Vapor-liquid Equilibrium for the Benzene-acetone System

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There are many conflicting data in the literature on the vapor-liquid–equilibrium phase relationships for the system benzene-acetone. Figure 1 illustrates the disagreement among the different investigators who have studied the problem. Composition and temperature data have been obtained by Soday and Bennett (*4*), Reinders and De Minjer (*3*), Othmer (*2*), Tallmadge and Canjar (*5*), and most recently by Canjar, Horni, and Rothfus (*1*). The last two investigations were carried out in this laboratory.

Activity coefficients were calculated by use of the expression

$$\gamma_i = \frac{y_i}{x_i}\frac{P}{P_i^0} \qquad (1)$$

and the data cited above. The logarithm of the ratio of activity coefficient of acetone to activity coefficient of benzene is plotted vs. mole fraction of acetone in Figure 1.

It will be noted that there is wide disagreement not only among all the investigators but also in the two works carried out in this laboratory. The first work, by Canjar and Tallmadge (*5*), was carried on for the primary purpose of obtaining integral isobaric heats of vaporization. The vapor-liquid-equilibrium data were obtained as a by-product of the experimental measurements. The second work, by Canjar, Horni, and Rothfus (*1*), was specifically designed for the determination of precise vapor-liquid–equilibrium data to be used in the study of a ternary system. In spite of this the former came closer to satisfying the thermodynamic consistency test

$$\int_0^1 \log\frac{\gamma_1}{\gamma_2}\,dx_1 = 0 \qquad (2)$$

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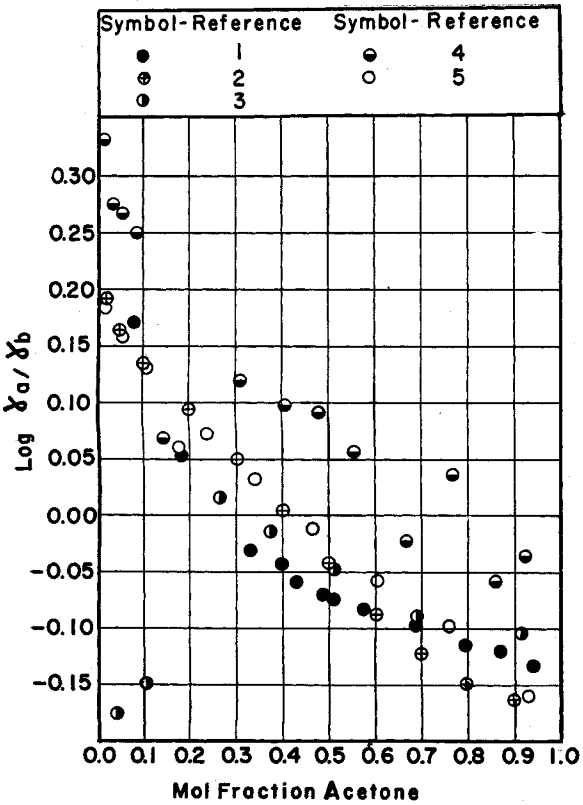

Fig. 1.

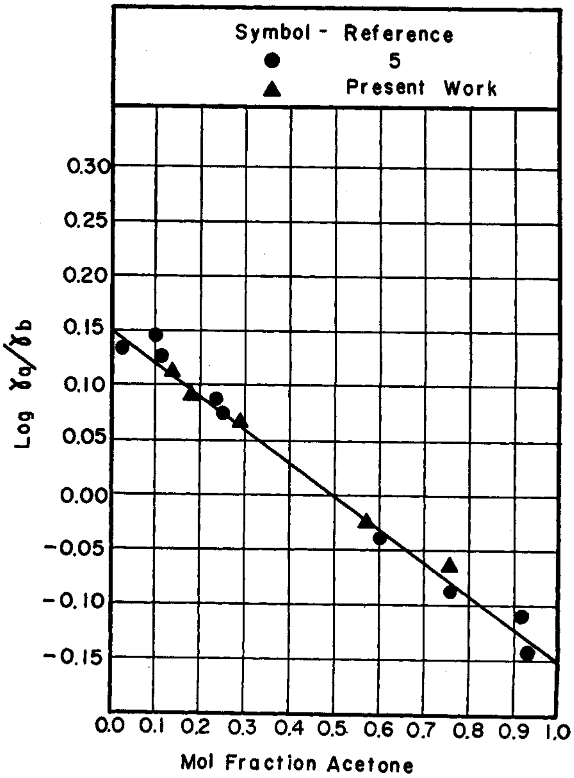

Fig. 2.

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than the latter. To resolve this discrepancy the system acetone and benzene was studied again by means of the apparatus described in (*1*). Preparation and purity of chemicals were also the same as described in (*1*). The results of this remeasurement are given in Figure 2, where they are compared with the original data of Canjar and Tallmadge, with which they are essentially in agreement. The Canjar-Tallmadge data given in Figure 1 represent smoothed temperature-composition data. The plot was taken from reference *1*.

The explanation of the disagreement between this work and the previous work obtained in the same laboratory by Canjar, Horni, and Rothfus (*1*) will help future investigators using the Othmer still. Our early experience with the Othmer stills indicated that high boiling or heat-input rates gave erratic and scattered results. Lower boiling rates on the other hand gave extremely precise and reproducible results. Therefore low boiling rates were used in the earlier investigation (*1*). In the present work it was found that the temperature in the Othmer still increased asymptotically with the rate of vapor boil-up. A boil-up rate of 120 ml./hr. yielded essentially a maximum temperature reading with no evidence of entrainment. The data given in Figure 2 were obtained with this rate. Unfortunately other investigators did not report their boil-up rates, and comparison is impossible.

The final data for the system acetone-benzene can be given by the relationship (strictly valid only for a system pressure of 1 atm.)

$$\log_{10} \gamma_i = 0.15(1 - x_i)^2 \qquad (3)$$

where γ_i, activity coefficient, is given by relationship (1) and vapor pressures of the pure components are given by the following:

Acetone

$$\log_{10} P_{atm.} = 4.14366 - \frac{1{,}161.0}{224.0 + t°\text{C.}} \qquad (4)$$

Benzene

$$\log_{10} P°_{atm.} = 4.02484 - \frac{1{,}211.033}{220.790 + t°\text{C.}} \qquad (5)$$

LITERATURE CITED

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