density (ρ) Kgm^{-3}	US velocity U ms^{-1}	Compressibility βa 10^{-10} m^{-2} N^{-1}	Free length L_f m	Impedance Z Kgm^2s^{-1}
298	0	1016.9	1190.07	6.943473	3.4E-12	1.210182
	0.125	995	1207.27	6.895537	3.42E-12	1.201234
	0.25	970.8	1266.9	6.417791	3.34E-12	1.229907
	0.375	947	1332.5	5.949027	3.26E-12	1.261688
	0.5	919.2	1382.4	5.692756	3.24E-12	1.270702
	0.625	890.7	1442.86	5.392873	3.2E-12	1.285155
	0.75	858.1	1505	5.145044	3.18E-12	1.291441
	0.875	859.3	1565	4.751454	3.06E-12	1.344805
	1	802.6	1583.77	4.967257	3.24E-12	1.271134
303	0	1015	1211.01	6.717977	3.38E-12	1.229175
	0.125	993.3	1220	6.763942	3.42E-12	1.211826
	0.25	968.1	1280.74	6.29735	3.35E-12	1.239884
	0.375	943.9	1339.31	5.90625	3.28E-12	1.264175
	0.5	915.4	1400.6	5.56879	3.24E-12	1.282109
	0.625	886	1460.8	5.289136	3.21E-12	1.294269
	0.75	855.2	1519.2	5.066434	3.19E-12	1.29922
	0.875	855.6	1581.54	4.67271	3.07E-12	1.353166
	1	799.2	1598.43	4.897306	3.25E-12	1.277465

Table 1(b). Ultrasonic Velocity and other thermodynamic parameters for **Methanol + Aniline** at different temperatures.

Temp. °K	Mole Fraction c.	Density (ρ) Kgm^{-3}	US velocity U ms^{-1}	Compressibility βa 10^{-10} m^{-2} N^{-1}	Free length L_f m	Impedance Z Kgm^2s^{-1}
308	0	1008.4	1217.57	6.689279	3.41E-12	1.227798
	0.125	988.2	1241.76	6.562659	3.41E-12	1.227107
	0.25	964	1299.33	6.144464	3.34E-12	1.252554
	0.375	940.7	1360.69	5.741567	3.27E-12	1.280001
	0.5	911.4	1420.65	5.436467	3.23E-12	1.29478
	0.625	882	1481.48	5.165827	3.2E-12	1.306665
	0.75	850.5	1539.26	4.962514	3.2E-12	1.309141
	0.875	850.2	1599.29	4.598588	3.08E-12	1.359716
	1	795.2	1632.79	4.716968	3.23E-12	1.298395
313	0	1006.4	1213.03	6.752837	3.46E-12	1.220793
	0.125	983.9	1260.59	6.395895	3.41E-12	1.240295
	0.25	960	1320.69	5.972099	3.33E-12	1.267862
	0.375	946.8	1379.33	5.551437	3.24E-12	1.30595
	0.5	907	1441.67	5.304702	3.23E-12	1.307595
	0.625	877.2	1500.74	5.061631	3.21E-12	1.316449
	0.75	845.7	1560.83	4.853695	3.2E-12	1.319994
	0.875	846.1	1621.54	4.49493	3.08E-12	1.371985
	1	791.2	1649.33	4.646208	3.24E-12	1.30495

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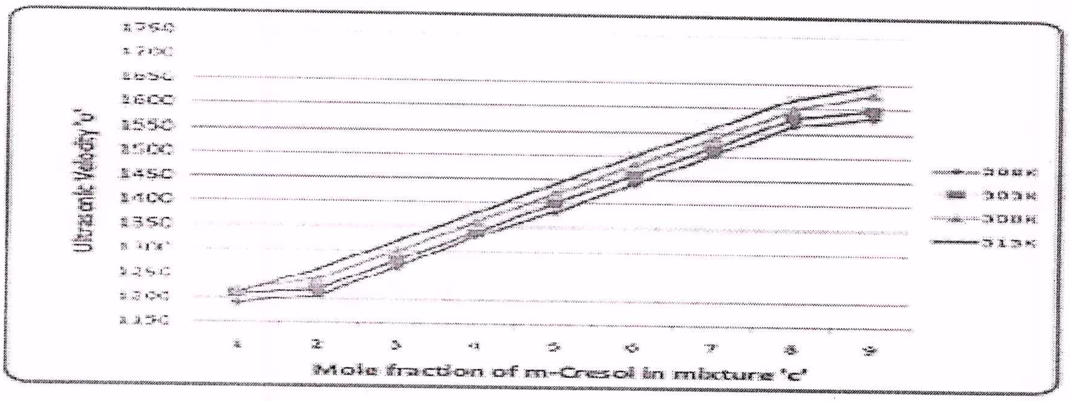
OPEN ACCESS Original Research Article

Fig 1 (a) .Plot of Ultrasonic Velocity 'υ' and Adiabatic Compressibility 'βa' versus Mole fraction of Methanol + Aniline at 298, 303, 308, 313⁰K.



