Asian Journal of Chemistry Vol. 22, No. 6 (2010), 4299-4303

Densities, Viscosities and Viscosity Deviations of Binary Liquid Mixtures of 2-Butanol with Non-Polar Solvent at 303.15 K

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Densities and viscosities have been measured for the binary liquid mixtures of 2-butanol with some non-polar solvent *e.g.*, Benzene, toluene, xylene, hexane and carbon tetrachloride over the entire composition range at 303.15K. From density and viscosity data, the values of viscosity deviation ($\Delta\eta$) of the binary mixtures have been determined at 303.15 K. The excess properties are found to be negative depending on the molecular interactions and the nature of liquid mixtures.

Key Words: Densities, Viscosities, Binary liquid mixtures, 2-Butanol, Non-polar solvent.

INTRODUCTION

Studies on thermodynamic and transport properties are important in understanding the nature of molecular interactions in binary liquid mixtures. These properties are extremely useful for designing many types of transport and process equipment in chemical industries. There has been a recent upsurge of interest[1,2] in the study of thermodynamic properties of binary liquid mixtures. These have been extensively used to obtain information on intermolecular interactions in these systems.

In this paper, we report experimental data for density (ρ) and viscosity (η) of the following mixtures at 303.15 K: 2-Butanol with some non-polar solvent *e.g.*, benzene, toluene, xylene, hexane and carbon tetrachloride using these data, viscosity deviation ($\Delta\eta$) have been calculated.

EXPERIMENTAL

All the organic liquids used in the study were of analytical grade. 2-Butanol benzene, toluene, xylene, hexane and carbon tetrachloride were obtained from Merck Limited. The organic liquids were further purified for purity better than 99 %, as reported in literature[3,4]. Liquid mixtures of various compositions were prepared by mass in a 30 cm^3 flask. The average uncertainty in the mole fraction of the mixtures were estimated to be less than ± 0.0001. Density and viscosity measurements were carried out using a thermostatically controlled water bath (Zenith) to maintain temperature.

The binary liquid mixtures of different known compositions were prepared in stopper measuring flasks. The density and viscosity were measured as a function of

composition of the binary liquid mixture at 303.15 K. The density was determined using a pyknometer with in 0.00001 × 10^3 K g^{-3}. The weight of the sample was measured using electrical single pan analytical balance (K-Roy).

An Ostwald's viscometer was used for the viscosity measurement. The flow time's measurement were made using an electric stopwatch with a precision of ± 0.015. An average of 4 or 5 sets of flow times was taken for each liquid mixture. A controlled to ± 0.01 K, was used for all the measurements.

RESULTS AND DISCUSSION

The density (ρ) and viscosity (η) of binary liquid mixtures of 2-butanol with some non-polar solvent *e.g.*, benzene, toluene, xylene, hexane and carbon tetrachloride were measured at 303.15 K as a function of the composition of the corresponding binary liquid mixtures. The viscosity deviation (Δη) for binary mixtures were determined using the well-known equation[5-8] and are given in Table-1.

TABLE-1
VALUE OF DENSITY (ρ), VISCOSITY (η) AND VISCOSITY DEVIATION (Δη) FOR THE BINARY MIXTURES OF 2-BUTANOL (1) WITH SOME NON-POLAR SOLVENT (2) AT 303.15 K

2-Butanol (1) + benzene (2)			
Mole fraction (X_i)	ρ × 10^{-3} (kg m^{-3})	η (m Pa s)	Δη (m Pa s)
0.0000	0.8610	0.5740	0.0000
0.0912	0.8590	0.5713	-0.1400
0.1709	0.8530	0.6218	-0.2096
0.2142	0.8482	0.6732	-0.2233
0.3076	0.8363	0.7130	-0.3241
0.4044	0.8315	0.7407	-0.4422
0.4981	0.8286	0.8610	-0.4629
0.6602	0.8254	0.9926	-0.5755
0.8145	0.8136	1.2015	-0.5988
0.9496	0.8066	1.6605	-0.3432
1.0000	0.7984	2.0790	0.0000
2-Butanol (1) + hexane (2)			
0.0000	0.6438	0.3478	0.0000
0.0874	0.6427	0.3502	-0.1640
0.1466	0.6614	0.3566	-0.2445
0.2062	0.6827	0.3857	-0.3185
0.2558	0.7061	0.4091	-0.3813
0.4211	0.7138	0.5824	-0.4944
0.6524	0.7468	0.9446	-0.5116
0.6841	0.7690	0.9531	-0.5792
0.8930	0.7748	1.1762	-0.7180
0.9700	0.7892	1. 7402	-0.7146
1.0000	0.7984	2.0790	0.0000
2-Butanol (1) + carbon tetrachloride (2)			
0.0000	1.5711	0.8861	0.0000
0.0097	1.4142	0.9061	-0.0085

