Characteristic Analysis of Binary Mixtures of Polar Liquids O-Chlorophenol and Nitrobenzene in Non-Polar Solvent Benzene Exposed to Ultrasonic Frequency

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Abstract

Ultrasonic wave is established as an effective means for analyzing certain physical properties of the materials. Ultrasonic is an area of intense scientific and technological research. Science and technology of ultrasonic is widely sought in the recent years for Industrial and medical applications. In liquid systems and solids the study of propagation behavior Hence the authors selected certain binary and ternary liquid systems i-e O-Chlorophenol in Benzene, Nitro benzene in benzene and o-chlorophenol and nitro benzene in benzene for the evaluation of U.S.V(Ultrasonic Velocity) and adiabatic compressibility . A standard frequency of 2 MHz of Ultrasonic waves has been used as a source for the selected liquid system. The results obtained are interpreted on the basis of molecular interactions. The variation of ultrasonic velocity with different concentration shows the effective molecular interaction in the pure liquid and liquid mixtures.

KEYWORDS: Molecular interaction, binary and ternary liquids, adiabatic compressibility

INTRODUCTION:

Ultrasonic is an area of intense scientific and technological research. Science and technology of ultrasonic is widely sought the resent years for industrial and medical application. Recent development in ultrasonic study has also maintained a steady face for the past several decades to meet intense demands. The change in the wavelength of ultrasound waves in different medium is due to the elastic properties and the induced particle vibration in the medium. Further the wavelength of ultrasonic wave is small and hence it exhibits some unique phenomenon in addition to the properties of sound waves. The study of propagation of ultrasonic wave in liquid systems and solids is now rather well established. The ultrasonic wave is an effective means for examining certain physical properties of the material. It is universally adopted to examine the changes in such physical properties while they occur. The ultrasonic velocity and density measure of certain dielectric liquids can be used to compute acoustical parameters such as adiabatic compressibility, free length, acoustic impedance, Rao's constant, and Wada's constant. The primary effect of dissolving an alcoholic material is to decrease the compressibility of the solvent. This decrease in the compressibility is attributed to the influence of

electrostatic field of ions and the surrounding solvent molecules. Here an attempt is made to explain the acoustical proportions of o-chlorophenol and nitrobenzene.

COMPUTATION:

SOUND WAVELENGTH:

$$\lambda = 2[d/n]$$

Where, d is the distance through which the reflector is shifted for n maxima

FREQUENCY OF QUARTZ CRYSTAL:

$$U = f\lambda$$

Where, U is the velocity of sound waves

MEASUREMENT OF DENSITY:

$$\rho_s = (RD)\,\rho_{mix}$$

Where, ρ_s is the density of sample, RD is the relative density of system; ρ_{H2O} is the density of water.

ADIABATIC COMPRESSIBILITY:

$$\beta_T = (1/U^2\rho)$$

MOLAR SOUND VELOCITY AND MOLAR COMPRESSIBILITY:

$$U^{1/3}V = R$$

Where, R is Rao's number

FREE LENGTH:

$$L_f = K\,\beta_T^{1/2}$$

EXPERIMENTAL STUDY:

The ultrasonic speed is determined by single frequency ultrasonic interferometers.
[0809677 Mittal New Delhi] at 2MHz. The accuracy in ultrasonic velocity was found to be ±0.05%. The accuracy in density measurements is found to be 0.0001% g/cm^3.

RESULT AND DISCUSSION:

