Density and Ultrasonic Velocity of Binary Mixtures of Benzaldehyde and Methanol at Different Temperatures

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Abstract: Density (ρ) and ultrasonic velocity (U) of benzaldehyde (BZ), methanol (MeOH) and their binary mixtures were measured in the temperature range from 293.15 K to323.15 K (in the interval of 10 K). Experimentally measured densities and ultrasonic velocities of the mixture were used to evaluate other physical and acoustical parameters such as acoustic impedance (Z), adiabatic compressibility (β), free length (L_f) and molar volume (V_m).A comparison with other experimental data in the literaturehas been made.

INTRODUCTION

Ultrasonic velocity measurements are widely used to study molecular interactions in pure liquids and theirmixtures. The study of ultrasonic velocity of different liquid mixtures finds applications in industrial and technological processes. Using ultrasonic method the structural information of materials at molecular levels can be obtained[1].Ultrasonic studies of Benzaldehyde in mixed state with other polar solvents were carried out by many researchers in recent past [1-4].

Recently we studied the excess dielectric properties and Kirkwood correlation parameter of binary mixtures of Benzaldehyde and Methanol at different temperatures [5]. In present work we report the ultrasonic velocity (u), acoustic impedance (Z), adiabatic compressibility (β), free length (L_f) and molar volume (V_m) data of the binary mixtures of benzaldehyde and methanol at 293.15 K to 323.15 K (In interval of 10 K). Aim of the present paper is to study the effect of concentration and temperature variation on the acoustical parameters of the binary mixture of BZ and MeOH.

MATERIALS AND METHODS

MeOH(AR grade) and BZ (AR grade) were purchased from Ranbaxy laboratories limited and SD fine-chem limited,(India) respectivelyand used as received. Binary mixtures of MeOH and BZ were prepared at eleven different concentrations by volume and were converted into mole fraction of BZ in the mixture by using equation expressed in reference[6].Ultrasonic velocities (U) of the prepared samples were measured using ultrasonic interferometer (F-81S) at 2MHz frequency. Density of the mixtures was taken from recently published article of the same system [5]. The measurement was carried out at four different temperatures and was controlled by the constant temperature water bath with an accuracy of ± 0.1 K.

EVALUTION OF PARAMETERS

From the experimentally measured values of ultrasonic velocity (U) different optical parameters were evaluated by using the following relations [1,6].

$$Z = \rho * U \tag{1}$$

$$\beta = \frac{1}{\rho U^2} \tag{2}$$

$$L_f = \frac{K}{U\rho^{\frac{1}{2}}} \tag{3}$$

$$V_m = \frac{(X_1M_1+X_2M_2)}{\rho} \tag{4}$$

Where Z, β, L_f and V_m are acoustic impedance, adiabatic compressibility, free length and molar volume respectively. ρ is density, K is Jacobson's constant, is depends on temperature and is given by K= (93.875+0.375T)*10^{-8} , with T being the absolute temperature [1], X is mole fraction M is molecular weight, suffix 1 and 2 are for BZ and MeOH respectively.

RESULTS AND DISCUSSION

Comparison of experimental and literature values of ultrasonic velocity of BZ and MeOH at different temperatures is shown in TABLE 1. The experimental value shows good agreement with literature for MeOH and BZ. In FIGURE 1 the temperature dependent (a) ultrasonic velocity, (b) acoustic impedance, (c) adiabatic compressibility and (d) free lengthwith mole fraction of BZ have been presented.

