© 2019 IJSRST | Volume 5 | Issue 4 | Print ISSN: 2395-6011 | Online ISSN: 2395-602X
Themed Section : Science and Technology

Use of Ultrasonic Interferometer to Study the Interaction Between Solvent-Solvent Molecules in a Tertiary Mixture at Different Temperatures

Sanjeev R. Dudhat*[1], Sonali S. Chine[2], C. S. Patil[3]

[1]Engineering Sciences, SRES's , College of Engineering, Kopargaon, SPPU, Pune, Maharashtra, India

[2]Engineering Sciences, SRES's , College of Engineering, Kopargaon, SPPU, Pune, Maharashtra, India

[3]Department of Chemistry, Deogiri college Aurangabad, Dr. BAMU, Maharashtra, India

ABSTRACT

The basic parameters like viscosity (η), density(ρ) and velocity (U) can be measured by ultrasonic Interferometer. From these three parameters various thermodynamical and acoustical parameters such as specific acoustic impedance (Z), Intermolecular free length (L_f), adiabatic compressibility 's (β) etc can be estimated using standard relations from measured values of Ultrasonic viscosities, densities and velocities in the wide range of concentrations at 35^0 C, 40^0C and 45^0C temperatures for Acetone + Propanol-2 +Chloroform tertiary system. The solvent-solvent interactions are studied on the basis of increase or decrease in ultrasonic velocity, density, viscosity and other derived acoustical parameters in terms of structure making and structure breaking tendencies of various solvent molecules.

Keywords: Density, Ultrasonic Interferometer, Ultrasonic Velocity, Viscosity, Water Bath

I. INTRODUCTION

The study of molecular interactions in the liquid mixtures is of considerable importance in the elucidation of the structural properties of the molecules. Lagemann and Dunbar [4] were the first to point out the sound velocity approach for qualitative determination of the degree of association in liquids. Recent developments have made it possible to use ultrasonic energy in medicine, engineering, agriculture and other industrial applications.[5,6] .Ozawa and Minamisawa [7] have observed concentration of ultrasonic velocity invariant with respect to temperature in alcohol-water mixtures. Hanel[8] has measured sound velocity and thickness of thin samples by time – resolved acoustic microscopy. Bae and Yun [9] have studied the ultrasonic velocity in binary solutions of silicon dioxide and water. Knowledge of thermodynamic and acoustical properties is of great importance in studying the physio-chemical behavior and molecular interactions in a variety of liquid mixtures(1,3). The compositional dependence of thermodynamic properties has proved to be a very useful tool in understanding the nature and extent of pattern of molecular aggregation resulting from intermolecular interaction between components.

II. EXPERIMENTALDETAILS

Ultrasonic velocity for the mixture was measured using the ultrasonic interferometer (Model M 81) supplied by Mittal Enterprises, New Delhi, that has a reproducibility of ± 0.4 m/s at 25^0 C with a fixed frequency of 3 MHz. The temperature was maintained constant by circulating water from a thermodynamically controlled water bath (accuracy ±0.1 ^{0} C). The temperature of the cell is measured using a thermocouple was found to accurate to ± 0.25 ^{0} C. The density of the mixtures has been measured using a sensitive pycnometer with an accuracy of 0.5 kg/m^3. Chemicals used in this study are ultra pure ,supplied by Sigma-Aldrich Ltd and used without purification. Tertiary system is studied at different temperatures, 35^0 C, 40^{0}C and 45^{0}C with different concentrations of the system .Especially for this system ultrasonic velocities, densities and viscosities of the mixtures have been measured at different temperatures.

III. THEORY

Other acoustical parameters such as adiabatic compressibility ((β),Intermolecular free length (L_f) ,Molar Sound velocity(R), Specific acoustic impedance (Z) etc can also be determined.:

Intermolecular free length (L_f) $=K\beta^{1/2}$ (1)

Adiabatic compressibility (β)= $\frac{1}{U^2\rho}$ (2)

Where k values for different temperatures were taken from the work of Jacobson[29]; at 35,40 and 45^o C the K values are 637, 642 ,647 respectively.:

Molar sound velocity (R) $=U^{1/3} V$ (3)

Molar compressibility(B) = $\left(\frac{M}{\rho}\right) \beta^{-1/7}$ (4)

where V and M are the molar volume and molecular weight of the mixtures, respectively.:

Specific acoustic impedance (Z) $=\rho U$ (5)