- The selected substance for the measurement is o-chlorophenol (OCP) and nitrobenzene (NB) in the solvent benzene. With non polar solvent benzene and their values are reported in table-1 and 2. Similarly these measurements are carried out for their binary mixtures (OCP+NB) and the ratios. These values are recorded in table 3-4.
- For all the systems, it is observed that with increase of concentration shows the increase of ultrasonic velocity (table 1-5). But the variation is not found to be linear. This can be shown in Figure 1.The increase in the polar nature of the two components (OCP + NB) which leads to the dipole attractive force. This may also be due to the electron deficient carbon of OCP and negatively charged oxygen of NB. This causes the positively Polarized nitrogen in NO_2. This complex formation between the two component molecules leads to a decrease in the intermolecular distances and increase in the sound velocities. This complex formation is found to be maximum at 0.030 concentration.
- From Table 1 to 5, it shows an increase of concentration decreases the adiabatic compressibility. This may be due to the fact that OCP + NB in dilute solution are considerably ionized into H- cation and Cl-anion.These ions surrounded by a layer of solvent molecules firmly bound and oriented towards the ion. The orientation of solvent molecules around the ions is attributed to the influence of electrostatic field of the ions increasing the internal pressure which lowers the compressibility of the solute. The adiabatic compressibility β_T has an inverse relation with ultrasonic velocity; the mixture studied here shows a decrease in compressibility, as the concentration increases, which may be due to the H-bond formation. The strengthening of intermolecular forces results in the decrease of adiabatic compressibility β_T and an increase of ultrasonic velocity. This confirms the existence of complex formation. The decrease of adiabatic compressibility (β_T) may also be due to the closed packing of ionic group in the solute which increases in ionic repulsion and finally increases the internal pressure.
- From the table 1, it is observed that the increase of concentration of the solute on the solvent increases the density value. This may be due to the fact that the density of the individual solute may be more than the density of the solvent. The nitrobenzene and the chlorophenol are polar liquids which can interact by forming H bonding through dipole- dipole interaction (OH-NO_2). The chlorophenol is a liquid which is associated through H- bonding and in pure state it exhibits equilibrium between the monomer and multimer spices. The graphical representation of ultrasonic velocity versus concentration shown in figure 1 and the adiabatic compressibility (β_T) versus concentration is shown in figure 2. In both the cases the variation is found to be non-linear. The adiabatic compressibility (β_T) has the inverse relationship with velocity. The mixture (OCP + NB) studied here shows the compressibility minimum at 30% of concentration of the mixture where the velocity is found to be maximum. This is found to be true for all ratios. The solvent strengthen the intermolecular forces resulting the decrease of adiabatic compressibility (β_T) and an increase of ultrasonic velocity (U). This causes the complex formation at that particular concentration. So the

complex formation is found to be maximum at 30% of concentration of solutes in the solvent.

TABLE-1
ULTRASONIC PARAMETERS OF O-CHLOROPHENOL IN BENZENE AT 300K

Weight fraction (W_f)	Ultrasonic velocity U ms^{-1}	Density ρ kgm^{-3}	Adiabatic compressibility β_T X $10^{-10}m^2N^{-1}$
0.005	1263.04	877.43	7.1438
0.010	1277.17	878.59	6.9777
0.015	1294.32	879.75	6.7851
0.020	1315.17	880.50	6.5652
0.025	1338.05	881.21	6.3383
0.030	1353.04	881.62	6.1957

TABLE-2
ULTRASONIC PARAMETERS OF NITROBENZENE IN BENZENE AT 300K

Weight fraction (W_f)	Ultrasonic velocity U ms^{-1}	Density ρ kgm^{-3}	Adiabatic compressibility β_T X $10^{-10}m^2N^{-1}$
0.005	1201.8	873.35	7.9277
0.010	1208.2	875.89	7.8207
0.015	1214.1	876.85	7.7361
0.020	1216.7	878.93	7.6854
0.025	1233.2	880.39	7.4685
0.030	1240.1	880.91	7.3814

TABLE-3
ULTRASONIC PARAMETERS OF O-CHLOROPHENOL IN NITROBENZENE (1:3) IN BENZENE AT 300K

Weight fraction (W_f)	Ultrasonic velocity U ms^{-1}	Density ρ kgm^{-3}	Adiabatic compressibility β_T X $10^{-10}m^2N^{-1}$
0.005	1224.7	874.07	7.6274
0.010	1240.2	877.38	7.4092
0.015	1256.4	877.85	7.2156
0.020	1272.3	878.90	6.0282
0.025	1288.3	882.11	6.8305
0.030	1304.4	885.18	7.6401

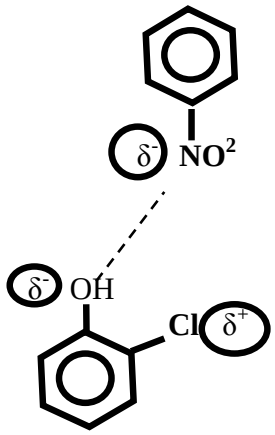
TABLE-4
ULTRASONIC PARAMETERS OF O-CHLOROPHENOL IN NITROBENZENE (1:1) IN BENZENE AT 300K

Weight fraction (W_f)	Ultrasonic velocity U ms^{-1}	Density ρ kgm^{-3}	Adiabatic compressibility β_T X $10^{-10}m^2N^{-1}$
0.005	1241.32	874.45	7.4215
0.010	1256.44	877.35	7.2201
0.015	1272.96	879.22	7.0189
0.020	1293.76	880.48	6.8091
0.025	1326.73	881.73	6.4430
0.030	1335.20	883.05	7.6076

