UNESCO/IUPAC Postgraduate Course in Polymer Science

Lecture:

Polymer Membranes and Membrane Operations

Zbyněk Pientka

Jan Schauer

Institute of Macromolecular Chemistry ASCR, Heyrovsky sq. 2, Prague -162 06

http://www.imc.cas.cz/unesco/index.html

unesco.course@imc.cas.cz

Membranes

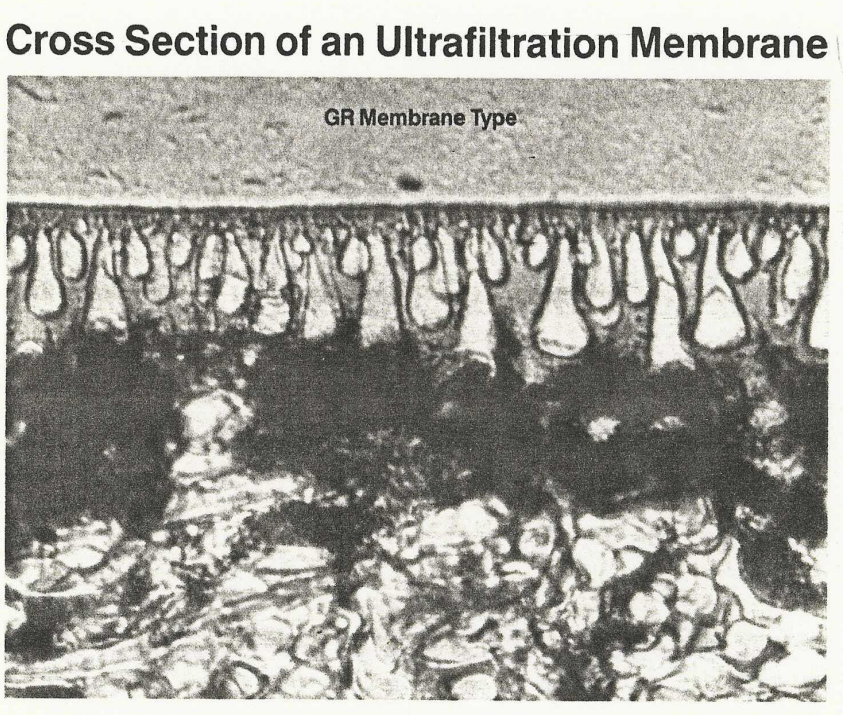
- A thin barrier that permits preferential mass transport under a driving force.
- Semipermeable membranes are used to separate species in a fluid on the basis of size, charge or other characteristics
- The ability to preferably transport (i.e., allow to permeate) one **group** of the mass species present in the system under consideration is called **permselectivity** (membranes permselective for cations, e.g.).

Ultrafiltration (UF)

- removes particles from a fluid (liquid & gas) by passage through a microporous membrane
- purifying and concentrating macromolecular (10^3 - 10^6 Da) solutions, especially protein solutions

