Thermoacoustic Investigation of Intermolecular Interaction in Binary Solutions using Some Excess Thermoacoustic Parameters and its Theoretical Comparison

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ABSTRACT

Intermolecular interaction studies using ultrasonic technique in the binary liquid mixtures of Acetone and bromobenzene at different temperatures 318.15K and 323.15K. Using the measured values of ultrasonic velocity and density, acoustical parameters and their excess values such as excess adiabatic compressibility (β_a^E), excess molar volume (V_a^E) and excess free length (L_f^E) has been are evaluated. From the properties of these excess parameters the nature and strength of the interactions in these binary systems have been discussed. The experimental ultrasonic velocities has been compared with the calculated values from the acoustic theories such as Free-length theory (FLT), Collision factor theory (CFT) and Nomoto theory (NOM) at temperatures 318.15K and 323.15K.

KEYWORDS: Ultrasonic parameters, molecular interaction and ultrasonic theories.

1. Introduction

In recent years ultrasonic technique has become a powerful tool in providing information regarding the molecular behaviour of liquids owing to its ability of characterizing physiochemical behaviour of the medium. The study of intermolecular interaction plays an important role in the development of Molecular sciences hence it is emerging in the field of forensic sciences, space research and also in wars. Determination of ultrasonic velocity and absorption coefficient has furnished methods for studying molecular and structural properties of liquids.[1-9] A survey of literature[10-16] indicates that adiabatic compressibility, free length and molar volume and there excess values are useful in understanding the intermolecular interactions between the molecules in binary mixtures.

2. Experimental

Ultrasonic interferometer model F-81 of fixed frequency 2 MHz having accuracy ±.03% and hydrostatic plunger method having accuracy ±.05% were used for measurement of ultrasonic velocity and density of pure acetone and chlorobenzen and its solution of different mole concentrations from 0.1, 0.2, ------ 0.9 at different temperatures. The calibration of the apparatus was done with air and deionizer double-distilled water.

3. Result and Discussion

The values of excess adiabatic compressibility (β_{ad}^E), excess volume (V_a^E), excess free length (L_f^E) and ultrasonic velocity using different theories have been calculated using following formulae.[17-26]

$$\beta_{ad} = \frac{1}{u^2 \rho} \quad (1)$$

$$L_f = K \times \beta^{1/2} \quad (2)$$

$$\beta_{ad}^E = \beta_{(Expt)} - \beta_{(Ideal)} \quad (3)$$

$$V_a^E = V_{(Expt)} - V_{(Ideeal)} \quad (4)$$

$$L_f^E = L_{f(Expt)} - L_{f(Ideal)} \quad (5)$$

$$U_{FLT} = \frac{K}{L_{f(Mix)} \rho_{(Mix)}^{1/2}} \quad (6)$$

$$U_{CFT} = U_\infty \times \left[\frac{(x_A S_A + x_B S_B)}{(x_A B_A + x_B B_b)} \right]^3 \quad (7)$$

$$U_{NOT} = \left[\frac{(x_A R_A + x_B R_B)}{(x_A V_A + x_B V_b)} \right]^3 \quad (8)$$

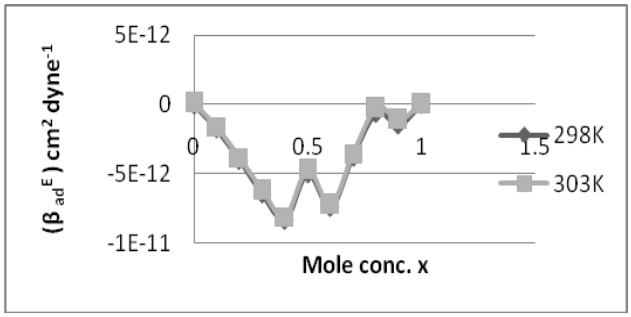
3.1 Table-1: Excess adiabatic compressibility (β_a^E), excess molar volume (V_a^E), excess and free length (L_f^E), U experimental, U Free-length theory (FLT), U Collision factor theory (CFT) and U Nomoto theory (NOT) of Acetone + Chlorobenzene at temperatures 303.15K & 308.15K.

3.1.1 303.15K

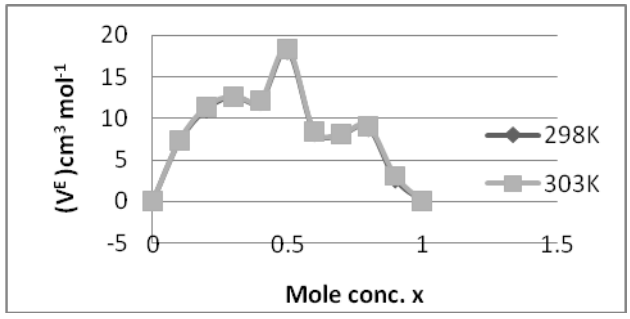
Mole Conc. x	$\beta_a{}^E$	$V_a{}^E$	$L_f{}^E$	U_{Expt}	U_{FLT}	U_{CFT}	U_{NOT}
0.1	-1.8E-12	7.279144	-1.8E-09	115840	89125.99	105201.5	115840
0.2	-4E-12	11.17145	-2.9E-09	116990	77335.19	101284.2	116990
0.3	-6.4E-12	12.67022	-3.3E-09	118405	73364.07	100247.2	118405
0.4	-8.3E-12	12.07906	-3.1E-09	119560	74312.77	101288.5	119560
0.5	-5E-12	18.20431	-4.6E-09	120630	63274.8	96127.83	120630
0.6	-7.4E-12	8.33665	-2E-09	118750	83766.25	105655.8	118750
0.7	-3.8E-12	8.076013	-1.8E-09	116700	84863.08	106140.1	116700
0.8	-6.2E-13	8.928626	-1.9E-09	115860	82837.61	105521.8	115860
0.9	-1.5E-12	2.734978	-4.1E-10	115515	106014	111822.9	115515

