GDM 307 KÜTLE AKTARIMI VE TEMEL İŞLEMLER

EKSTRAKSİYON

- Ekstraksiyon, çözünürlük farkına dayanan bir ayrıştırma işlemi olarak tanımlanabilir.
- Amacı: uygun bir çözücü kullanarak hedef komponentin karışımdan ayrıştırılmasıdır.
- Ekstraksiyon işlemi iki ana grupta incelenir;
  - Sıvı sıvı ekstraksiyonu
  - Katı sıvı ekstraksiyonu (liçing)

Liçing hakkında genel bilgi:

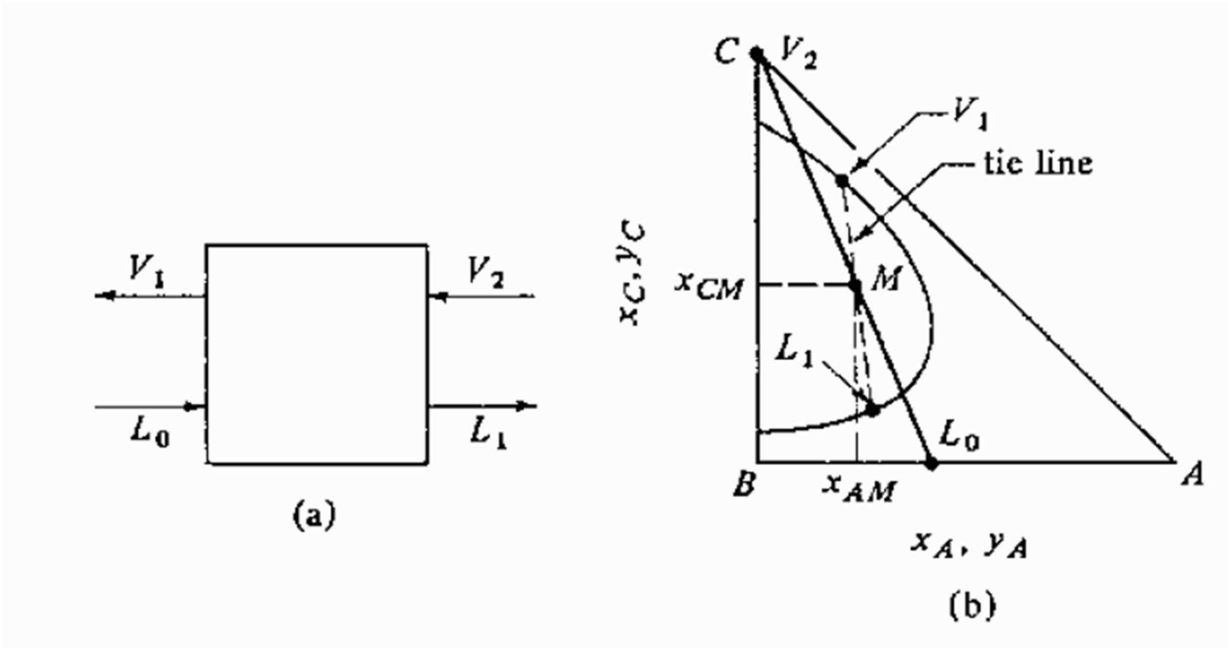
- Liçing hedef komponentin katı matriks içinden ayrıştırıldığı ekstraksiyon işlemidir. Ayrıştırılmak istenen komponentin içinde çözünebildiği bir sıvı solvent kullanılır.
- Hedef komponent katıdan çözücü içine doğru difüze olur.
- Daha sonra, katı ve sıvı fazlar birbirinden ayrıştırılır ve istenen madde sıvı fazdan alınır.

- Gıda endüstrisi için en sık rastlanan örnekler;
  - çözünebilir kahve üretimi sırasında kahve içindeki çözünür maddelerin ekstraksiyonu;
  - Yağlı tohumlardan organik çözücülerle yenilebilir yağ ekstraksiyonu;
  - Soya fasülyelerinden protein ekstraksiyonu.

- Tek kademeli ve çok kademeli işlemlere rastlamak mümkündür.

Sıvı sıvı ekstraksiyonu:

- Tek kademeli denge ekstraksiyonu
  - Tüm çıkış akımları birbirleriyle denge halindedir.



