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Archives of Physics Research, 2013, 4 (1):29-34
(http://scholarsresearchlibrary.com/archive.html)

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ISSN : 0976-0970
CODEN (USA): APRRC7

Ultrasonic velocities and Thermo-Acoustical Parameters of Cumene with P-Xylene at 303K and 308K

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ABSTRACT

The Ultrasonic velocities , density and Viscosityhave been measured for the mixture of P-Xylene in Cumene at temperatures 303K and 308K.The experimental data's have been used to calculate the acoustical parameters namely molar volume(V_m), adiabatic compressibility(β), free length(L_f), acoustical impedance(Z) and the viscous relaxation time(τ) were evaluated. The obtained results support the occurrence of molecular association through intermolecular hydrohen bonding in this binary liquid mixtures.

Keywords:- *Ultrasonic velocity, adiabatic compressibility, viscous relaxation time.*

INTRODUCTION

In recent years, the measurement of ultrasonic velocity has been adequently employed in understanding the molecular interaction in pure liquids and liquid mixtures. The ultrasonic velocity measurements are highly sensitive to molecu;lar interaction and can be used to provide qualitative information about physical nature and strength of moleculkar interaction in liquid mixtures [1-5].

The ultrasonic study is a powerful tool in characterizing the various aspects of physicochemical behaviour of liquid mixtures. The variation of ultrasonuc velocity and related acoustical parameters throw much light upon the structural and changes associated with the liquid mixtures having weakly interacting componebts as well as strongly interacting components[6]. Thermodynamic and acoustical studies of liquid-liquid mixtures have been pursued for a number of years as a mean of probing the intermolecular interaction between mo0lecules[7].

The present work deals with the ultrasonic velocity and computation opf related parameters in binary system of Cumene with P-Xylene at temperatures 303K and308K.

MATERIALS AND METHODS

Solutions of different molality (m) were prepared for each binary system. The ultrasonic velocity in the mixtures was measured using a variable path fixed frequency ultrasonic interferometer working at 2 MHz frequency (Mittal Enterprises, New Delhi). The accuracy of sound velocity was ±0.1 ms^{-1}. The density and viscosity of the mixture were measured using a specific gravity bottle (5 mL) and Ostwald's viscometer (10 mL) respectively. The accuracy in density measurement was ±0.0001 kg m^{-3} and that in viscosity measurement was ±0.001 $mNsm^{-2}$.

RESULTS AND DISCUSSION

Various acoustical parameters such as adiabatic compressibility (β), Intermolecular free length (L_f), molar volume (V_m), viscous relaxation time(τ) and specific acoustical impedance (Z), were calculated using the experimental data of ultrasonic sound velocity, density and viscosity by the following equations (1-5).

$$\beta = 1/U^2\rho \quad (1)$$

$$L_f = k\mathrm{T}(\beta)^{1/2} \quad (2)$$

$$Z = U\rho \quad (3)$$

$$T = 4/3\ \beta\eta \quad (4)$$

$$V_m \quad X_1M_1 + X_2M_2 / \rho \quad (5)$$

Where M_1, M_2 are the molecular weights of the components and ρ the density of the mixture . X_1 and X_2 are mole fraction of Cumene and P-Xylene respectively.

The experimental values of density and sound velocity have been used to determine V_m, β, L_f and viscous relaxation time (τ) for the system under study.The derived parameters at 303K and 308K are reported in tables 1-2 respectively. The parameters V_m, β, L_f, Z and τ have been ploted against mole fraction of Cumene in figures 1-5.Table-1 and -2 presents the smoothening cofficients and variations at 303K and 308K for the system under investigated.

The deviation of V_m with mole fraction X of Cumene + P-Xylene at 303K and 308K is represented in fig.-1. This shows that This shows that the V_m are always –ve for all the studied temperature and for any composition. Roux and Denoyers(1987) suggested that V_m is the resultant contribution from several opposig effetcts. These may be devided arbitrary into three types, namely, physical, chemical and structural. Physical contributions, that are nonspecific interactions between the real species present in the mixture, contribute a positive ternm of V_m. The chemical or specific intermolecular interactions result in a volume decrease, and these include charge transfer type forces and other complex forming interactions. This effects contributes negative value of V_m. The structural contribution are mostly negative and arises from several effects, especially from interstitial accomodation and changes of free volume.

The deviation of adiabatic compressibility for cumene and p-xylene system with temperature is recorded in tables 1 and2. The compressibility data over the entire composition range are shown in fig.-2. β increases with rise in temperature but the magnitude of increase is very less. The intermolecular free length as shown in table 1-2 decreases with increase in concentration of p-xylene which implies strong interactions between the components.L_f values as shown in fig.-3 exhibit strong interaction. The values of L_f are suppported by the variation of β which also exhibit insignificant interactions in the system of cumene and p-xylene.