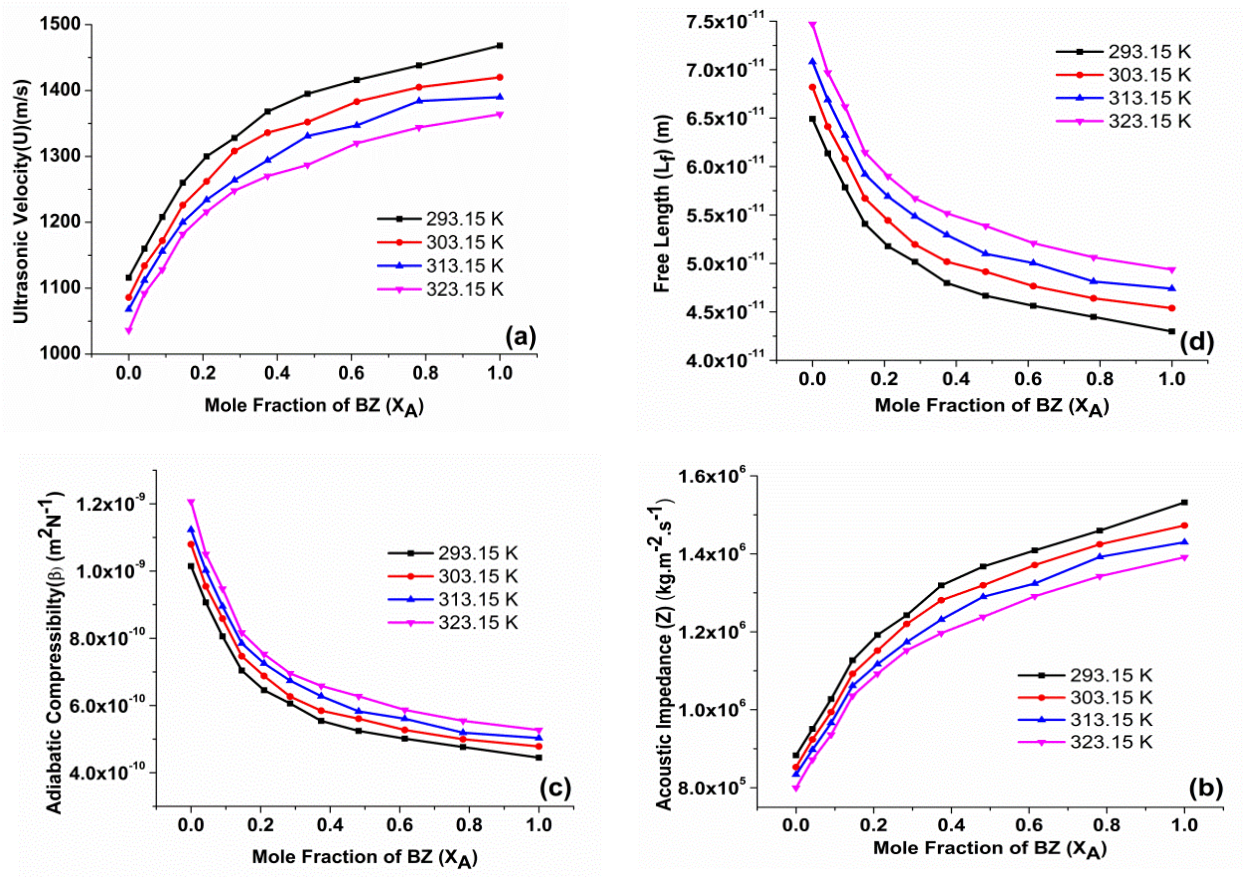

FIGURE 1. (a) Ultrasonic velocity (U) (b) Acoustic impedance (Z) (c) Adiabatic compressibility (β) and (d) Free length (L_f) versus mole fraction of BZ (X_A)

The values of ultrasonic velocity and acoustic impedance of the mixture increase nonlinearly with increasing the mole fraction of BZ, whereas adiabatic compressibility and free length decrease nonlinearly with increasing the mole fraction of BZ. The non-linear increase of Z and decreases of β and L_f with increasing mole fraction of Benzaldehyde in the system indicates the presence of molecular interactions between unlike molecules[8,9]. Free

length decrease with increase in the mole fraction of BZ that indicates the strong interaction between BZ and MeOH.The decrease of U and Z with temperature indicates the decrease in cohesive forces, while increase of β and L_f with temperature indicates the increase in cohesive forces. The increasing temperature has two opposite effects namely increase of molecular interactions (Structure formation) and destruction of structure formed previously as aresult of thermal fluctuation [10].The variation of molar volume (V_m) with mole fraction of BZ (X_A) is shown in TABLE 1. Molar volume of the mixtures increases with increasing the mole fraction of BZ and also increase with increasing temperature.

TABLE 1: Comparison of experimental ultrasonic velocity (U) of pure BZ and MeOH with literature at different temperature

Pure Solvent	**T/K**	**Ultrasonic Velocity(U) ms^{-1}**	
		Exp.	**Lit.**
BZ	303.15	1420	1452[1]
MeOH	293.15	1116	1116[7]
	303.15	1086	1084[7]
	313.15	1068	1050[7]
	323.15	1036	-

TABLE 2: Molar volume of the binary mixture of BZ and MeOH at different temperatures

Molar Volume (V_m)				
Mole Fraction of BZ(X_A)	**293.15 K**	**303.15 K**	**313.15 K**	**323.15 K**
1	101.6874	102.3149	103.1603	104.0402
0.781898	88.62829	88.7587	89.42714	90.08759
0.614397	77.94656	78.24196	78.90178	79.31416
0.481717	69.09373	69.4317	69.87536	70.41428
0.374023	61.96306	62.34535	62.78381	63.4517
0.284864	56.79881	57.00089	57.22747	57.58208
0.209834	51.8976	52.15767	52.55466	52.98311
0.145821	47.89414	48.10206	48.42222	48.89983
0.090565	45.55337	45.70117	46.34995	46.70922
0.042384	42.916	43.18774	43.58139	44.06359
0	40.4952	40.79744	41.03947	41.49623

CONCLUSION

Ultrasonic velocity, acoustic impedance, adiabatic compressibility, free length and molar volume of binary mixtures of BZ and MeOH were reported at four different temperatures. The value of U, Z and V_m increase whileβ,and L_f decrease with increasing mole fraction of BZ. Ultrasonic velocity and free length are reciprocal of eachother. The valuesof U, Z are reduce with increase temperature while for β, L_f are increases with increases in temperatures and this behavior with temperature is because of the cohesive force.

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