

Membrane Technologies Microfiltration, Ultrafiltration, Nanofiltration and Reverse Osmosis

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Presentation Outline

- Membrane advantages
- Membrane Basics
- Membrane Operations



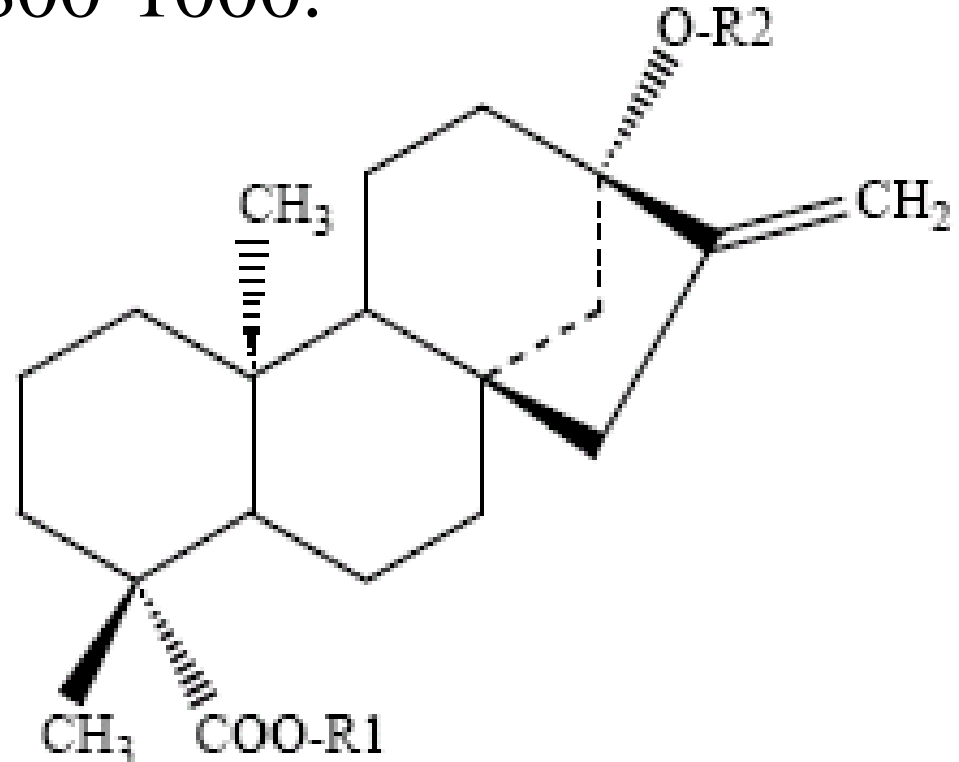
Advantages

- High chemical stability.
- High temperature resistance.
- High separation ratios.
- High flux.
- Tailored systems.
- Easy scale-up.

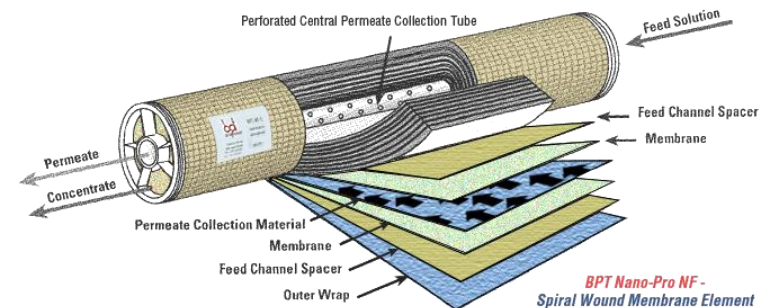
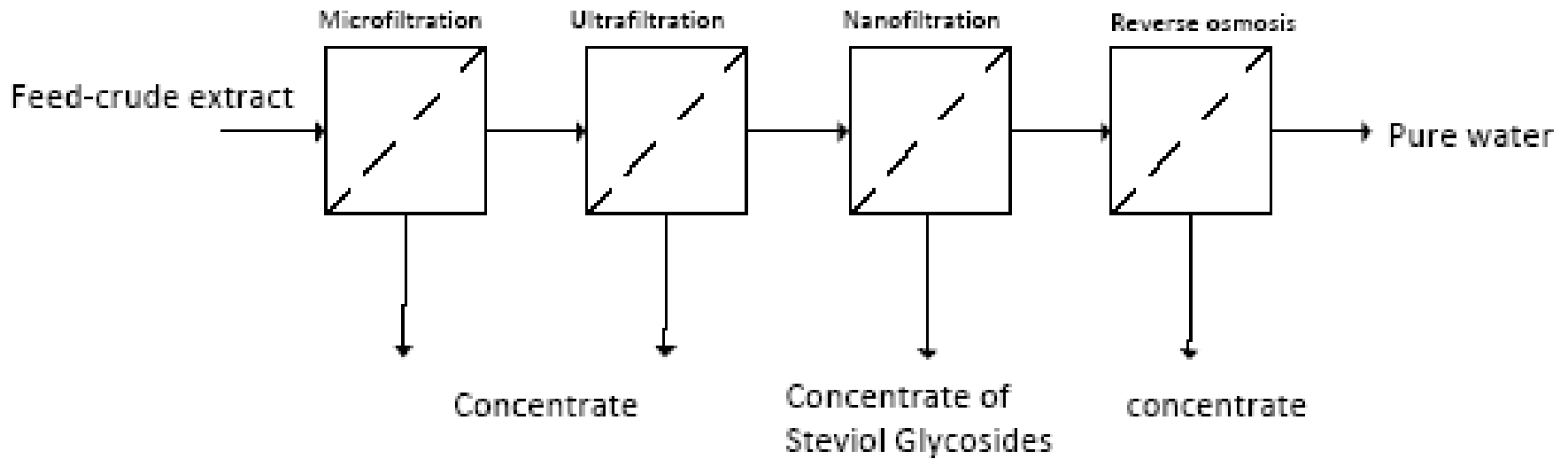