- Madde denklikleri:
- Toplam:

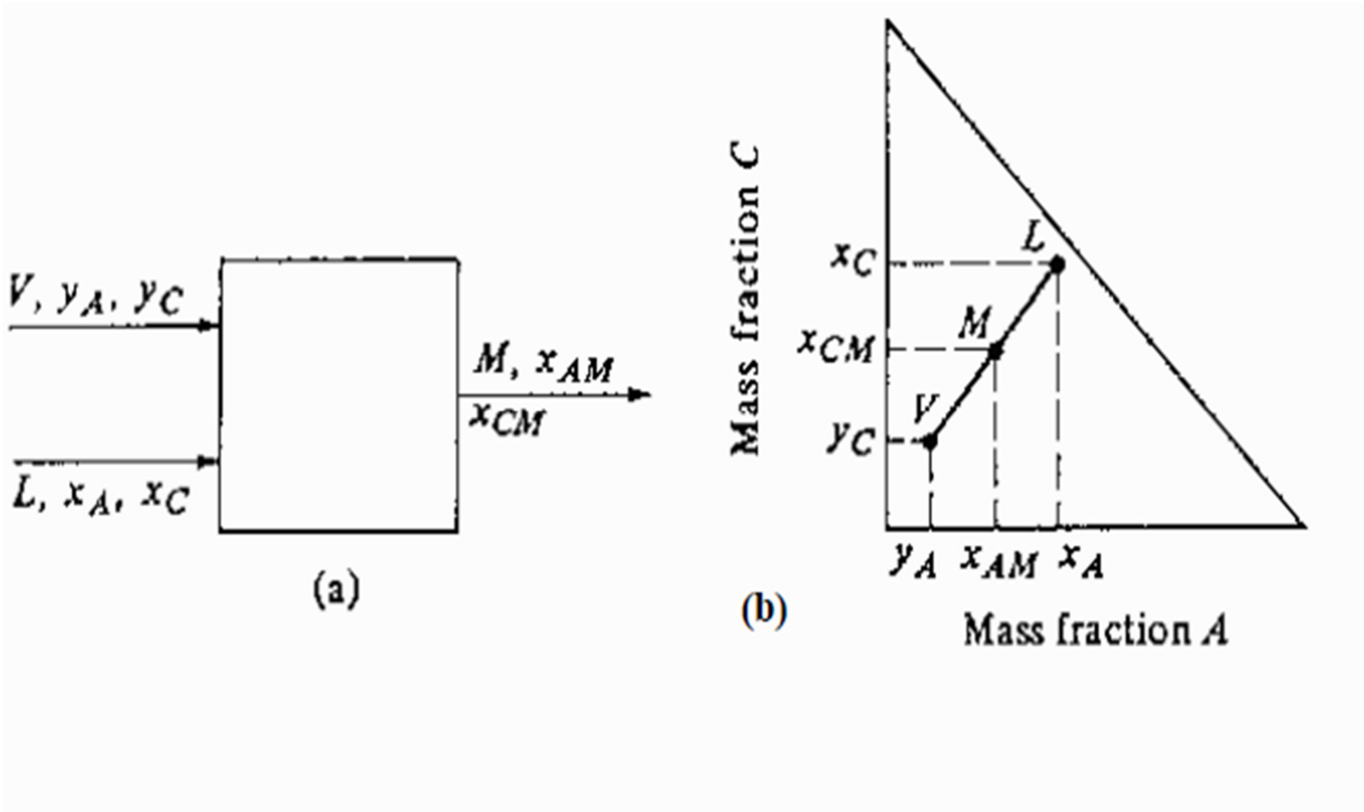
$$L_0 + V_2 = L_1 + V_1 = M$$

- A:

$$L_0 x_{A0} + V_2 y_{A2} = L_1 x_{A1} + V_1 y_{A1} = M x_{AM}$$

- C:

$$L_0 x_{C0} + V_2 y_{C2} = L_1 x_{C1} + V_1 y_{C1} = M x_{CM}$$



(a) Process flow (b) Graphical addition

- Kütle denklikleri;
- Toplam:

$$L + V = M$$

- (A):

$$Lx_A + Vy_A = Mx_{AM}$$

- (C):