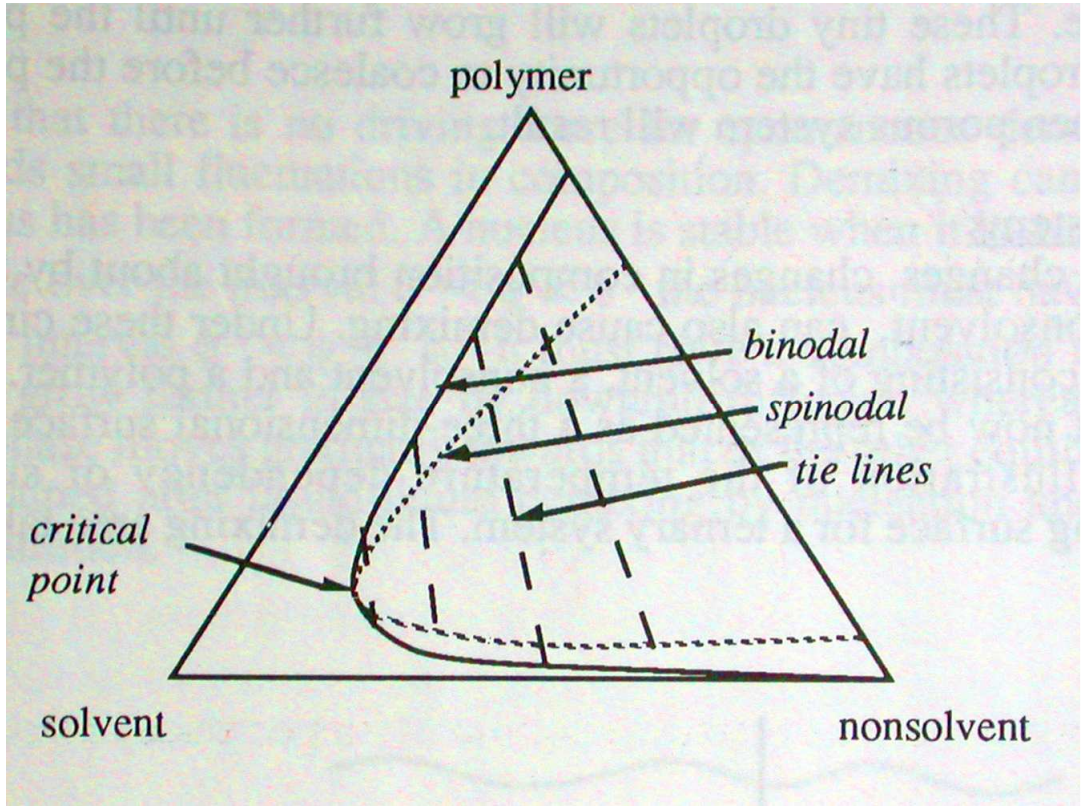
Ultrafiltration membranes

- Structure: asymmetric porous



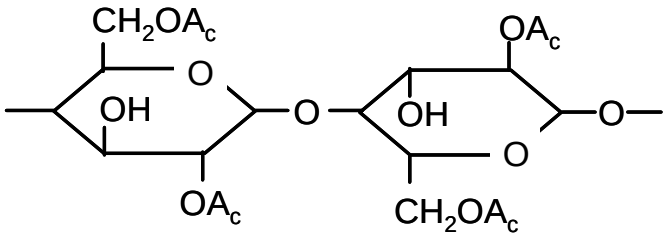
Ultrafiltration membranes

- Structure: asymmetric porous
- Preparation: phase inversion



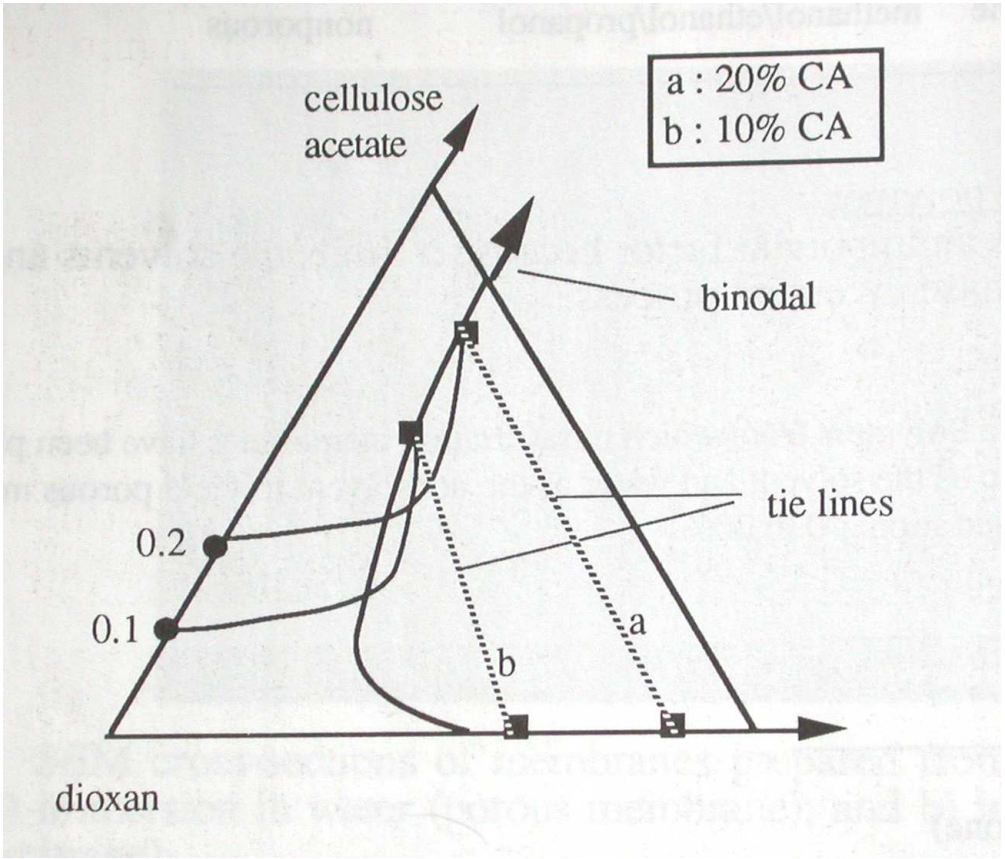
Ultrafiltration membranes

