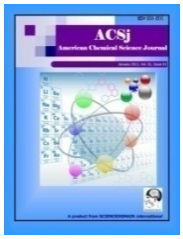

American Chemical Science Journal
3(4): 468-478, 2013

SCIENCEDOMAIN *international*
www.sciencedomain.org

Densities, Viscosities and Ultrasonic Studies of Binary Liquid Mixture of Ethylamine and Benzyl Alcohol at Different Temperatures

Chandra Mohan Saxena[1*], Archna Saxena[1], Ashok Kumar Srivastava[1] and Naveen Kumar Shukla[1]

[1]Department of Chemistry, D.B.S. (P. G.), College Govind Nagar Kanpur (U.P.), India.

Authors' contributions

This work was carried out in collaboration between all authors. Author CMS designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Author AS managed the analyses of the study. Authors AKS and NKS managed the literature searches. All authors read and approved the final manuscript.

Research Article

Received 11th June 2013
Accepted 10th July 2013
Published 4th August 2013

ABSTRACT

Ultrasonic studies, densities and viscosities of binary liquid mixture of ethylamine and benzyl alcohol have been measured at different temperatures at 30ºC, 35ºC and 40ºC. The experimental value of speed of sound (u), isentropic compressibility (βs), intermolecular free length (L_f), viscosity (η), available volume (Va), molar volume (Vm) and Nissan's parameter (d) have been calculated of ethyl amine and benzyl alcohol in the pure state as well as mixture over whole composition range were measured at 30ºC, 35ºC and 40ºC. These properties also provide important information about molecular packing, molecular motion and various types of intermolecular interactions and their strength, influenced by the size shape and chemical nature of component molecules.

Keywords: Binary mixture; ethyl amine; benzyl alcohol; ultrasonic interferometer.

**Corresponding author: Email: drcmsaxena01@gmail.com;*

1. INTRODUCTION

The ultrasonic studies find extensive applications, as sound speed in liquids and liquid mixtures is intrinsically related with many parameters which characterize the physico chemical behavior of the liquids and liquid systems. Mixed solvents rather than single pure liquids are of utmost practical importance in most chemical and industrial process as they provide a wide range mixtures of two or more components in varying proportions so as to permit continuous adjustment of the derived properties of the medium. Intermolecular interaction in various binary liquid mixtures at different temperatures have been studied by several authors [1-4]. Physico chemical properties like density, viscosity and speed of sound have got considerable importance in forming theoretical models as well as their applications in a number of branches of science. A considerable progress has been made theoretical understanding of liquid-liquid mixture [5-8]. The binary mixture are indispensable for many chemical process industries e.g. petroleum petrochemicals, where physico chemical processes are involved to handle the mixtures of hydrocarbons ,alcohols, ketones etc. for accurate designing equipment it is necessary to know the interaction between the components of mixture. The thermodynamic studies of binary solutions have attracted much attention of scientists and experimental data on a number of systems are available from review and publication [9–22]. Viscosity, density measurements and the properties derived from these are excellent tools to detect solute – solute and solute – solvent interactions. It is used in so many fields of scientific researches in physics, chemistry, biology, medicines and industry. The present paper deals with the measurement of density, viscosity, speed of sound, molar volume, available volume, Nissan's parameter and their excess values of binary liquid mixture ethyl amine and benzyl alcohol at different temperatures, 30ºC, 35ºC and 40ºC. This technique using ultrasonic instruments is in the tremendous use in measuring the rate of flow of blood through the human body and getting images of vital organs of the body like kidney, liver blood vessel and foetus etc.

2. METHOD AND METARIAL

The organic liquid ethylamine and benzyl alcohol were obtained from E-merck. Density and viscosity measurements were carried out using a thermostatically controlled well stirred water bath to maintain temperature. The densities of pure components and binary mixtures were measured using precalibrated pyknometer with an accuracy of ±0.053% at 30ºC, 35ºC and 40ºC. Viscosities of the pure liquids and their mixtures were measured using Ostwald viscometer. The flow of time of pure liquids and liquid mixtures were measured using an accurate stop watch with a precision of ± 0.1s. The purity of chemicals was checked by comparing with their densities with literature values [22-23]. Ultrasonic velocity was measured by single crystal ultrasonic interferometer model (M – 84) at 2 M Hz. Frequency. All measurements were made in a thermostatically controlled water bath with temperature accuracy of ± 0.1ºC.

