Vol. 4 (2000) Nos.1-4. **Journal of International Academy of Physical Sciences** pp.79-81

Studies of Viscous Properties of Binary Liquid Mixtures

R. S. Singh
T. D. P. G. College, Jaunpur
V. K. Singh
Department of Chemistry, Rastriya P. G. College, Jamuhai, Jaunpur
Amit Pandey and Bishan Datt Bhatt
Department of Chemistry, University of Allahabad, Allahabad-211 002, India.

(Received July 15, 2000)

Abstract : Viscosities of eight binary liquid mixtures have been computed using various empirical and semi-empirical relations (Frenkel relation, Kendall-Munroe relation, Additive relation, Bingham relation and Hind-Ubbelhode relation). Theoretically computed values of viscosity have been compared with experimental findings. A relative merit of various relations used has also been studied.

1. Introduction

Viscosity of liquids and liquid mixtures play important role in understanding the liquid flow in the chemical industry. So calculation of viscosity of liquid mixtures from the knowledge of viscosity of pure liquids becomes important. Various relations like Frenkel[1], Kendall-Munroe[2], Additive[3-4], Bingham[5] and Hind-Ubbelhode[6] have been proposed to compute viscosity of liquid mixtures from the knowledge of viscosity of component liquids. These relations have been tested for validity by many workers[7-9].

In the present paper, an attempt has been made to present theoretical analysis and to study the validity of above mentioned relations for binary liquid mixtures in light of structure of molecules and interactions involved. Due to wide range of structural differences in component liquids, the study becomes more important. Diglyme is taken as one of the component for the current study, which has been used as monomer in engineering applications including polymerisation processes and under-water research. The alkanes (C_6-C_{16}) are taken for the study as they are used in hydrocarbon processing industries.

2. Theory

The number of relations proposed for predicting the viscosity of liquid mixtures for binary liquid mixtures have been discussed here.

(a) Bingham[5] proposed the following relation based upon ideal mixing of solutions :

$$\eta = \sum_{i=1}^{n} x_i \eta_i \tag{1}$$

where x_i and η_i are mole fraction and viscosity of pure components.

(b) Logarithmic relation proposed by Kendall and Munroe[2] is as given below :

$$\ln \eta = \sum_{i=1}^{n} x_i \ln \eta_i . \tag{2}$$

(c) Based upon Arrhenius model[3] and Eyring's model[4], the additive viscosity relation is given as :

$$\ln \eta V = \sum_{i=1}^{n} x_i \ln \eta_i V_i \tag{3}$$

where V is molar volume.

(d) Frenkel[1], with the help of Eyring's equation, proposed the logarithmic relation which can be used for binary liquid mixtures as :

$$\ln \eta = x_1^2 \ln \eta_1 + x_2^2 \ln \eta_2 + 2 x_1 x_2 \ln \eta_{12} \tag{4}$$

where η_{12} is the viscosity at equimolar concentration.

(c) Hind et al[6]. proposed the additive relation which can be used for binary liquid mixture as :

$$\eta = x_1^2 \eta_1 + x_2^2 \eta_2 + 2 x_1 x_2 \eta_{12} \tag{5}$$

where η_{12} is an interaction parameter.

3. Results and Discussion

The viscosities of binary liquid mixtures have been computed using the various relations. The necessary experimental data for calculation have been taken from the work of Aminabhavi et al[10-12]. The average percentage deviations as obtained from various relations have been shown in Table 1. These results indicate that nearly all the relations used here give the good results in case of binary liquid mixtures comprising diglyme and esters. Frenkel and Hind-Ubbelhode methods give quite satisfactory results in the liquid mixtures containing diglyme with higher alkanes and esters, but show larger deviations in case of lower alkanes. These results may be improved by the use of different concept for the computation of interaction term. Bingham method shows larger deviations in most of the cases under investigation. This shows the need of interaction parameters (A_{ij}) in the simple additivity relations, which is necessary parameter in the real solutions.

Table 1

Average percentage deviation in the viscosity from various relations

S.N.	System	Fren	K & M	Add.	Bing	Hind
1	Diglyme + Hexane	11.09	3.87	6.16	18.41	18.41
2	Diglyme + Heptane	11.74	7.45	7.12	16.42	16.41
3	Diglyme + Octane	11.71	8.46	6.86	13.06	13.06
4	Diglyme + 2, 2, 4-trimethylpentane	10.55	7.90	5.86	13.32	13.31
5	Diglyme + Nonane	11.03	10.15	8.39	11.91	11.90
6	Diglyme + Decane	10.43	10.27	9.22	10.58	10.58
7	Diglyme + Dodecane	8.34	7.91	10.30	8.72	8.72
8	Diglyme + Tetradecane	6.45	4.01	12.29	8.91	9.11
9	Diglyme + Hexadecane	5.68	0.13	15.37	11.89	11.89
10	Diglyme + Ethyl acetate	– 1.97	– 4.75	0.61	1.17	1.16
11	Diglyme + Methyl benzoate	– 0.39	– 2.10	– 3.48	1.40	1.39
12	Diglyme + Ethyl benzoate	0.81	– 1.22	– 1.08	3.11	3.11
13	Diglyme + Diethyl succinate	4.21	0.29	3.17	8.46	8.46

References

1. J. Frenkel, *Kinetic theory of liquids*, Oxford University Press, London, 1946.
2. J. Kendall and K. P. Munroe, *J. Amer. Chem. Soc.*, **39** (1917) 1787.
3. S. Arrhenius and M. Vatenskapsakad, *Nobelin St.*, **2** (1913) 25.
4. S. Glastone, K. J. Laidler and H. Eyring, *Theory of rate processes*, McGraw-Hill, New York, 1941.
5. E. C. Bingham, *Fluidity and Plasticity*, McGraw-Hill, New York, 1922.
6. R. K. Hind, E. McLaughlin and A. R. Ubbelhode, *Trans. Farad. Soc.*, **56** (1960) 328.
7. J. D. Pandey and B. R. Chaturvedi, *Chemica Scripta*, **18** (1981) 227.
8. R. P. Rastogi, J. Nath and J. Mishra, *J. Phys. Chem.*, **71** (1964) 2524.
9. J. D. Pandey, A. K. Shukla, Shikha and N. Tripathi, *J. Ind. Chem. Soc.*, **73** (1996) 269-273.
10. T. M. Aminabhavi, I. A. Mritunjaya, B. Gopalkrishna and R. S. Khinnavar, *J. Chem. Eng. Data*, **39** (1994) 522-528.
11. T. M. Aminabhavi and B. Gopalkrishna, *J. Chem. Eng. Data*, **39** (1994) 529-534.
12. T. M. Aminabhavi, H. T. S. Phayde, R. S. Khinnavar and B. Gopalkrishna, *J. Chem. Eng. Data*, **39** (1994) 251-260.