- Structure: assymetric porous
- Preparation: phase inversion
- Material: cellulose acetate, polysulfone



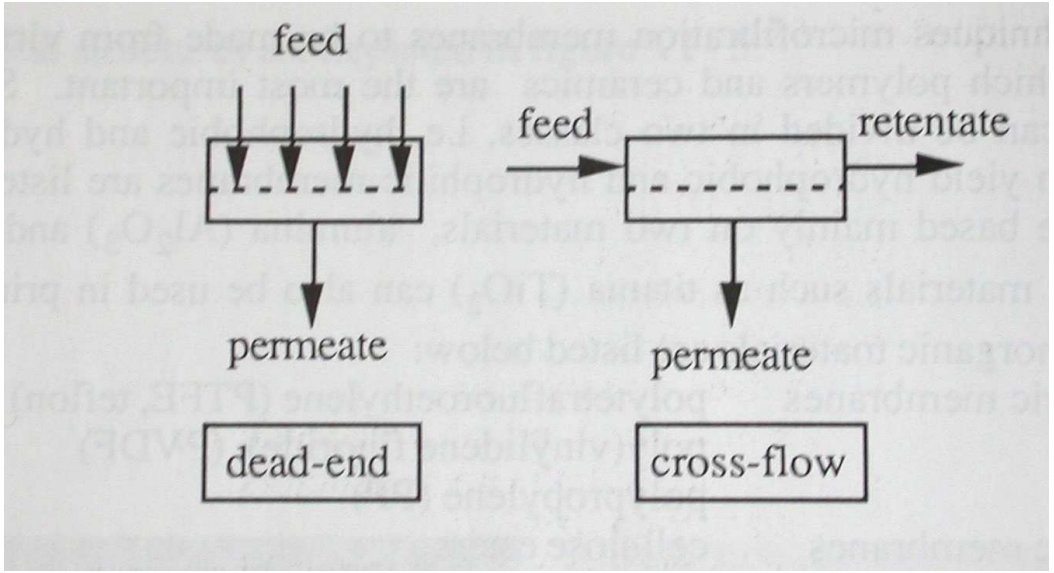
Ultrafiltration membranes

- Structure: assymetric porous
- Preparation: phase inversion
- Material: cellulose acetate, polysulfone
- Pore sizes: 1..100 nm



