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Ultrasonic study of Velocity in the Binary Mixtures of p-Xylene with Benzyl benzoate as Common Component

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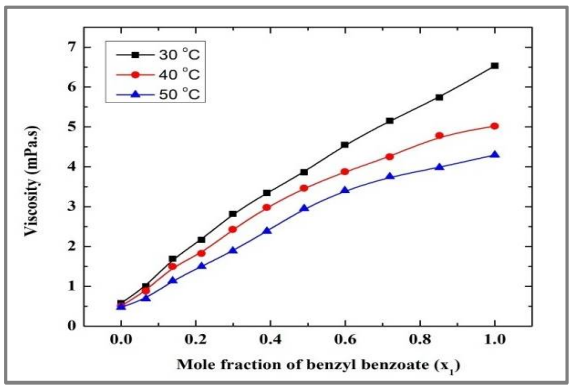
ABSTRACT

Density, viscosity and ultrasonic velocity have been measured in the binary mixture of p-Xylene with benzyl benzoate as common component at different temperatures 30°C, 40°C and 50°C. Also, the theoretical velocities are evaluated from the knowledge five theories viz., FLT, CFT, NOMOTO, VANDAEL and JUNJIE. FLT, CFT, NOMOTO and JUNJIE appear to agree well with the experimental results.

Graphical Abstract



Keywords: Binary mixtures, p-Xylene, Benzyl benzoate, Theoretical velocities.

INTRODUCTION

Ultrasonic methods has been accepted as an important tool in predicting the molecular interactions in the binary mixtures and these techniques are comparable to other techniques like Infrared spectroscopy, NMR spectroscopy and Dielectric relaxation studies etc. Though several binary

mixtures have been studied, the binary mixtures with at least one component as p-Xylene or benzyl benzoate have been referred [**1-10**] owing to the nature of the liquids in our present investigation. In the present investigation, the binary mixtures of the p-Xylene with benzyl benzoate as common component have been chosen owing to their importance in medicine and chemistry. Benzyl benzoate is used as an anti-parasitic insecticide, as a food additive in artificial flavor, and as a solubilizing agent in the preparation of oily injections and also a good solvent for various chemical reactions. p-Xylene is the principal precursor to teraphtalic acid and dimethyl teraphtalate. Both monomers used in the production of polyethelene teraphtalate (PET) plastic bottles and polyester clothing. Ultrasonic velocity, density and viscosity have been measured in the binary mixtures of benzyl benzoate with p-Xylene at 30 ^{o}C, 40 ^{o}C and 50 ^{o}C. From the thermodynamic and other parameters computed from the measured data, excess parameters have been calculated and the intermolecular interactions have been estimated. Theoretical evaluation of velocities has also been made and FLT, VANDEAL, CFT, NOMOTO and JUNJIE have been found to be better.

MATERIALS AND METHODS

The chemicals used in the present investigation Benzyl benzoate and p-Xylene are extra pure grade from LOBA Chemie Private Limited. The binary mixture was prepared by mixing the weighted quantities of pure liquids. Density of binary mixture has been measured using a double stem capillary type pycnometer with an accuracy of 2 parts in 10^5. Weights are taken using a Digital balance with an accuracy of ±0.001 mg. Viscosity has been measured using Ostwald Viscometer with an accuracy of ±0.1%. Ultrasonic velocity has been measured using a single crystal Interferometer working at frequency 2MHz with an accuracy of ±0.05%. Above all devices Pycnometer, Viscometer and Interferometer are standardized with triply distilled water as reference liquid before carrying out all the measurements in test liquids.