$$Lx_C + Vy_C = Mx_{CM}$$

$$\frac{L}{V} = \frac{y_A - x_{AM}}{x_{AM} - x_A}$$

$$\frac{L}{V} = \frac{y_c - x_{cM}}{x_{cM} - x_c}$$

$$\frac{x_c - x_{cM}}{x_A - x_{AM}} = \frac{x_{cM} - y_c}{x_{AM} - y_A}$$

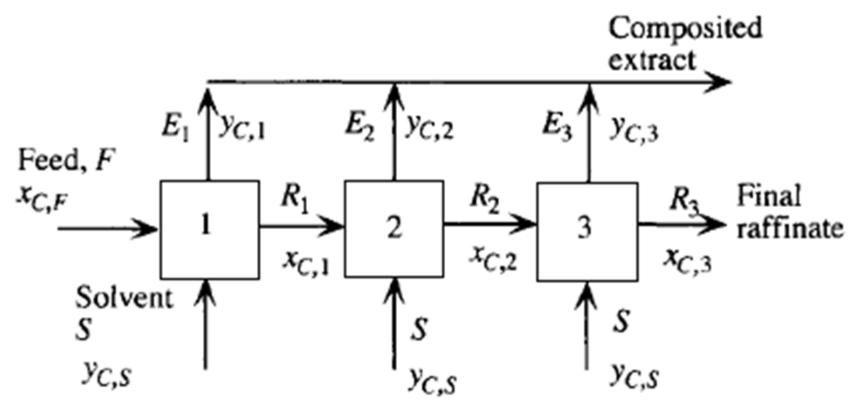
- Kaldıraç kuralı

$$\frac{L(kg)}{V(kg)} = \frac{VM}{LM}$$

$$\frac{L(kg)}{V(kg)} = \frac{VM}{LV}$$

Multistage Cocurrent Extraction

- Multistage cocurrent extraction can be decided as extension of a single-stage extraction.
- In this kind of extraction the raffinate is successively contacted with fresh solvent, and may be done continuously or in batches.

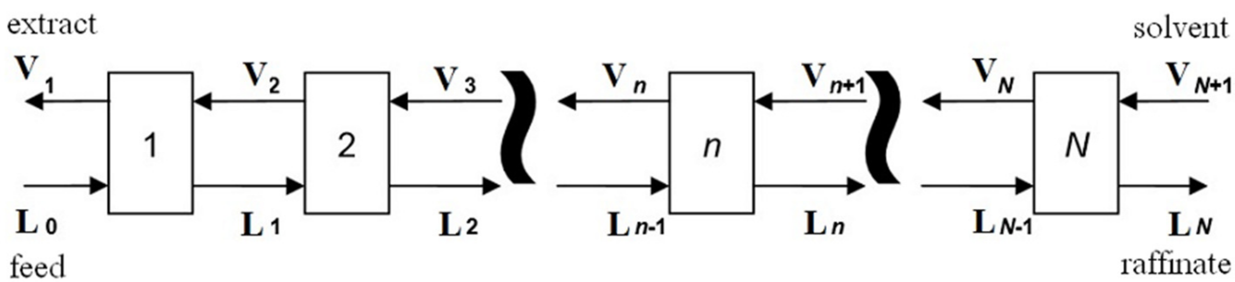


The schematic diagram for a three-stage crosscurrent extraction process

- A single final raffinate results, and the extracts can be combined to provide a composited extract, as shown.
- The stage number can be adjusted depending on the process.The calculations for single stage extraction can be performed for the first stage.
- Subsequent stages are dealt with in the same manner, except that the feed to any stage is the raffinate from the previous stage.
- Unequal amounts of solvent can be used in the various stages. For a given final raffinate concentration, the greater the number of stages the less total solvent will be used.

Multistage Countercurrent Extraction

- Multistage countercurrent extraction is often employed to use less solvent and to obtain a more concentrated exit extract stream.



Schematic representation of a multistage countercurrent extraction process

- The feed stream containing the solute A to be extracted and the solvent stream enters at opposite ends. The extract and raffinate streams flow countercurrently from stage to stage, and the final products are the extract stream V_1 leaving stage 1 and the raffinate stream L_N leaving stage N.