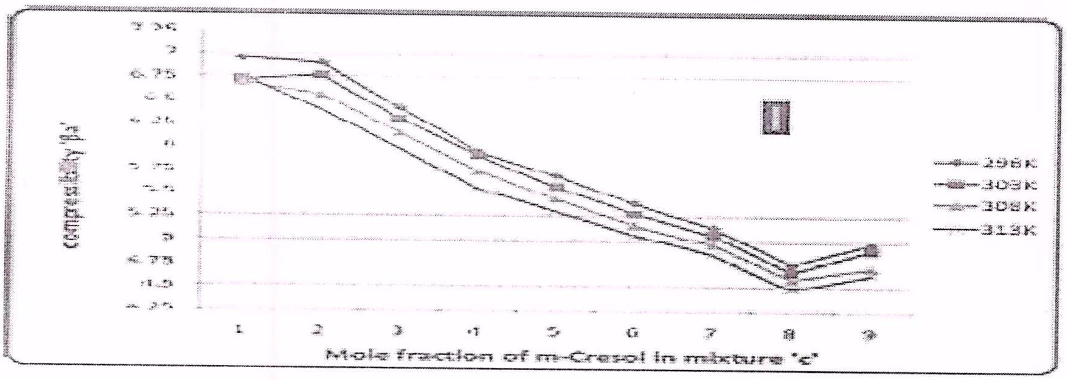
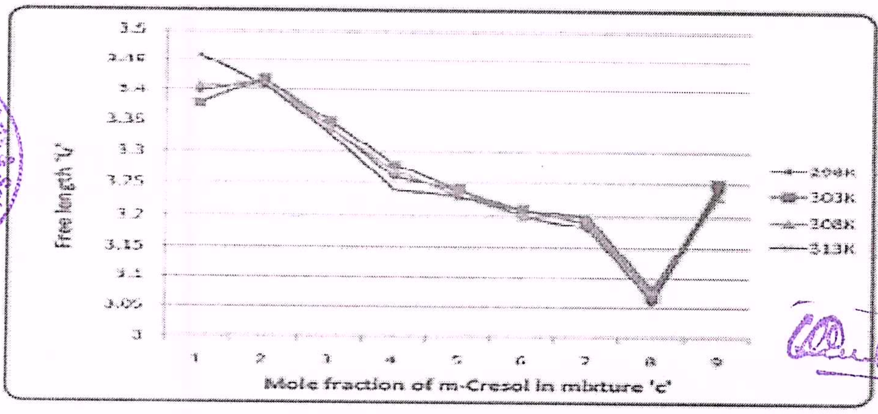


Fig. 1 (b) Plot of Free length 'Lf' and Acoustic Impedance 'Z' versus Mole fraction of Methanol + Aniline at 298, 303, 308 and 313⁰K.



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Volume-XI, Issue No.-I
Jan – Feb 2022

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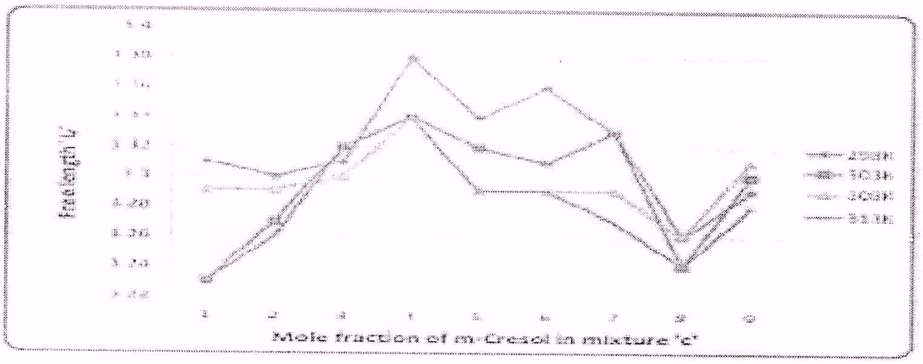
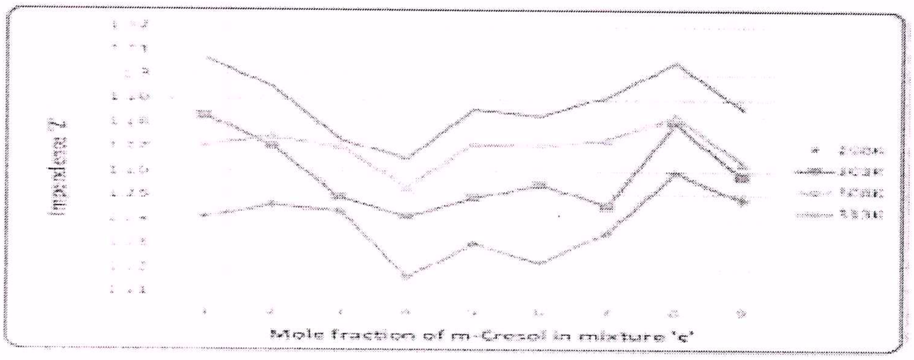
Fig 2 (b) Plot of Free length 'Lf' and Acoustic Impedance 'Z' versus Mole fraction of 1-Propanol + Aniline at 298, 303, 308 and 313^{0}K.