Theoretical aspects: A formula for evaluating ultrasonic velocity theoretically, developed by Schaaffs based on the collision factors of the molecules.

$$\text{Ultrasonic velocity } U = U_{\infty} S r_f \qquad \text{---1}$$

$$U = \frac{U_{\infty} S B}{V_T} \qquad \text{---2}$$

$$\text{where collision factor } S = \frac{U_{exp}}{U_{\infty}\left(\frac{B}{V_T}\right)} \qquad \text{---3}$$

According to Nomoto's theory , theoretical ultrasonic velocity can be written as

$$U_{NOMOTO} = \left(\frac{R}{V}\right)^3 = \left[\frac{(X_A R_A + X_B R_B)}{(X_A V_A + X_B V_B)}\right]^3 \qquad \text{---4}$$

The theoretical ultrasonic velocity in binary liquid mixtures according to Junjie's theory [**7**] is given by

$$U_{JUNJIE} = \frac{\frac{X_A M_A}{\rho_A} + \frac{X_B M_B}{\rho_B}}{\left[\left(X_A M_A + X_B M_B\right)\left(\frac{X_A M_A}{V_A^{\,2}\rho_A} + \frac{X_B M_B}{V_B^{\,2}\rho_B}\right)\right]^{1/2}} \qquad \text{---5}$$

The ultrasonic velocity in binary liquid mixtures according to Vandael's theory [8] is given by

$$U_{VANDAEL} = \frac{1}{\left[\left(X_A M_A + X_B M_B\right)\left(\frac{X_A}{M_A U_A^{\,2}} + \frac{X_B}{M_B U_B}\right)\right]^{1/2}} \quad \text{---6}$$

If ρ_{mix} is the density of the liquid mixture, then theoretical velocity in the mixture U_{mix} can be evaluate by using the relation

$$U_{FLT} = \frac{K}{L_{mix}\ \rho_{mix}^{\,1/2}} \quad \text{---7}$$

Nutsch –Kuhnkies[3] extended this theory to binary mixtures also. Thus ultrasonic velocity in binary mixture is

$$UCFT = \frac{U_{\infty}\ S_{mix}\ B_{mix}}{V_T^M} \quad \text{---8}$$

The viscosity of a binary liquid mixture can be calculated by employing the measured values of density of a liquid and time of flow of the liquid of the system at any temperature.

$$\text{Viscosity} \qquad \eta = \frac{\rho t}{\rho^1 t^1}\eta^1 \quad \text{---9}$$

RESULTS AND DISCUSSION

Binary mixtures of Benzyl Benzoate with p-Xylene: Ultrasonic velocity, density and viscosity have been measured in the binary mixtures of benzyl benzoate with p-Xylene over the entire composition range of benzyl benzoate at 30°C, 40°C and 50°C presented in table 1. As observed from table 1 the velocity, density and viscosity increases from p-Xylene to Benzyl benzoate at all temperatures 30°C, 40°C and 50°C (**Figures 1-3**).

Table 1. Ultrasonic velocity, density and viscosity in the mixtures of p-Xylene

Mole fraction of Benzyl benzoate	Velocity (ms^{-1})	Density (kgm^3)	Viscosity (mill.Pa.s)	Mole fraction of Benzyl benzoate	Velocity (ms^{-1})	Density (kgm^3)	Viscosity (mill.Pa.s)	Mole fraction of Benzyl benzoate	Velocity (ms^{-1})	Density (kgm^3)	Viscosity (mill.Pa.s)
Benzyl benzoate + p-Xylene at 30°C				**Benzyl benzoate + p-Xylene at 40°C**				**Benzyl benzoate + p-Xylene at 50°C**			
0.00000	1288.1	852.83	0.5782	0.00000	1253.68	846.18	0.5065	0.00000	1205.94	830.39	0.4757
0.06635	1318.5	876.49	0.9980	0.06635	1273.20	869.19	0.8814	0.06635	1234.81	854.41	0.6859
0.13786	1343.8	905.52	1.6902	0.13786	1302.63	897.83	1.4956	0.13786	1256.66	872.04	1.1398
0.21514	1365.6	930.53	2.1665	0.21514	1321.74	923.83	1.8249	0.21514	1279.65	918.67	1.4966
0.29894	1381.9	956.25	2.8182	0.29894	1348.76	948.09	2.4251	0.29894	1301.26	943.73	1.8891
0.39010	1412.7	983.85	3.3436	0.39010	1385.39	977.46	2.9783	0.39010	1330.88	969.75	2.3825
0.48964	1416.9	999.71	3.8614	0.48964	1399.56	997.46	3.4650	0.48964	1350.37	985.22	2.9524
0.59879	1450.3	1033.76	4.5519	0.59879	1411.82	1027.81	3.8770	0.59879	1373.92	1017.82	3.4025
0.71898	1461.3	1056.39	5.1548	0.71898	1430.93	1049.79	4.2518	0.71898	1389.32	1042.88	3.7503
0.85199	1488.6	1079.81	5.7409	0.85199	1452.06	1076.75	4.7837	0.85199	1413.03	1066.40	3.9831
1.00000	1506.90	1119.35	6.5325	1.00000	1471.44	1109.75	5.0210	1.00000	1440.00	1107.09	4.2983

