THERMO-ACOUSTICAL STUDIES IN TWO-FOLD FLUID BLENDS AT DIFFERENT TEMPERATURES

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ABSTRACT

Speed of sound, viscosity and density of a fluid blend of p-Methoxy benzoic acid (p-MBA) with alkanols (1-propanol/1-butanol/1-pentanol/1-hexanol) have been examined from 303.15 K to 313.15 K (5K interval) temperature at 2 MHz frequency. Several thermo acoustic properties like isentropic compressibility (K_s), molar volume (V_m), surface tension (γ), specific acoustic impedance (Z) and their excess outcomes were deliberated from these measured data. These excess properties have been fitted to the Redlich-Kister type polynomial equation using the least square method to appraise parameters and standard deviations.

Keywords: Fluid Blend, Speed of Sound, Redlich-Kister type polynomial, Thermo acoustic Properties, p-Methoxy Benzoic Acid.

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INTRODUCTION

Speed of sound of fluids and fluid blends has abundant importance in appraising the prospects of speaks coalition and also utilize in majority of industrial processes originate hypothetical interest in perceiving the *nature* of auxiliary opus¹. Thermo-acoustic properties have been worn to perceive various sorts of a coalition of mite packing in hume fragment interactivities and their durability ascendance by the size of pure pieces and the mix. The diverged properties flits a spry bit in appraising the solidness due to particle adaption and expanse to fragment interactivities in the blends through charge transfer interactivity of p-Methoxy benzoic acid. It is a cognition enhancer and *metabolite* of aniracetam. p-Methoxy benzoic acid is phenolic acid, organic moles often erect in anis-seed, a common food spice. Its aliphatic layout commits to the volume diminution of profuse systems. p-MBA molecules are spherical so it intricate in many reactions such as electrophilic & nucleophilic substitution, oxidation and reduction to form many salts. Alkanols are dominant intermediates in the synthesis of profuse organic chemicals also utilized for perfume industry^{2, 3}. They emanate the metal alkanolate and H- gas by retaliating from active metals. They were also utilized for initiation of H- bonds between -OH groups with weak proton donor ability and dislocate electron pairs on the oxygen atom of ether. Many researchers carried out acoustic parameters to study the *molecular* interactivities between fluid blends.⁴⁻⁸ The aim of the present paper explicate thermo acoustic studies by the profuse hypothesis of excess properties and also RK- polynomial equation upshots from measured values by obtaining inter/intra *molecular* interactions among a twofold fluid mix of p-MBA with 1-propanol/1-butanol/1-pentanol/1-hexanol are collated with various theoretical relations at T= 303.15 K to 313.15 K.^{14, 15, 18}

EXPERIMENTAL

The chemicals utilized in this study are p-MBA with alkanols (1-propanol/ 1-butanol/1-pentanol/1-hexanol) which are of AR grade obtained from Hi-Media Laboratories Pvt. Ltd, Mumbai India, and Sisco research lab Pvt. Ltd, Mumbai, India with purities of greater than 99%. p-Methoxy benzoic acid is attainable in powder type and it was soluble in water with the array of 530 mg/100 ml at room temperature.

The samples were making just to begin the experiment with the succor of mass disparity and uncertainty in blends concentration.

Table-1: Collation of measured to Literature Values of Densities (ρ) Viscosities (η) and Speed of Sound (U) for Pure Fluids

Fluid	Temp (K)	Density(ρ) Kg.m ⁻³		Viscosity(η) mPa s		Speed of sound(U) m s ⁻¹		C _p J K ⁻¹ mol ⁻¹	α k K ⁻¹
		Expt	Litt	Expt	Litt	Expt	Litt		
p-Methoxy benzoic acid	303.15	---	1.188	---	1.585	1559.4	---	204.07 ^d	1.000 ^e
	308.15	---	1.123	---	1.428	1539.6	---	205.03 ^d	1.001 ^e
	313.15	---	1.097	---	1.341	1520.2	---	205.00 ^d	1.003 ^e
1-Propanol	303.15	0.799	0.796 ^a	1.611	1.610 ^a	1181.8	1190.2 ^a	140.21 ^d	1.237 ^e
	308.15	0.794	0.793 ^a	1.460	1.461 ^a	1168.8	1171.8 ^a	146.10 ^d	1.348 ^e
	313.15	0.784	0.787 ^a	1.317	1.317 ^a	1149.8	1150.0 ^a	158.60 ^d	1.409 ^e
1-Butanol	303.15	0.807	0.802 ^a	2.053	2.054 ^a	1225.4	1225.8 ^a	179.50 ^d	1.228 ^e
	308.15	0.794	0.794 ^a	1.902	1.903 ^a	1202.8	1201.8 ^a	181.60 ^d	1.362 ^e
	313.15	0.790	0.792 ^a	1.620	1.620 ^a	1153.8	1192.6 ^a	192.20 ^d	1.427 ^e
1-Pentanol	303.15	0.815	0.813 ^a	3.012	3.013 ^a	1245.2	1254.9 ^a	201.70 ^d	1.215 ^e
	308.15	0.805	0.808 ^a	2.642	2.649 ^a	1232.8	1239.6 ^a	212.30 ^d	1.357 ^e
	313.15	0.802	0.806 ^a	2.305	2.309 ^a	1223.4	1218.0 ^a	240.60 ^d	1.516 ^e
1-Hexanol	303.15	0.812	0.812 ^b	3.516	3.513 ^b	1286.2	1288.0 ^b	240.65 ^d	0.807 ^e
	308.15	0.803	0.808 ^c	3.181	3.182 ^c	1276.8	1272.5 ^c	247.70 ^d	0.818 ^e
	313.15	0.802	0.805 ^b	2.782	2.781 ^b	1261.4	1252.0 ^b	249.15 ^d	0.837 ^e