The deviation of acoustic impedance Z are found to be positive as shown in fig.-4. The effect of an increase in the temperatures appears to increase the excess properties, suggesting the presence of specific molecular interactions. As the temperature increases the value of β and L_f become more negative and Z becomes positive , this may be due to thermal dissociation opf hetero aggregates in liquid mixtures and more interstitial accomodation of one component in to another.The deviation of viscous relaxation time (τ) are found to be negative as shown in fig.-5.

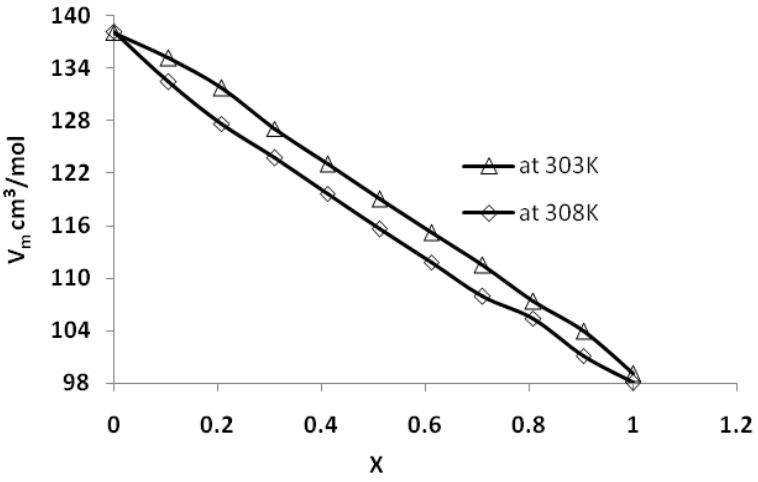

Fig.-1:- Plot of V_m against X of Cumene with P-Xylene at 303K and 308K

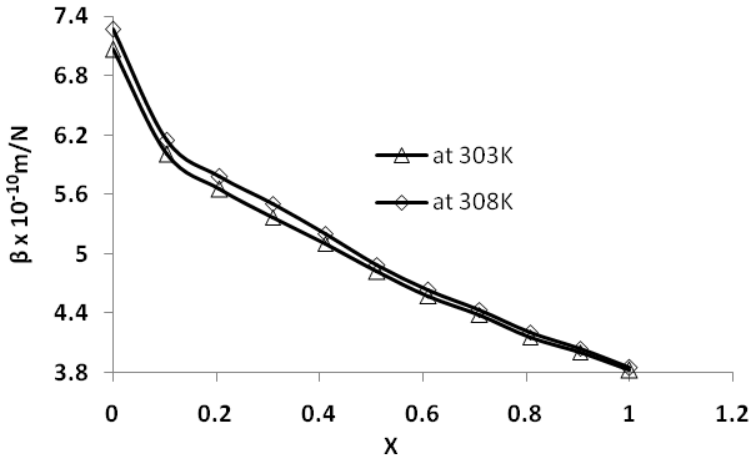

Fig.-2:- Plot of β against X of Cumene with P-Xylene at 303K and 308K

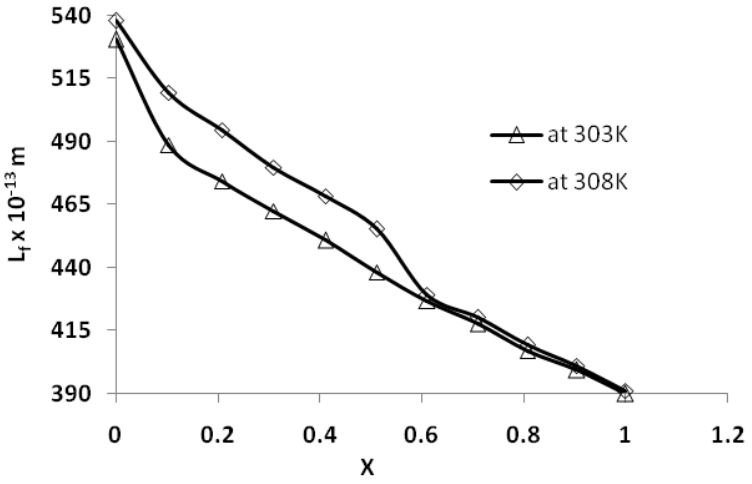

Fig.-3:- Plot of L_f against X of Cumene with P-Xylene at 303K and 308K

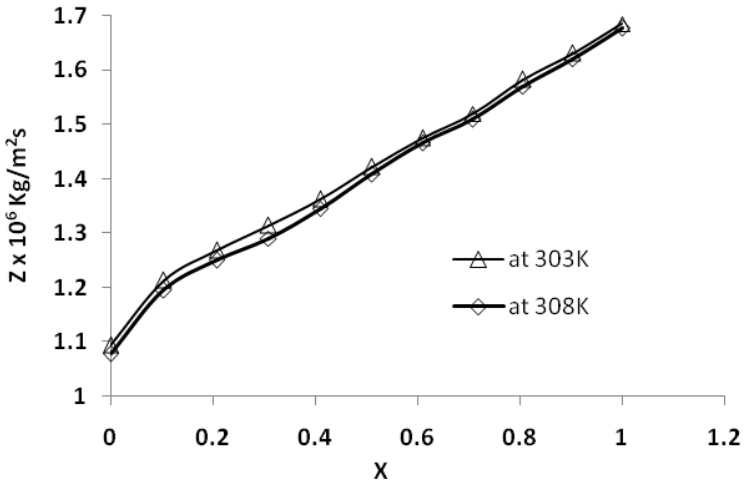

Fig.-4:- Plot of Z against X of Cumene with P-Xylene at 303K and 308K

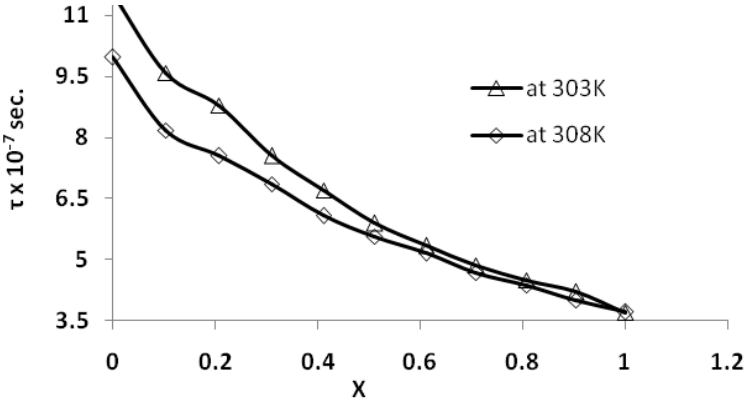

Fig.-5:- Plot of τ against X of Cumene with P-Xylene at 303K and 308K

Table 1. Cumene + P-Xylene at 303K

Mole of fraction of Cumene	Density(ρ) Kg/m^3	U m/sec.	$\eta x10^3/ Nsm^{-2}$	$\beta \times 10^{-10} m^2/N$	Molar Volume V_m cm^3/mol	$L_f \times 10^{-13}$ m	$Z \times 10^6$ Kg/m^2s	**$\tau \times 10^{-7}$** (sec.)
0.0000	852	1288	1.227	7.0680	138.038	530.465	1.0937	11.563
0.1041	885	1371	1.198	6.0063	135.167	488.772	1.2133	9.593
0.2073	909	1395	1.168	5.6505	131.746	474.298	1.2680	8.799
0.3095	929	1415	1.053	5.3714	127.118	462.436	1.3145	7.544
0.4108	949	1436	0.984	5.1054	123.017	450.841	1.3627	6.698