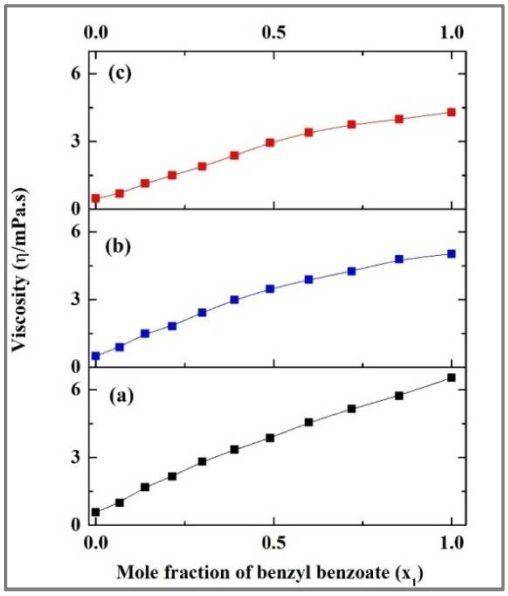


Figure 1. Variation of viscosity (η/mPa.s) of the binary mixture of Benzyl Benzoate and p-Xylene at (a) 33°C, (b) 40°C and (c) 50°C with the mole fraction of Benzyl benzoate.

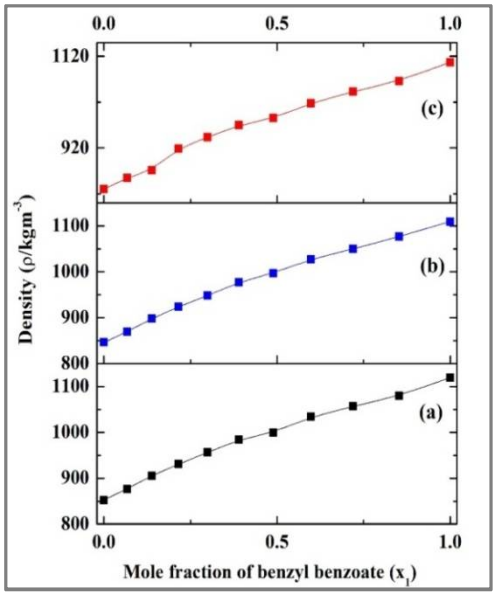


Figure 2. Variation of density (ρ/km^{-3}) of the binary mixture of Benzyl benzoate and p-Xylene at (a) 33°C, (b) 40°C and (c) 50°C with the mole fraction of Benzyl benzoate.