- The material balances on all N stages are;

$$L_0 + V_{N+1} = L_N + V_1 = M$$

$$L_0 x_{A0} + V_{N+1} y_{AN+1} = L_N x_{AN} + V_1 y_{A1} = M x_{AM}$$

$$L_0 x_{C0} + V_{N+1} y_{CN+1} = L_N x_{CN} + V_1 y_{C1} = M x_{CM}$$

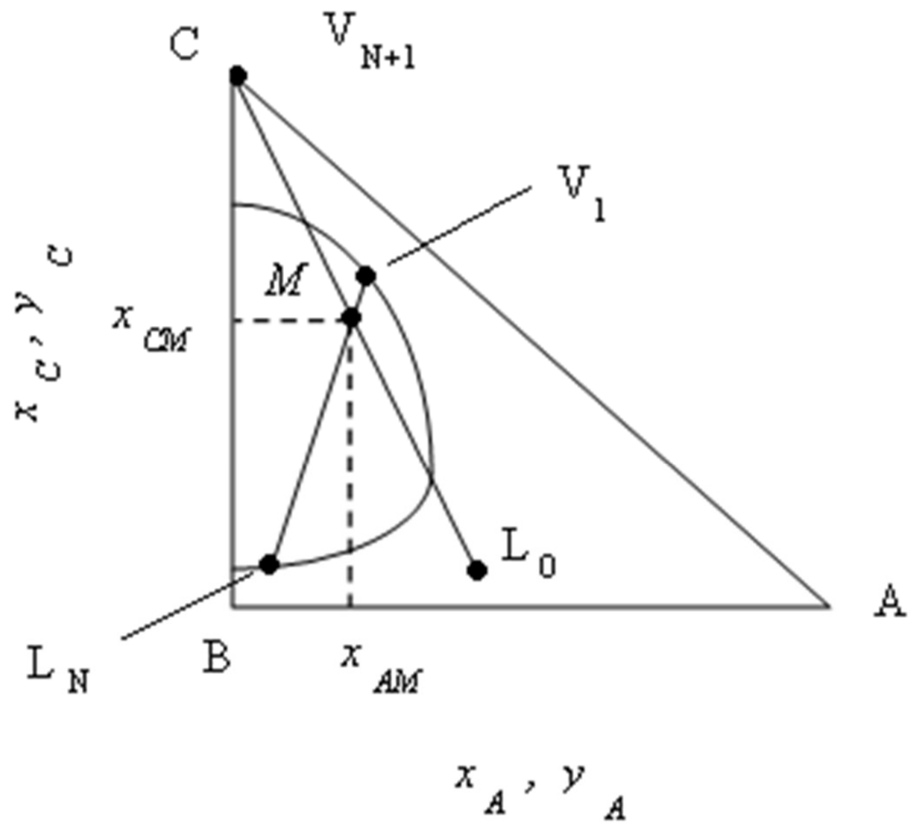
$$x_{AM} = \frac{L_0 x_{A0} + V_{N+1} y_{AN+1}}{L_0 + V_{N+1}} = \frac{L_N x_{AN} + V_1 y_{A1}}{L_N + V_1}$$

$$x_{CM} = \frac{L_0 x_{C0} + V_{N+1} y_{CN+1}}{L_0 + V_{N+1}} = \frac{L_N x_{CN} + V_1 y_{C1}}{L_N + V_1}$$

- The point M is the cross section point of two lines which are V_{N+1}–L_0 and V_1–L_N. In the processes, the flows and compositions of L_0 and V_{N+1} are the known properties.
- The desired exit composition x_{AN} is set. When the points L_0, V_{N+1} and M of which coordinates are known are plotted, these three points can be connected with a straight line.
- Bu using the following information the unknowns can be calculated:

– L_N, M and V_1 must lie on the same line;

– L_N and V_1 must lie on the phase envelope.

