課程資訊	
課程名稱	薄膜分離與永續工程 Membrane Separations and Sustainable Engineering
開課學期	114-1
授課對象	工學院 化學工程學研究所
授課教師	杜育銘
課號	ChemE5078
課程識別碼	524EU2450
班次	
學分	3.0
全/半年	半年
必/選修	選修
上課時間	星期四 8,9,10(15:30~18:20)
上課地點	綜 302
備註	本課程以英語授課。化工選修課程。與吳紀聖、康敦彥、歐德理合授 總人數上限：50 人
課程簡介影片	
核心能力關聯	核心能力與課程規劃關聯圖
課程大綱	
為確保您我的權利,請尊重智慧財產權及不得非法影印	
課程概述	This course aims to provide students with an introduction, applications, and an overview of mass transport, membrane separation processes, and sustainable technology. Students will examine the solution-diffusion model, transport mechanisms in porous membranes, and concentration polarization, compare theoretical models with experimental data, and explore how polymer and inorganic porous structures influence sorption, diffusion, and permeation. Key applications include CO2 capture, membrane distillation, membrane pervaporation, membrane reactors, separations in liquids, gases, and vapors, drug delivery, electrical dialysis, and biosensors. Finally, membranes will be linked with sustainability and green chemistry principles, highlighting potential future applications and considerations required for their sustainable preparation, application, and afterlife.

課程目標	1. Build core knowledge in mass transfer, mass/energy balances, and membrane separation processes. Students will be able to (a) explain transport mechanisms such as solution – diffusion, gas/liquid transport in porous membranes, and concentration polarization, etc; (b) compare theoretical models with experimental data; and (c) analyze how material structure governs transport. The course also introduces industrial membrane modules, flow configurations, and fouling mechanisms as a basis for applied studies. 2. Understand the structure and properties of polymeric and inorganic membranes, and analyze how module design and operating conditions affect separation efficiency and overall performance. Connect material features (e.g., crystallinity, ordering, biaxial drawing) to permeability/selectivity. Students will further examine the properties of inorganic and bioinspired porous materials across membrane processes and relate material structure and module design to system-level optimization. 3. Develop an engineering mindset grounded in the 12 principles of green chemistry and green engineering. Students will evaluate environmental and social impacts across material synthesis, advanced applications, and end-of-life/aftertreatment, and justify design choices aligned with sustainability. 4. Demonstrate interdisciplinary thinking to apply membrane technologies in energy, environmental, and biomedical domains, and assess their benefits and challenges. Students will outline designs for CO_2 capture, seawater desalination, drug delivery, and sensing, and evaluate trade-offs within the contexts of sustainable engineering and the circular economy.
課程要求	待補
預期每週課前或/與課後學習時數	6 hours after the lecture
Office Hours	
指定閱讀	1. Marcel Mulder, “Basic Principles of Membrane Technology,” 2nd Edition, Kluwer Academic Publisher, 1996 2. R.W. Baker, John Wiley & Sons, “Membrane Technology and Applications,” 2nd Edition, Inc., New York (2004). 3. J. D. Seader, E. J. Henley, and D. K. Roper, “Separation Process Principles: With Applications Using Process Simulators,” 4th Edition, 2016. 4. 12 Principles of Green Chemistry – https://www.acs.org/green-chemistry-sustainability/principles/12-principles-of-green-chemistry.html.

	5. 12 Principles of Green Engineering – https://www.acs.org/green-chemistry-sustainability/principles/12-design-principles-of-green-engineering.html.
參考書目	待補
評量方式 (僅供參考)	<table><tr><th>No.</th><th>項目</th><th>百分比</th><th>說明</th></tr><tr><td>1.</td><td>Midterm</td><td>40%</td><td>Midterm exam on Membrane transport theory, gas and liquid separations</td></tr><tr><td>2.</td><td>Final Exam</td><td>40%</td><td>Final exam on Electrically driven processes and sustainable principles</td></tr><tr><td>3.</td><td>Homework</td><td>20%</td><td>1 assignment from each instructor</td></tr></table>
針對學生困難提供學生調整方式	<table><tr><td>上課形式</td><td></td></tr><tr><td>作業繳交方式</td><td></td></tr><tr><td>考試形式</td><td></td></tr><tr><td>其他</td><td>由師生雙方議定</td></tr></table>

