Binary Liquid-Vapor Phase Diagram

Tetrachloroethane-cyclohexanone Binary System

Background:

Raoult’s Law: At a given temperature for an ideal solution of miscible solvents the vapor pressure, $p_i$, of a constituent $i$ above the solution is proportional to the vapor pressure of the pure solvent $p_0^i$ at the same temperature and is scaled by the mole fraction of the solvent, $x_i$, of $i$ in the solution.

$$p_i = x_i p_0^i$$

For a binary mixture one component is considered the solvent ($x_i$ larger) and the other is the solute.

Non-ideal solutions deviates from the Raoult’s Law.

Ideal solutions are dilute solutions, practically.

For a binary ideal single phase system $p$ (total v.p.) and $x_i$’s follows:

$$p = x_A p_A^* + x_B p_B^*$$

The composition of B in the liquid phase has to be less than the starting $x_B$.

For a binary solutions for mole fractions are not closer to unity of a component could be different than that predicted by Raoult’s Law. If actual $p_B >$ ideal $p_B$ (predicted), it is termed a positive deviation. The composition of B in vapor phase is greater than $x_B$. 

$$L = \text{liquid composition}$$

$$V = \text{vapor composition}$$
If the temperature is increased the pressure of both components would increase. At one point when the total pressure p equals the atmospheric pressure the solution boils. The boiling temperature in inversely related to vapor pressure.

For solutions which are far away from ideality the p vs x produces a solution which will be in equilibrium with a vapor of the same composition = azeotropic mixture.

Set up and procedure (in brief)

Obtain samples from the solution and the condensed vapor at different temperatures for various compositions of solution (see lab text). Measure the refractive index of each sample ASAP. Use the calibration plot to determine the composition of the samples.
Collect a series of samples from the boiling liquid and the vapor (condensed) in equilibrium with the liquid different boiling temperatures.

Measure the refractive index of the liquids.

1. Use calibration curve to find the wt% of C₆H₁₀O.
2. Convert to mole fraction of C₆H₁₀O (both liquids).
3. Calculate the mole fraction of C₂H₄Cl₂.
4. Plot T (boiling point) vs mole fraction for the two phases (liquid and vapor).
5. Determine azeotropic composition and its boiling point.

For the azeotropic mixture (azeotrope) the composition of the vapor is equal to the composition of the liquid left (definition of the azeotrope).

Plot T vs x₂.

Determine the composition and the boiling temperature of the azeotropic mixture.