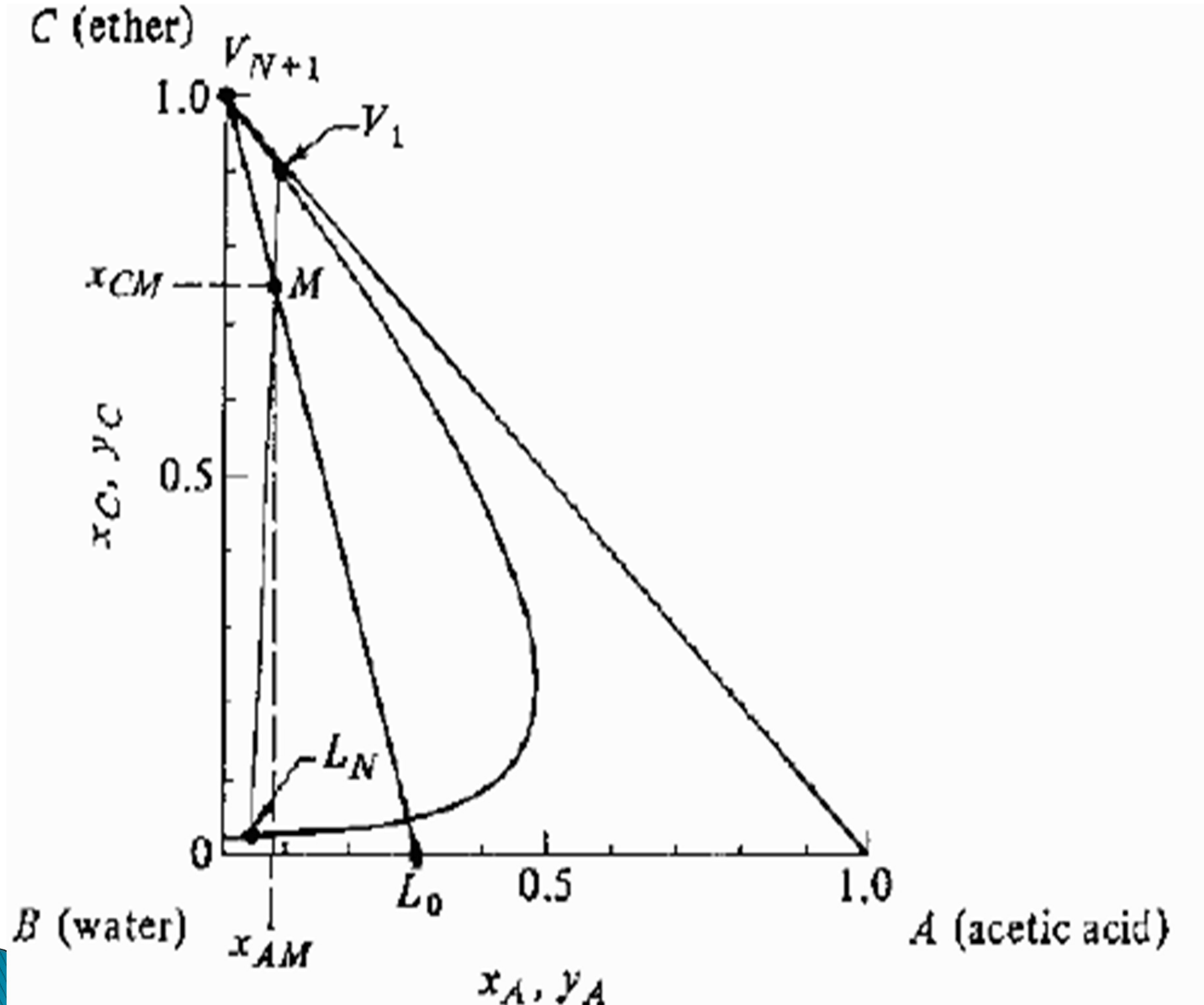

C
V N+1
V 1
M
x CM
x C , y C
L 0
A
L N
B
x AM
x A , y A

Example

Multistage countercurrent extraction is used to extract an aqueous solution of L_0 (400 kg/h) which contains 30 wt% acetic acid (A). The pure solvent used for the extraction is isopropyl ether at a rate of V_{N+1} (1200 kg/h). The exit acetic acid concentration in the aqueous phase should be 5%. Calculate the compositions and amounts of the ether extract V_1 and the aqueous raffinate L_N by using the equilibrium data given in following table.

Table The equilibrium data for Acetic acid (A)–Water (B)–Isopropyl ether solvent (C) at 20 °C