Standard uncertainties 'u' are $u(x_1) = 0.0001$, $u(\rho) = 0.01 \text{ kg. m}^{-3}$, $u(\eta) = 0.003 \text{ mPa.s}$, $u(U) = 0.9 \text{ m s}^{-1}$

^a Reference [11] ^b Reference[13] ^c Reference[12] ^d Reference[16] ^e Derived from density data

An interferometer (M-81S, M/s Mittal Enterprises, India) may use to measure the speed of sound at 2 MHz frequency with an exactness of $\pm 0.1 \text{ m s}^{-1}$ for p-Methoxy benzoic acid with alkanols and uncertainty in the speed of sound to be established by $\pm 0.9 \text{ m s}^{-1}$. The density of mixtures was measured with standard technique (specific gravity bottle) and uncertainty in density is $\pm 0.01 \text{ kg m}^{-3}$. The viscosities were measured with an Ostwald viscometer. The viscometer was calibrated at different temperatures using redistilled water. The uncertainty in viscosity measurement is up to $\pm 0.003 \text{ mPa.s}$. The experimental values were compared with their literature values and noted in table 01.

RESULTS AND DISCUSSION

Figures-1(a-d) reveals the upshots of K_s^E , the inter *molecular* distance between particles increases due to variation of thermal energy resulting decrease of excess isentropic compressibility (K_s^E) in methoxy elements. The thickness of mix increases and speed of sound decreases then negative outcomes of K_s^E are affirmed by the decreasing with a sore in enchanting of alkanols increasing. This prudent a slower release of interactivity in p-MBA molecules.

Figures-2(a-d) reveals the upshots of V_m^E , the excitation energy of p-MBA increases with the rise of thermal energy and hence molar volume decreases. Negative outcomes of V_m^E due to decreases of the force of cohesion in -OH fragments in alkanols arises *molecular* attraction in the mix. It is also discerned that at a stable temperature the captivation of p-MBA velocity increases which transpire the structural changes also rise of inter *molecular* forces in the mixture.^{9,10}

Figures-3(a-d) reveals the upshots of γ^E , the captivation of p-MBA increases then the attenuation coefficient of alkanols increases when the wave is more and more attenuated. The congregation of alkanols is low then (γ^E) are positive and gradually decreases with an increase in the concentration of p-MBA. When increases in temperature excess values of surface tension are positive it indicates weak

interactivity between mites. The upshots of V_m^E and γ^E are confining the fact that both are converse in nature.

Fig.-1(a-d): Excess Isentropic Compressibility of p-Methoxy Benzoic Acid with 1-Propanol/1-Butanol/1-Pentanol/1-Hexanol at Different Temperatures

Figures-4(a-d) reveals the results of Z^E in two-fold/ternary fluid blends are utilized to appraise the absorption of sound in the medium. Alteration in the Z^E evaluates discern of spatial variation in the less intensity span of ultrasonic wave the excess acoustic impedance (Z^E) becomes less and the values are negative. Also suggests with an increase of temperature decreases in enthrallment of p-MBA indicating that inter *molecular* interactivity betwixt jots will be weaker and weaker.^{13, 17}

Fig.-2(a-d): Excess Molar Volume of p-Methoxy Benzoic Acid with 1-Propanol/1-Butanol/1-Pentanol/1-Hexanol at three Different Temperatures

R-K Polynomial

The deviated values of p-MBA systems were correlated with R-K equation¹⁴ at three different temperatures 303.15K, 308.15K and 313.15 K.