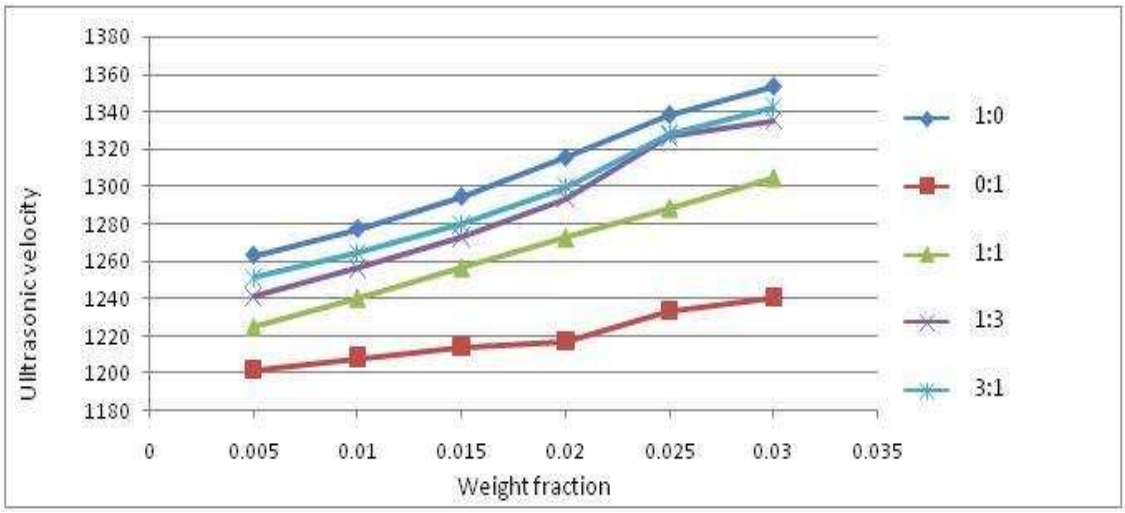
TABLE-5
ULTRASONIC PARAMETERS OF O-CHLOROPHENOL IN NITROBENZENE (3:1) IN BENZENE AT 300K

Weight fraction (W_f)	Ultrasonic velocity U ms^{-1}	Density ρ kgm^{-3}	Adiabatic compressibility β_T X $10^{-10}m^2N^{-1}$
0.005	1251.36	874.78	7.3002
0.010	1264.36	876.06	7.1404
0.015	1279.60	877.49	6.9599
0.020	1299.76	878.43	6.7229
0.025	1328.21	879.83	6.4426
0.030	1342.21	881.06	6.3001

