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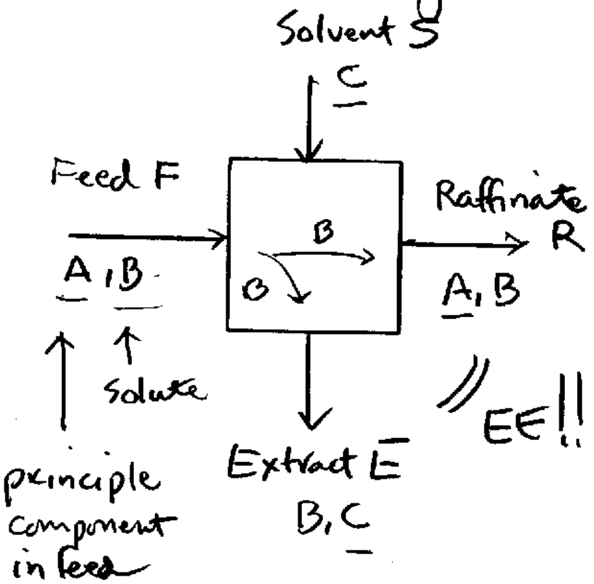
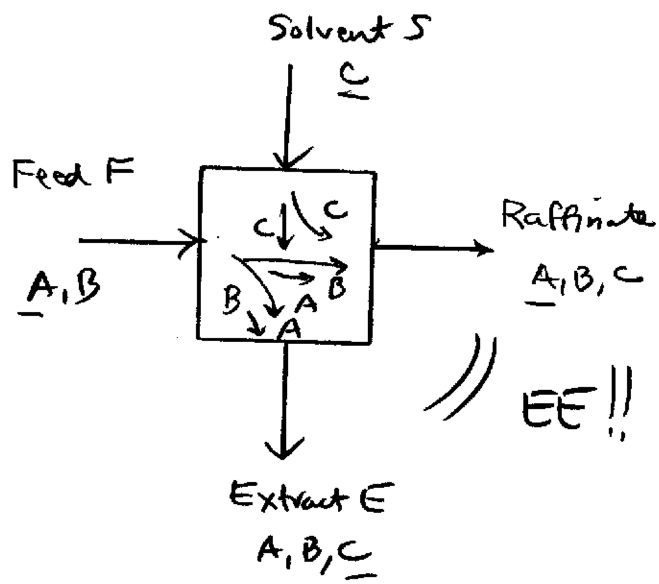
4.5 Ternary Liquid Liquid Extraction

Two principle types of situations arise when working with ternary L/L systems.



near insolubility



partial solubility

Note that it is also possible to contact a feed with a solvent that already contains B, A or A and B. This is common in situations where recycled solvents are employed.

Consider that the solvent is pure C, then mass balances provide

F_A = feed rate of carrier A (usually water)

S = flow rate of solvent C

X_B = ratio of mass (or moles) of solute B to mass (or moles) of the other component in the feed (F), 7-2 raffinate (R) or extract (E).

Note X_B is <u>not</u> a mole fraction

The solute (B) material balance is

$$X_B^{(F)} F_A = X_B^{(E)} S + X_B^{(R)} F_A \qquad (4\text{-}21)$$

and at equilibrium

$$\frac{X_B^{(E)}}{X_B^{(R)}} = \underbrace{K'_{D_B}}_{\text{distribution coefficient based on mass ratios}} \qquad (4\text{-}22)$$

Substituting (4-21) into (4-22)

$$X_B^{(R)} = \frac{X_B^{(F)} F_A}{F_A + K'_{D_B} S} \qquad (4\text{-}23)$$

We can define an "extraction factor" as

$$E_B \equiv K'_{D_B} S / F_A \qquad (4\text{-}24)$$

Large values of E_B are indicative of large extractions of solute into solvent (also $E_B \uparrow$ implies $K'_{D_B} \uparrow$)

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The fraction of B (solute) which is not extracted is

$$\frac{X_B^{(R)}}{X_B^{(F)}} = \frac{1}{1+E_B}$$

Note that mole/mass ratios are related to mole/mass fractions by

$$X_i = \frac{x_i}{1-x_i}$$

This relationship is only true when streams contain only two components (nearly immisible case).

K'_{D_i} can be related to a mole/mass fraction K_{D_i} by

$$K'_{D_i} = \frac{x_i^{(1)}/(1-x_i^{(1)})}{x_i^{(2)}/(1-x_i^{(2)})} = K_{D_i}\left(\frac{1-x_i^{(2)}}{1-x_i^{(1)}}\right)$$

For x_i small, $K'_{D_i} \approx K_{D_i}$

The value of $K_{D_i} = \dfrac{\gamma_B^{(2)}}{\gamma_B^{(1)}}$

Perry's has a large compilation of K_D values.