The molar volume of binary liquid mixture is given by

$$Vm = [X_1M_1 + X_2M_2] \div \rho \quad (1)$$

Where Vm is molar volume , M_1 and M_2 are molecular weight of pure components and X_1 and X_2 are mole fractions of the component 1 and 2 and 'ρ'is the density of the liquid.

Excess volume (V^E) of binary liquid mixtures of varying composition were calculated using relations

$$V^E = V^{obs} - V^{id} \quad (2)$$

Where V^{obs} is the experimental value of volume of binary liquid mixture

$$Vobs = (M_1X_1 + M_2X_2) \div \rho \quad (3)$$

'ρ' is the density of binary liquid mixture of given composition measured. V^{id} refers to the Value for ideal binary mixture

$$Vid = X_1V_1 + X_2V_2 = X_1M_1 \div \rho_1 + X_2M_2 \div \rho_2 \quad (4)$$

Where M_1 and M_2 are molar masses and ρ_1, ρ_2 are densities of component liquid in pure state. X_1 and X_2 are mole fractions of first and second liquid.

Thermodynamic properties like isentropic compressibility (βs) and intermolecular free length (L_f) are calculated using following relations

$$\beta s = 1 / u^2\rho \quad (5)$$

$$L_f = K / u\,\rho^{1/2} \quad (6)$$

Where 'K' is temperature constant, 'u' is speed of sound and 'ρ' is the density of liquid.

Available volume may be calculated as

$$Va = \rho [Vm - u / u_\infty] \quad (7)$$

Where Vm' is molar volume, 'u' is speed of sound of the liquid, 'u_∞' is the speed of sound at infinity, which is equal to 1600 m/sec.

$$\text{Nissan's parameter } (d) = Ln\,\eta^E / X_1X_2 \quad (8)$$

'η^E' is the excess value of viscosity, X_1 and X_2 are the mole fractions of the liquid 1 & 2.

3. RESULTS AND DISCUSSION

The results are shown in Tables (1 to 4) and Figs. (I to IV). Deviations in the properties computed demonstrated that their exist a molecular interaction between unlike molecules of the liquid mixture. The experimental values of speed of sounds, densities, molar volumes and their excess values for the system of ethylamine and benzyl alcohol are shown in Table 1. The Table 2 shows isentropic compressibility, intermolecular free length and their excess values for the system (ethylamine +benzyl alcohol). Table 3 shows available volume and their excess values for the system (ethylamine +benzyl alcohol). Table 4 shows the viscosity and their excess values, $L_n\,\eta^E$ (Logarithm of excess value of viscosity) and Nissan's parameter (d) have been calculated for the system (ethyl amine +benzyl alcohol). All the experimental values are taken in table (1 – 4) at three different temperatures, 30ºC, 35ºC and 40ºC. The Figs. I, II, III and IV shows the excess molar volume (Vm^E), excess isentropic compressibility (βs^E), excess intermolecular free length (L_f^E) and excess viscosity (η^E) with

mole fraction of ethyl amine (X_1) for the mixture of ethyl amine and benzyl alcohol at the temperature 30ºC, 35ºC and 40ºC.

Table 1. Ultrasonic velosities, densities, molar volumes and their excess values for the system ethyl amine + benzyl alcohol