0.1836	1.3757	0.9564	-0.1488
0.3278	1.2936	0.9683	-0.3090
0.4470	1.2560	1.1503	-0.2693
0.5351	1.2126	1.1960	-0.3287
0.6172	1.1419	1.3065	-0.3162
0.6891	1.1021	1.6410	-0.0676
0.7997	1.0726	1.8996	-0.0590
0.9076	0.9561	1.9608	-0.0086
1.0000	0.7984	2.0790	0.0000
	2-Butanol (1) + toluene (2)		
0.0000	0.8676	0.5141	0.0000
0.1097	0.8533	0.5668	-0.1189
0.2008	0.8504	0.6001	-0.2283
0.3537	0.8496	0.5999	-0.4771
0.4509	0.8467	0.6588	-0.5599
0.5514	0.8395	0.7088	-0.6684
0.6514	0.8216	0.8002	-0.7336
0.7807	0.8131	0.9948	-0.7415
0.8843	0.8026	1.2515	-0.6470
0.9946	0.7913	1.3780	-0.9752
1.0000	0.7984	2.0790	0.0000
	2-Butanol (1) + xylene (2)		
0.0000	0.8133	0.8324	0.0000
0.1143	0.7966	0.4961	-0.4785
0.2131	0.7967	0.4969	-0.6014
0.3155	0.8059	0.5499	-0.6760
0.4363	0.8267	0.6269	-0.7504
0.5433	0.8359	0.7090	-0.8010
0.6228	0.8467	0.8143	-0.7949
0.7154	0.8537	1.0226	-0.7021
0.8295	0.8614	1.2241	-0.6430
0.8916	0.8701	1.5398	-0.4047
1.0000	0.7984	2.0790	0.0000

The experimentally determined viscosity deviation ($\Delta\eta$) for binary liquid mixtures of of 2-butanol with non-polar solvent fitted to the following relationship:

$$\Delta\eta = \eta - \sum_{i=1}^{i} (X_i \eta_i) \quad (1)$$

where η is the dynamic viscosities of the mixture and X_i , η_i are the mole fraction and viscosity of ith component in the mixture, respectively. The estimated uncertainty for viscosity deviation ($\Delta\eta$) is ± 0.004 m Pa. S.

A perusal of Table-1 shows that the values of viscosity deviation ($\Delta\eta$) are negative over the entire composition rang for all the binary mixtures studied and the negative value increases as the mole fraction of 2-butanol increase. It is observed in many systems that there is no simple correlation between the strength of the interactions and the observed properties. Viswanathan *et al.*[9] therefore, suggested the observed excess property is a combination of an interaction and a non-interaction part. The

non-interaction part in the form of size effect can be comparable to the interaction part and may be sufficient to reverse the trend set by the latter. In general, the negative values imply the presence of dispersion forces[10] in 3 mixtures.

The plot of viscosity deviation ($\Delta\eta$) verses mole fraction (X_i) for different binary mixtures of 2-butanol with benzene, toluene, xylene, hexane and carbon tetrachloride, have been presented in Figs. 1-5, respectively.

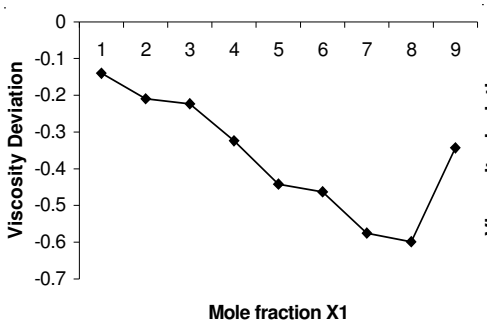

Fig. 1. Experimental viscosity deviation ($\Delta\eta$) for 2-butanol (1) + benzene (2) mixtures at 303.15 K

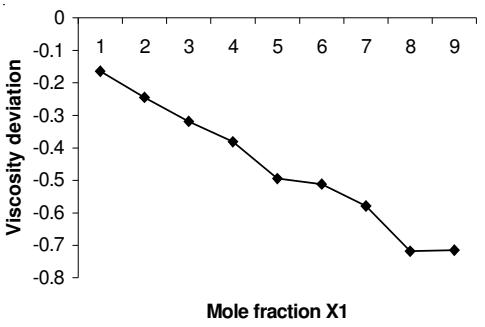

Fig. 2. Experimental viscosity deviation ($\Delta\eta$) for 2-butanol (1) + hexane (2) mixtures at 303.15 K

