CE 407 Notes
Liquid extraction countercurrent examples

Problems

1. A 450 kg/h feed stream with composition 38 mass percent acetone (solute, C), 62 mass percent water (diluent, A) is to be contacted countercurrently with 300 kg/h of an MIK-rich solution of which the precise composition is 90 mass percent MIK (solvent, B), 9 mass percent acetone and the balance water. The exiting raffinate should contain acetone and water in the ratio 16/84 by mass. What will be the ratio mass acetone/mass MIK in the exiting extract? Note that you are NOT being asked to determine the number of stages required. The phase diagram for the system water(A) + MIK(B) + acetone(C) is supplied.

2. A 700 kg/h feed stream comprising 30 mass % trimethylamine ("TMA," solute, C) and 70 mass % benzene (diluent, A) is contacted countercurrently with water (solvent, B) in a countercurrent multistage liquid extraction battery. Exiting raffinate should contain 5 mass % TMA (C) and 95 mass % benzene (A) on a water(B)-free basis. Solvent water enters pure at a flow rate of 300 kg/h.

(a) What are the flow rates of the exiting raffinate and extract streams, i.e., what are the flow rates L_N and V_1?

(b) What is the TMA mass fraction $x_1 = (x_C)_1$ of the raffinate (L_1) stream leaving stage 1?

The phase diagram for the ternary system benzene(A) + water(B) + TMA(C) is supplied free of charge (even though it is actually a $1,699.95 value).

3. A 500 kg/h feed stream with composition 45 mass % acetone (solute, C) and 55 mass % water (diluent, A) is to be contacted with trichloroethane (solvent, B) in a countercurrent liquid extraction battery. Entering trichloroethane is pure. The exiting raffinate should contain 20.2 mass % acetone on a trichloroethane-free basis.

(a) What is the minimum flow rate of trichloroethane required to achieve the

desired composition of the exiting raffinate (corresponding to an infinite number of stages)?

(b) Suppose that solvent trichloroethane enters at a rate of 125 kg/h. What will be the composition and flow rate of the exiting extract (V_1) stream, and how many ideal stages will be required?

mass fractions in water(A)-rich layer		mass fractions in $C_2H_3Cl_3$(B)-rich layer	
$C_2H_3Cl_3$ (B)	acetone (C)	$C_2H_3Cl_3$ (B)	acetone (C)
0.005	0.060	0.909	0.088
0.007	0.171	0.738	0.251
0.010	0.269	0.592	0.385
0.012	0.308	0.539	0.430
0.016	0.357	0.475	0.482
0.021	0.409	0.400	0.540
0.038	0.460	0.337	0.574
0.065	0.518	0.263	0.603

4. Consider the feed solution from the previous problem (**3**). What flow rate of trichloroethane would be required to achieve the desired composition of the exiting raffinate if extraction were carried out in a mixer-settler equivalent to only a **single** ideal stage?

5. A 450 kg/h feed stream with composition 38 mass % acetone (solute, C) and 62 mass % water (diluent, A) is to be contacted countercurrently with an MIK(solvent B)-rich solution of which the precise composition is 90 mass % MIK, 9 mass % acetone and the balance water. The exiting raffinate should contain 16.5 mass % acetone (C) and 83.5 mass % water (A) on an MIK(B)-free basis.

(a) What is the minimum flow rate $(V_{N+1})_{\min}$ of the entering MIK-rich solvent stream required to achieve the desired separation (corresponding to an infinite number of stages)?

(b) Suppose twice the minimum flow rate of entering MIK-rich solvent is used $[V_{N+1} = 2\,(V_{N+1})_{\min}]$. What will the composition of the exiting extract be on a water(A)-free basis?

The phase diagram for the system water(A) + MIK(B) + acetone(C) is supplied.

6. A 10 kg/min feed stream with composition 40 mass % acetone (solute, C) and 60 mass % trichloroethane (diluent, A) is to be contacted with water (solvent, B) in a countercurrent liquid extraction battery. The exiting raffinate should contain 15 mass percent acetone (C) and 85 mass percent trichloroethane (A) on a water(B)-free basis. Water will enter pure at a rate of 15 kg/min.

(a) What will the amounts of exiting raffinate and extract be?

(b) How many ideal stages will be required?

Hint : You will want to draw your ternary diagram on the left side of your sheet of graph paper.

mass fractions in trichloroethane(A)-rich layer		mass fractions in water(B)-rich layer	
water (B)	acetone (C)	water (B)	acetone (C)
0.003	0.088	0.935	0.060
0.011	0.251	0.822	0.171
0.023	0.385	0.721	0.269
0.031	0.430	0.680	0.308
0.043	0.482	0.627	0.357
0.060	0.540	0.570	0.409
0.089	0.574	0.502	0.460
0.134	0.603	0.417	0.518