G1780: Analysis of Separation Processes

DESCRIPTION

This course covers the analysis and design of separation processes involving phase equilibria and mass transfer. Among the equilibrium-controlled separation processes, distillation, gas absorption/stripping and liquid-liquid extraction are studied. With respect to rate-controlled separation processes, special attention is paid to membrane-based separation processes as well as other advanced separation technologies such as adsorption. In addition, students will acquire the following transversal concepts and competences: continuous and batch processing, counter-current and co-current flow patterns, separation equipment, modeling of the performance of various separation systems, optimization of the design of separation systems to achieve targets for product purity, experience using modern computer software for designing separation processes and ability to develop and apply criteria for selecting among available separation technologies.

OUTCOMES:

1) Combine mass balances, energy balances, thermodynamic equilibrium constraints, and constitutive models for convective mass transfer to develop mathematical models for the performance of various separation systems.
2) Optimize designs of separation systems to achieve targets for product purity.
3) Acquire experience using modern computer software for designing separation processes.
4) Develop and apply criteria for selecting among available separation technologies.

TOPICS COVERED

- Equilibrium Based Separations (Distillation, Extraction, Absorption, Stripping, Leaching and Crystallization)
- Rate Controlled Separations (Membranes, Adsorption, Ion Exchange and Chromatography)
- Bioseparations (Electrophoresis, Precipitation and Filtrations)
- Introduction to Commercial Process Simulators (Aspen Plus and Aspen Custom Modeler)
- Selection of Separation Processes
- Separation Process Design

COURSE OUTLINE

1. Introduction to separation processes
   - 1.1. Definitions and classification: methods for achieving chemical separations
   - 1.2. Difficulty and cost of chemical separations
   - 1.3. Examples of environmental and industrial applications
2. Continuous Separations by Selective Permeation through Membranes
   - 2.1. Overview
   - 2.2. Mechanisms of Permselectivity for Gases
   - 2.3. Mechanisms of Permselectivity for Liquids
   - 2.4. Mass Balances and Design Calculations for Membrane Separators
3. Batch Separations by Selective Adsorption on Solids
   - 3.1. Properties of Porous Adsorbents
   - 3.2. Adsorption Isotherms
   - 3.3. Dynamics of Flow-Through Adsorption Beds
   - 3.4. Chromatography – Fixed-Bed Separation for Composition Analysis
   - 3.5. Liquid-Phase Ion Exchange on Porous Resin Beads
4. Separations with Multiple Equilibrium Stages
   - 4.1. Choosing the Optimal Flow Pattern
   - 4.2. Tray-Column Technology
   - 4.3. Continuous Gas Absorption and Stripping
   - 4.4. Continuous Binary Distillation

    - 4.5. Continuous Multi-Component Distillation
    - 4.6. Batch Binary Distillation
    - 4.7. Continuous Liquid-Liquid Extraction
5. Rate-Based Analysis of Continuous Separations in Packed Columns
    - 5.1. Overview
    - 5.2. Packed-Column Technology
    - 5.3. Two-Film Theory of Inter-Phase Mass Transfer
    - 5.4. Application to Gas Absorption and Stripping
    - 5.5. Application to Binary Distillation
6. Bioseparation processes
    - 6.1. Electrophoresis
    - 6.2. Precipitation
    - 6.3. Filtrations
7. Selecting Among Separation Options
    - 7.1. Overview
    - 7.2. "Separation Factor" for Comparing Binary Pairs
    - 7.3. Effects of Feed Concentration and Flow Rate
    - 7.4. Optimizing Multiple Separation Tasks for Multi-Component Mixtures

Textbook*: - Rate-Controlled Separations. Wankat P.C., 1996, Blackie Academic & Professional.*
- Separation Process Principles (4th ed.). Seader J.D., Henley E.J., Roper D.K., 2016, John Wiley & Sons, Inc.