The Asian Journal of Experimental Chemistry, Vol. 3 No. 1&2 : 55-57 (June & Dec. 2008)

Viscosity of multicomponent liquid systems predictions from ternary data and statistical method

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Accepted : *October, 2008*

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ABSTRACT

Theoretical prediction of viscosity of three ternary systems namely n- pentane + n- hexane + benzene, n- hexane + cyclohexane + benzene, and n- cyclohexane + n- heptane + toluene have been made on the basis of empirical, semi empirical and statistical mechanical theories using the properties of pure components. Theoretical results are compared with the experimental measured value at 298.15 K. Results are in good agreement.

Key words : Viscosity, Hexane, Ternary liquid, Mole fraction, Flory's.

Viscosity is one of the important tools to describe the various characteristics of fluids and fluid mixtures. It appears from the literature that theoretical evaluation of viscosity in ternary liquid mixtures has been a subject of active interest in the last few decades and several empirical several and semi imperial relations (Powell and Eyring, 1941; Glaston *et al.*, 1941; Partingtone, 1951 and Reid and Sherwood, 1966) have been proposed and used to represent the composition dependence of viscosity in ternary liquid mixtures. In the present paper viscosity has been computed using (Bingham, 1922; Arrhenius, 1931) model and Eyring (Glaston *et al.*, 1941) model, Frenkel, 1946 and Hind *et al.*, 1960 suggesting equations by means of which the viscosity of ternary liquid mixtures can be evaluated. A different approach has been used in the theoretical calculation of viscosity by Frenkel, 1946 and Hind, 1960 relations.

Theoretical:

A number of mathematical equations have been employed for the prediction of properties of multicomponent systems for those of the contributing ternary systems.

Bingham (1992) considering ideal mixing of solutions, proposed the following equation for a binary liquid mixtures.

$$\eta = x_1\eta_1 + x_2\eta_2 \quad \text{.........................(1)}$$

Which for any n component mixture can be expressed as

$$\eta_i = \sum_{i=1}^{n} x_i\eta_i \quad \text{.........................(2)}$$

where x_i and η_i are, respectively the mole fraction and viscosity of pure component.

According to Kendall and Munroe (1787) the viscosity of multicomponent systems can be evaluated by the relation

$$\text{In}\,\eta = \sum_{i=1}^{n} x_i\,\text{In}\,\eta_i \quad \text{.........................(3)}$$

Frenkel, 1945 with the help of Eyring model developed the following logarithmic relation for non-ideal binary liquid mixtures. Which can be written for the ternary solution as :

$$\text{In}\,\eta = (x_1)^2\text{In}\,\eta_1 + (x_2)^2\text{In}\,\eta_2 + (x_3)^2\,\text{In}\,\eta_3 + 2(x_1x_2\,\text{In}\,\eta_{12} + x_2x_3\,\text{In}\,\eta_{23} + x_1x_3\,\text{In}\,\eta_{13}) + 3(x_1x_2x_3\text{In}\,\eta_{123}) \quad \text{.......................(4)}$$

For ternary liquid mixtures the relation suggested by Hind and Ubbelhode (Hind *et al.*, 1960) may be used as.

$$\eta = (x_1)^2\,\eta_1 + (x_2)^2\eta_2 + (x_3)^2\,\eta_3 + 2(x_1x_2\eta_{12} + x_2x_3\eta_{23} + x_1x_3\,\eta_{13}) + 3(x_1x_2x_3\eta_{123} \quad \text{.....(5)}$$

In the present investigation, a different approach has been adopted to obtain the constant h_{12}, h_{23}, h_{13} and h_{123}. These quantities are obtained from the respective pure components of the mixtures taking then equimolecular composition and following additivity rule, thus

$$\eta_{ij} = 0.5\,\eta_i + 0.5\eta_j \quad \text{.........................(6)}$$

Similarly $\eta_{1,2,3}$ is obtained from pure components as.

$$\eta_{1,2,3} = 1/3\ \eta_1 + 1/3\ \eta_2 + 1/3_3\ \eta_3 \quad \text{.................(7)}$$