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NOTE

A New Approach for Refractive Index of Binary Liquid Mixture

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In the present work a comparative study of five mixing rules of refractive index has been carried out to test their validity for nine binary liquid mixtures at 313.5 K. All the mixing rule perform well within the limit of experimental error but the performance of Lorentz-Lorenz (L-L) and Gladstone-Dale(G-D) relation is comparatively better than those of others. A new approach has also given satisfactory results which can be successfully use to predict the refractive index of the binary liquid mixture which requires only refractive index of its pure component.

Key Words: Refractive index, Binary mixture, Refraction.

Various theoretical rules used for predicting refractivity of binary liquids are due to Lorentz-Lorenz (L-L)[1,2], Gladstone-Dale (G-D)[3], Wiener (W)[4], Hellers[5], Argo-Boit (A-B)[6]. Argo-Biot and Hellers relations are found to follows either Lorentz-Lorenz (L-L) or Wiener equation for dilute solutions, especially when the refractive indices of both the liquids are nearly the same. Most of the mixing rule do not account for the change in the volume and refractivity on mixing. The problem was attacked recently by Aminabhavi[7,8], who pointed out the usefulness of mixing rules in treating the binary refractive index and density data.

As obtained by various workers[9-11], a similar attempt is made here for nine binary liquids mixture of cyclopentane + benzene, cyclopentane + toluene, cyclopentane + ethyl benzene, cyclohexane + benzene, cyclohexane + toluene, cyclohexane + ethyl benzene, methyl cyclohexane + benzene, methyl cyclohexane + toluene and methyl cyclohexane + ethyl benzene at 313.5 K. The experimental values of density and refractive index of the pure component required for the evaluation of refractive index of the binary mixture were obtained from the available literatures[12-14].

In the present papaer, a new approach has been carried out to predict the theoretical values of the refractive index of these mixtures. A comparative assessment has been deduced on the basis of average percentage deviations.

Following mixing rules are used to calculate the refractive index of binary mixtures.

$$\left(\frac{\eta_{12}^2-1}{\eta_{12}^2+2}\right)_{\rho_{12}}^{1}=\left(\frac{\eta_1^2-1}{\eta^2+2}\right)_{\rho_1}^{W_1}+\left(\frac{\eta_2^2-1}{\eta_2^2+2}\right)_{\rho_2}^{W_2} \quad (1)$$

Gladstone-Date (G-D) relation:

$$\left(\frac{\eta_{12}-1}{\rho_{12}}\right)=\left(\frac{\eta_1-1}{\rho_1}\right)W_1+\left(\frac{\eta_2-1}{\rho_2}\right)W_2 \quad (2)$$

Wieners (W) relation:

$$\left(\frac{\eta_{12}^2-\eta_1^2}{\eta_{12}^2+2\eta_1^2}\right)=\phi_2\left(\frac{\eta_2^2-\eta_1^2}{\eta_2^2+2\eta_1^2}\right) \quad (3)$$

Hellers (H) relation:

$$\left(\frac{\eta_{12}-\eta_1}{\eta_1}\right)=\frac{3}{2}\phi_2\left(\frac{m_1^2-1}{m_1^2+2}\right) \quad (4)$$

Argo-Biot (A-B) relation:

$$\eta_{12}=\eta_1\phi_1+\eta_2\phi_2 \quad (5)$$

New approach (N.A):

$$\eta_{12}=X_1^2\eta_1+X_2^2\eta_2+2\eta_1\eta_2\eta_{12} \quad (6)$$

The notations used in the eqns. 1 to 5 have their usual meanings.

TABLE-1
AVERAGE PERCENTAGE DEVIATION (APD) FOR VARIOUS REFRACTIVITY MIXING RULES AT 313.5 K

System		10^3 (Average percentage deviation)					
		(L-L) eqn. 1	(G-D) eqn. 2	(W) eqn. 3	(H) eqn. 4	(A-B) eqn. 5	(N-A) eqn. 6
1.	Cyclopentane + Benzene	49.10	11.70	-36.60	-750.50	-47.20	-98.80
2.	Cyclopentane + Toluene	64.20	35.40	33.50	-32.60	0.30	119.50
3.	Cyclopentane + Ethyl benzene	34.87	7.50	41.30	43.80	4.70	216.20
4.	Cyclohexane + Benzene	9.70	-25.20	-127.80	-113.80	-134.40	-269.80
5.	Cyclohexane + Toluene	887.20	118.40	-163.00	-147.10	-82.90	-95.40
6.	Cyclohexane + Ethyl benzene	19.80	-8.40	-75.90	-60.60	-82.10	1.70
7.	Methyl cyclohexane + Benzene	0.70	-31.10	-86.30	-71.40	-118.00	-366.90
8.	Methyl cyclohexane + Toluene	15.90	-9.70	-33.70	-18.70	-64.30	-187.00
9.	Methyl cyclohexane + Ethyl benzene	19.70	-16.30	48.10	0.70	-52.60	-78.50

In eqn 6, which is new approach, η_1 and η_2 are the refractive index of the pure components of the binary mixture. η_{12} is the equimolecular refrctive index obtain by relation:

$$\eta_{12} = 0.5\eta_1 + 0.5\eta_2$$

The necessary data required for the evaluation of refractive index of the mixture has been collected from the literatures[12-14].

Percentage deviation of the refractive index values can be obtained by the relation:

$$\Delta\,\% = \left(\frac{\eta_{mix_{exp}} - \eta_{mix_{calc}}}{\eta_{mix_{exp}}} \right) \times 100 \qquad (7)$$

where $\eta_{mix_{exp}}$ is the experimental value of refractive index of the mixture and $\eta_{mix_{calc}}$ is the value of refractive index of the binary liquid mixture calculated from various eqns. 1-6.

The refractive index of the binary mixture obtained from various mixture rules were evaluated and compared with the exeprimental values to obtain the average percentage deviation which are recorded in the Table-1.

A look at the average percentage deviation (APD) for various relations are given in the Table-1, shows that all the relation give good agreement with the exerpimental values especially Lorentz-Lorenz (L-L) relations and Gladstone-Dale (G-D) relations, the exception is in the case of system-5. Since the Lorentz-Lorenz (L-L) relation based on a sounder theoretical basis, its performance is found to be better as also found by other workers[9-11].

For the system 3 and 6 Gladstone-Dale (G-D) relations appear to give quite satisfactory results. Weiener's (W) relation has been found to predict satisfactory agreement generally. The system 8, 9 exhibit best performance for Hellers (H) relation. Argo-Biot (A-B) relation, as evident from the table, gives very small deviations for the system 2 and 3. The relation 6 used as a new approach (N-A) well given satisfactory results within the experimental limits and found extremely good against the observed values for the system 6.

Standard average percentage deviation from minimum to maximum ranges from 3×10^{-3} to 0.887. The deviation between the theoretical and observed values of refractive indices for all the system under present investigation may be reduced if the concepts of excess volume (V^E) is taken in to consideration in various mixing rules, as suggested by Aminabhavi *et al.*[7,8].

Conclusion

The various mixing rules for the refractive index give satisfactory results near to the experimental values for the binary mixture. The new approach used in the present paper can also be successfully utilized to find out the refractive index of the binary mixture at wide range of temperature and composition, which requires only the refractive indexes of pure component without bothering of evaluating other parameters. The present study may be of great theoretical and physico-chemical significance in the field of solution chemistry, molecular biology, physical science, bioscience, *etc*.

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