3.1.2 308.15K

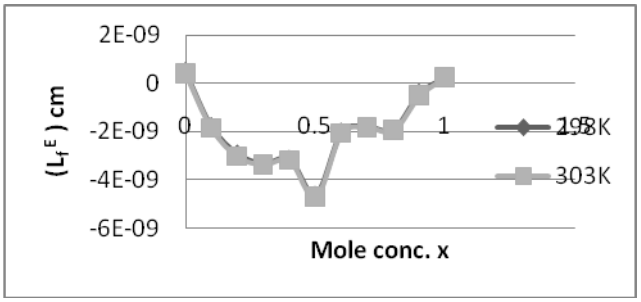
Mole Conc. x	$\beta_a{}^E$	$V_a{}^E$	$L_f{}^E$	U_{Expt}	U_{FLT}	U_{CFT}	U_{NOT}
0.1	-1.6E-12	7.332959	-1.8E-09	114600	88076.62	104069.4	114600
0.2	-3.9E-12	11.37613	-3E-09	115700	76317.86	100017	115700
0.3	-6.2E-12	12.66012	-3.3E-09	116800	72911.58	99181.01	116800
0.4	-8.1E-12	12.13765	-3.2E-09	117900	73695.03	100106	117900
0.5	-4.7E-12	18.40351	-4.7E-09	119000	62729.4	94875.88	119000
0.6	-7.2E-12	8.400847	-2E-09	117000	82872.61	104341.7	117000
0.7	-3.6E-12	8.084476	-1.8E-09	115000	84113.55	104846.4	115000
0.8	-2.5E-13	9.034772	-1.9E-09	114100	81900.71	104120.5	114100
0.9	-1.1E-12	3.074622	-4.9E-10	113800	103153.4	110053.7	113800



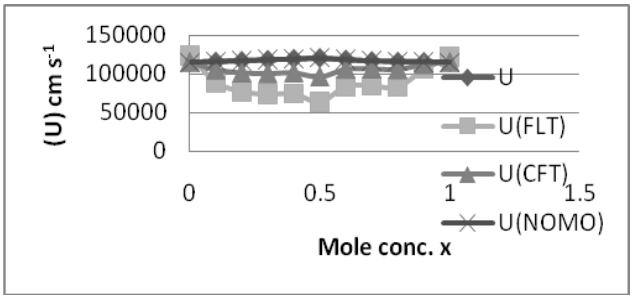
3.1.3 Figure: 1 β_{ad}^E **versus mole concentration x**



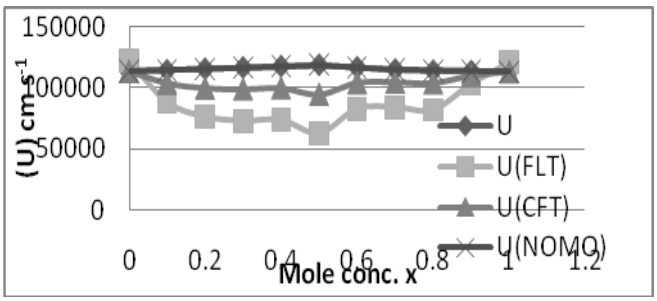
3.1.4 Figure: 2 V_a^E **versus mole concentration x**



3.1.5 Figure: 3 L_f^E **versus mole concentration x**



3.1.6 Figure: 4 Comparisons of Expt. & Theoretical (LFT, CFT & NOM) ultrasonic velocity at 298.15K



3.1.7 Figure: 5 Comparisons of Expt. & Theoretical (LFT, CFT & NOM) ultrasonic velocity at 303.15K

The fig. 1 and fig. 2 shows system study fall under the category of β_{ad}^E < 0 and V_a^E >0. The observed negative excess compressibility shows the decrease in adiabatic compressibility than the ideal one. This indicates an attractive hetromolecular interaction leading to an association between solute and solvent. From fig. 3 V_a^E <0 this indicates there may be larger size of molecular clusters and interaction of long range would lead to clusters of large size. The fig. 3 show decreases in value of L_f^E upto 0.5 mole concentrations and then it going to increase. The fig. 4 & 5 shows comparison of ultrasonic velocity which predicts that in above system NOM & CFT are more applicable than FLT.

4. Conclusion

In the study binary system of Acetone + Bromobenzene there was larger value of V^E as well as $\beta_{ad}{}^E$. Being a

mixture of polar liquids, strong dipole-dipole interaction may be existing in the mixtures. In the above type of system Collision factor theory and Nomoto theory are more applicable than free length theory.

5. References

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