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STUDY OF ACOUSTICAL PARAMETERS IN SOME BINARY LIQUID MIXTURES AT 303K

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Abstract

This paper reports the experimental study of ultrasonic velocity, density and viscosity for binary liquid mixtures of methanol- bromobenzene and ethanol – bromobenzene at 3MHz ultrasonic frequency at 303k temperature. From these results, acoustic parameters such as adiabatic compressibility (β), free length (L_f) and acoustic impedance are calculated. This study is very useful to explain the nature of intermolecular interactions in the mixtures.

Key Words

Binary mixture; ultrasonic velocity; acoustic impedance, adiabatic compressibility; free length

Introduction

Ideal binary liquid mixtures are mixtures with zero volume change on mixing. Due to molecular interactions between the components of binary liquid mixture, the real liquid mixture is formed either with increase or decrease in volume. This decrease or increase in the volume on mixing the liquid can be taken as the criteria and measure of molecular interaction. Due to the recent developments made in the theories of liquid mixtures and experimental techniques, the study of binary liquid mixture has attracted several researchers to study the propagation of ultrasonic wave in liquid and mixtures (Marcus, 1977). Ultrasonic wave is a branch of acoustic dealing with sound above the audible range (20H_z to 20,000 H_z) and in many respects to microwave physics. Ultrasonic frequencies are higher than 20kg Hz and their Wavelengths are small. The sound waves of frequency lower than audible limit (less than 20Hz) are called infrasonic. The study of propagation of ultrasonic waves in liquid and liquid mixtures is very useful for the study of the nature of intermolecular interactions in the in the mixture of liquids system (Rajendran, 1996).

The measurements of ultrasonic velocity play an important role in understanding the physico-chemical behavior of liquids and it can be coupled with other experimental data such as density and viscosity to calculate various acoustical parameters such as adiabatic compressibility, free length and acoustic impedance, which are useful in understanding the molecular interactions in binary mixtures (Galt, 1996 and sabesan et al; 1987). Since the thermodynamic properties derived from the measurment of ultrasonic velocity, density and viscosity for binary mixtures, which are also useful in understanding the nature and type of intermolecular interactions between component molecules (Kumar et al; 2010 and Singh et al; 2005).

In the present investigations, ultrasonic velocity, density and viscosity of binary mixtures have been calculated and used to determine the acoustic parameters such as adiabatic compressibility (β), free length (L_f) and acoustic impedance (Z) to understand the intermolecular interactions between the component molecules in mixtures. Ultrasonic studies were carried out in the following two binary mixtures containing bromobenzene with methanol and ethanol at 303K temperature.

Experimental method

The chemical used in this study were purified by standard procedure (Perrin & Amarego, 1988). Continuous variation of job's method was used to prepare the binary mixture of required proportions. This mixture were preserved in conical flasks and left undisturbed to obtain thermal equilibrium.

In this investigation, the ultrasonic velocities' were measured by using the variable path interferometer having a high frequency generator and measuring cell. In the interferometer a stationary wave is setup between the generating crystal and reflector to measure the wave length of ultrasonic wave. In this way, the velocity of ultrasonic wave could be calculated at a fixed frequency of 3 MHz. The density of liquids and liquid mixture were determined by using specific gravity bottle and an electronic balance for the measurement of mass of liquid mixture. Similarly, viscosities were measured by using Ostwahs's. viscometer method at desired temperature.

From the measured values of ultrasonic velocity (V), density (ρ) and viscosity (η) of the binary mixture of liquids, the acoustical parameters like adiabatic compressibility (β), intermolecular free length (L_f) and acoustic impedance (Z) were calculated using fhe following relations (More et al; 2013).

Adiabatic compressibility

$$\beta = \frac{1}{pv^2}$$

Where,

$$p = density\ of\ experimental\ liquid$$

V = ultrasonic velocity

Intermolecular free length

$$L_f = K\beta^{1/2}$$

Where, K is the temperature dependent constant

acoustic impedance

$$Z = v \times p$$

The experimental results of ultrasonic velocity (V) density (p) and viscosity (η) along with mole fractions are taken for the two binary mixtures of compositions of methanol and ethanol with bromobenzene at the temeperature 303K. From these values the acoustic parameters such as adiabatic compressibility (β), free length (L_f), and acoustic impedance (Z) have been calculated in the table 1, 2, 3, and 4. The graphical representation for the above said parameters against the mole fraction (X) of bromobenzene is depicted in figures 1, 2, 3, 4, 5 and 6.

