

LIQUID LIQUID EXTRACTION

USED WHEN DISTILLATION NOT PRACTICAL

- MIXTURES w/ BOILING POINTS CLOSE TOGETHER
- DILUTE SOLUTIONS WHERE YOU NEED TO BOIL A LOT OF SOLVENT

DISTILLATION USUALLY PREFERRED

- LLE DOES NOT LEAD TO FINAL PRODUCT!
- LLE USUALLY NEED ANOTHER SEPARATION

OVERVIEW : A SOLVENT IS ADDED TO ORIGINAL MIXTURE FORMING 2 PHASE SYSTEM

: SOLUTE PREFERENTIALLY GOES TO SOLVENT PHASE

: ORIGINAL MIXTURE CONTAINS SOLUTE (WHAT WE WANT TO GET) AND DILUENT (THE MATERIAL THAT IS CARRYING THE SOLUTE)

EQUIPMENT EXAMPLES NOTE CE 427 HAS LLE FOR REMOVING LACTIC ACID FROM H₂O

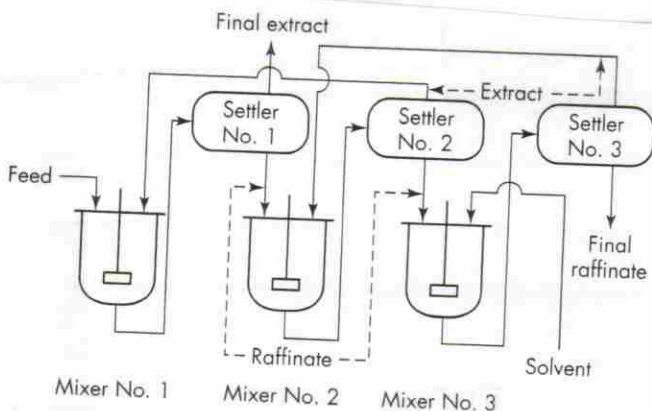


FIGURE 23.4 Mixer-settler extraction system.

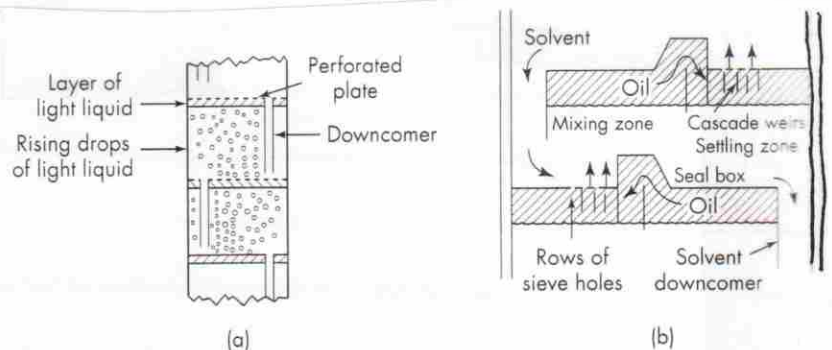
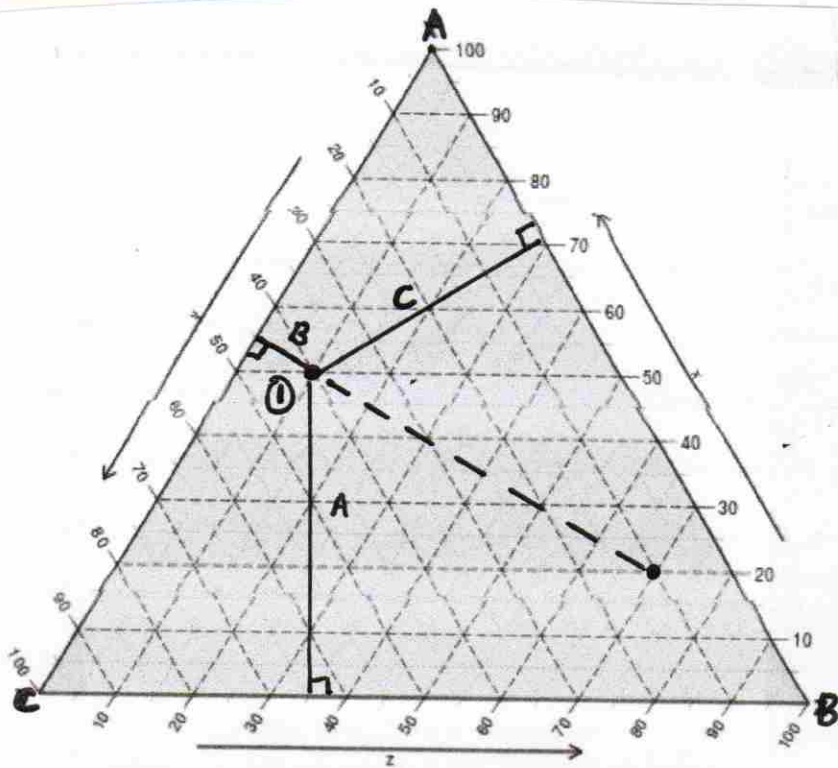


FIGURE 23.5 Perforated-plate extraction towers: (a) perforations in horizontal plates; (b) cascade weir tray with mixing and settling zones. (After Bushell and Fiocco.)