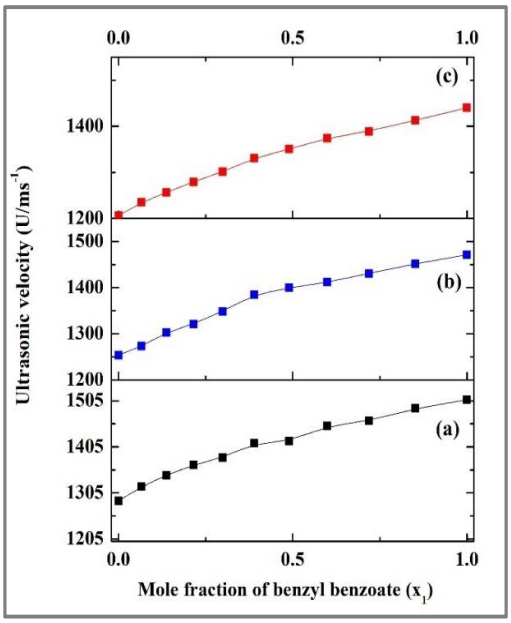


Figure 3. Variation of ultrasonic velocity (U/ms^{-1}) of the binary mixture of Benzyl benzoate and p-Xylene at (a) 33°C, (b) 40°C and (c) 50°C with the mole fraction of Benzyl benzoate.

The percentage deviations w.r.t. the five theories in the binary mixture have been presented in table 2. Maximum percentage deviations at all three temperatures with p-Xylene for all the five theories CFT, FLT, VANDAEL, JUNJIE and NOMOTO are 0.87(<1), 0.83(<1), --10.81(>1), 0.85(<1) and 0.99(<1) ; 0.89 (<1), .-9.35(>1), 0.91(<1), and -1.89(>1) and 0.99(<1), 0.67(<1), -9.41(>1), 0.93(<1) and 0.71(<1) respectively. From the above values, it may be envisaged that except in VANDAEL, most of the % deviations are less than unity i.e, for the system of Benzylbenzoate and p-Xylene, all the other four theories have a sharp edge.

Table 2. Percentage Deviations in Theoretical Velocities

Mole fraction of Benzyl benzoate	$\%U_{CFT}$	$\%U_{FLT}$	$\%U_{Vandael}$	$\%U_{Junjie}$	$\%U_{Nomoto}$
Benzyl benzoate+p-Xylene at 30°C					
0.00000	--	--	--	--	--
0.06635	0.14706	0.6088	-3.34	0.0075	-0.7749
0.13786	0.8482	0.8333	-5.94	0.5305	-0.1104
0.21514	0.3108	0.2952	-7.92	0.7160	-0.1535
0.29894	0.2130	-0.1146	-9.15	0.4442	-0.7852
0.39010	0.2052	-0.0186	-10.29	0.4865	-0.7849
0.48964	0.6377	0.3621	-10.30	0.85549	-0.1620
0.59879	0.5442	0.2388	-10.81	-0.5397	-0.9231
0.71898	0.8798	0.3113	-8.85	0.6025	-0.1169
0.85199	0.0605	0.1728	-6.22	0.6854	-0.4059
1.00000	--	--	--	--	--
Benzyl benzoate+p-Xylene at 40°C					
0.00000	--	--	--	---	---
0.06635	0.4832	0.5525	-2.56	0.1867	0.0590
0.13786	0.9979	0.8994	-5.53	0.0639	-0.6214
0.21514	0.9237	0.0284	-7.37	0.0697	-1.4760
0.29894	0.5141	0.3130	-9.35	0.5845	-1.8943
0.39010	0.1344	0.1031	-8.45	0.6839	-0.9567
0.48964	0.5745	-0.3130	-8.23	0.6827	0.0462
0.59879	0.5036	0.7340	-8.70	0.3108	-0.0662
0.71898	0.1867	0.3317	-9.22	0.9157	-0.4075
0.85199	0.6430--	0.3108	-6.17	0.5676	-0.2736
1.00000		--	--	--	--
Benzyl benzoate+p-Xylene at 50°C					
0.00000	--	--	--	--	--
0.06635	0.3826	0.2082	-3.31	0.8978	-0.6047
0.13786	0.7896	0.2095	-5.71	0.1344	-0.6008
0.21514	0.9954	0.5488	-7.82	-0.3681	-0.6504
0.29894	0.3790	0.2820	-9.41	0.4016	-0.5591
0.39010	0.1312	0.2501	-8.15	0.9326	-0.0352
0.48964	0.0333	0.5622	-8.39	0.6055	-0.7165
0.59879	0.3887	0.4234	-8.20	0.4677	-0.6659
0.71898	0.7440	0.6791	-.932	0.6332	0.0011
0.85199	0.6452	0.4974	-6.17	-0.2714	0.0975
1.00000	--	--	--	--	--

APPLICATION

The ultrasonic study helps in understanding the molecular interactions in liquid mixtures. These properties are extremely useful for the design of process equipment in chemical industries and the data on some of the properties associated with the liquids and liquid mixtures like velocity, viscosity and density find extensive application molecular dynamics.

