

Ultrasonic Study of Binary Liquid Mixture of n-Hexane and Acetic Acid

H.K Semwal¹, Manish Uniyal², S.C Bhatt³

Department of physics, HNB Garhwal University Srinagar Garhwal, Uttarakhand-246174, India

Abstract: *The velocity of ultrasonic wave in binary liquid mixtures of n-hexane and acetic acid has been measured at 1,2,3,4,5,6 and 7 MHz frequencies at room temperature with the help of ultrasonic interferometer. Isentropic compressibility (ks), Acoustic impedance (Z) and Relaxation time(T) have been calculated for the whole composition range for these binary mixtures.*

Keywords: Ultrasonic waves, Isentropic compressibility, Acoustic impedance, Relaxation time.

1. Introduction

The propagation of ultrasonic waves in any liquid mixture has become a fundamental test to investigate its properties. Ultrasonic wavelength measurement has been adequately employed for to understand the nature of molecular interaction in pure liquids, binary and ternary mixtures and the Ionic interactions in electrolytic solutions.

The study of properties of the liquid mixture of polar as well as non-polar components finds application in various fields like medical, industrial and technological processes etc., as such liquid mixtures provide a wide range solutions with appropriate properties [1-3]. When acoustic waves are propagated through a liquid, dissipation of acoustic energy that is associated with changes in the molecular structure of the medium results from the finite time that is required for these changes to take place.

Miscibility of ethylene-vinyl acetate with polystyrene was studied in toluene solution using viscometer and ultrasound analysis [4]. Ultrasonic velocity and density for binary liquid mixtures of N, N – dimethyl formamide with methoxyl ethanol, 2-ethoxy ethanol and 2-butoxyl ethanol have been determined at 308.5 k over the entire mole fraction range and different acoustic parameters have been calculated [5]. Velocity of ultrasonic waves in different liquid medium have been measured [6-7] at room temperature and adiabatic compressibility, acoustic impedance and relaxation time have been calculated for these liquids.

Measurement of ultrasonic velocity [8-11] has been adequately employed in understanding the molecular interactions in pure, binary, and higher order multi-component liquid mixtures. The propagation of ultrasonic velocity in a medium is a thermodynamic property and has come to be recognized as a very specific and unique tool for predicting and estimating various physio-chemical properties of the systems under consideration [12].

Many researchers have studied the acoustical behavior of liquids and liquid system, true information is used to study the nature of interaction and application of these systems. Ultrasonic velocities have been measured in binary organic liquid mixtures using a variable frequency fixed path ultrasonic interferometer.

In the present investigations we have measured Ultrasonic velocity in binary liquid mixture of n-hexane and acetic acid at room temperature with the help of ultrasonic interferometer at different frequencies ranging from 1MHz to 7MHz and calculated isentropic compressibility, Acoustic impedance and Relaxation time for this mixed system.

2. Experimental Measurement

The Ultrasonic interferometer is a simple and direct device to determine the ultrasonic velocity in liquid. The principle used in the measurement of ultrasonic velocity is based on the determination of wavelength in the liquid mixture. The ultrasonic waves of known frequency are produced by quartz crystal fixed at the bottom of the measuring liquid cell.

The measuring cell is connected to the output terminal of the high frequency generator through the spherical cable. A mobile metallic plate kept parallel to the quartz crystal reflects these waves. If the separation between these two plates is exactly a whole multiple of the sound wavelength, standing waves are formed in the medium. These acoustic resonances gives rise to an electrical reaction on the generator, driving the quartz crystal and anode current of the generator become maximum.

The high frequency generator is designed to excited the quartz crystal fixed at the bottom of the measuring cell. If the distance is now increased or decreased and the variation is exactly one half the wavelengths or multiple of it, anode current become maximum. A number of maxima reading of anode current are passed and their number n is counted. The total distance (d) moved by the micrometer gives the value of the wavelength as-

$$D = n\lambda/2$$

The least count of the micrometer used for measuring the wavelength is .001mm. Now the ultrasonic velocity can be obtained if the wavelength is known.

3. Calculation

The ultrasonic velocity measurements are extensively used to study physio-chemical behavior of liquids with the help of measured ultrasonic velocity and density, using following formula. Acoustic parameters like Isentropic compressibility, Acoustic impedance and Relaxation-time

have been calculated and results are tabulated, plotted and discussed.

