

## Membrane technologies

### Outline

#### 1. Introduction

Overview on principles, concepts, state-of-the-art and industrial relevance

#### 2. Membranes

- 2.1 Membrane materials, preparation and manufacturing of membranes
- 2.2 Characterization of membranes
- 2.3 Transport in membranes
- 2.4 Polarisation phenomena
- 2.5 Membrane fouling

#### 3. Module and process design principles

- 3.1 Modules
- 3.2 Membrane systems and operation

#### 4. Membrane processes

- 4.1 Pressure-driven membrane processes
  - 4.1.1 Microfiltration<sup>1</sup>
  - 4.1.2 Ultrafiltration
  - 4.1.3 Reverse osmosis
  - 4.1.4 Nanofiltration
- 4.2 Concentration difference as driving force
  - 4.2.1 Gas separation and vapour permeation
  - 4.2.2 Pervaporation
  - 4.2.3 Dialysis
  - 4.2.4 Carrier-mediated transport

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<sup>1</sup> underlined are membrane processes with particular relevance for water treatment and purification

- 4.3 Electrically driven membrane processes
  - 4.3.1 Electrodialysis
  - 4.3.2 Membrane electrolysis
- 4.4 Thermally driven membrane processes
  - 4.4.1 Membrane distillation
- 4.5 Membrane contactors
  - 4.5.1 Gas-liquid contactors
  - 4.5.2 Liquid-liquid contactors
- 4.6 Membrane reactors
  - 4.6.1 Membrane reactor concepts for (bio)chemical synthesis
  - 4.6.2 Fuel cell systems

## **5. Exemplary membrane technologies for water treatment and purification**

- 5.1 Production of ultrapure water
- 5.2 Desalination of seawater
- 5.3 Production of drinking water
- 5.4 Waste water treatment (MBR)

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### Main reference books:

Marcel Mulder, *Basic Principles of Membrane Technology*, 2<sup>nd</sup> Ed., Kluwer, 1996.

Richard Baker, *Membrane Technology and Applications*, Wiley, 2004.

Heinrich Strathmann, *Introduction to Membrane Science and Technology*, Wiley-VCH, 2011.

### Additional books:

Klaus Ohlrogge, Katrin Ebert (Eds.), *Membranen – Grundlagen, Verfahren und industrielle Anwendungen*, Wiley-VCH, 2006.

Enrico Drioli, Lidietta Giorno (Eds.), *Membrane operations – Innovative separations and transformations*, Wiley-VCH, 2009.

### Lecture material:

<http://duepublico.uni-duisburg-essen.de>

**Membrane Technologies - Parts 1 to 7**