CONCLUSION

Experimental findings of velocity, viscosity and density in the binary mixtures of benzyl benzoate and p-Xylene at 30°C , 40°C and 50°C are useful in the computation the thermodynamic parameters of a binary mixture such as Adiabatic compressibility, Internal pressure, Molar Volume, Free length , Enthalpy and Activation energy can be calculated using this measured values.

REFERENCES

[1]. J. Siva Sankar, M. Geeta Lakshmi, P. S. Naidu, K. Ravindra Prasad, Excess parameters of the binary mixtures of benzyl benzoate in dichloromethane and isobutanol, *J. Pure Appl Ultrason*, **2007**, 29, 82-88.

[2]. M. Geeta Lakshmi, P. S. Naidu, K. Ravindra Prasad, Molecular interactions in binary mixtures of benzyl benzoate with alcohols, *J Pure Appl Ultrason.*, **2008**, 30, 18-23.
[3]. P. Ramesh, M. Geeta Lakshmi, N. JayaMadhuri, P. S. Naidu, K. Ravindra Prasad Molecular interactions in the Binary Mixtures of Benzyl benzoate in Benzene and substituted Benzenes - an Ultrasonic Study, *Invertis Journal of Science and Technology*, **2011**, 4, 14-30.
[4]. P. Mallikarjuna, N. Jaya Madhuri, K. Ravindra Prasad, Molecular Interactions in the binary mixture of benzyl benzoate- An Ultrasonic Study, *J. Pure Appl.Ultrason*, **2010**, 32, 59-69
[5]. J. Nageswara Rao, N. Jayamadhuri, J. Glory, P. S. Naidu, K. Ravindra Prasad, Excess thermodynamic and other allied parameters in the binary mixtures of and Azo Compounds with benzyl benzoate as common component, *Physical Chemistry an Indian Journal*, **2014**, 9(3), 81-91.
[6]. N. Jaya Madhuri, P. S. Naidu, J. Glory, K. Ravindra Prasad, Ultrasonic investigations Molecular Interaction in Binary Mixtures of Benzyl Benzoate with acetonitrile and Benzonitrile, *E-Journal of Chemistry*, **2011**, 89(1), 457-469.
[7]. N. Jaya Madhuri, J. Glory, P. S. Naidu, K. Ravindra Prasad. Ultrasonic study and allied properties of the binary mixtures of acetophenone and NN' dimethyl formamide with benzyl Benzoate as common component, *J. Pure Appl Ultrason*, **2011**, 33, 63.
[8]. N. Jayamadhuri, J. Glory, P. S. Naidu, K. Ravindra Prasad. Study of molecular interactions in the binary mixtures of benzyl benzoate with carbon disibhide and diethyl ether, Proceedings of Eighteenth National Symposium on Ultrasonics. Proceedings of Eighteenth National Symposium on Ultrasonics, NSU-XVIII VIT University, Vellore, **2009**, December, 21-23, 405-408.
[9]. Sk. Fakruddin, Ch. Srinivasu, B. R. Venkateswara Rao, K. Narendra, Excess Transport Properties of Binary Mixtures of Quinoline with Xylenes at Different Temperatures, *Advances in Physical Chemistry*, **2012**.
[10]. Tulshidas S. Savale, Janardhan M. Shewale, Pandarinadh S. Nikam Densities and Viscosities of binary mixtures of Xylenes with Propan-1 ol at 298.15, 303.15, 308.15 and 313.15 K., *Int. J. Chem. Sci.*, 8(2), **2010**, 991-1006.