- 1) Ultrasonic velocity (u) was calculated from the ultrasonic wavelength.
 $U = n\lambda$
- 2) Isentropic compressibility
 $K_s = U^{-2} \rho^{-1}$
- 3) Acoustic impedance
 $Z = \rho XU$

4) Relaxation time

$$\tau = 4\eta/3\rho U^2$$

Where

- τ = relaxation time
- η = viscosity
- ρ = density of liquid mixture
- U = ultrasonic velocity of waves

Table 1.1: Ultrasonic velocity in Binary liquid mixture of n-hexane and acetic acid at different frequencies & composition:

Binary liquid mixture composition (volume)		Density	Ultrasonic velocity(m/s) at different frequencies						
n-Hexane%	Acetic acid%	(g/cc)	1MHz	2MHz	3MHz	4MHz	5MHz	6MHz	7MHz
0	100	.997	4914	4917	4919	4920	4921	4922	4923
20	80	.606	5718	5629	5630	5632	5633	5635	5636
40	60	.696	5758	5187	5189	5190	5189	5190	5192
60	40	.664	6914	5735	5735	5736	5737	5737	5738
80	20	.617	6967	6628	6629	6630	6631	6631	6632
100	0	.586	6916	7318	7319	7320	7321	7321	7322

Table 1.2: Isentropic compressibility of Binary liquid mixture of n-hexane and acetic acid at different frequencies & composition

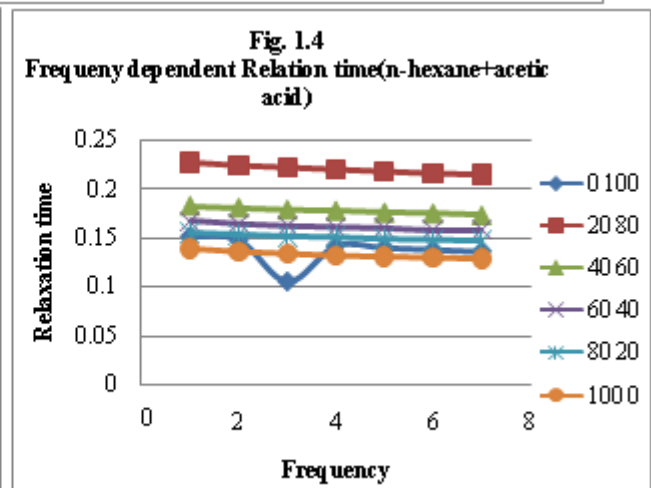
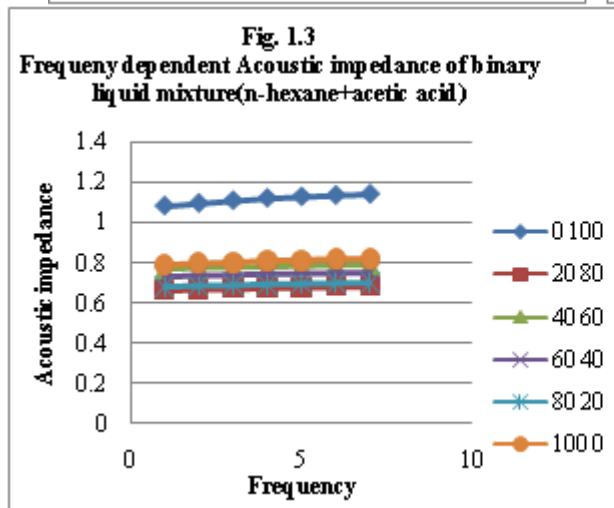
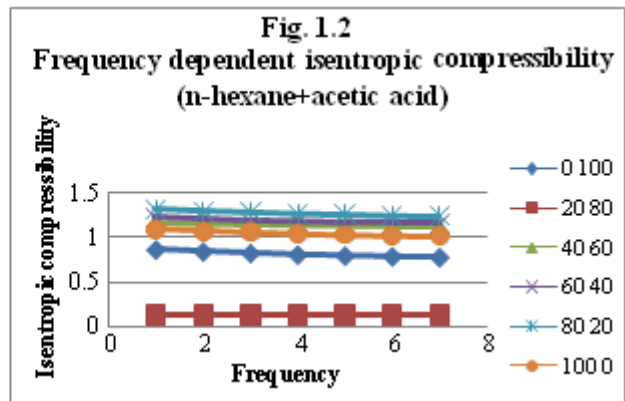
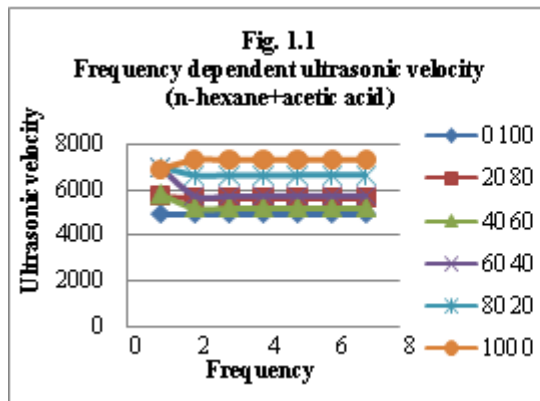
Binary liquid mixture composition (volume)		Isentropic compressibility(Kg ⁻¹ ms ⁻²) at different frequencies(x10 ⁻³)						
n-Hexane%	Acetic acid%	1MHz	2MHz	3MHz	4MHz	5MHz	6MHz	7MHz
0	100	.865	.843	.825	.807	.795	.785	.777
20	80	.136	.134	.133	.132	.131	.1299	.129
40	60	1.178	1.164	1.151	1.141	1.133	1.123	1.115
60	40	1.23	1.21	1.19	1.18	1.17	1.169	1.162
80	20	1.317	1.298	1.285	1.269	1.262	1.249	1.242
100	0	1.092	1.075	1.059	1.045	1.031	1.024	1.017