3 COMPONENT MIXTURE : TERNARY DIAGRAM



① 50% A
10% B
40% C

②
20% A
70% B
10% C

ANY MIXTURE OF THESE
TWO WILL LIE ON DASHED
LINE CONNECTING THEM

A point on the OUTER EDGE IS A BINARY
MIXTURE

②

Common Case: 1 Pair is Immiscible

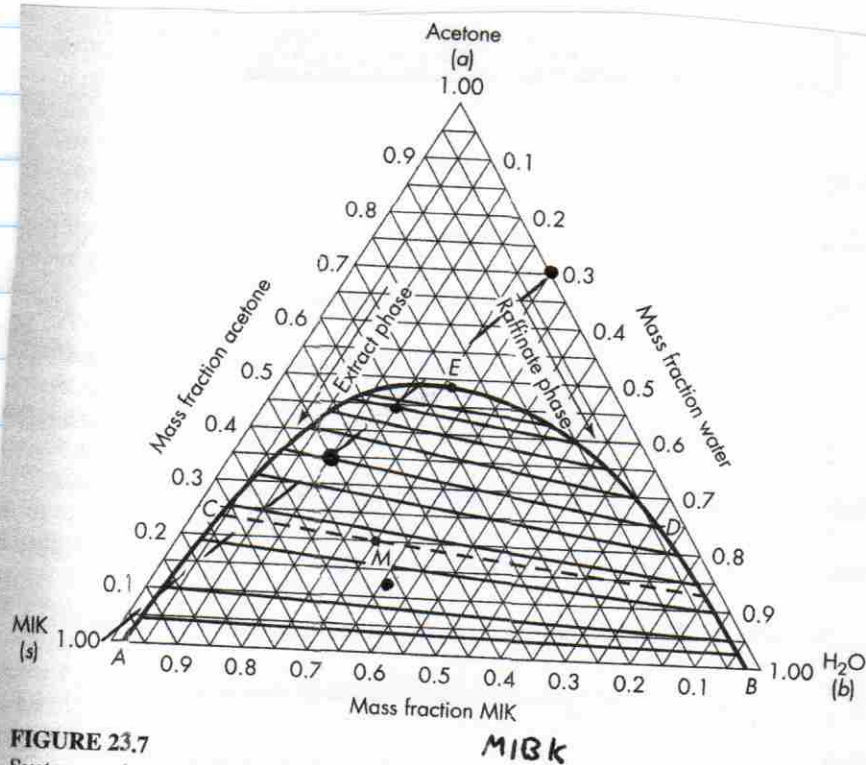


FIGURE 23.7
System acetone-MIK-water at 25°C. (After Othmer, White, and Trueger.¹¹)

• Acetone and
MIBK - totally
miscible

• Acetone and
H₂O - totally
miscible

• MIBK and H₂O
- NOT SO MISCIBLE

MIXTURES INSIDE BUBBLE WILL SEPARATE INTO 2 PHASES
EXTRACT - rich in Solvent
RAFFINATE - rich in Diluent

TIE LINES CONNECT COMPOSITIONS OF EXTRACT AND
RAFFINATE THAT WILL BE IN EQUILIBRIUM

OF THE INFINITE NUMBER OF TIE LINES POSSIBLE
THE ONE THAT PASSES THROUGH THE OVERALL (COMBINED)
COMPOSITION IS THE ONE THAT GIVES THE COMPOSITIONS
OF OUR TWO PHASES.

