CHE 213: Mass Transfer and Separation Processes

Department of Chemical Engineering
Indian Institute of Technology Kanpur

Academic Year 2023-24-II

Course Information

Lectures: TWF (11:00 - 12:00), Location: L16
Experiments: MTTh (14:00 - 17:00 UOP lab)
Please refer to the CHE 213 lab document for relevant information

Simulations: Alternate wednesdays (14:00 - 17:00 CC02 Linux Lab (Room No 301, New Core Lab))
Refer to the Sim lab document for details

Instructor: Soumik Das
Email: dsoumik@iitk.ac.in
Office: ESB-II 609 **Office hours:** By appointment

Course Objective

The course will help prepare the students to understand fundamental aspects of mass transfer and their applications in chemical engineering processes with the help of simulations and experiments.

Course Outline(actual number of topics covered might vary)

1. Introduction: overview of mass transfer related unit operations in process industries, microscale systems and biological applications
2. Design and performance of unit operations: rate and equilibrium stage based modeling approaches
3. Molecular diffusion: Fick's first law, equimolar and non-equimolar counterdiffusion, diffusion coefficients, unsteady state diffusion
4. Convective mass transfer: Mass transfer coefficient, introduction to dimensionless numbers in mass transfer, film theory, boundary layer theory, species continuity balance
5. Continuous contactors: material balance and operating line, cocurrent, counter-current continuous processes
6. Equilibrium stage contactors: co-current/counter-current/cross- current cascades, operating and equilibrium lines, number of equilibrium stages
7. Absorption: Henry's law, Raoult's law, material balance, operating line, minimum liquid flowrates, number of equilibrium stages, deviation from ideal systems (stage and Murphee efficiency), Number of transfer units (NTU), height of transfer units (HTU), Packed and staged columns, hydrodynamic considerations: loading and flooding criterion
8. Distillation: Vapor-liquid equilibrium, T-x-y approach, bubble and dew points calculation, Flash calculations. Ponchon-Savarit and McCabe-Thiele methods for equilibrium stage calculations, Minimum and total reflux, optimum design, deviation from ideal system
9. Extraction: Liquid equilibrium and system of three liquids, equilateral-triangular coordinates, single-stage extraction, multi¬stage crosscurrent extraction, continuous countercurrent multistage extraction

10. Adsorption and chromatography*: Physical and chemical adsorption, adsorbents, adsorption equilibrium and isotherms, single-stage, multi-stage cross-current operations, equilibrium and operating lines, packed-bed continuous contactor, breakthrough curves, rate equations for non-porous and porous adsorbents
11. Humidification and Drying*: Dry and wet bulb temperatures, humidity, relative and percentage humidity, psychometry chart, and adiabatic saturation temperature; Equilibrium, drying rate curve, rate and time of batch drying, mechanisms of batch drying, continuous drying

Course assessment

- Lecture: 60 %
    1. End-semester examination: [30/60]
    2. Mid-semester examination: [20/60]
    3. Scheduled class quiz (best of 2/3): [10/60]
- Simulation: 20 %
    1. 1 Practice session + 5 simulation sessions
    2. In-lab submission: [20/20]
- Experiments: 20 %
    1. Experimental session lab reports : [10/20]
    2. End-semester experimental exam: [10/20]

Policies

- Additional e-resources will be available on HelloIITK (hello.iitk.ac.in)
- Class attendance must be above 90 % until first Quiz. Upon failing, the student will be barred from all quizzes.
- Make-up classes for simulations will only be considered on a case-by-case basis
- All evaluation components are compulsory. No make-up will be held for a missed quiz and mid-sem exam
- Use of unfair means, including copying in exams, plagiarism in lab and sim reports, carrying mobile phones in exam hall etc. will have severe consequences. This includes deregistration from the course or receiving a failing grade.

Extra lectures

2-3 potential extra lectures might be held on Saturdays to compensate for missed classes. More information will be provided in due time.

Reference Books

1. R. E. Treybal, Mass Transfer Operations, 3rd ed., McGraw Hill, New York, 1980.
2. B. K. Dutta, Principles of Mass Transfer and Separation Processes, Prentice-Hall of India Pvt Ltd, 2007.
3. J. D. Seader and E. J. Henley, Separation Process Principles, Wiley, New York, 1998.