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Process Chem and Pharmaceutical Engineering 1

Liquid-liquid Separation Part 2

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Chapter Description

- Aims
  - Solve problems related to extraction process by applying the formula relevant to specific unit operations
- Expected Outcomes
  - Describe the concept of equilibrium between two liquids phases
- References
  - Unit Operations of Chemical Engineering, Warren L. McCabe, Julian C. Smith, Peter Harriott

Choice of solvent

- Selectivity
- Distribution coefficient
- Insolubility of solvent
- Recoverability of solute from solvent
- Density difference between liquid phases
- Interfacial tension
- Chemical reactivity
- Cost
- Viscosity, vapor pressure
- Flammability, toxicity

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Selectivity

- $B = \frac{(mass\ fraction\ B\ in\ E)/(mass\ fraction\ A\ in\ E)}{(mass\ fraction\ B\ in\ R)/(mass\ fraction\ A\ in\ R)}$

- B > 1
- Preferentially uptake of solute by solvent over the carrier

Distribution Coefficient

- $K = y/x$
- Large values are desirable since less solvent is required for a given degree of extraction.

Recoverability of Solvent and Solute

- No azeotrope formed between solvent and solute
- Mixtures should have a high relative volatility
- Solvent should have a small latent heat of vaporization

Density – a density difference is required between the twophases

Chemical reactivity – solvent shouldbe stable and inert

Physical properties – low viscosity, low vapor pressure, non-flammable, non-toxic

Interfacial tension – the larger the interfacial tension between the two phases the more readily coalescence of emulsions will occur to give two distinct liquid but the more difficult will be the dispersion ofone liquid in the other to give efficient solute extraction

Extraction Equipment

Mixer settlers

- Used primarily in the metals industry due to:
- Large flows
- Intense mixing
- Long residence time
- Corrosive fluids

Column contactor

- Static – spray, packed, tray
- Agitated – pulsed, rotary, reciprocating

centrifugal

- Used primarily in the pharmaceutical industry due to:
- Large flows
- Intense mixing
- Long residence time
- Corrosive fluids

Mix/decant Tank

Characteristics

- Mix- settle – phase separate in a single tank
- Batch processing only
- Requires multiple solvent additions for more than one stage (crossflow operation)
- Typically used for small capacity operations or intermittent processing

Mixer/Settlers

Characteristics

- Handle very high flowrates
- Good for processes with relatively slow reactions (residence time required)
- Provide intense mixing to promote mass transfer
- Require large amount of floor space
- Suitable when few theoretical stages required
- Large solvent inventory (and losses)

Centrifugal Extractor

Characteristics

- Counter current flow via centrifugal force
- Low residence time ideally suited for some pharmaceutical applications
- Handles low density difference between phases
- High speed device requires maintenance
- Susceptible to fouling and plugging due to small clearance

Packed Column

Characteristics

- High capacity:
- 20-30 m^3/m^2-hr (Random)
- 500-750 gal/ft^2-hr (Random)
- 40-80 m^3/m^2-hr (Structured)
- 1,000-2,000 gal/ft^2-hr (Structured)
- Poor efficiency due to backmixing wetting
- Limited turndown flexibility
- Affected by changes in wetting characteristics
- Limited as to which phase can be dispersed
- Requires low interfacial tension for economic usefulness

Sieve Tray Column

Characteristics

- High capacity: 30-50 m^3/m^2-hr
- 750-1,250 gal/ft^2-hr
- Good efficiency due to minimum backmixing
- Multiple interfaces can be a problem
- Limited turndown flexibility
- Affected by changes in wetting characteristics
- Limited as to which phase can be dispersed

Rotating Disk Contactor

Characteristics

- Reasonable capacity: 20-30 m^3/m^2-hr
- Limited efficiency due to axial back mixing
- Suitable for viscous materials
- Suitable for fouling materials
- Sensitive to emulsions due to high shear mixing
- Reasonable turndown (40%)

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Scheibel Column

Characteristics

- Reasonable capacity:
- 15-25 m^3/m^2-hr
- 350-600gal/ft^2-hr
- High efficiency due to internal baffling
- Good turndown capability (4:1) and high flexibility
- Best suited when many stages are required
- Not recommended for highly fouling systems or systems that tend to emulsify

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KARR Reciprocating Column

Characteristics

- Highest capacity: 30-60 m^3/m^2-hr, 750-1500 gal/ft^2-hr
- Good efficiency
- Good turndown capacity (4:1)
- Uniform shear mixing
- Best suited for systems that emulsify

Pulsed Extractor

Characteristics

- Reasonable capacity:
- 20-30 m^3/m^2-hr
- Best suited for nuclear applications due to lack seal
- Also suited for corrosive applications since can be constructed out or non-metals
- Limited stages due to back mixing
- Limited diameter/height due to pulse energy required

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Conclusion of The Chapter

- This chapter discussed about choice of solvent and extraction's equipment

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Unit Operations of Chemical Engineering, Warren L. McCabe, Julian C. Smith, Peter Harriott

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