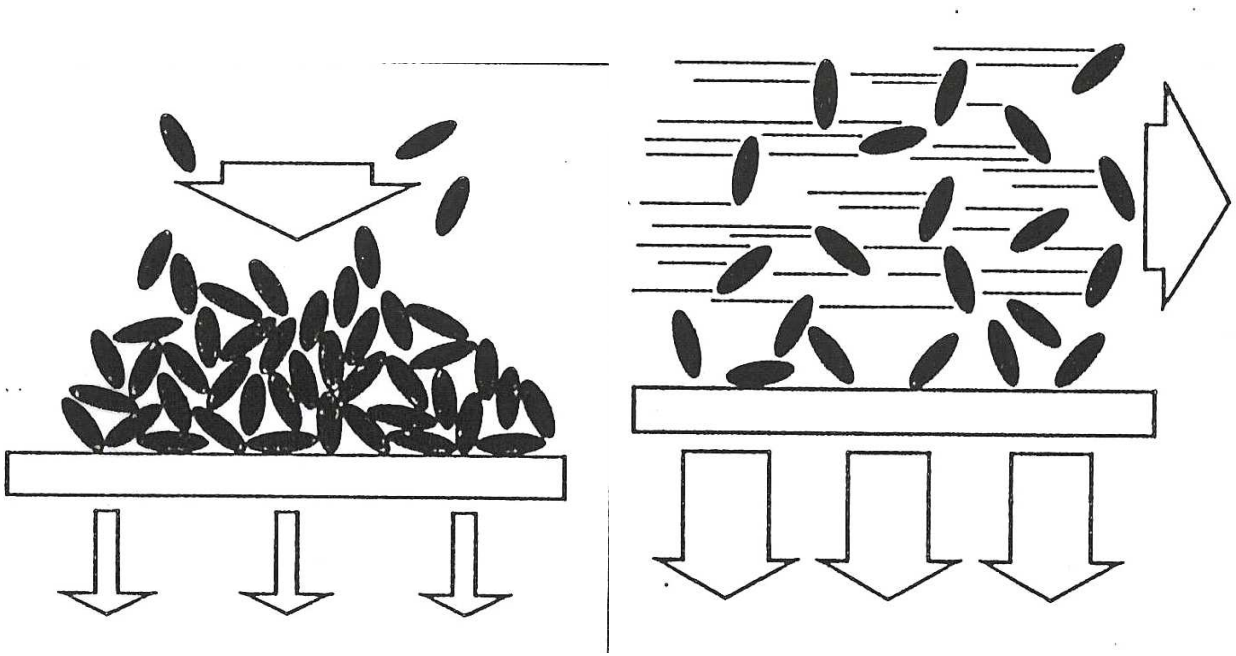
Ultrafiltration

- Schematic of filtration process
- Pressure 1 .. 10 bar



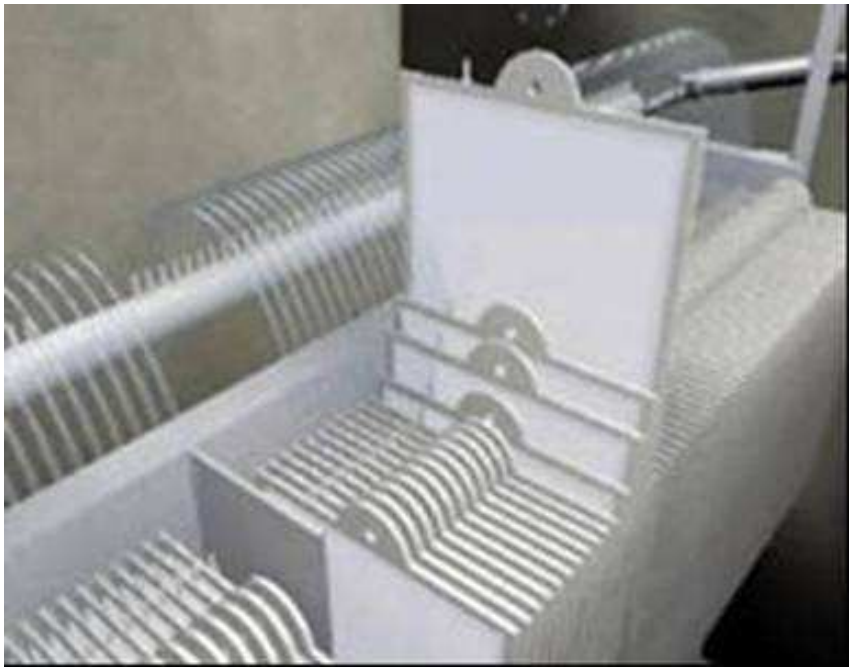
Ultrafiltration

- Fouling



Form of the UF membranes

Flat sheets



Tubular

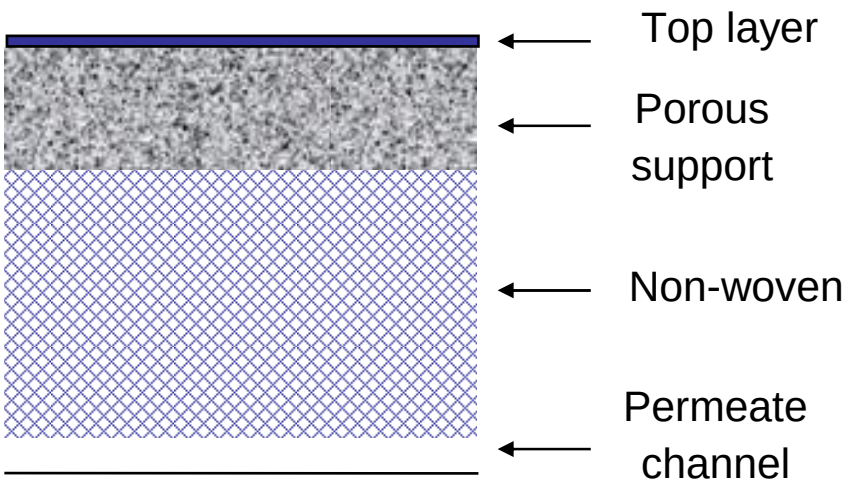
Hollow fibers

Reverse osmosis (RO)