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OPEN ACCESS

Original Research Article

Table 2 (a) Ultrasonic Velocity and other thermodynamic parameters for 1-Propanol + Aniline at different temperatures.

Temp. °K	Mole Fraction c.	Density (ρ) Kgm^{-3}	US velocity U ms^{-1}	Compressibility βα $10^{-10}\ m^{-2}\ N^{-1}$	Free length L_f m	Impedance Z Kgm^2s^{-1}
298	0	1016.9	1220.87	6.597553	3.31E-12	1.241503
	0.125	994.1	1253.68	6.400244	3.3E-12	1.246283
	0.25	968.5	1284.37	6.259218	3.31E-12	1.243912
	0.375	942.5	1290.71	6.368854	3.38E-12	1.216494
	0.5	917.8	1340.06	6.067412	3.34E-12	1.229907
	0.625	889.7	1374	5.953645	3.36E-12	1.222448
	0.75	856.7	1441.25	5.619434	3.33E-12	1.234719
	0.875	839	1501.33	5.28793	3.26E-12	1.259616
	1	802.6	1555.47	5.149648	3.29E-12	1.24842
303	0	1015	1264.24	6.164174	3.23E-12	1.283204
	0.125	990.1	1283.33	6.132594	3.27E-12	1.270625
	0.25	965.1	1294.66	6.181818	3.32E-12	1.249476
	0.375	938.9	1322.5	6.089607	3.34E-12	1.241695
	0.5	913.1	1367.88	5.853096	3.32E-12	1.249011
	0.625	886	1416.13	5.628077	3.31E-12	1.254691
	0.75	852.6	1461.43	5.491597	3.33E-12	1.246015
	0.875	834.2	1534.29	5.092311	3.24E-12	1.279905
	1	799.9	1572.58	5.055205	3.3E-12	1.257907

Table 2 (b) Ultrasonic Velocity and other thermodynamic parameters for 1-Propanol + Aniline at different temperatures.

Temp. °K	Mole Fraction c.	Density (ρ) Kgm^{-3}	US velocity U ms^{-1}	Compressibility βα $10^{-10}\ m^{-2}\ N^{-1}$	Free length L_f m	Impedance Z Kgm^2s^{-1}
308	0	1008.4	1260.79	6.238521	3.29E-12	1.271381
	0.125	985.5	1293.34	6.066217	3.29E-12	1.274587
	0.25	961.7	1321.25	5.95649	3.3E-12	1.270646
	0.375	935.4	1340	5.953783	3.34E-12	1.253436
	0.5	910.7	1396.36	5.631575	3.29E-12	1.271665
	0.625	882.2	1440.7	5.461172	3.29E-12	1.270986
	0.75	848.5	1500.71	5.233047	3.29E-12	1.273352
	0.875	830.6	1544.67	5.045877	3.26E-12	1.283003
	1	795.1	1589.36	4.978903	3.31E-12	1.2637
313	0	1006.4	1298.57	5.892487	3.23E-12	1.306881
	0.125	981.6	1319.26	5.853352	3.26E-12	1.294986
	0.25	957	1330.59	5.902005	3.32E-12	1.273375
	0.375	931.4	1358.67	5.816153	3.34E-12	1.265465
	0.5	905.6	1420	5.476296	3.29E-12	1.285950
	0.625	878.5	1460.71	5.334948	3.29E-12	1.283234
	0.75	844.1	1529.73	5.062634	3.27E-12	1.291245
	0.875	826.2	1580	4.848424	3.24E-12	1.305396
	1	791.1	1625.82	4.782155	3.28E-12	1.286186