Observations in Ternary Liquid Phase Equilibria of n-Propanol-Benzene-Ethylene Glycol System

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Ternary miscibility of n-Propanol-Benzene-Ethylene Glycol at a constant temperature of 25°C. has been investigated and determined. The miscibility diagram was found to give the first type of miscibility curve, that is *n*-Propanol was completely miscible in all proportions with Benzene and Ethylene Glycol, while Benzene and Ethylene Glycol were found to be partially miscible. The plait point was determined by drawing tie lines and using the Sherwood method (*3*) as well as by logarithmic method of Hand (*1*). Both correlate well.

EXPERIMENTAL DETAILS

Materials and Equipment

1. Benzene: a reagent grade with boiling temperature range of 79.8 to 80.4°C. (at 760 mm. mercury) and residue after evaporation 0.001% claimed by the manufacturer were confirmed to American Chemical Society specifications.
2. Ethylene Glycol: boiling range was 196.3 to 197.5°C. (at 760 mm. mercury) and water maximum 0.13%.
3. *n*-Propanol: boiling range of 96.8 to 97.9°C. was found adequate for the present use.

The purity of all above reagents was also tested by experimentally determined values of boiling temperature and refractive index which agreed with the literature (*2*).

A balance model "Selecta Rapid 200" and refractometer model "Abbe-56" were used.

An inner water jacket was employed to maintain a constant temperature. The refractive index precision attainable was ± 0.0001.

Experimental Procedure

Equilibrium Determination. Benzene and *n*-Propanol were weighed and mixed well in a standard tapered stopcock bottle. A constant temperature bath was maintained at 25.0°C. and the bottle inserted for twenty minutes. In another bottle ethylene glycol was also maintained at the same temperature. Ethylene glycol was added into the benzene-*n*-propanol solution until a cloud point was obtained. The final weighing was done to determine ternary composition. To make sure that too much glycol had not been added one drop of *n*-propanol should clear the cloudy solution. Finally the refractive index of this clear solution was measured.

Tie Line Determination. Knowing the binary phase diagram of the ternary system (from the above data) a few compositions in the heterogeneous phase were chosen and these known mixtures were prepared and put into the constant temperature bath of 25.0°C. until they split into two distinct clear layers. Refractive indices of both layers were measured in each composition and from the previous data it was determined where these compositions lie on the binodal curve of the predetermined ternary equilibrium diagram. The line joining the two layer composition points should also pass through the point where originally started. Several of these tie lines were determined this way.

EXPERIMENTAL RESULTS

Ternary Miscibility

A ternary system consisting of benzene-ethylene glycol-*n*-propanol was studied at a constant temperature of 25.0°C. Figure 1 shows the miscibility diagram.

Tie-Lines

Five tie lines were experimentally determined as shown in Figure 1.

Plait Point

The plait point *P* was estimated by Sherwood's method (*3*) as shown in Figure 1, curve II and also by Hand's method (*1*) as shown in Figure 2.

DISCUSSION OF RESULTS

The ternary system consisting of *n*-Propanol-Benzene Ethylene Glycol was found to give the first type of ternary liquid equilibrium diagram (*4*) as shown in Figure 1. At 25.0°C., (Figure 1) 96 wt. % of benzene completely mixes with 4 wt. % ethylene glycol and 94 wt. % of ethylene glycol completely mixes with 6 wt. % of benzene.

Five tie lines denoted by numbers 1, 2, 3, 4 and 5 in Figure 1 were experimentally determined and it was noticed that their end point compositions lie fairly well on the binodal curve.

To determine the plait point, two methods were employed. These two methods (*1, 3*) give the same plait point, the composition being in weight fractions as 79.7% Benzene, 7.2% Ethylene Glycol, and 13.1% *n*-Propanol. In Sherwood's method it is desired to have several tie lines close to the plait point because in this region the slope of the tie lines changes greatly; however, this drawback is not present in the method suggested by Hand. In Figure 2, plait point estimation has been done according to Hand. It should be mentioned at this stage that the refractive index in regions closer to point *D* or *E* in Figure 1 changed very little, but there were great changes in the compositions. Hence one has to be more careful in those regions.

The results of this investigation show that the plait point compositions estimated by the two different methods are identical, however, in many cases, it is possible to get a slight difference in plait point compositions.