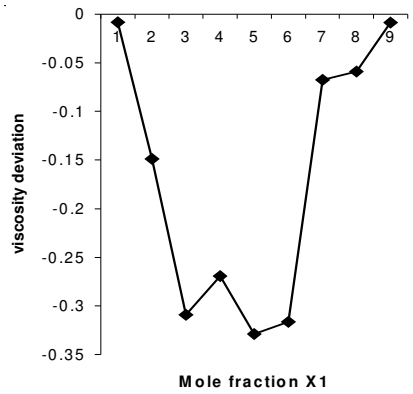

Fig. 3. Experimental viscosity deviation ($\Delta\eta$) for 2-butanol (1) + carbon tetrachloride (2) mixtures at 303.15 K

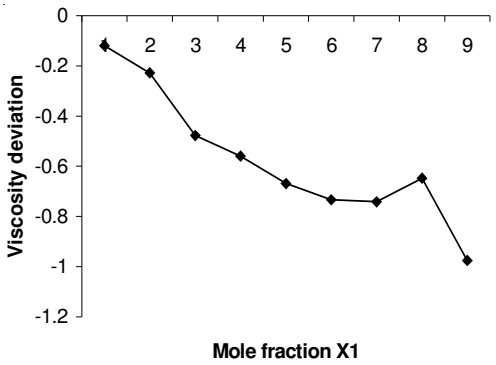

Fig. 4. Experimental viscosity deviation ($\Delta\eta$) for 2-butanol (1) + toluene (2) mixtures at 303.15 K

Conclusion

Viscosity measurements on binary liquid mixtures can be suitably applied for the study of molecular interaction between polar 2-butanol and non-polar benzene, toluene, xylene, hexane and carbon tetrachloride solvent. A negative value of viscosity deviation ($\Delta\eta$) increases as he mole fraction of 2-butanol increases.

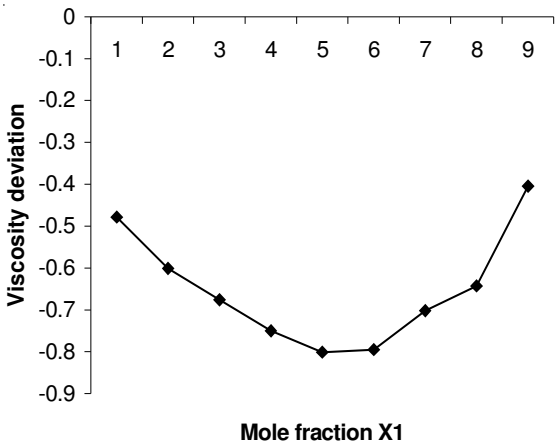

Fig. 5. Experimental viscosity deviation ($\Delta\eta$) for 2-butanol (1) + xylene (2) mixtures at 303.15 K

ACKNOWLEDGEMENT

The authors are thankful to the U.G.C. New Delhi for the financial assistance.

REFERENCES

1. E. Perez, M. Cardoso, A.M. Mainar, J.I. Parde and J.S. Urieta, *J. Chem. Eng. Data*, **48**, 1306 (2003).
2. J.N. Nayak, T.M. Aminabhavi and M.I. Aralaguppi, *J. Chem. Eng. Data*, **48**, 1152 (2003).
3. A. Vogel, Practical Organic Chemistry, Longman, London, edn. 4 (1978).
4. J.A. Riddick, W.B. Bunger and T.K. Sakano, Techniques of Chemistry: Organic Solvent, Willey, New York, edn. 4 (1968).
5. R.J. Fort and W.R. Moore, *Trans. Faraday Soc*., **62**, 1112 (1966).
6. L. Pikkarainen, *J. Chem. Eng. Data*, **28**, 81 (1983).
7. D. Papaioannou, M. Bridakis and C. G. Panayiotou, *J. Chem. Eng. Data*, **38**, 370 (1993).
8. S. Glasston, K.J. Laidler and H. Eyring, The Theory of Rate Processes, McGraw-Hill New York (1941).
9. S. Viswanathan and M.A. Rao, *J. Chem. Eng. Data*, **45**, 764 (2000).
10. M.N. Roy, B. Sinha and V. Dakua, *J. Chem. Eng. Data*, **51**, 590 (2006).

(*Received*: 3 July 2009; *Accepted*: 8 February 2010) AJC-8406