At – 30ºC					
Mole fraction of Ethylamine (X_1)	**Ultrasonic Velocity m/sec**	**Density g/ml**	**Molar Volume (exp) ml/mole**	**Molar Volume (add) ml/mole**	**Excess molar Volume ml/mole**
0.0000	1513	1.0357	104.41	104.41	0.00
0.1025	1510	1.0283	98.87	99.34	-0.47
0.2008	1508	1.0145	94.10	94.50	-0.40
0.2992	1504	0.9999	89.27	89.63	-0.36
0.4006	1498	0.9820	84.37	84.63	-0.26
0.4986	1492	0.9635	79.59	79.79	-0.20
0.5991	1484	0.9414	74.73	74.82	-0.09
0.6992	1472	0.9147	70.00	69.88	+0.12
0.7992	1460	0.8839	65.31	64.94	+0.37
0. 8986	1456	0.8493	60.59	60.03	+0.56
1.0000	1450	0.8190	55.04	55.04	0.00
At - 35ºC					
0.0000	1498	1.0326	104.72	104.72	0.00
0.1025	1496	1.0247	99.21	99.64	-0.43
0.2008	1495	1.0110	94.43	94.78	-0.35
0.2992	1491	0.9958	89.63	89.91	-0.28
0.4006	1486	0.9783	84.70	84.90	-0.20
0.4986	1480	0.9594	79.93	80.05	-0.12
0.5991	1472	0.9370	75.08	75.09	-0.01
0.6992	1464	0.9096	70.39	70.13	+0.26
0.7992	1453	0.8795	65.64	63.19	+0.45
0.8986	1444	0.8455	60.87	60.27	+0.60
1.0000	1434	0.8156	55.27	55.27	0.00
At- 40ºC					
0.0000	1482	1.0295	105.04	105.04	0.00
0.1025	1481	1.0210	99.57	99.95	-0.38
0.2008	1480	1.0072	94.78	95.08	-0.30
0.2992	1479	0.9917	90.00	90.21	-0.21
0.4006	1474	0.9740	85.07	85.19	-0.12
0.4986	1467	0.9552	80.29	80.33	-0.04
0.5991	1457	0.9319	75.49	75.36	+0.15
0.6992	1450	0.9050	70.75	70.40	+0.35
0.7992	1443	0.8750	65.97	65.45	+0.52
0. 8986	1434	0.8409	61.19	60.53	+0.66
1.0000	1417	0.8121	55.51	55.51	0.00

Table 2. Isentropic compressibilities, inter molecular free lengths and their excess values for the system ethylamine + benzylacohol

Mole fraction of ethylamine X_1	Isentropic compressibility (exp) cm^2/dyne {$*10^{12}$}	Isentropic compressibility (add)cm^2/ dyne {$*10^{12}$}	Excess Isentropic compressibility cm^2/dyne {$*10^{12}$}	Inter molecular Free length (exp) A^0	Intermolecular Free length (add) A^0	Excess inter molecular Free Length A^0
At- 30°C						
0.0000	42.17	42.17	0.00	0.4097	0.4097	0.0000
0.1025	42.65	43.79	- 1.14	0.4120	0.4169	- 0.0049
0.2008	43.34	45.36	- 2.02	0.4154	0.4239	- 0.0085
0.2992	44.21	46.92	- 2.71	0.4195	0.4309	- 0.0114
0.4006	45.38	48.53	- 3.15	0.4250	0.4381	- 0.0131
0.4986	46.62	50.09	-3.47	0.4308	0.4451	- 0.0143
0.5991	48.23	51.68	- 3.45	0.4382	0.4522	-0.0140
0.6992	50.45	53.28	- 2.83	0.4481	0.4593	- 0.0112
0.7992	53.07	54.86	- 1.79	0.4596	0.4664	- 0.0068
0.8986	55.54	56.45	- 0.91	0.4702	0.4735	-0.0033
1.0000	58.07	58.07	0.00	0.4808	0.4808	0.0000
At- 35°C						
0.0000	43.15	43.15	0.00	0.4181	0.4181	0.0000
0.1025	43.60	44.83	-1.23	0.4202	0.4255	-0.0053
0.2008	44.25	46.45	-2.20	0.4234	0.4327	-0.0093
0.2992	45.17	48.07	-2.90	0.4277	0.4400	-0.0123
0.4006	46.29	49.74	-3.45	0.4330	0.4474	-0.0144
0.4986	47.58	51.36	-3.78	0.4390	0.4546	-0.0156
0.5991	49.25	53.00	-3.75	0.4466	0.4619	-0.0153
0.6992	51.29	54.65	-3.36	0.4558	0.4692	-0.0134
0.7992	53.84	56.30	-2.46	0.4670	0.4766	-0.0096
0.8986	56.72	57.94	-1.22	0.4793	0.4838	-0.0045
1.0000	59.62	59.62	-0.00	0.4914	0.4914	0.0000
At- 40°C						
0.0000	44.22	44.22	0.00	0 .4269	0.4269	.0000
0.1025	44.65	45.96	-1.31	0.4289	0.4347	0.0058
0.2008	45.32	47.65	-2.33	0.4321	0.4420	-0.0099
o.2992	46.09	49.32	- 3.23	0.4358	0.4495	- 0.0137
0.4006	47.25	51.12	- 3.87	0.4413	0.4571	- 0.0158
0.4986	48.64	52.74	- 4.10	0.4477	0.4646	- 0.0169
0.5991	50.54	54.45	- 3.91	0.4564	0.4722	- 0.0158
0.6992	52.55	56.17	- 3.62	0.4653	0.4798	- 0.0145
0.7992	54.88	57.88	- 3.00	0.4656	0.4874	- 0.0118
0.8986	57.83	59.58	- 1.75	0.4882	0.4949	- 0.0067
1.0000	61.32	61.32	0.00	0.5027	0.5027	0.0000

