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INTERACTION BETWEEN SOLVENT-SOLVENT MOLECULES IN A TERNARY MIXTURE AT DIFFERENT TEMPERATURES BY ULTRASONIC TECHNIQUE

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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 35^0C, 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.

1. 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.

2. Experimental Details

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 25^0C with a fixed frequency of 3 MHz. The temperature was maintained constant by circulating water from a thermodynamically controlled water bath (accuracy ±0.1^0C). The temperature of the cell as measured using a thermocouple was found to accurate to ± 0.25^0C. 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, 35^0C, 40^0C and 45^0C with different concentrations of the system. Especially for this system ultrasonic velocities, densities and viscosities of the mixtures have been measured at different temperatures.

3. 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^oC 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) =ρU (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:

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

and

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

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)	$1 dyn^{-1}\ cm^2$	$10\ N^{-1} m^2$
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 (Acetone) (Propanol) (Chloroform) X_1 X_2 X_3	Ultrasonic velocity m/sec	Density(ρ) gm/cm^3	Viscosity (η) centipoise
35^{0}C	0.2890 0.05220 0.6910	858	1.4111	0.3211
	0.2892 0.05220 0.6911	860	1.4109	0.3209
	0.2898 0.05220 0.6912	864	1.4108	0.3207
	0.3900 0.05220 0.6916	866	1.4102	0.3202
	0.3901 0.05220 0.6918	867	1.3999	0.3199
	0.3904 0.05220 0.6920	870	1.3997	0.3198
	0.3906 0.05220 0.6922	868	1.3992	0.3196
	0.3910 0.05220 0.6928	865	1.3990	0.3194
	0.3914 0.05220 0.6929	864	1.3987	0.3187
	0.3916 0.05220 0.6930	862	1.3984	0.3188
40^0 C	0.2890 0.05220 0.6910	864	1.3983	0.3187
	0.2892 0.05220 0.6911	865	1.3981	0.3185
	0.2898 0.05220 0.6912	868	1.3979	0.3183
	0.3900 0.05220 0.6916	870	1.3975	0.3179
	0.3901 0.05220 0.6918	872	1.3973	0.3177
	0.3904 0.05220 0.6920	875	1.3971	0.3172
	0.3906 0.05220 0.6922	874	1.3962	0.3169
	0.3910 0.05220 0.6928	873	1.3960	0.3167
	0.3914 0.05220 0.6929	871	1.3958	0.3168
	0.3916 0.05220 0.6930	869	1.3952	0.3166
45^0 C	0.2890 0.05220 0.6910	870	1.3951	0.3164
	0.2892 0.05220 0.6911	871	1.3949	0.3162
	0.2898 0.05220 0.6912	873	1.3946	0.3161
	0.3900 0.05220 0.6916	875	1.3945	0.3158
	0.3901 0.05220 0.6918	877	1.3943	0.3156
	0.3904 0.05220 0.6920	880	1.3939	0.3150
	0.3906 0.05220 0.6922	879	1.3937	0.3148
	0.3910 0.05220 0.6928	878	1.3932	0.3146
	0.3914 0.05220 0.6929	877	1.3930	0.3140
	0.3916 0.05220 0.6930	872	1.3929	0.3138

4. RESULTS

Measurement of ultrasonic velocity is the best tool to investigate solvent-solvent, solute-solute and ion solvent interactions. Therefore, in last four decades ultrasonic interferometric study created its own identity for determining solute- solvent interactions. So in the present work different parameters were studied for synthesized ligands, which are used as solutes. 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.

5. CONCLUSION

It is seen from that at 35^0 C ultrasonic velocity (U) increases with increasing concentration attains a maximum value at 0.3904 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 decreases in concentration of the solution. From this study it is clear that properties, which are directly or indirectly responsible for this are protic nature of solvent, dielectric constant, polarity, density, tendancy of forming hydrogen bonding, surface tension, viscosity of solvent etc.

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REFERENCES

1. R.J.Lagemann, W.S.Dunbar, "Solvent-Solvent interaction in a aqueous medium of binary mixture at different temperature", Indian Journal of pure Physics and Chemistry, 1945; 49: 231.
2. S.K.Chauhan, V.R.Singh, "Solvent-Solvent interaction in a aqueous medium of binary mixture", Indian Journal of pure Physics and Chemistry, 1993; 31: 635.
3. R.L.Blokhra, A.Nag, "Study of Solvent-Solvent interaction in a aqueous medium", Indian Journal of pure Physics and Chemistry, 1991; 29: 756.
4. A.Ozawa, A.Minamisawa, "Study of Solvent-Solvent interaction in a aqueous medium", Indian Journal of pure Physics and Chemistry, 1998; 37: 279.
5. Hanel, A.Skumiel, Acustica, "Solvent-Solvent interaction in a aqueous medium of binary mixture", Indian Journal of pure and Applied Physics, 1995; 81: 117.

6. Bae, Yun, "Study of Solvent-Solvent interaction in a aqueous medium", Journal of Applied Physics, 1998; 84: 668.
7. M.Rastogi, A.Awasthi, M.Gupta, P.Shukla, "Solvent-Solvent interaction in a aqueous medium of binary mixture", Journal of. Molecular Liquid(Netherland), 2003; 107: 185.
8. M.Rastogi, A.Awasthi, M.Gupta, J.P.Shukla., "Study of Solvent-Solvent interaction in a aqueous medium", Indian Journal of pure Physics and Chemistry, Journal of. Molecular Liquid, 1999; 80(1): 77.
9. S.B.Khasare, B.A.Patki, "Solvent-Solvent interaction in a aqueous medium of binary mixture", Indian Journal of pure and Applied Physics, 1987; 25: 180.
10. A.awasthi, J.P.Shukla, "Study of Solvent-Solvent interaction of binary mixture at different temperatures", Ultrasonics (GB), 2003; 41: 477.
11. A.N.Kannappan, R.Palani,. "Solvent-Solvent interaction in a aqueous medium of binary mixture" Indian Journal of Physics, 1996; 70B(1): 59.
12. S.K.Saxena, M.C.Saxena, "Study of Solvent-Solvent interaction of binary mixture at different temperatures", 1981; 19: 550.
13. D.D.Perrin, W.L.F.Armarego, Purification of Laboratory Chemistry, third ed., Pergamon Press. Oxford, 1988.
14. H.Dunken, H.Fitsche, "Study of Solvent-Solvent interaction of binary mixture at different temperatures" Journal of Chem and Physics, 1942; 2: 345.
15. B.Jacobson, "Solvent-Solvent interaction in a aqueous medium of binary mixture" Journal of Chemistry and Physic, 1952; 8: 27.