

ENCH 445: Lecture 1 -- Basic Concepts

Goals of course can be illustrated by describing several illustrative separation processes:

1. Production of decaffeinated instant coffee, which consists of the steps of:
 - A. Caffeine removal from (usually steamed) green beans
 - B. Roasting and grinding of green beans
 - C. Coffee extraction (removal of soluble coffee solids from insoluble coffee solids)
 - D. Multieffect evaporation to remove bulk of water from extract, with recovery of aroma components
 - E. Spray (or freeze) drying of remainder of water.

2. Caffeine removal in above process can be accomplished by several methods:
 - A. Direct method: contacting green beans with methylene chloride
 - B. Indirect method: contact green beans with hot water, caffeine removed from hot water by contacting with methylene chloride or ethyl acetate
 - C. Swiss method: contact green beans with hot water, caffeine removed from hot water by adsorption onto activated carbon.
 - D. Contact green beans with supercritical carbon dioxide.

3. Points to consider for above process:
 - A. Cost of separation equipment for a chemical process is generally greater than 50% of capital cost, and for production of decaffeinated instant coffee it is greater than 90%.
 - B. Why concentrate extract in several steps?
 - C. Why is aroma recovery a consideration in step 1.D but not 1.E?
 - D. What considerations lead to the selection of solvents in decaffeination steps?

4. This brings us to the goals of the course, which are:
 - A. Develop skills in qualitative reasoning and conceptual design
 - B. Develop skills in quantitative design

5. Example 2: Sweetening of sour gas
 - A. Natural gas often contains small amounts of hydrogen sulfide, the removal of which is termed "sweetening."
 - B. The most common process is countercurrent absorption into a mixture of water and ethanolamine.
 - C. Quantitative design considerations:
 - i. What are the diameter and height for absorption column?
 - ii. What is inside the absorption column (is it empty, full of a "packing", or does it have "plates")?
 - iii. For a given flow rate of natural gas, what should the flow rate of absorbing liquid be?
 - iv. What is the operating pressure?

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- v. Mechanical-type design questions (e.g., how thick should the walls of absorption column be) will not be considered.

6. General features of separation processes

- A. All separation processes require a "separating agent" to function, due to the fact that mixing is a spontaneous process. Separation processes are the opposite of mixing process and are therefore never spontaneous. The separating agent makes the separation process run in the desired direction.
- B. Separation processes can be classified by various methods, e.g.,
 - i. What is the separating agent (energy, mass etc.)?
 - ii. Is it a mechanical process (heterogenous feed) or a diffusional process (homogeneous feed) where there is diffusional transfer from a "feed" phase to a "product" phase?
 - iii. Diffusional processes can be further subdivided into equilibration processes, which operate through equilibrium between phases, or rate-governed processes, which involve differential rates of mass transfer to achieve a separation.