CHE407: Separation Processes
Tutorial-4

Prof. M. E. Abashar

QUESTION (1)

A recfiication column is fed 100 kgmol/h of a mixture of 50 mol% benzene and 50 mol% toluene at 101.325 kPa abs pressure. The feed is saturated vapor at the dew point temperature. The distillate is to contain 90 mol% benzene and the bottoms 10 mol% benzene. Find the following:

(a) Minimum reflux ratio R_m.

(b) Minimum number of theoretical plates at total reflux.

(c) Theoretical number of trays at an operating reflux ratio R=1.2 R_m.

(d) The Murphree tray efficiency (E_M) is estimated as 0.55:

(i) Draw the effective equilibrium curve.

(ii) Find the actual number of trays.

(iii) Find the overall column efficiency (E_O).

QUESTION (2)

(a) Derive from first principles:

(i) Fenske's equation for N_m:

$$N_m + 1 = \frac{\log\left[\left(\frac{x_d}{1-x_d}\right)\left(\frac{1-x_w}{x_w}\right)\right]}{\log(\alpha_{av})} \tag{1}$$

(ii) Underwood's equation for q=1:

$$R_m = \frac{1}{(\alpha_{av}-1)}\left[\frac{x_d}{x_f} - \frac{\alpha_{av}(1-x_d)}{(1-x_f)}\right] \tag{2}$$

(iii) Underwood's equation for q=0:

$$R_m = \frac{1}{(\alpha_{av}-1)}\left[\frac{\alpha_{av}x_d}{x_f} - \frac{(1-x_d)}{(1-x_f)}\right] - 1 \tag{3}$$

(b) A feed of benzene and toluene containing 40 mol% benzene is to be distilled at 1.0 atm pressure to give a distillate containing 90 mol% benzene and a bottoms containing 10 mol% benzene. Calculate:

(i) N_m.

(ii) R_m for saturated liquid feed.

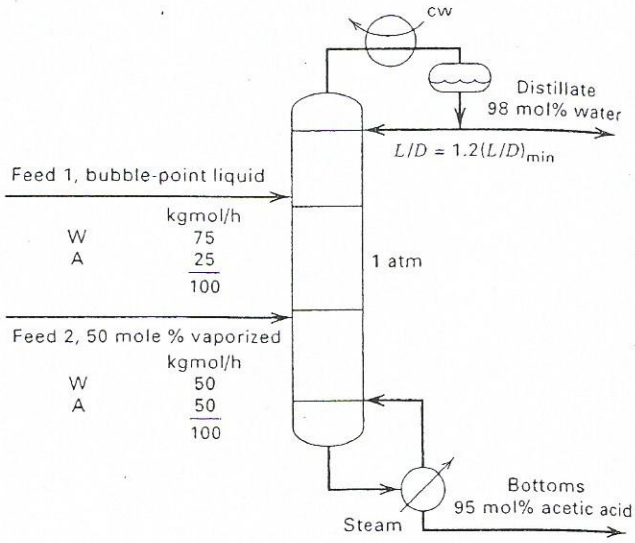
(iii) R_m for saturated vapor feed.

QUESTION (3)

Enriching Tower for Benzene–Toluene. An enriching tower is fed 100 kg mol/h of a saturated vapor feed containing 40 mol % benzene (*A*) and 60 mol % toluene (*B*) at 101.32 kPa abs. The distillate is to contain 90 mol % benzene. The reflux ratio is set at 4.0 : 1. Calculate the kg mol/h distillate *D* and bottoms *W* and their compositions. Also, calculate the number of theoretical plates required.

QUESTION (4)

It is desired to distill two feeds 1 and 2 of water (W) and acetic acid (A) mixture as shown in the Figure below. Calculate the theoretical stages required for the distillation separation at 1.0 atm.



WATER (W)/ACETIC ACID (A), 1 ATM

x_W	0.0055	0.053	0.125	0.206	0.297	0.510	0.649	0.803	0.9594
y_W	0.0112	0.133	0.240	0.338	0.437	0.630	0.751	0.866	0.9725