STRUCTURAL REPRESENTATION OF WEAK INTERACTION BETWEEN O-CHLOROPHENOL AND NITROBENZENE

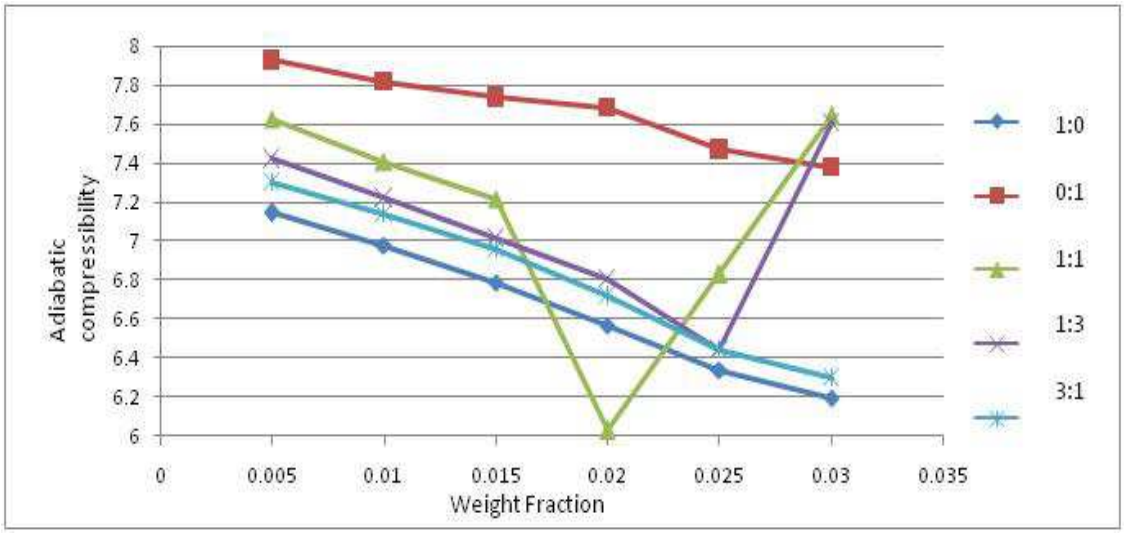


O-CHLOROPHENOL + NITROBENZENE IN BENZENE AT 300K



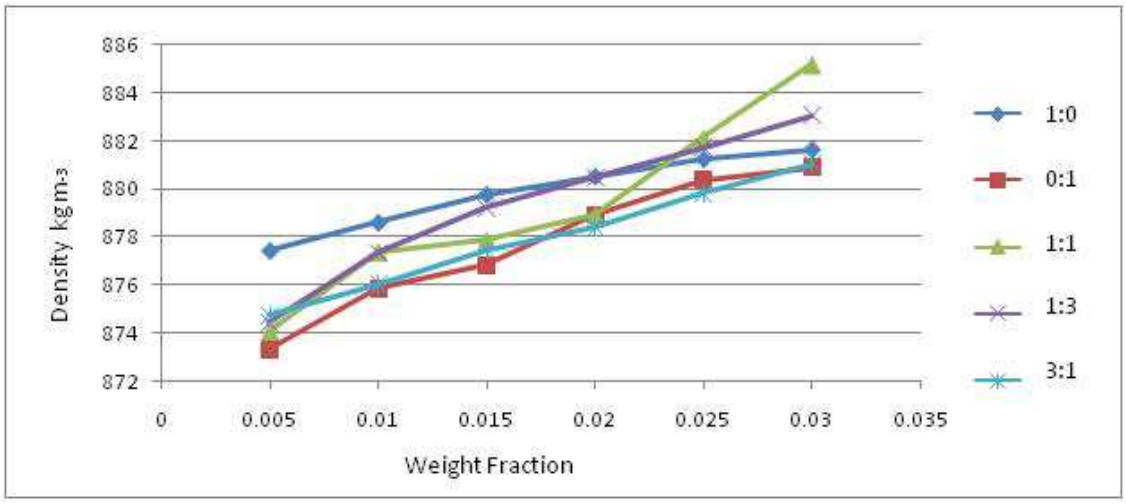
[FIG-1] VARIATION OF ULTRASONIC VELOCITY OF O-CHLOROPHENOL + NITROBENZENE IN BENZENE WEIGHT FRACTION AT 300K

O-CHLOROPHENOL + NITROBENZENE IN BENZENE AT 300K



[FIG-2] VARIATION OF ADIABATIC COMPRESSIBILITY OF O-CHLOROPHENOL + NITROBENZENE IN BENZENE WEIGHT FRACTION AT 300K

O-CHLOROPHENOL + NITROBENZENE IN BENZENE AT 300K



[FIG-3] VARIATION OF ADIABATIC COMPRESSIBILITY OF O-CHLOROPHENOL + NITROBENZENE IN BENZENE WEIGHT FRACTION AT 300K

CONCLUSION:

The acoustical parameters are determined for o-chlorophenol in benzene and nitrobenzene in benzene of various concentrations at 300K. The variation in the ultrasonic velocity, adiabatic compressibility suggests that the charge transfer complex is formed between o-chlorophenol and benzene & nitrobenzene and benzene. The decrease in dielectric compressibility with increase of concentration may due to the fact that (OCP + NB) in dilute solution are considerably ionized into hydrogen cation and chlorine anion. These ions are surrounded by the layer of solvent molecules formally bound and oriented towards ions. The orientation in the solvent molecules around the ions is attributed due to the influence of electrostatic field of ions there by increasing the internal pressure which lowers the compressibility of the solution. The increase in the ultrasonic velocity with increase of concentration may be due to the polar nature of the two components (OCP + NB) which leads to the dipole attractive forces. This may also be due to the electron deficient carbon of OCP and negatively charged oxygen of nitro benzene (NB). This causes the positively polarized nitrogen in NO_2. This complex formation between the two component molecules leads to a decrease in the intermolecular distances and increase in sound velocities. This complex formation is found to be maxima at 0.030 concentrations.

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