Table 3. Available volumes and their excess values for the system ethylamine + benzyl alcohol

Mole fraction of ethyl amine X_1	Available volume (exp) ml / mole	Available volume (add) ml / mole	Excess available volume ml /mole
At - 30ºC			
0.0000	5.67	5.67	0.00
0.1025	5.56	5.60	- 0.04
0.2008	5.41	5.56	- 0.15
0.2992	5.35	5.51	- 0.16
0.4006	5.37	5.45	- 0.08
0.4986	5.37	5.41	- 0.04
0.5991	5.41	5.36	+ 0.05
0.6992	5.60	5.30	+ 0.30
0.7992	5.71	5.25	+ 0.46
0.8986	5.45	5.20	+ 0.25
1.0000	5.16	5.16	0.00
At - 35ºC			
0.0000	6.67	6.67	0.00
0.1025	6.44	6.56	-0.10
0.2008	6.19	6.48	-0.29
0.2992	6.10	6.38	-0.28
0.4006	6.03	6.28	-0.25
0.4986	5.99	6.19	-0.20
0.5991	6.00	6.10	-0.10
0.6992	5.98	6.00	-0.02
0.7992	6.02	5.90	-0.12
0.8986	5.93	5.81	+0.12
1.0000	5.73	5.73	0.00
AT - 40ºC			
0.0000	7.74	7.74	0.00
0.1025	7.40	7.59	- 0.19
0.2008	7.10	7.45	- 0.35
0.2992	6.80	7.31	- 0.51
0.4006	6.69	7.16	- 0.47
0.4986	6.67	7.04	- 0.37
0.5991	6.65	6.90	- 0.25
0.6992	6.63	6.75	- 0.12
0.7992	6.47	6.61	- 0.14
0.8986	6.34	6.47	- 0.13
1.0000	6.34	6.34	0.00

Table 4. Viscosities and their excess values, $\ln\eta^e$ and nissan's parameter (d) for the system ethylamine+ benzyl alcohol

Mole fraction of ethyl amine X_1	Viscosity (exp) Cp	Viscosity (add) Cp	Excess Viscosity Cp	$\ln\eta^E$	'd'
AT- 30ºC					
0.0000	2.832	2.832	0.000	0.000	0.000
0.1025	2.731	2.625	+0.106	+ 0.091	+ 0.989
0.2008	2.510	2.427	+0.083	+ 0.128	+ 0.797
0.2992	2.291	2.229	+0.062	+ 0.158	+ 0.753
0.4006	1.982	2.022	+0.040	+ 0.139	+ 0.578
0.4986	1.844	1.828	+0.016	+ 0.196	+ 0.784
0.5991	1.593	1.626	- 0.033	+ 0.166	+ 0.691
0.6992	1.328	1.425	- 0.098	+ 0.108	+ 0.513
0.7992	1.151	1.224	- 0.073	+ 0.089	+ 0.554
0.8986	0.984	1.024	- 0.040	+ 0.056	+ 0.614
1.0000	0.821	0.821	0.000	0.000	0.000
At- 35ºC					
0.0000	2.412	2.412	0.000	0.000	0.000
0.1025	2.318	2.238	+0.080	+0.083	+0.902
0.2008	2.139	2.073	+0.066	+0.121	+0.753
0.2992	1.948	1.906	+0.042	+0.146	+0.696
0.4006	1.757	1.735	+0.022	+0.164	+0.682
0.4986	1.547	1.570	-0.023	+0.155	+0.620
0.5991	1.321	1.401	-0.080	+0.118	+0.491
0.6992	1.115	1.232	-0.117	+0.068	+0.323
0.7992	0.970	1.064	-0.094	-0.050	-0.311
0.8986	0.840	0.895	-0.055	-0.025	-0.274
1.0000	0.725	0.725	0.000	0.000	0.000
AT - 40^{0}C					
0.0000	2.017	2.017	0.000	0.000	0.000
0.1025	1.935	1.875	+ 0.060	+ .077	+ 0.837
0.2008	1.786	1.738	+ 0.048	+ 0.110	+ 0.685
0.2992	1.632	1.603	+ 0.019	+ 0.134	+ 0.639
0.4006	1.455	1.464	- 0.009	+ 0.135	+ 0.562
0.4986	1.267	1.328	- 0.061	+ 0.099	+ 0.396
0.5991	1.073	1.190	- 0.117	+ 0.059	+ 0.245
0.6992	0.920	1.051	- 0.131	+ 0.022	+ 0.104
0.7992	0.793	0.914	- 0.121	- 0.011	- 0.069
0.8986	0.694	0.776	- 0.082	- 0.031	- 0.340
1.0000	0.637	0.637	0.000	0.000	0.000