- Separation of low molecular weight solutes (salts, small organic molecules) from a solvent
- Desalination of sea water
- Ultrapure water
- Concentration of food juice or milk

RO membranes

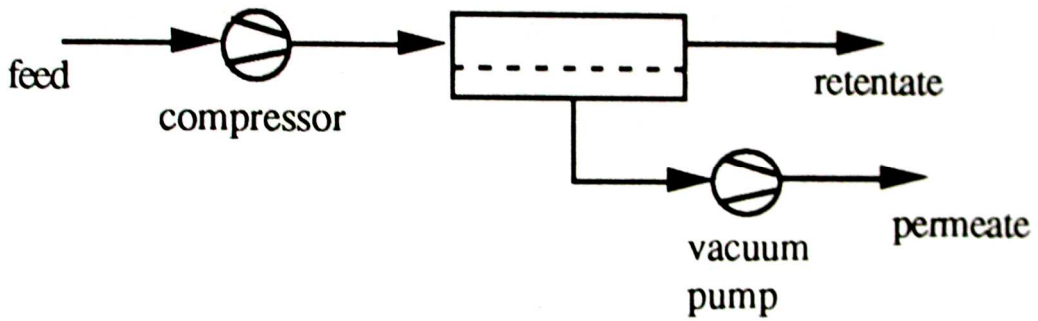
- Structure: integral asymmetric or composite
- Material: aromatic polyamide, cellulose triacetate
- Pore sizes: nonporous or pores < 2nm