課程進度

週次	日期	單元主題
第 1 週	9/04 (Prof. Tu)	Introduction and Overview: • Liquid, gas, and vapor permeation; • Sustainable technology and process intensification Overview of Types of Membranes and Modules • Isotropic membranes • Biomimetic and bioinspired channel-based membranes • Hollow fiber membranes
第 2 週	9/11 (Prof. Tu)	Overview of Membrane Transport Theory: • Solution-diffusion model a. Diffusion coefficient b. Sorption coefficient in polymers

		• Transport in porous membranes a. Permeation in ultrafiltration and surface diffusion b. Knudsen diffusion and surface diffusion in microporous membranes c. Polymers with intrinsic microporosity (PIMs) • Concentration polarization a. Boundary layer film theory b. Determination of the Peclet number • Membrane fouling mechanisms
第 3 週	9/18 (Prof. Tu)	Fundamentals of Transport of Small Molecules in Polymers: • Effect of polymer structure on penetrant transport and separation a. Crystallinity b. Liquid crystalline order c. Uniaxial drawing of amorphous and semicrystalline polymers d. Biaxial drawing of polymers • Effect of penetrant properties on membrane transport and separation • Small molecule transport in hydrogels
第 4 週	9/25 (Prof. Tu)	Overview of Membrane Applications: • Separations (Reverse osmosis, Micro-, Ultra-, Nano-filtration, Pervaporation, and Membrane distillation) • Medical applications (Hemodialysis, Biosensors, and Controlled drug delivery) • Ion exchange membranes • Monomer and solvent removal from polymers
第 5 週	10/02 (Prof. Kang)	Membranes for CO2 Capture: • Introduction to CO2 capture • Non-membrane-based CO2 capture techniques • Materials for gas separation membranes • Membrane-based CO2 capture techniques
第 6 週	10/09 (Prof. Kang)	Membrane materials and their development • - Polymer membranes • - Carbon molecular sieve membranes • - Zeolite membranes • - MOF membranes • - Others: silica, 2D materials, liquid, mixed-matrix membranes
第 7 週	10/16 (Prof. Kang)	Measurements, calculations, and mass transfer mechanisms: • Measurements of permeation • - Calculation for a membrane gas separation module • - Measurements of adsorption

		• - Measurements of diffusion • - Relationships between adsorption and diffusion
第 8 週	10/23 (Prof. Tu)	Midterm exam on Membrane transport theory, gas and liquid separations
第 9 週	10/30 (Prof. Wu)	Membrane Separation Processes 1: • Pressure-driven process – MF, UF, NF, Pressure Retarded Osmosis, Piezodialysis
第 10 週	11/06 (Prof. Wu)	Membrane Separation Processes 2: • Concentration-driven process – Dialysis, Gas separation, Prevaporation, Carrier mediated transport, Liquid membrane.
第 11 週	11/13 (Prof. Wu)	Membrane Separation Processes 3: • Thermally driven process – Membrane distillation. • Electrically driven process – Electrical dialysis, membrane electrolysis
第 12 週	11/20 (Prof. Wu)	Module Design and Industrial Processes • Dead-end operation, Cross-flow operation, Cascade operation, Plate module, Spiral wound module, Rotating module, Monolith membrane
第 13 週	11/27 (Prof. Aldous)	Green and Sustainable Chemistry and Chemical Engineering: • The 12 Principles of Green Chemistry, • The 12 Principles of Green Chemical Engineering
第 14 週	12/04 (Prof. Aldous)	Sustainability Principles Applied to Membranes: • Linking specific principles to example Membrane Separation Processes
第 15 週	12/11 (Prof. Aldous)	Energy and the Circular Economy • Sustainable energy (sources, harvesting, storage) • Bio-derived membranes • The Circular Economy and design for the afterlife
第 16 週	12/18 (Prof. Tu)	Final exam on Electrically driven processes and sustainable principles