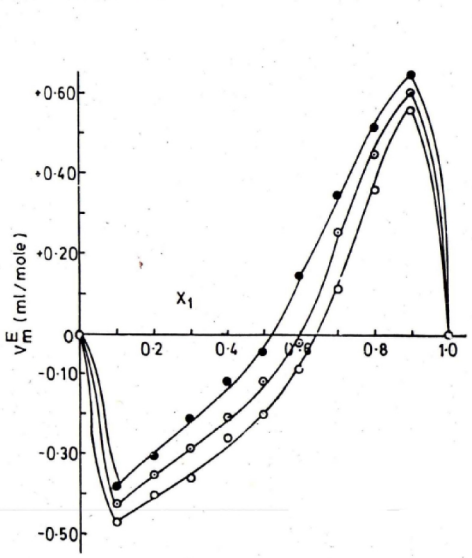

Fig.- I EXCESS MOLAR VOLUME V_m^E Vs MOLE FRACTION X_1 OF ETHYL AMINE FOR ETHYL AMINE + BENZYL ALCOHOL AT —o— 30°C, —⊙— 35°C & —●— 40°C.

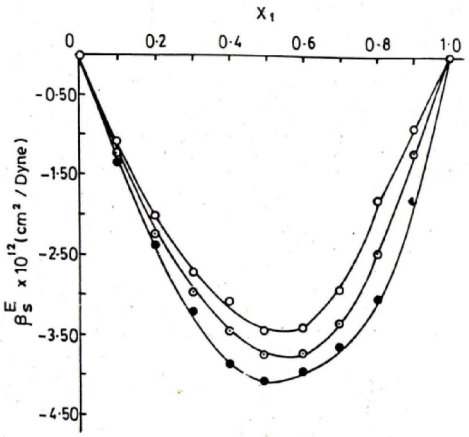

Fig.-II EXCESS ISENTROPIC COMPRESSIBILITY β_s^E Vs MOLE FRACTION X_1 OF ETHYL AMINE FOR ETHYL AMINE + BENZYL ALCOHOL AT —o— 30°C, —⊙— 35°C AND —●— 40°C.

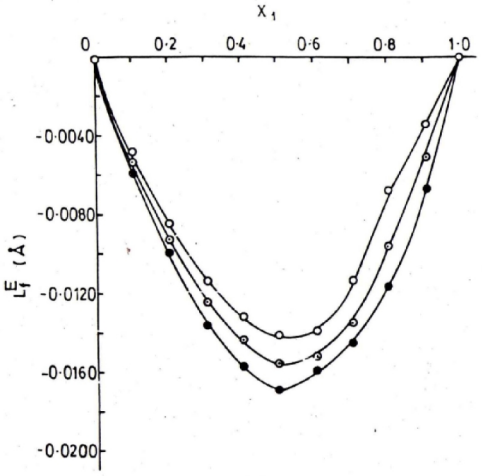

Fig.- III EXCESS INTERMOLECULAR FREE LENGTH L_f^E Vs MOLE FRACTION X_1 OF ETHYLAMINE FOR ETHYL AMINE + BENZYL ALCOHOL AT —o— 30°C, —⊙— 35°C & —●— 40°C.