TFC membrane

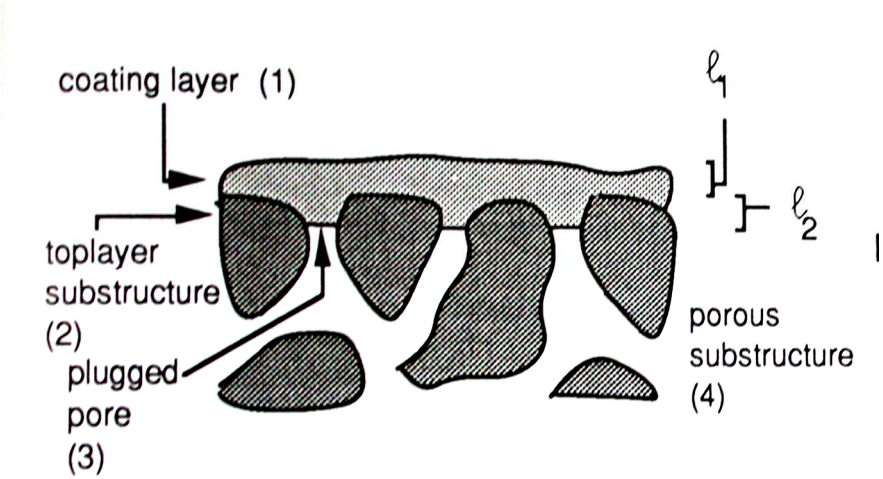
Gas separation

- H_2, He recovery
- VOC vapours from air
- oxygen enrichment (O_2 /N_2)
- Biogas purification (CH_4/CO_2)



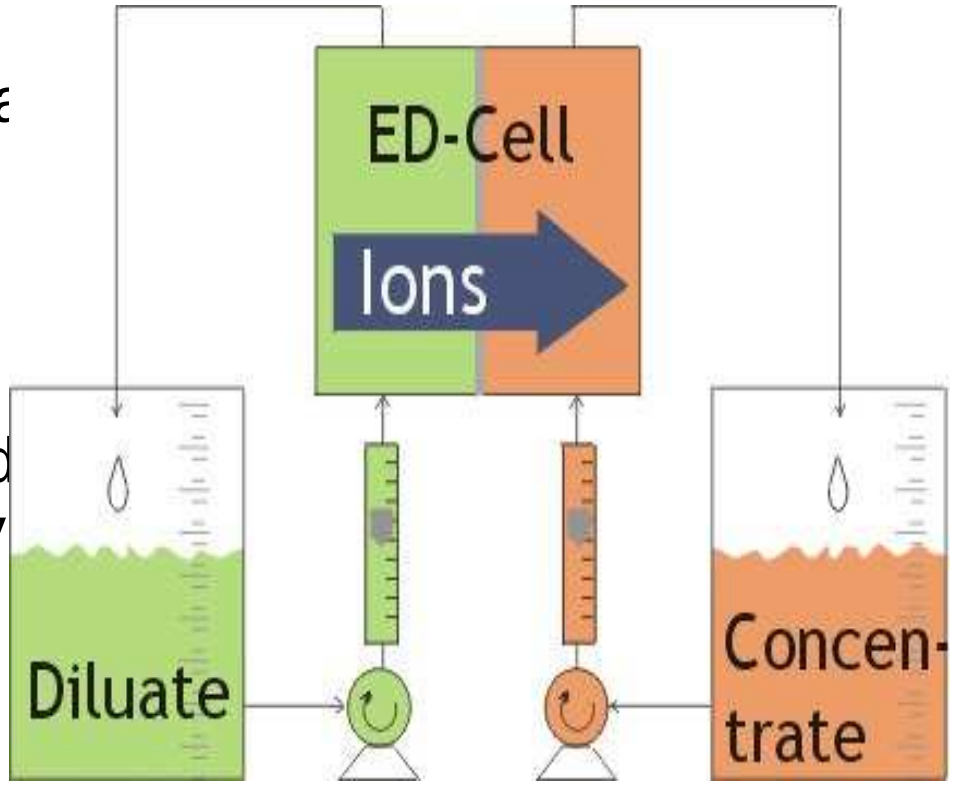
Gas separation membranes

- Nonporous membranes
- Solution-diffusion mechanism
- Mechanism of small molecule diffusion
- Composite membranes



