Overview

• Brief thermodynamics review
• Binary flash with energy balance
• Multicomponent flash
Graphical:

\[ y_a = -\left[ \frac{(1-f)}{f} \right] x_a + \left[ \frac{1}{f} \right] Z_a \]

Equilibrium curve

**Solution!**

What if \( f \) is unknown, but \( T \) is known?

Limits:

\[ f = 0 \]
\[ f = 1 \]
Binary Flash Energy Balance

EB on CV:

\[ F \ h_f + Q_{\text{flash}} = V \ H_V + L \ h_L \]

\[ h_f = Z_a \ C^L_{Pa} \ (T_{\text{Feed}} - T_{\text{ref}}) + Z_b \ C^L_{Pb} \ (T_{\text{Feed}} - T_{\text{ref}}) \]

\[ h_L = x_a \ C^L_{Pa} \ (T - T_{\text{ref}}) + x_b \ C^L_{Pb} \ (T - T_{\text{ref}}) \]

\[ H_V = y_a \ [\lambda_a \ (T_{\text{ref}}) + C^V_{Pa} \ (T - T_{\text{ref}})] + y_b \ [\lambda_b \ (T_{\text{ref}}) + C^V_{Pb} \ (T - T_{\text{ref}})] \]
Figure 2-4. Enthalpy-composition diagram for ethanol-water at a pressure of 1 kg/cm² (Bosnjakovic, Technische Thermodynamik, T. Steinkopff, Leipzig, 1935)
Alternative Thermodynamics

Older (hand methods):
\[ y_a = K_a x_a \]
\[ y_b = K_b x_b \]

Relative Volatility (VLE):
\[ \alpha_{ab} \equiv \frac{K_a}{K_b} = \frac{y_a / x_a}{y_b / x_b} = \frac{P_a^*}{P_b^*} \]

Raoult’s law

Relative Volatility (VLE):
\[ y_a = \frac{\alpha_{ab} x_a}{1 + x_a (\alpha_{ab} - 1)} \]

Aside (couple with MB)
\[ \frac{(1-f)}{f}(\alpha_{ab} - 1)x_a^2 + \left[ \alpha_{ab} + \frac{(1-f)}{f} - (\alpha_{ab} - 1)\frac{Z_a}{f} \right]x_a - \frac{Z_a}{f} = 0 \]
Separation Factor or Relative Volatility

\[ \alpha = \frac{P^*_a}{P^*_b} \]

\[ \alpha_{ab} = \frac{X_P^*_a}{P^*_b} \]
DePriester Chart

a) Ethane
b) n-heptane

\[ P = 13.79 \text{ bar} \]
\[ T = 25 \degree \text{C} \]

\[ \alpha_{ab} = \frac{K_a}{K_b} = 2.4 \]
\[ K_a = 2.6 \text{ or } 2.4 \]
\[ K_b = 0.01 \]
Effect of Pressure:

Figure 10.6: Ethane/η-heptane: $y_x$ diagram. (Reproduced by permission. F. H. Barr-David, *AIChE J.*, vol. 2, p. 426–427, 1956.)

*Seader & Henley (2006)
Constant Relative Volatility?

\[ \alpha_{ab} \text{ Const} \]

\[ \alpha = 4.8 \]
Alternative Thermodynamics

$K_i$ with multicomponent flash: $y_i = K_i x_i$

Into MB:

$$x_i = \frac{Z_i}{K_i \left( \frac{V}{F} \right) + \left( \frac{L}{F} \right)}$$

$$\sum x_i = 1$$

$$1 = \sum \left[ \frac{Z_i}{K_i \left( \frac{V}{F} \right) + \left( \frac{L}{F} \right)} \right] = \sum \left[ \frac{Z_i}{K_i(f) + (1 - f)} \right]$$

Sequential solution: suggestions p 35-37 (Rachford-Rice Eqn)

Simultaneous solution technique: suggestions p 40-43
Sizing Flash Drums

\[ \frac{h_{\text{total}}}{D} \approx 3 \text{ to } 5 \]

\[ u_{\text{perm}} = K_{\text{drum}} \sqrt{\frac{\rho_L - \rho_V}{\rho_L}} \]

\[ V^{\text{V}} \left( \frac{\text{mol}}{\text{hr}} \right) = \frac{u_{\text{perm}} A_c \rho_V}{M_W^V} \]
Overview

- Flash Unit Operation
- Staged systems
- McCabe-Thiele
Simulators

Flash input: **MeOH – Water**: 1.013 bar; $Z_{\text{MeOH}}=0.6$; 
Find $f$ to give $X_{\text{MeOH}} < 0.2$

Sensitivity Analysis:

Design Spec:
Questions?