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ULTRASONIC STUDY OF VISCOUS BEHAVIOR OF BINARY LIQUID MIXTURES OF TRI-ETHYLAMINE WITH ALKANOLS AT 303.15K

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ABSTRACT

The ultrasonic velocity (U), the density (ρ) and the excess ultrasonic velocity (UE) of tri-ethylamine with Methanol, Ethanol, Propanol and Butanol have been measured at 303.15K using ultrasonic interferometer over the entire range of composition. From the measured data of ultrasonic velocity, density and excess ultrasonic velocity (UE) have been estimated using standard relations. The present study also indicates the strong molecular interaction in the present liquid systems.

Keywords: Binary liquid mixtures, statistical theory, ultrasonic velocity, excess ultrasonic velocity, ultrasonic Interferometer, molecular interaction, entropy, thermal expansion co-efficient, isothermal compressibility, reduced volume, equimolecular, noise waves, dipole moment.

INTRODUCTION

The rapid development of ultrasonic techniques and the introduction of new materials for producing powerful ultrasonic vibrations have opened up wide fields of research and technical applications in physics, chemistry, biology, medicine and industry. Most of the physical properties change whenever there is a change in the composition and structure of the liquid mixture. Then non-linear dependence of the physic-chemical properties with composition has been attributed to the size, shape and polarity of the molecules. Ultrasonic velocity is one such property which is very important for the study of molecular interactions in solution. It gives information about the extent of interaction and some other parameters such as adiabatic compressibility and free lengthy. Velocity determination of ultrasound waves enables us to study the properties of the medium, in which it travels, owing to the important of ultrasound velocity in the investigation of molecular interaction in solutions, its measurements have been carried out in the different binary liquid mixture studies in the present work.

EXPERIMENT

THEORY AND APPARATUS

ULTRASONIC AND ULTRASOUND:

The term ultrasonic's refers to the science and technology dealing with acoustic waves of frequency higher than the nominal limit of audibility by the human ear. It must be called nominal limit, since it is not definable in exact terms, but only on some statistical basis, because it also depends on sex and age and it varies considerably from person to person. Sound waves can be classified into three types viz. infrasonic waves, audible or sound waves and ultrasonic waves.

The longitudinal waves whose frequency lies below 20Hz (cycle per second) are called infrasonic waves. Human ear is not sensitive to these waves. The waves are produced by large vibrating bodies such as during an earth quake. Audible or sound waves are those longitudinal waves whose frequency range produce the sensation of sound when enter into human ear. Thus these waves are called either audible or sound waves. Audible waves are produced by vibrating bodies such as vocal cords (human and animal voice), stretched strings (violin, guitar etc.), stretched membranes (drum, loudspeaker), air columns (flute) and by irregular motions of bodies (tree leaves, doors etc.). Those audible waves which are produced by regular periodic motions of definite frequencies given pleasing effects on the ear and are called 'musical sound waves. On the other hand, those waves which are produced by irregular non-periodic disturbances of bodies produced an irritating effect on the ear and are called 'noise waves'.

The longitudinal waves whose frequency lies between 20,000 Hz to about 5 × 108 Hz are 'ultrasonic waves'. The ultrasonic range of full acoustic spectrum is broken down into three subsections, low frequency / airborne, conventional/industrial and high frequency/ acoustic microscopy as shown in figures 1.1 . Human ear is not sensitive to these waves. This types of waves can be produced either by the high frequency vibration of a quartz crystal under an alternating electric field or by the vibration of a ferromagnetic rod under an alternating magnetic field. Application of ultrasound really started on the technological front, with the development of underwater transducer during world war I. Human efforts in under-water detection were spurred in 1912 by the sinking of RMS Titanic by collision with an iceberg. It was soon demonstrated that the resolution for iceberg detection was improved at higher frequencies, leading to the developments of ultrasonic as opposed to audible waves. This led to the pioneering work of 'Linguine', who is generally credited as the force of the field of ultrasonic. Longitudinal waves having frequency higher than 108 Hz are called hypersonic waves.

For the present study, 'Ultrasonic Interferometer' (model F-80 dual frequency) is used to measure, Ultrasound velocities of sample at 303.15 K , which gave accurate and satisfactory results.

Figure 1.1. Ultrasonic Interferometer

MATERIALS AND METHOD:

In this experiment all the chemicals of binary liquid mixtures like: Tri-ethylamine and Primary alcohols (Methanol, Ethanol, Propanol, and Butanol). All the solvent were of 'Merck India Limited' (A.R) grade. The non polar used also of 'Merck Indi limited'.

The binary mixtures under the present study are:

Tri-ethylamine + Methanol (System I)

Tri-ethylamine + Ethanol (System II)

Tri-ethylamine + Propanol (System III)

Tri-ethylamine + Butanol (System IV)

All the chemicals were purified before used by fractional distillation over one meter long column collecting the middle fraction only. The purities of the chemicals were checked by 'densities measurement'.