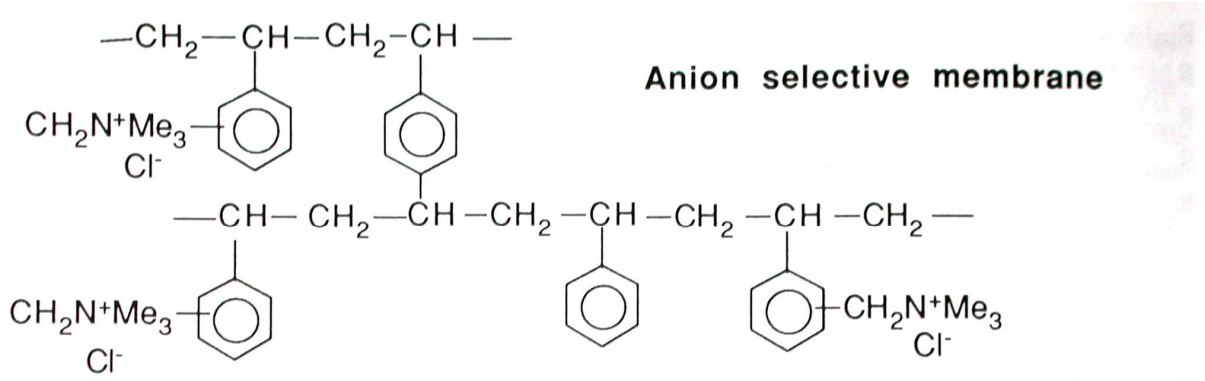
Electrodialysis

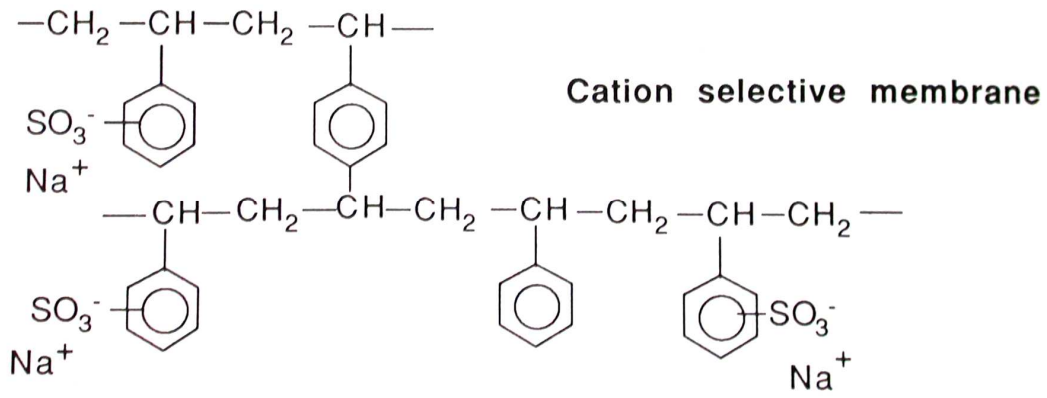
- Transport of ions from a solution through ion-exchange membranes under electric field gradient
- Desalintaion in food and pharmaceutical industry
- Separation of amino acids