Discussion and Result

Table-1

The value of Ultrasonic velocity (V), density (p) and viscousity (η) for binary mixture of methanol- bromobenzene at 303K.

Mole fraction of bromobenzene	Ultrasonic velocity (V) ms^{-1}	Density (ρ) kgm^{-3}	Viscosity (η)Nsm^{-2}
0.0000	1059.5	785.0	0.5461
0.1350	1120.0	860.4	0.6921
0.2679	1134.0	912.7	0.7546
0.4512	1171.3	975.6	0.7954
0.6857	1190.4	1020.4	0.8435
0.8455	1226.0	1080.9	0.8822
1.0000	1251.4	1095.3	0.9123

Table-2

The values of ultrasonic velocity (v), density (p) and viscosity (η) for binary mixture of ethanol- bromobenzene at 303K.

Mole fraction of bromobenzene	Ultrasonic velocity (V)ms^{-1}	Density (ρ) kg^{-3}	Viscosity (η) N&m^{-2}
0.0000	1140.2	795.0	0.2516

Mole fraction of bromobenzene	Ultrasonic velocity (V)ms^{-1}	Density (ρ) kg^{-3}	Viscosity (η) N&m^{-2}
0.1350	1170.0	850.5	0.4621
0.2679	1184.5	912.3	0.5322
0.4512	1195.4	975.6	0.6541
0.6857	1230.6	1018.7	0.7351
0.8455	1232.8	1067.2	0.8521
1.0000	1251.5	1095.5	0.9124

Table-3

The values of acoustical parameters such as adiabatic compressibility (β), free length (L_f) and acoustic impedance (Z) for binary mixtures of methanol- bromobenzene at 303K are calculated from the measured values of ultrasonic velocity (V) and density (p) from the table 1.

Mole fraction of bromobenzene	Adiobatic compressibility ($\beta x10^{-10}$)$kg^{-1}ms^{2}$	Free Length (L_f) A^0	Acoustic impedance ($Zx10^6$) $kgm^{-2}S^{-1}$
0.0000	11.3424	0.6732	0.8317
0.1350	9.5380	0.6009	0.9556
0.2679	8.2991	0.5758	1.0486
0.4512	7.4712	0.5463	1.1427
0.6857	6.6561	0.5157	1.2383
0.8455	6.1550	0.4959	1.3258
1.0000	5.8304	0.4826	1.3706

Table-4

The values of acoustical parameters adiabatic compressibility (β), Free length (L_f) and acoustic impedance (Z) for binary mixture of ethanol- bromobenzene at 303K are calculated from the measured values of ultrasonic velocity (V) and density (p) from the table 2.

Mole fraction of bromobenzene	Adiabatic compressibility ($\beta x10^{-10}$) $kg^{-1}ms^{2}$	Free length (L_f) A^0	Acoustic impedance ($Zx10^6$) $kgm^{-2}s^{-1}$
0.0000	9.6754	0.6217	0.9064
0.1350	8.5892	0.5858	0.9985
0.2679	7.8339	0.5595	1.0787
0.4512	7.1730	0.5353	1.1603
0.6857	6.5014	0.5086	1.2701
0.6455	6.1655	0.4963	1.3356
1.0000	5.8280	0.4825	1.3710