0.5112	976	1457	0.917	4.8228	119.037	438.185	1.4220	5.896
0.6107	997	1480	0.875	4.5757	115.200	426.812	1.4755	5.338
0.7093	1013	1500	0.833	4.3846	111.497	417.804	1.5195	4.869
0.8071	1043	1518	0.810	4.1607	107.383	406.997	1.5832	4.493
0.9040	1066	1530	0.788	4.0073	103.932	399.424	1.6309	4.210
1.0000	1085	1553	0.725	3.8214	99.068	390.049	1.6850	3.694

Mole fraction, Ultrasonic velocity, Adiabatic compressibility, Molar volume, Free length, Acoustical impedance and viscous relaxation time of Cumene + P-Xylene at 303K.

Table 2. Cumene + P-Xylene at 308K

Mole of fraction of Cumene	Density(ρ) Kg/m^3	U m/sec.	$\eta x10^3/ Nsm^{-2}$	$\beta \times 10^{-10} m^2/N$	Molar Volume V_m cm^3/mol	$L_f \times 10^{-13}$ m	$Z \times 10^6$ Kg/m^2s	**$\tau \times 10^{-7}$** (sec.)
0.0000	846	1275	1.029	7.2712	138.244	538.035	1.0785	9.976
0.1041	878	1361	0.998	6.1450	132.423	509.530	1.1949	8.177
0.2073	903	1384	0.980	5.7814	127.668	494.617	1.2497	7.554
0.3095	918	1406	0.934	5.5104	123.756	479.760	1.2907	6.862
0.4108	942	1428	0.876	5.2058	119.678	468.368	1.3451	6.083
0.5112	971	1451	0.853	4.8915	115.646	455.252	1.4089	5.563
0.6107	995	1473	0.836	4.6320	111.843	429.430	1.4656	5.163
0.7093	1010	1494	0.791	4.4358	107.925	420.236	1.5089	4.678
0.8071	1037	1514	0.767	4.2069	105.411	409.250	1.5700	4.372
0.9040	1061	1527	0.742	4.0420	101.138	401.149	1.6207	3.998
1.0000	1082	1550	0.724	3.8460	98.104	391.309	1.6771	3.712

Mole fraction, Density, Ultrasonic velocity, Viscosity, Adiabatic Compressibility, Molar Volume, Free Length, Acoustical impedance and Viscous Relaxation time of Cumene + P-Xylene at 308K.

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