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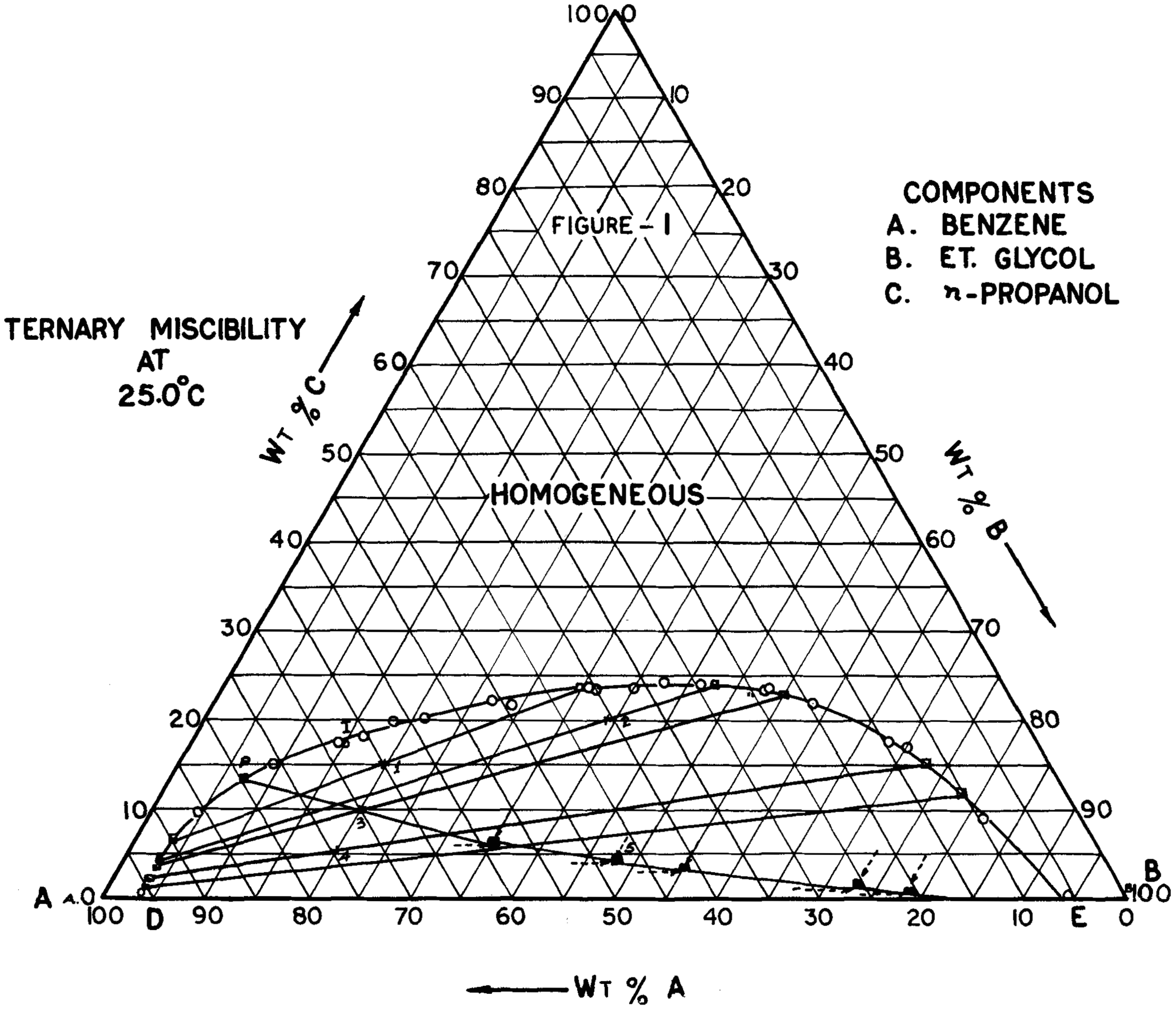

Fig. 1. Ternary liquid phase equilibrium and plait point estimation (3).

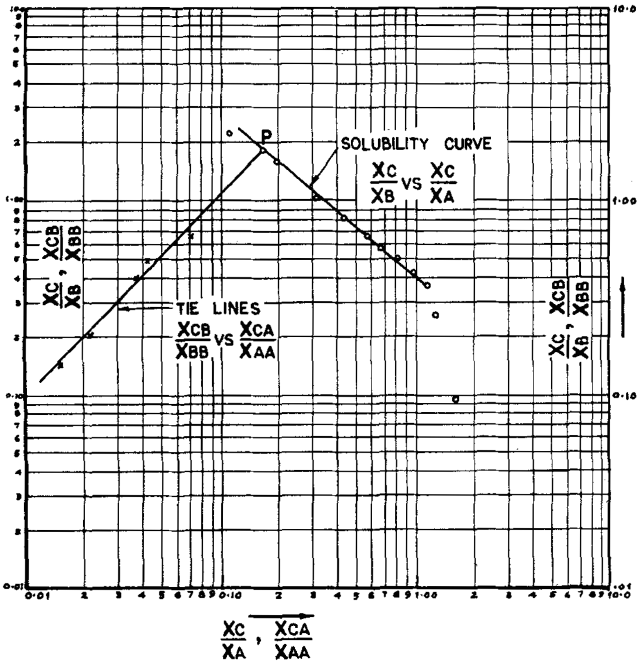

Fig. 2. Plait point estimation (1).

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NOTATION

X_A = wt. % of component A in liquid phase
X_B = wt. % of component B in liquid phase
X_C = wt. % of component C in liquid phase
X_{AA} = wt. % of A in A rich phase
X_{BB} = wt. % of B in B rich phase
X_{CA} = wt. % of C in A rich phase
X_{CB} = wt. % of C in B rich phase

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