Table 1.3: Acoustic impedance of Binary liquid mixture of n-hexane and acetic acid at different frequencies & composition

Binary liquid mixture composition (volume)		Acoustic impedance(Kgm ⁻² s ⁻¹) at different frequencies						
n-Hexane%	Acetic acid%	1MHz	2MHz	3MHz	4MHz	5MHz	6MHz	7MHz
0	100	1.085	1.099	1.112	1.124	1.132	1.139	1.145
20	80	.666	.671	.6744	.6775	.6799	.6829	.6853
40	60	.768	.773	.777	.780	.7836	.7871	.7899
60	40	.734	.740	.744	.7476	.7509	.7536	.7556
80	20	.684	.689	.692	.697	.699	.702	.704
100	0	.792	.798	.804	.810	.815	.818	.821

Table 1.4: Relaxation time of Binary liquid mixture of n-hexane and acetic acid at different frequencies & composition

Binary liquid mixture composition (volume)		Relaxation time(second) at different frequencies						
n-Hexane%	Acetic acid%	1MHz	2MHz	3MHz	4MHz	5MHz	6MHz	7MHz
0	100	.152	.148	.105	.142	.140	.138	.136
20	80	.227	.224	.222	.220	.218	.216	.215
40	60	.183	.181	.179	.178	.176	.175	.173
60	40	.167	.164	.162	.161	.160	.158	.158
80	20	.156	.154	.152	.151	.149	.148	.147
100	0	.139	.136	.134	.132	.131	.130	.129



4. Result and Discussion

Ultrasonic velocity has been measured by variable path interferometer at different frequencies from 1MHz to 7MHz at room temperature in Binary liquid mixture of n-hexane and acetic acid.

Ultrasonic velocity in binary liquid mixtures (n-hexane + acetic acid) presented in table-1.1 and fig1.1. From the table and figure it is observed that in binary liquid mixture ultrasonic velocity increases with increasing frequency, while with increasing composition of n-hexane in liquid mixture the ultrasonic velocity also increases.

Isentropic compressibility of binary liquid mixture have been calculated using formula $K_s = U^{-2} \rho^{-1}$ and acoustic impedance is calculated by the equation $Z = \rho \times U$. From the table-1.2 and figure-1.2, the isentropic compressibility of binary liquid mixture is decreasing with increasing frequency while increasing the composition of n-hexane in liquid mixture the isentropic compressibility is decreasing.

In binary liquid mixture table-1.3 and figure-1.3 shows that acoustic impedance slightly increases with increasing frequency while increasing the composition of n-hexane in liquid mixture the acoustic impedance also increases. Relaxation time is also calculated using formula $\tau = 4\eta / 3\rho U^2$. The values of relaxation time are also shown in table-1.4 and figure-1.4. It is observed that relaxation time in binary liquid mixture (n-hexane + acetic acid) slightly decreases with increasing frequency while increasing the

composition of n-hexane in liquid mixture the relaxation time decreases.

5. Conclusion

The variation of ultrasonic velocity, Isentropic compressibility, Acoustic impedance and Relaxation time for different compositions of binary liquid mixtures n-Hexane and acetic acid at different frequencies at room temperature have been shown in table 1.1 to 1.4 & respectively and plotted in figures 1.1 to 1.4 respectively. From table and figure it is observed that ultrasonic velocity slightly increases with increase in frequency for liquid mixture. Isentropic compressibility, acoustic impedance and relaxation time show a transition type behavior with increasing percentage of acetic acid, their values depend upon the composition ratio of carbon and hydrogen atom in binary liquid mixture.

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