A series of binary mixtures of Tri-ethylamine alcohols covering the whole concentration range i.e. 0.0-1.0 mole fractions, were prepared gravimetrically for each system studied. The sample were prepared in a rubber seal glass vials and the liquid were added with the help of syringe in order to avoid losses due to evaporation during sample preparation. The weighing was done using electrical single pan analytical balance with an accuracy of +1.0 × 10^{-8} kg. Ultrasound velocities of sample were measured at 303.15 K using model F-80 dual frequency ultrasonic interferometer (M/s Mittal Enterprises, New Delhi). At a constant frequency of 3MHz, the sample were kept in the cell of interferometer and closed by rotating anti-clock wise, the upper part of the cell. The minimum amount of liquid needed was about 1.2×10^{-2} liter. The micrometer was slowly moved upward and the first reading was taken when the current meter shows maximum. The micrometer is further moved upward till 20 such maxima were passed on, and second reading on the micrometer was again noted. The temperature of the experimental solution was mentioned constant 303.15K by circulating water around the cell with the help of a pump from a thermostat regulated at required temperature better than +0.03K. The average of the two measurements of ultrasound velocities for each sample was taken which were accurate to +0.03%.

The density accurate to $+0.00001\times10^{3}$ kg/L for each sample was determined by pyknometer after equilibrating in a thermostat for half an hour.

Table- 1.1 :Comparison of experimental values of density and ultrasonic velocity with literature values of pure liquid components at 303.15K.

Component liquid	Density (ρ) x 10^{-3} (g/ml)		Sound velocity (U) (ms^{-1})	
	Exp.	Lit.	Exp.	Lit.
Tri-ethylamine	0.7190	0.719	1096	1096
Methanol	0.7820	0.782	1120	1098
Ethanol	0.7810	0.781	1139	1139
Propanol	0.7570	0.7946	1198	1179
Butanol	0.8025	0.8020	1391	1223

RESULT AND DISCUSSION

The experimental values of ultrasonic velocity are reported in table 1.2- 1.5 for all the binary system study at 303.15K. A perusal of table 1.2- 1.5 shows that the sound velocity decreases with mole fraction of primary alcohol for all the binary mixture in the presence of investigation of ultrasound waves are high frequency. Mechanical waves there velocity in the medium depends in velocity and density of the medium the decreases in velocity with increases mole fraction of tri-ethylamine for the binary mixtures.

The excess ultrasound velocity (UE) if evaluated from the experimental value of ultrasound velocity for component liquid and their mixtures vials.

UE = Umix - (V1X1+ V2X2)

Where Umix is sound velocities in mixture and U1U2 and X1X2 are the sound velocity and mole fraction respectively of the component liquid (1) and (2). Excess ultrasound velocity evaluated, on the basis of the above equation for all the binary mixture of experimental temperature are given in 1.2- 1.5 table.

It is evident from the tables the excess sound velocity values are negative for all the binary mixture. Normally more the dipole moment, stronger is the intermolecular interaction, which result in decreasing of free space between molecules and increase in the ultrasonic velocity.

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Moreover its negative value has increased with increased in mole fraction of first named component. These values are indications of stronger molecular interaction in the system.

The negative deviations of high magnitude lead to the unstable complex formation between the hetero-molecules of the mixtures. In the present study the negative excess refractive indices indicate the breaking the hydrogen bond of alcohol polymer, as alcohol is diluted with tri-ethylamine and association between unlike molecules causing concentration with increasing concentration of tri-ethylamine.

Table- 1.2 : Value of density ( ), ultrasonic velocity (U) and excess ultrasonic velocity (UE) for binary liquid mixture of Tri-ethylamine and methanol at 303.15K.

Mole fraction (X_1)	Density (ρ) (g ml^{-1})	Ultrasonic velocity (U) (ms^{-1})	Excess ultrasonic velocity (U^E)
0.0000	0.7810	1139	-
0.218	0.7808	1130	-8.06
0.0446	0.7792	1128	-9.08
0.0953	0.7784	1126	-8.90
0.1529	0.7775	1125	-7.42
0.2192	0.7680	1123	-6.57
0.2969	0.7629	1120	-6.25
0.3870	0.7565	1118	-4.35
0.4956	0.7430	1115	-2.68
0.6275	0.7315	1110	-2.01
1.0000	0.7190	1096	-

Table- 1.4: Value of density (ρ), ultrasonic velocity (U) and excess ultrasonic velocity (U^E) for binary liquid mixture of Tri-ethylamine and propanol at 303.15K.

Mole fraction (X_1)	Density (ρ) (g ml^{-1})	Ultrasonic velocity (U) (ms^{-1})	Excess ultrasonic velocity (U^E)
0.0000	0.757	1198	-
0.1098	0.753	1189	-15.62
0.2173	0.749	1174	-10.83
0.3225	0.745	1152	-13.10
0.4255	0.743	1147	-7.56
0.5264	0.74	1136	-8.30
0.6250	0.737	1123	-11.25
0.7216	0.732	1117	-7.39
0.8164	0.729	1110	-4.72
0.9091	0.721	1198	-7.27
1.0000	0.719	1096	-

Table-1.5: Value of density (ρ), ultrasonic velocity (U) and excess ultrasonic velocity (U^E) for binary liquid mixture of Tri-ethylamine and Butanol at 303.15K.

Mole fraction (X_1)	Density (ρ) (g ml^{-1})	Ultrasonic velocity (U) (ms^{-1})	Excess ultrasonic velocity (U^E)
0.0000	0.8025	1391	-
0.1240	0.795	1365	-10.58
0.2184	0.784	1301	-25.57
0.3239	0.772	1276	-19.44
0.4269	0.767	1245	-20.06
0.5279	0.758	1215	-20.26
0.6265	0.749	1195	-11.18
0.7231	0.742	1170	-7.68
0.8174	0.737	1145	-4.86
0.9102	0.728	1110	-12.4
1.0000	0.711	1096	-

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