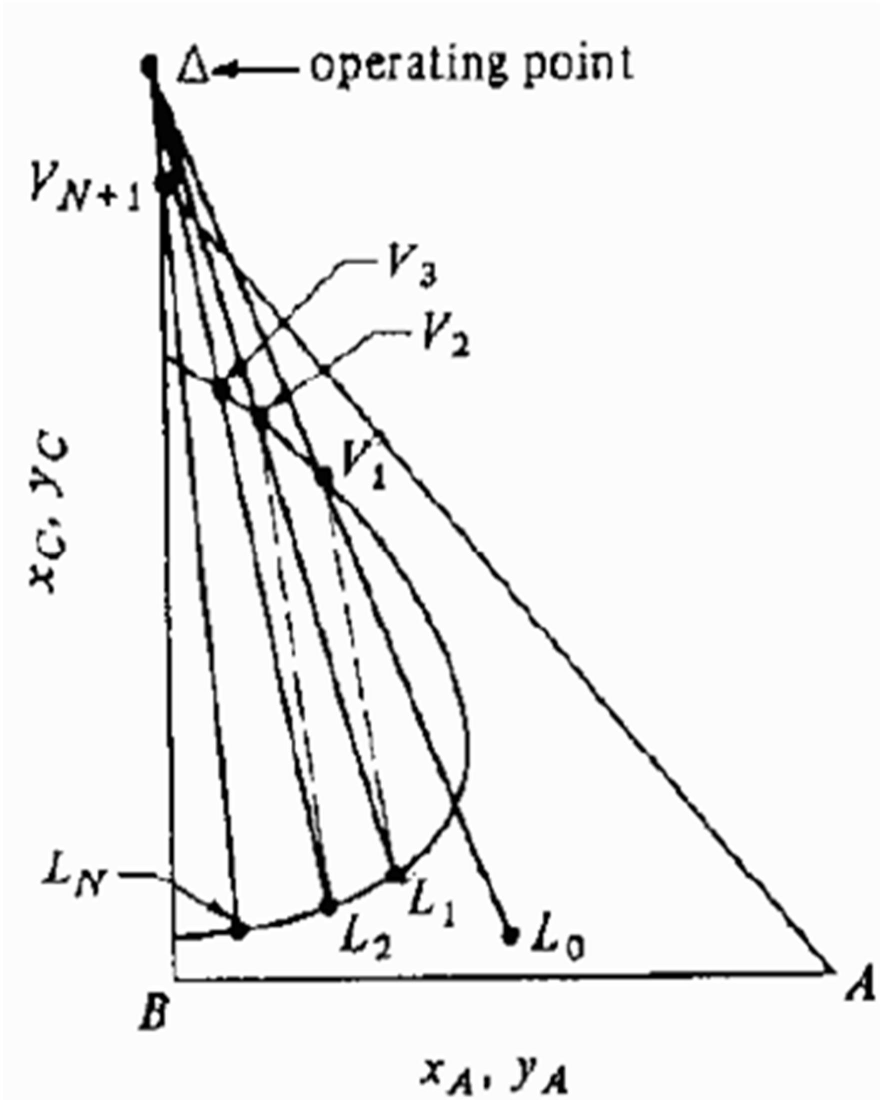
Water layer (wt %)			Isopropyl Ether layer (wt %)		
Acetic Acid	Water	Isopropyl Ether	Acetic Acid	Water	Isopropyl Ether
0	98.8	1.2	0	0.6	99.4
0.69	98.1	1.2	0.18	0.5	99.3
1.41	97.1	1.5	0.37	0.7	98.9
2.89	95.5	1.6	0.79	0.8	98.4
6.42	91.7	1.9	1.93	1.0	97.1
13.30	84.4	2.3	4.82	1.9	93.3
25.50	71.1	3.4	11.40	3.9	84.7
36.70	58.9	4.4	21.60	6.9	71.5
44.30	45.1	10.6	31.10	10.8	58.1
46.40	37.1	16.5	36.20	15.1	48.7



C (ether)
V_{N+1}
1.0
V_1
x_{CM}
M
0.5
x_C, y_C
L_N
0
L_0
0.5
1.0
B (water)
x_{AM}
A (acetic acid)
x_A, y_A

The method to calculate number of stages

- -Locate L_0 on the diagram.
- -Draw the line $L_0\Delta$ which locates V_1 on the phase boundary.
- -Locate L_1 by using the tie line through V_1.
- \- Draw the line $L_1\Delta$ which locates V_2 on the phase boundary.
- -Locate L_2 by using the tie line through V_2.
- -Repeat this stepwise procedure until the desired raffinate composition L_N is reached.


Δ
operating point
V_{N+1}
V_3
V_2
V_1
x_C, y_C
L_N
L_1
L_2
L_0
B
A
x_A, y_A

Example

An aqueous solution of acetic acid (A) and water (B) mixture with a flow rate of 150 kg/h is being extracted by pure isopropyl ether (C) of 450 kg/h in a countercurrent multistage extraction unit. The water concentration of the inlet aqueous solution is given as 70 wt% and the exit acid concentration in the aqueous phase is given as 10 wt %. Calculate the number of stages required.