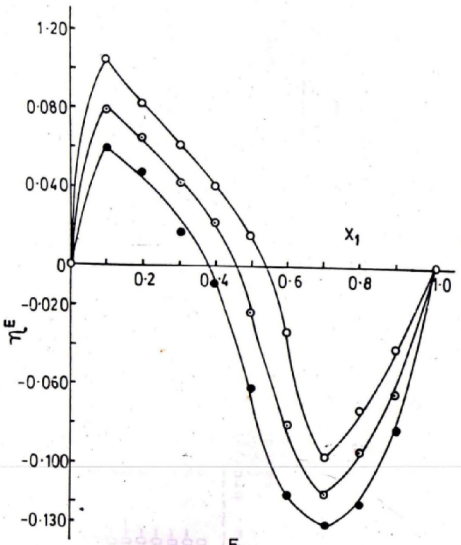

Fig.-IV EXCESS VISCOSITY η^E Vs MOLE FRACTION X_1 OF ETHYL AMINE FOR ETHYL AMINE + BENZYL ALCOHOL AT —o— 30°C, —⊙— 35°C & —●— 40°C

The mixture of ethylamine have been prepared by adding benzyl alcohol in respective system (Table – 1 to 4) and the excess functions of these derived properties which are better measure of strength of interactions are also calculated and plotted against mole fraction of ethyl amine (Figs. - I to IV). Ethyl amine and benzyl alcohol are polar compounds and in addition the alcohols are associating in nature. Thus the mixture is polar-polar systems. In case of ethyl amine and benzyl alcohol at 30ºC, 35ºC and 40ºC, the speed of sound, density, molar volume, viscosity and available volume decrease with the increase in amount of benzyl alcohol shown in (Tables – 1,3 & 4) and Fig. (I and IV), while isentropic compressibility and intermolecular free length increase under similar condition Table 2 and Figs. II and III. In the system of ethyl amine and benzyl alcohol the excess value of isentropic compressibility (βs^E), excess value intermolecular free length (L_f^E) are negative and the value of Nissan's parameter (d) are positive .The excess values of (βs^E) and (L_f^E) are negative in amine rich mixture and positive in alcohol rich mixtures. The magnitude of change in (ethylamine + benzyl alcohol) system is higher and the sign and magnitude of the variation of (βs), (L_f) and (d) indicate a weak interaction. In this case the π electrons of benzene ring are also supposed to be involved in the interaction.

4. CONCLUSION

Hence it can be concluded from these studies of ultrasonic speed, density and viscosity measurements that the negative value of excess molar volume (Vm^E) and excess available volume (Va^E) shows different molecular size attributed to the presence of dispersion forces between the mixing components and suggest the presence of specific interactions of the binary mixture at the temperature 30ºC, 35ºC and 40ºC. While the positive values of excess molar volume (Vm^E), and logarithm values of excess viscosity ($Ln\eta^E$) may be due to the presence of strong and specific molecular interactions between the unlike molecules of the binary mixture (ethyl amine and benzyl alcohol) at the temperatures 30ºC, 35ºC and 40ºC.

ACKNOWLEDGEMENT

Authors are thankful to Dr. A. K. Srivastva, Principal, D.B.S. College, Kanpur. Dr. R. K. Khare, Head of the chemistry department and Dr. Sunil Srivastava, Bursar, D.B.S. College, Kanpur for providing lab facility. I am also thankful to U.G.C. New Delhi for supporting me.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Nain AK, et al. Molecular interactions in binary mixtures of formamide with 1 butanol, 2 butanol,1,3butaneol at different temperatures. Journal of Fluid Phase Equilibria, 2008;265(1-2):46-56.
2. Bhoj Bhadur Gurung, Mahendra Nath Roy, Study of densities, viscosities and ultrasonic speeds of binary mixtures containing 1,2 diethoxy ethane with alkane 1-ol at 298.15 K. Journal of Solution Chemistry. 2006;35:1587-1606.
3. Zareena Begaum, et al. Thermodynamic, ultrasonic studies or binary liquid mixtures of anisaldehyde with akoxy ethanols at different temperatures. Journal of Molecular Liquids, volume 178, February 2013;99-112.