The excess adiabatic compressibility (β^E) and excess intermolecular free length (L_f^E) are evaluated by the following expressions:

$B^E = \beta_{exp} - \beta_{ideal}$ (6)

$(L_f^E) = L_{f.exp} - L_{f.ideal}$ (7)

For β_{ideal} and $L_{f.ideal}$, the densities and the ultrasonic velocities of various components in pure state at the three given temperatures have been measured. Further, the velocities of both the systems at different concentrations and temperatures have been evaluated theoretically using volume additive rule[21] as :

$U_{ideal} = U_1\emptyset_1 + U_2\emptyset_2 + U_3\emptyset_3$ (8)

Where U_1,U_2, and U_3 are the velocities of the three components of the ternary liquid mixture in pure state and $\emptyset_1$, $\emptyset_2$ and $\emptyset_3$ are their volume fractions .

Simillarly ideal density is evaluated using :

$P_{ideal} = \rho_1\, \emptyset_1 + \rho_2\, \emptyset_2 + \rho_3\, \emptyset_3$ (9)

Finally β_{ideal} and $L_{f.ideal}$ are evaluated using following equations :

$$\beta_{ideal} = \frac{1}{U^2_{ideal.}\ \rho_{ideal}} \quad (10)$$

and

$$L_{f.ideal} = K\beta^{1/2}_{ideal} \quad (11)$$

IV. RESULTS AND DISCUSSION

Table 1. Conversion of CGS units to SI units.

No	Parameter	CGS units	SI units
1	Ultrasonic velocity (U)	1 cms^{-1}	10^{-2}ms^{-1}
2	Density (ρ)	1 g cm^{-3}	10^3 Kg m^{-3}
3	Adiabatic compressibility (β)	1dyn^{-1} cm^2	10 N^{-1}m^2
4	Intermolecular free length(L_f)	1A^o	10^{-10} m
5	Molar sound velocity (R)	1 cm^3 mol^{-1} (cm s^{-1})$^{1/3}$	$10^{-20/3}$ m^3 mol^{-1} (ms^{-1})$^{1/3}$
7	Molar compressibility (B)	1 cm^3 mol^{-1} (dyn^{-1} cm^2)$^{-1/7}$	$10^{-43/7}$ m^3 mol^{-1} (N^{-1}m^2)$^{-1/7}$
8	Wave number (λ)	1 cm $^{-1}$	10 m^{-1}

Table 2. Ultrasonic velocity, Density and viscosity of Tertiary mixture at different temperatures

Temp	Mole Fraction			Ultrasonic velocity	Density(ρ)	Viscosity (η)
	(Acetone) X_1	(Propanol) X_2	(Chloroform) X_3	m/sec	gm/cm^3	centipoise
35 ^{0} C	0.2432	0.06832	0.7892	845	1.2700	0.4982
	0.2431	0.06834	0.7894	847	1.2692	0.4979
	0.2429	0.06836	0.7895	849	1.2689	0.4971
	0.2427	0.06839	0.7896	849	1.2688	0.4969
	0.2425	0.06842	0.7898	852	1.2682	0.4965
	0.2421	0.06845	0.7900	854	1.2580	0.4964
	0.2418	0.06847	0.7904	851	1.2580	0.4962
	0.2416	0.06847	0.7913	850	1.2578	0.4961
	0.2415	0.06850	0.7915	849	1.2575	0.4961
	0.2413	0.06852	0.7918	849	1.2574	0.4955
40^0 C	0.2432	0.06832	0.7892	849	1.2575	0.4954
	0.2431	0.06834	0.7894	851	1.2571	0.4953
	0.2429	0.06836	0.7895	853	1.2571	0.4951
	0.2427	0.06839	0.7896	856	1.2569	0.4947
	0.2425	0.06842	0.7898	858	1.2569	0.4946
	0.2421	0.06845	0.7900	865	1.2567	0.4943
	0.2418	0.06847	0.7904	861	1.2565	0.4943
	0.2416	0.06847	0.7913	860	1.2564	0.4940
	0.2415	0.06850	0.7915	858	1.2564	0.4938
	0.2413	0.06852	0.7918	857	1.2563	0.4930
45^0 C	0.2432	0.06832	0.7892	857	1.2564	0.4931
	0.2431	0.06834	0.7894	860	1.2561	0.4928
	0.2429	0.06836	0.7895	864	1.2559	0.4927
	0.2427	0.06839	0.7896	865	1.2550	0.4926
	0.2425	0.06842	0.7898	867	1.2549	0.4924
	0.2421	0.06845	0.7900	870	1.2540	0.4921
	0.2418	0.06847	0.7904	865	1.2538	0.4919
	0.2416	0.06847	0.7913	864	1.2535	0.4919
	0.2415	0.06850	0.7915	862	1.2533	0.4910
	0.2413	0.06852	0.7918	860	1.2532	0.4908

Ultrasonic velocity, density and viscosity for the acetone-propanol-2 and chloroform have been listed in table 2.The appropriate conversion of CGS units to SI units have been provided in Table 1.

