**Mass transfer II** **2024, Feb**

1. **Liquid-liquid extraction: Counter current operation [ Location of delta point]**

**EXAMPLE 8.4** (*Multistage countercurrent extraction*) It is planned to extract diphenyl hexane (DPH) from a solution in docosane (*A*) using 'pure' furfural (*B*) as the solvent. The feed enters the extractor cascade at a rate of 2000 kg/h with 45% DPH (*C*) that has to be reduced to 4% in the final raffinate. The solvent rate is 2500 kg/h. Determine the number of theoretical stages required. Extraction is to be carried out at 45°C. Several compositions on the extract and the raffinate arms and the tie-line data in mass% of the components at 45°C are given below.

*Equilibrium data*

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *A:* | 96.0 | 84.0 | 67.0 | 52.5 | 32.6 | 21.3 | 13.2 | 7.7 | 4.4 | 2.6 | 1.5 | 1.0 | 0.7 |
| *B:* | 4.0 | 5.0 | 7.0 | 10.0 | 20.0 | 30.0 | 40.0 | 50.0 | 60.0 | 70.0 | 80.0 | 90.0 | 99.3 |
| *C:* | 0 | 11.0 | 26.0 | 37.5 | 47.4 | 48.7 | 46.8 | 42.3 | 35.6 | 27.4 | 18.5 | 9.0 | 0.0 |

*Tie-line data*

| Raffinate (Docosane) phase, mass% | | | Extract (Furfural) phase, mass% | | |
|---|---|---|---|---|---|
| *A* | *B* | *C* | *A* | *B* | *C* |
| 85.2 | 4.8 | 10.0 | 1.1 | 89.1 | 9.8 |
| 69.0 | 6.5 | 24.5 | 2.2 | 73.6 | 24.2 |
| 43.9 | 13.3 | 42.6 | 6.8 | 52.3 | 40.9 |

**Step 1. Draw the ternary phase diagram in right angles triangle coordinate. And draw the three tie lines. [10]**

**Step 2. Mention the feed and the solvent point on the diagram. [5]**

**Step 3. Locate M and Rn, and calculate the slope of M and Rn. [7]**

**Step 4. Locate the d E1. [5]**

**Step 5. Join Rn and E. [3]**

**Step 6. Find the equation of RnS and FE1. [7]**

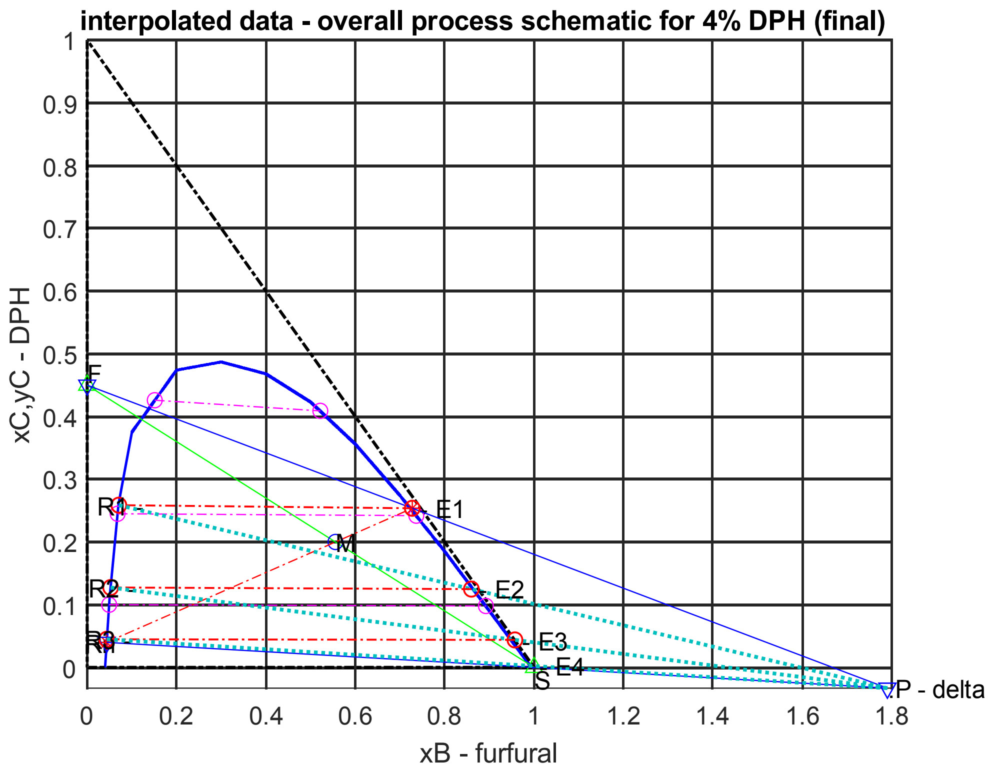
**Step 7. Locate the delta point , trough solving the eqn of st line for RnS and FE1. [6]**