★ THIS IS A MATERIAL BALANCE ★

CALCULATION of RELATIVE AMOUNTS of EXTRACT
AND RAFFINATE
(ALSO SINGLE STAGE LLE EXAMPLE)

START w/ 100 kg	70% Acetone 30% H ₂ O 0% MIBK	ADD 100 kg	0% Acetone 0% H ₂ O 100% MIBK	MIXTURE	35% Acetone 15% H ₂ O 50% MIBK
				200 kg	

FROM TERNARY DIAGRAM

	EXTRACT	RAFFINATE
% ACETONE	36	25
% WATER	7	71
% MIBK	57	4

TOTAL MASS BALANCE $E + R = M = 200 \text{ kg}$
 ACETONE MASS BALANCE $0.36 E + 0.25 R = 0.35 M$
 $0.36(M - R) + 0.25 R = 0.35 M$
 $E = 181.8 \text{ kg} \quad R = 18.2 \text{ kg}$

RECOVERY: INITIAL ACETONE = $0.7 \times 100 = 70 \text{ kg}$
 EXTRACTED ACETONE = $0.36(181.8) = 65.4 \text{ kg}$
 % RECOVERY = $\frac{65.4}{70} \times 100 = 93.5\%$

OF COURSE WE STILL NEED TO SEPARATE IT
FROM THE EXTRACT!

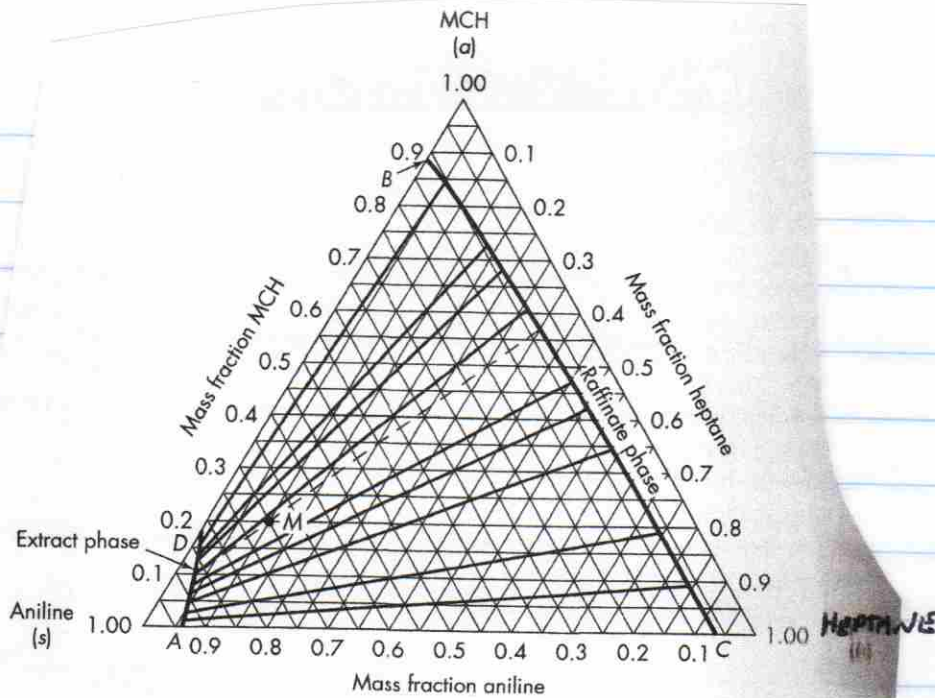


FIGURE 23.8
System aniline-*n*-heptane-MCH at 25°C: a, solute MCH; b, diluent, *n*-heptane; s, solvent, aniline. (After Varteressian and Fenske.¹⁸)

EVALUATING SOLVENT CHOICE

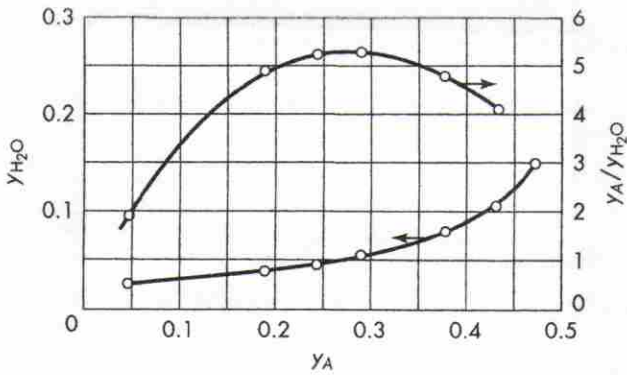


FIGURE 23.9
Composition of extract phase for MIK-acetone-H₂O.

SELECTIVITY

$$\beta = \frac{\text{wt fraction SOLUTE in E} / \text{wt frac diluent in E}}{\text{wt fraction SOLUTE in R} / \text{wt fract diluent in R}}$$

Distribution Coefficient

y^*/x at equilibrium

or $\frac{\text{wt fraction of solute in Extract}}{\text{wt fraction of solute in Raffinate}}$

larger is better!

- Solvent cannot be totally soluble in diluent!