It is seen from that at 350 C ultrasonic velocity (U) increases with increasing concentration of the solution which attains a maximum value at 0.7900 mole fractions. The non- linear variation of ultrasonic velocity with concentration indicates occurrence of complex formation between unlike molecules. The molecular association becomes maximum at those concentrations where velocity maxima occurs. This may be interpreted due to the formation of strong hydrogen bonding resulting into complex formation producing displacement of electrons and nuclei. The chemical interaction may involve the association due to hydrogen bonding, due to dipole –dipole interaction or due to the formation of charge transfer complexes. All these processes may lead to strong interaction of forces.(fort and Moore,1965). The density and viscosity of the tertiary solution decreases with decrease in concentration of the solution. The study shows that the mixture can be used in agriculture, industry and hospitals as a medicine at different temperatures to the some extent .Major drawback is that the solution mixture can not be used at higher temperature because of the less interaction between the solvent solvent molecules.

V. CONCLUSION

It is observed that when the reaction mixture is heated at 35,40 & 450 C the Ultrasonic Velocity increases up to certain concentration (0.7900 Mole Fraction)but the density and viscosity decreases as the concentration decreases. This indicates that the complex formation is takes place between unlike molecules. Here the strong hydrogen bonding results into complex formation. Due to dipole-dipole interaction association of water molecules takes place easily.

VI. ACKNOWLEDGEMENT

I am very much thankful to our Principal Dr. D. N. Kyatanavar and our Management for encouraging and supporting me for doing the Research work in our institute and made the facilities available for the same.

VII. REFERENCES

[1]. R. J. Lagemann, W.S.Dunbar.1995. Indian Journal of pure Physics and Chemistry(1995)
[2]. S.K.Chauhan, V.R.Singh.1993. Indian Journal of pure Physics and Chemistry(1993)
[3]. R.L.Blokhra, A.Nag .1991. Indian Journal of pure Physics and Chemistry (1991)
[4]. A.Ozawa, A.Minamisawa.1998. Indian Journal of pure Physics and Chemistry(1998)
[5]. Hanel, A.Skumiel, Acustica.1985. Indian Journal of pure and Applied Physics(1985).
[6]. Bae , Yun.1998.Journal of Applied Physics(1998).
[7]. M.Rastogi, A.Awasthi, M.Gupta, P.Shukl .(2003). Journal of.Molecular Liquid(2003).
[8]. M.Rastogi, A.Awasthi, M.Gupta, J.P.Shukla.1997. Journal of.Molecular Liquid(1999).
[9]. S.B.Khasare, B.A.Patki.1987. Indian Journal of pure and Applied Physics(1987).
[10]. A.awasthi, J.P.Shukla.2003.Ultrasonics (GB) (2003).
[11]. A.N.Kannappan, R.Palaniure.1996.Indian Journal of Physics(1996).
[12]. S.K.Saxena,M.C.Saxena.1981. Indian Journal of Physics (1981),550.
[13]. D.D.Perrin,W.L.F.Armarego,Purification of Laboratory Chemistry,.third ed.,Pergamon Press.Oxford.
[14]. H.Dunken,H.Fitsche.1962.Journal of Chem and Physics, (1962).
[15]. B.Jacobson.1952. Journal of Chemistry and Physic(952).

Cite this article as :

Sanjeev R. Dudhat, Sonali S. Chine, C. S. Patil, "Use of Ultrasonic Interferometer to Study the Interaction Between Solvent-Solvent Molecules in a Tertiary Mixture at Different Temperatures ", International Journal of Scientific Research in Science and Technology (IJSRST), Online ISSN : 2395-602X, Print ISSN : 2395-6011, Volume 5 Issue 4, pp. 103-106, ETCES-2019, January 2019.
Journal URL : http://ijsrst.com/IJSRST195423