**Step 8. Locate R1 through calculating the slope of the tie line, calculate the composition and flow rate of the first stage. [7]**

Home work: Write down the specific steps (point 1, point 2……) for constructing the stages in LLE for a multistage countercurrent operation and create a flowchart for along with the code in MATLAB. **10**

Step 1:

```
B = [0.04 0.05 0.07 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 0.993 1];
C = [0 0.11 0.26 0.375 0.474 0.487 0.468 0.423 0.356 0.274 0.185 0.09 0.001 0];
A = 1 - B - C;
tiexc = [0.1 0.245 0.426];
tiexb = [0.048 0.065 0.133];
tieyc = [0.098 0.242 0.409];
tieyb = [0.891 0.736 0.523];
lt = length(tiexc);
slope_tie = zeros(1,lt);
for i = 1:lt
slope_tie(i) = ….
end
```




**Interpolation of points for LLE curve, Use B and C [ solvent and solute level] to interpolate the points in between the given points.**

```
B1 = zeros(1,10001);
C1 = zeros(1,10001);

for i = 1:10001;
   B1(i) = …….
   C1(i) = interp1(…, ….., ……);
end
```

**Known variables including final raffinate condition:**

```
S =
F =
xbf =
xcf =
ybs =
ycs =
xcm =
```

**Finding the intersection of the LLE curve and RnM: [ Rn= final raffinate composition, M=mixture point]**
**Hint:calculate the slope of st line RnM**

```
slope =……..;
syms x y
[E1x, E1y] = vpasolve(LLE eqn 1, RnM eqn 2 ………………………………………… [0.3 1; 0.05 0.49]);
plot([Rendx E1x)],[Rendy E1y)],'r*-.','linewidth',0.5)
text(E1x, E1y,' E1')
```

**Finding the intersection of RnS and FE1**

```
slope1 = (E1y - 0.45)/(……….);
%[ line FE1]
slope2 = (Rendy - 0)/…………;
% [ line RnS]
syms x y
[delx, dely] = vpasolve( eqn 1……….., eqn 2…….., rang);
plot([Rendx delx],[Rendy dely],'bv-','linewidth',0.5)
```

**<u>Locating Ri from the slope of the tie line [just for stage 1]</u>**

```
syms x y
   [Rx(count), Ry(count)] = vpasolve([…eqn 1 , eqn 2……[x,y], [0 0.3; 0 0.49]);

   plot([Ex(count) Rx(count)],[Ey(count) Ry(count)],'o-
.','Color',[1,0,0],'linewidth',0.75)
```

**Locating tie lines through Ei points**

```
Ri = 1;
count = 1;
Ex(1) = E1x;
Ey(1) = E1y;


   if  ((0 < Ey(count)) && (Ey(count) <= 0.098));
       slope = 0 + (Ey(count) - 0)*slope_tie(1)/(0.098);

   elseif((0.098 < Ey(count)) && (Ey(count) <= 0.242));
       slope = slope_tie(1) + (Ey(count) - 0.098)*(slope_tie(2)-slope_tie(1))/(0.242 - 0.098);

…[complete the elsif statements according to given tie line]………………..
……………………..
……………………
   end
```