- other concerns

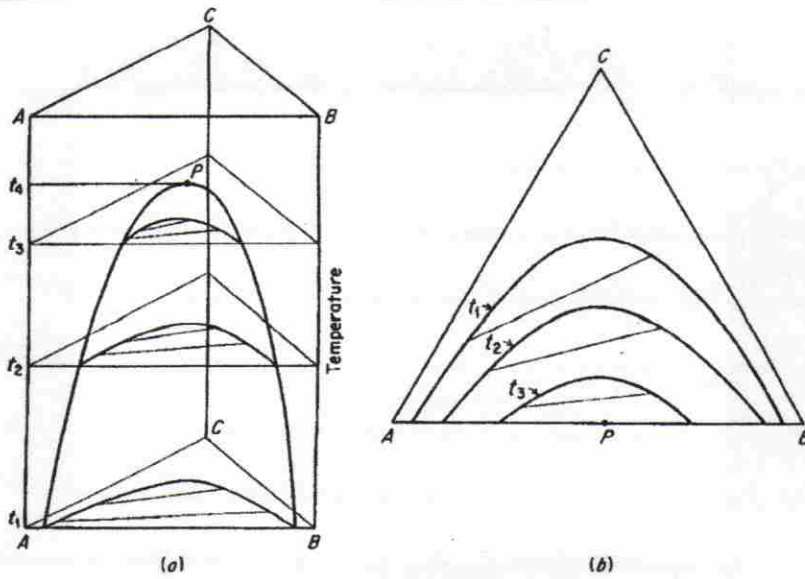


Fig. 10.24 Effect of temperature on ternary equilibria.

EFFECT of TEMPERATURE

As temperature rises
the 2 phase region
shrinks

RECTANGULAR COORDINATES

FOR DILUTE SOLUTIONS COORDINATES CAN BE STRETCHED
FOR BETTER RESOLUTION BY USING RECTANGULAR AXIS

Plot wt fraction of solute versus wt fraction diluent

(wt fraction of solvent easily obtained $w_{\text{solvent}} = 100 - \% B - \% C$)

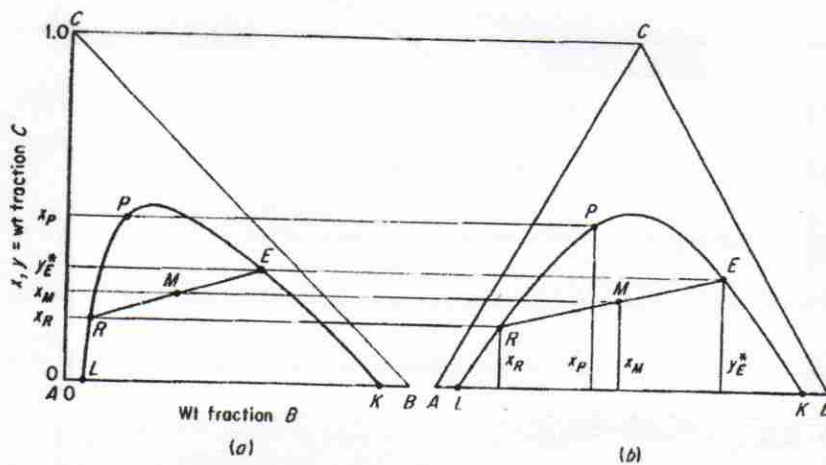


Fig. 10.29 Rectangular coordinates.

CROSS CURRENT

TAKE RAFFINATE and EXTRACT AGAIN USING FRESH
100% SOLVENT

FROM EARLIER EXAMPLE

18.2 Kg RAFFINATE	ADD 18.2 Kg Solvent	Mixture 36.4 Kg
25% Acetone	0%	12.5%
71% H ₂ O	0%	35.5%
4% MIBK	100%	52%

FROM TERNARY DIAGRAM

	EXTRACT	Raffinate
% Acetone	15	7
% H ₂ O	3	90
% MIBK	82	3

MASS BALANCE Total $E + R = M = 36.4 \text{ Kg}$
Acetone $0.15E + 0.07R = 0.125(36.4)$
 $R = 11.4 \text{ Kg}$ $E = 25 \text{ Kg}$

Recovery in 2nd Stage Initial Mass = $0.25(18.2) = 4.55 \text{ Kg}$
Mass Acetone in EXTRACT = $0.15(25) = 3.75 \text{ Kg}$
% Recovery = 82.4%

Overall Recovery $65.4 \text{ Kg in 1st Stage} + 3.75 \text{ Kg in 2nd} = 69.15$
Initial = $0.7(100) = 70 \text{ Kg}$

% Recovery = $\frac{69.15}{70} \times 100 = 98.8\%$
versus 93.5% in 1st stage