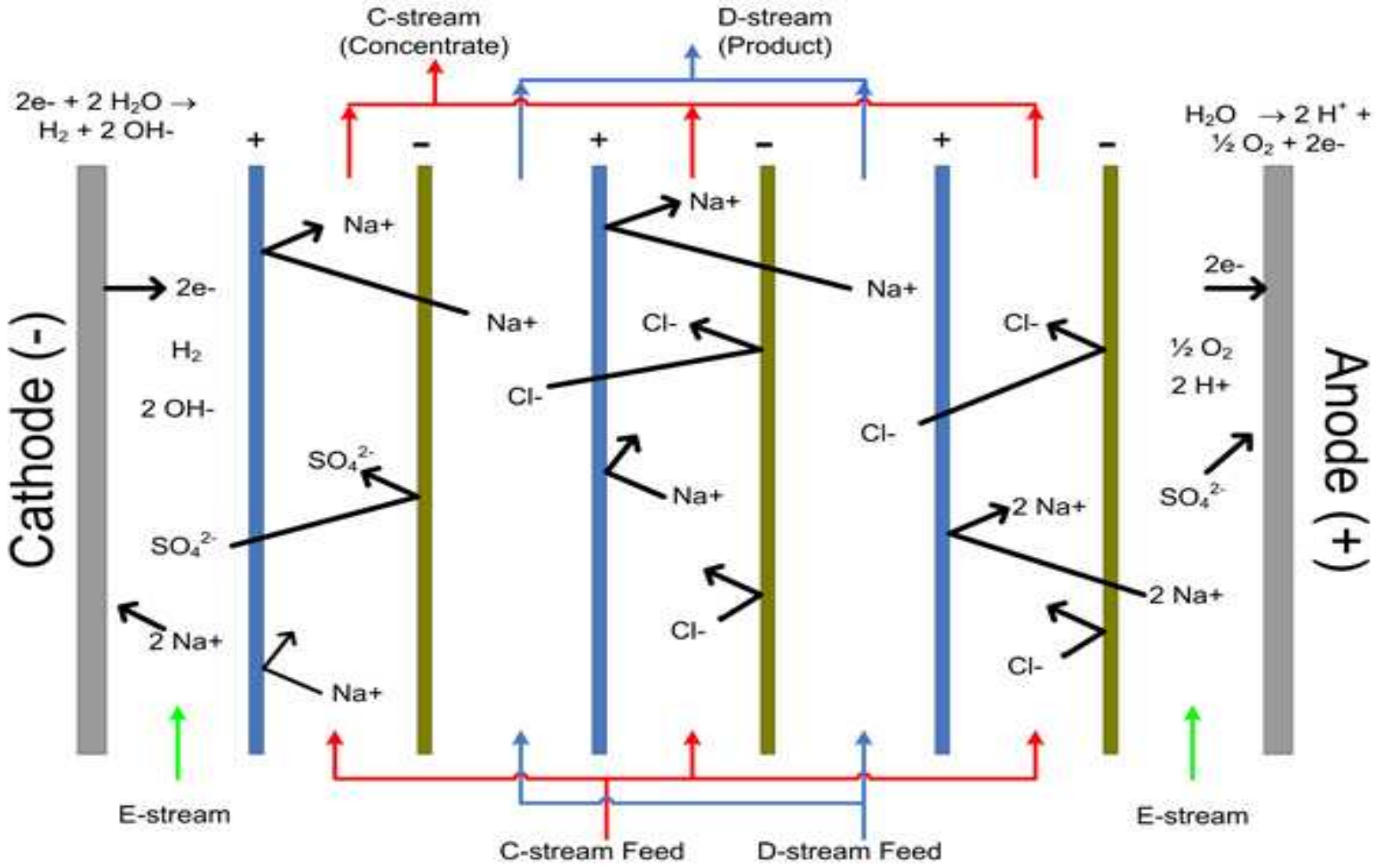
Membranes for electrodialysis

- Ion exchange membranes





Electrodialysis principle



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Overview of membrane operations

Driving force

Pressure gradient

- Microfiltration
- Ultrafiltration
- Reverse osmosis
- Gas separation

El.field

- Electrodialysis

Concentration gradient

- Dialysis

Overview of membrane operations

Size range of permeating species

- Ions and small molecules (about 1 nm): Gas diffusion, reverse osmosis, dialysis, electrodialysis
- Macromolecules (10 – 10^2 nm): Ultrafiltration, dialysis,
- Colloids (10^3 – 10^4 nm): Microfiltration
- Particles (10^4- 10^5 nm): Filtration

Advantages/disadvantages

Advantages

- **Prevent waste:** no additional reagents
- **Increase energy efficiency:** moderate conditions (temperature, pressure)
- **Minimize the potential for accidents:** membranes are reliable and long-lasting
- **Gentle conditions:** allow preserve biological activity

Disadvantages

- **Separation efficiency:** in some processes lower
- **Costs:** higher initial costs