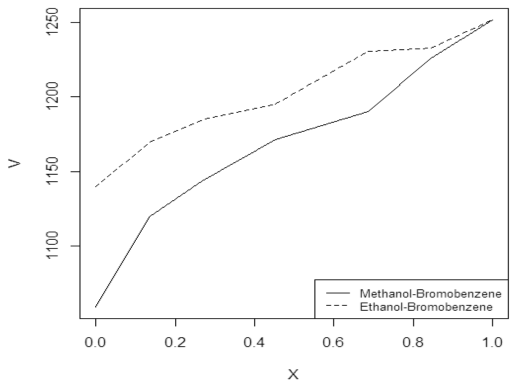

Figure 1

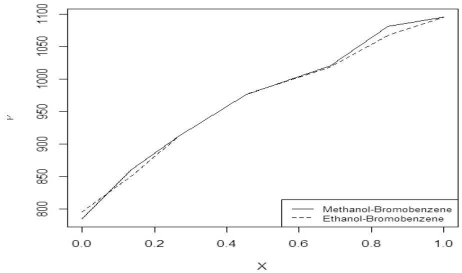

Figure 2

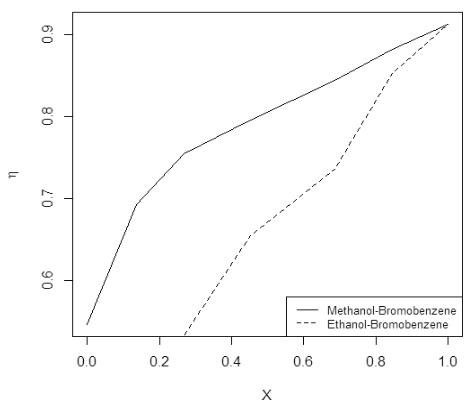

Figure 3

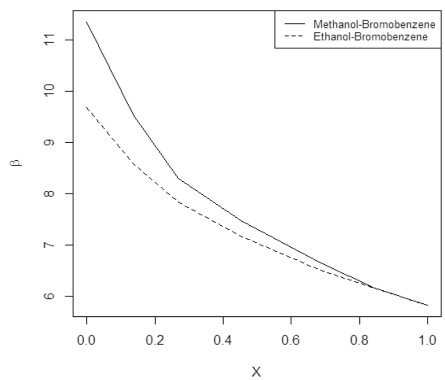

Figure 4

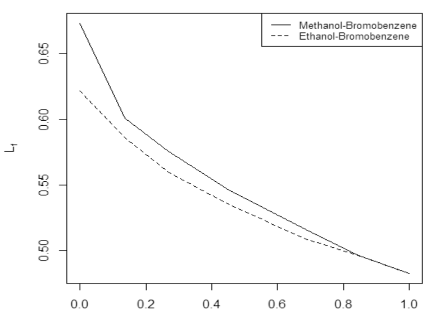

Figure 5

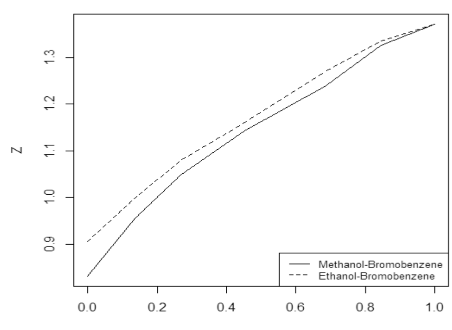

Figure 6

From the figure 1, 2 and 3, it is clear that the values of ultrasonic velocity (v), density (ρ) and viscosity (η) of mixtures increases with increases in the concentration of mole fraction of bromobenzene in these two systems of mixture because the velocity in medium depends upon binding force between the molecules. These figures also show that the viscosity increases with increases in mole fractions of bromobenzene which means bromobenzene is more viscous (sahu et al; 2012). Thus, we can say that there are molecular interactions between the components of binary mixtures. This indicates that ultrasonic velocity, density and viscosity increases with increase in chain length of alcohol (Rajathi et al; 2011 and Narendra et al 2012).

From the figure4, it can be noted that in the two binary mixtures of Liquid, adiabatic compressibility (β) decreases with increases in the concentration of mole fraction of bromobenzene. It means, there is formation of hydrogen bonds between bromobenzene (solute) and methanol amd ethanol (solvent) molecules. Fort and more suggested that hydrogen bonding between unlike components makes negative contribution of compressibility (fort and Moore, 1965).