Table-2 divulge the fitness of mix is debated from acquiring A_k and standard deviations for Redlich and Kister ($Y^E = V_m^E$, K_s^E and γ^E) upshots for the system. The pouncing of up comes not only flaunts the viability of blends but also anticipates the rising of digression/ atomic segregation. The standard deviations are satisfactorily obtained it stipulates the snap of H- bonds in the motes due to emerging of cohesive forces.^{12, 15}

Fig.-3(a-d): Excess Surface Tension of p-Methoxy benzoic acid with 1-Propanol/1-Butanol/1-Pentanol/1-Hexanol at three Different Temperatures

Fig.-4(a-d): Excess Acoustic Impedance of p-Methoxy benzoic acid with 1-Propanol/1-Butanol/1-Pentanol/1-Hexanol at three Different Temperatures

Table-2: R-K Polynomial Parameters (A_k) and Standard Deviation (σ) for p-Methoxy benzoic acid + alkanols at T= 303.15 K, 308.15K and 313.15K

Parameter	Temperature(K)	A_1	A_2	A_3	σ
p-Methoxy benzoic acid+ 1-Propanol					
$10^{12}K_s^E/(m^2.N^{-1})$	303.15	-0.2261	0.5568	3.9849	0.1135
	308.15	-0.2827	-0.1231	0.3656	0.0092
	313.15	-0.3568	-0.1346	0.3423	0.0058
$10^6V_m^E/(m^3.mol^{-1})$	303.15	-3.1189	0.5568	3.9849	0.1135
	308.15	-3.9807	0.6994	3.7063	0.1234
	313.15	-5.1653	0.2528	3.8522	0.1542
$10^{-9}\gamma^E/(N.m^{-1})$	303.15	33.7665	10.4235	-25.4134	0.5543
	308.15	35.8859	8.4657	-1.3575	0.0663
	313.15	41.8417	12.9645	1.6822	0.6840
p-Methoxy benzoic acid+ 1-Butanol					
$10^{12}K_s^E/(m^2.N^{-1})$	303.15	-2.5035	-1.4080	2.6677	0.0307
	308.15	-2.788	-2.255	0.680	0.055
	313.15	-3.3555	-2.4138	0.9208	0.0692
	303.15	-12.4452	-4.4964	6.9709	0.8618

$10^6 V_m^E$ /(m ³ .mol ⁻¹)	308.15	-2.5035	-1.4080	1.1893	0.0486
	313.15	-1.4891	-0.9349	-13.3124	0.7817
$10^{-9} \gamma^E$ (N-m ⁻¹)	303.15	36.5229	4.9217	-11.6947	0.6095
	308.15	27.6204	4.3478	-27.0134	0.7502
	313.15	32.8307	3.9953	-18.8907	0.5822
p-Methoxy benzoic acid+ 1-Pentanol					
$10^{12} K_s^E$ /(m ² .N ⁻¹)	303.15	-0.2148	-0.0637	0.3190	0.0055
	308.15	-10.8352	0.0364	6.6254	0.1563
	313.15	0.3463	-0.0896	0.3880	0.0037
$10^6 V_m^E$ /(m ³ .mol ⁻¹)	303.15	-3.2171	-0.5452	3.7652	0.1072
	308.15	-3.7694	-0.7339	2.7251	0.1221
	313.15	-402173	-0.9790	1.0340	0.1407
$10^{-9} \gamma^E$ (N-m ⁻¹)	303.15	32.5558	0.3914	-18.0808	0.6745
	308.15	37.6421	-5.1806	-0.1652	0.5076
	313.15	41.0641	-2.0253	24.3967	0.6774
p-Methoxy benzoic acid+ 1-Hexanol					
$10^{12} K_s^E$ /(m ² .N ⁻¹)	303.15	-5.0428	-4.1152	4.5158	0.2001
	308.15	-7.2290	-5.1098	5.8107	0.1718
	313.15	-8.6911	-7.0733	5.8150	0.1396
$10^6 V_m^E$ /(m ³ .mol ⁻¹)	303.15	-0.2178	-0.1697	0.1479	0.0213
	308.15	-0.2824	-0.1882	4.5158	0.0231
	313.15	-0.3291	-0.2291	0.0532	0.0278
$10^{-9} \gamma^E$ (N-m ⁻¹)	303.15	22.8646	11.7635	-25.8255	0.4520
	308.15	28.8243	14.0261	-22.5555	0.6235
	313.15	32.4061	17.5566	-13.5130	0.8002

CONCLUSION

The measured values for p-methoxy benzoic acid with alkanols were procured using standard techniques and the obtained data were compared with literature. The deviations of p-MBA with alkanols have positive /negative values given by V_m^E , K_s^E , γ^E and Z^E at the whole concentration range due to monomers in the binary system also impulse of charge distortion elements dominates inter *molecular* association between these systems. Since the p-MBA particles are spherical, then the preferment of temperature in – OH molecules eases an agitation in thermal energy ensue the detachment of piece forms the digressions in coefficients of R-K equation of this liquid mix.

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