4. Thanuja B, Charles Kanagam, et al. Studies on intermolecular interactions on binary mixtures of methyl orange – water system. Excess molar functions of ultrasonic parameters at different temperatures. Journal of Ultrasonics Sonochemistry. 2011;18:1274–1278.
5. Rajgopal K, Chenthilnath S. Study on excess thermodynamic parameters and theoretical estimation of ultrasonic velocity of 2-methyl 2-propanol with nitriles at different temperatures. Journal of Chemical Engineering. 2010;18:806–816.
6. Anil Kumar Nain. Ultrasonic and viscometric study of molecular interactions in binary mixtures of aniline with 1-propanol, 2-methyl propanol at different temperatures. Journal of Fluid Phase Equilibria. 2007;259(2):218-227.
7. Shahla Parveen, Divya Shukla, et al. Ultrasonic velocity, density, viscosity and their excess parameters of the binary liquid mixtures of tetra hydro Furan with methanol and o- crysol at varying temperatures. Journal of Applied Acoustics. 2009;70(3):507–513.
8. Rajgopal K, Chenthilnath S. Excess parameters studies on binary liquid mixtures of 2-methyl 2 – propanol with aliphatic nitriles at different temperatures. Journal of Molecular Liquids. 2011;160(2):72-80.
9. Yadav SS, AniruddhYadav, Ultrasonic study of binary liquid mixture between some brome alkanes and hydrocarbons, Journal of Ultrasonics. 2005;43:732–735.
10. Jagdish G. Baragi, Seema Maganur, et al. Excess of molar volumes and efractive indices of binary liquid mixtures of acetyl acetone with n- nonane, n-decane at 25ºC,30ºC,35ºC. Journal of Molecular Liquid. 2013;178:175-177.
11. Anwar Ali, Firdosa Navi, et al. Volumetric , ultrasonic and viscometric behavior of binary mixtures of styrene with ethyl alcohol and chloro benzene at different temperatures. Journal of Molecular Liquids. 2008;143(2-3):141-146.
12. M.V. Ratnam, Reema T.Sayed etal. Molecular interaction study of binary mixtures of methyl benzoate, viscometric and ultrasonic study. Journal of Molecular Liquids. 2012;166:9-16 .
13. Gyan Prakash Dubey, Kishan Kumar. Thermodynamic properties of binary liquid mixtures of diethylene tri amine with alcohols at different temperatures. Journal of Thermochimica. Acta. 2011;524(1-2):7-17.
14. kumar S, Jeevandham P. Densities, viscoties and excess properties of aniline and o-anisidine with 2 – alkoxy ethanols at 303.15ºK. Journal of Molecular Liquids. 2012;174:34–41.
15. Anil Kumar Nain. Ultrasonic study of molecular interactions in binary mixtures of methyl acryl ate with 1- alkanols at different temperatures. Journal of Chemical Thermodynamics. 59, april 2013;49-64.
16. Rajgopal K, Chenthilnath S. Molecular interaction studies and theoretical estimation of ultrasonic speeds in binary mixtures of toluene with nitriles at different temperatures. Journal of Thermochemica Acta. 2010;498(1):45-53.
17. Lovely Sarkar and Mahendra Nath Rao. Density, viscosity and ultrasonic speed of binary mixtures of 1,3 dioxane with 2,methoxy methanol. Journal of Chemical Engineering data. 2009;54(12):3307-3312.
18. Riyazuddin and Sadaffarin. Ultrasonic velocities and densities of phenyl alanine with aqueous $NaNO_3$ solution at (298.15 – 328.15) K. Journal of Chemical Engineering data. 2010;55(7):2643–2648.
19. Bedare GR, Bhandakkar VD, et al. Ultrasonic study of molecular interactions in binary mixtures 1,4 dioxan with methanol at 308K. European Journal of Applied Engineering and Scientific Researches. 2012;1(1):1-4.

20. San-Junbeng, Hai - Yun Hou, et al. Densities and excess volume of binary mixtures of N-N dimethyl formamide with aromatic hydrocarbons at different Temperature. Journal of Chemical Thermodynamics. 2007;39:474 -482.
21. Venkatesu P. Thermo physical contribution of N-N dimethyl formamide in the molecular interactions with other solvents. Journal of Fluid Phase Equlibria. 2010;298(2):173–191.
22. Cezary MK, nart, Magdalena Klimczak, et al. Densities and excess molar volumes for binary mixture of some glycols in 2 –methoxy ethanol at(293.15, 298.15, 303.15)K. Journal of Molecular Liquids. 2007;135(1–3):192–195.
23. Dean JA. Lange's Hand book of chemistry, McGraw Hill, New York; 1987.
24. David RL. CRC Hand book of chemistry and physics ,CRC Press Florida; 2000.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history.php?iid=242&id=16&aid=1817