In figure 5, Intermolecular free length (L_f) shows the similar behavior as adiabatic compressibility (β). The decreases in compressibility bring the molecules closer and hence decrease of intermolecular free length (L_f). Since, the intermolecular free length is related with ultrasonic velocity (V) in the mixture. The decrease in the value of adiabatic compressibility (β) and free length (L_f) with increase in ultrasonic velocity (V) confirms the strong molecular interaction between the unlink molecules through hydrogen bonding (vibhu, 2004).

It is also observed from the figure 6, that there is increase in acoustic impedance (Z) with increase in the mole fraction of bromobenzene in the two systems of mixtures. The increase in acoustic impedance indicates significant interaction between the components of mixtures, which increases the intermolecular distance i.e, it makes relatively wider gap between the molecules. This can be explained on the basic of lyophobic interaction between solute & solvent molecules (Jay kumar et al; 1996).

Conclusion

In the present investigation, the acoustic parameters like as adiabatic compressibility (β), free length (L_f) and acoustic impedance (Z) have been determined from the calculated values of ultrasonic velocity (V) and density (p) for the binary mixture of methanol- bromobenzene and ethanol-bromobrenzene at 303k. From this study, it is obtained that there are intermolecular interactions between the components of the binary mixtures i.e; molecular interaction increases with increase in concentration of bromobenzene in the above mixture of liquids.

Again, from this study, it may be noted that the adiabatic compressibility decreases with increase in the mole fraction of bromobenzene, it clearly indicates that relatively strong hydrogen bonding interactions takes place between the unlike molecules of the binary mixture.

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References

Fort, J.R. and Moore, W.R.(1965). Adiabatic compressibilities of binary liquid mixtures. J.of transactions of faraday society, 61, 261-265.

Jaykumar, A; karunanidhi, S. and KannappanV.(1996). Ultrasonic velocity and other acoustical parameters in binary mixtures of O-cresol, p- cresol, O- chlorophenol and p-chorophenol with ccl_4 at 303k. Indian J. of pure applied physics, 34, 761-763.

Kumar, S.K., Baskaran, R. and kubendran, T.R.(2010). Acoustic and thermodynamic properties of binary liquid mixture of acetophenone and benzene. J. applied science, 10, 1616-1621.

Marcus, Y.S. (1977). Introduction of liquid state chemistry. Newyork: wiley publication.

More, K.D.kawale, R.S., Gawali, P.G.(2013). Ultrasonic Study of binary mixture of acetic acid and toluene. International J. of science and research, 6,264-269.

Narendra, K; Sirinivas, ch. And Murthy, N.(2012). Excuss properties of binary mixtures of o-xylene, m-xylene and p-xylene with anisaldehyde at different temperatures. Journal of applied science, 12(2), 136-144.

Perrin, D.D. and Armarego, W.L.F. (1988). Purification of laboratory chemistry 3rdedition.U.K.: Oxford.

Rajathi, K.,Askar, S.J. and Rajendarn, A.(2011). Ultrasonic study of molecular dynamics in same binary mixtures. Journal of chem. and Pharma. Research, 3(5), 348-358.

Rajendra, V., (1996). Behavior of acoustical parameters of mixed alkali silicate glasses. Indian J. pure & applied physics, 33,29-33.

Sabesan,R. Natarajan, M andVradarajan, K.(1987). Ultrasonic study of molecular dynamics in some binary mixtures. J. of chem. & pharma. research,64,57-61.

Sahu,S., Nath, G. and Paikarey.R.(2012). Study of molecular interactions in binary mixtures at variable frequency using ultrasonic techniques. Research J. of chemical sciences 2(11),64-66.

Singh, P.J. and Sharma, S.K.(1996). Dielectric behavior of ketone- amine binary mixtures at Microwave frequencies. Pramana journal of physics, 46, 259-270.

Singh, S.,Rattan, V.K., Kapoor, S; Kumar R. and Rampal, A. (2005). Thermophysical Properties of binary mixture of cyclohexane+nitrobenzene, cyclohexanone+nitrobenzene and cyclohexane+cyclohexaneone. Journal of chemical Eng., 50,288-292.

Vibhu, I. (2004). Ultrasonic and infrared study of molecular interaction in ternary mixtures of I- napthol and 2-napthol with 2- propane in benzene. Pramana journal of physics, 62, 1147-1155.