Steviol Glycosides

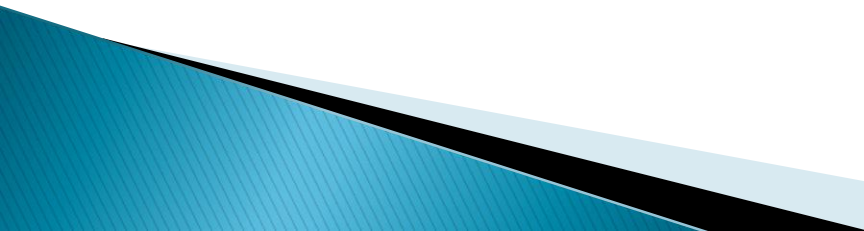
- Family of molecules organized around the Steviol nucleus.
- Molecular weight 800-1000.
- Size 1-2 nm.



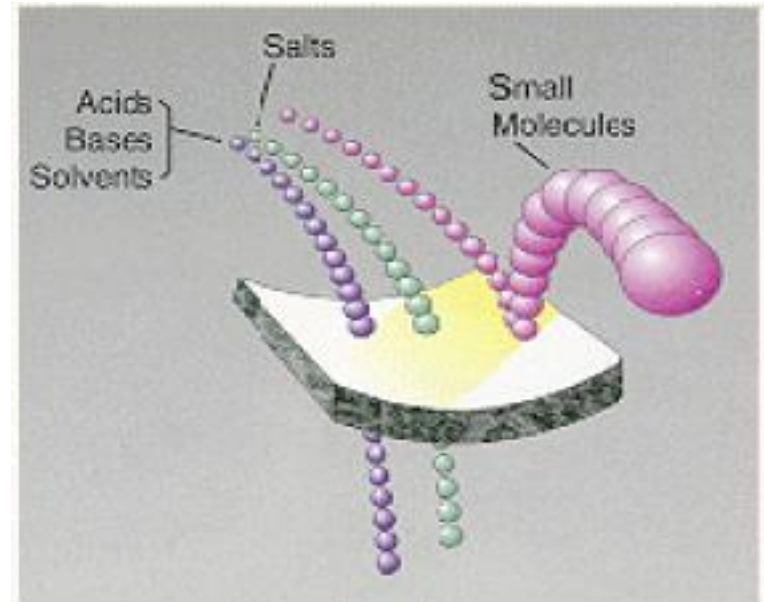
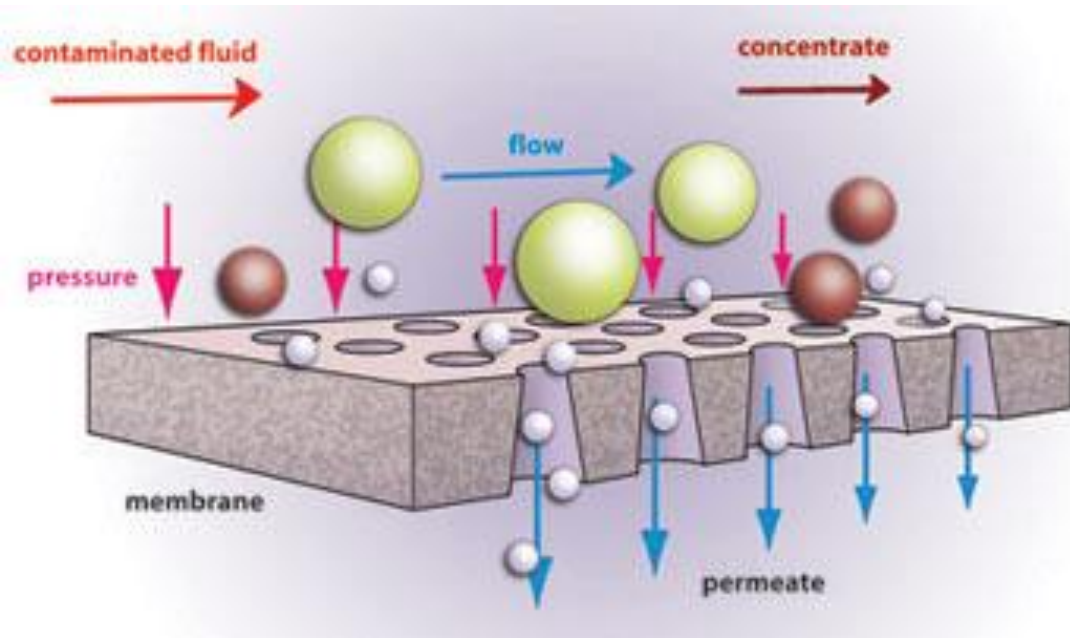
Cascade filtration techniques



Membrane Extraction technologies

- A membrane is a selective barrier that permits the separation of certain species in a fluid by combination of sieving and diffusion mechanisms.
 - Membranes can separate particles and molecules and over a wide particle size range and molecular weights.
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Membrane separation



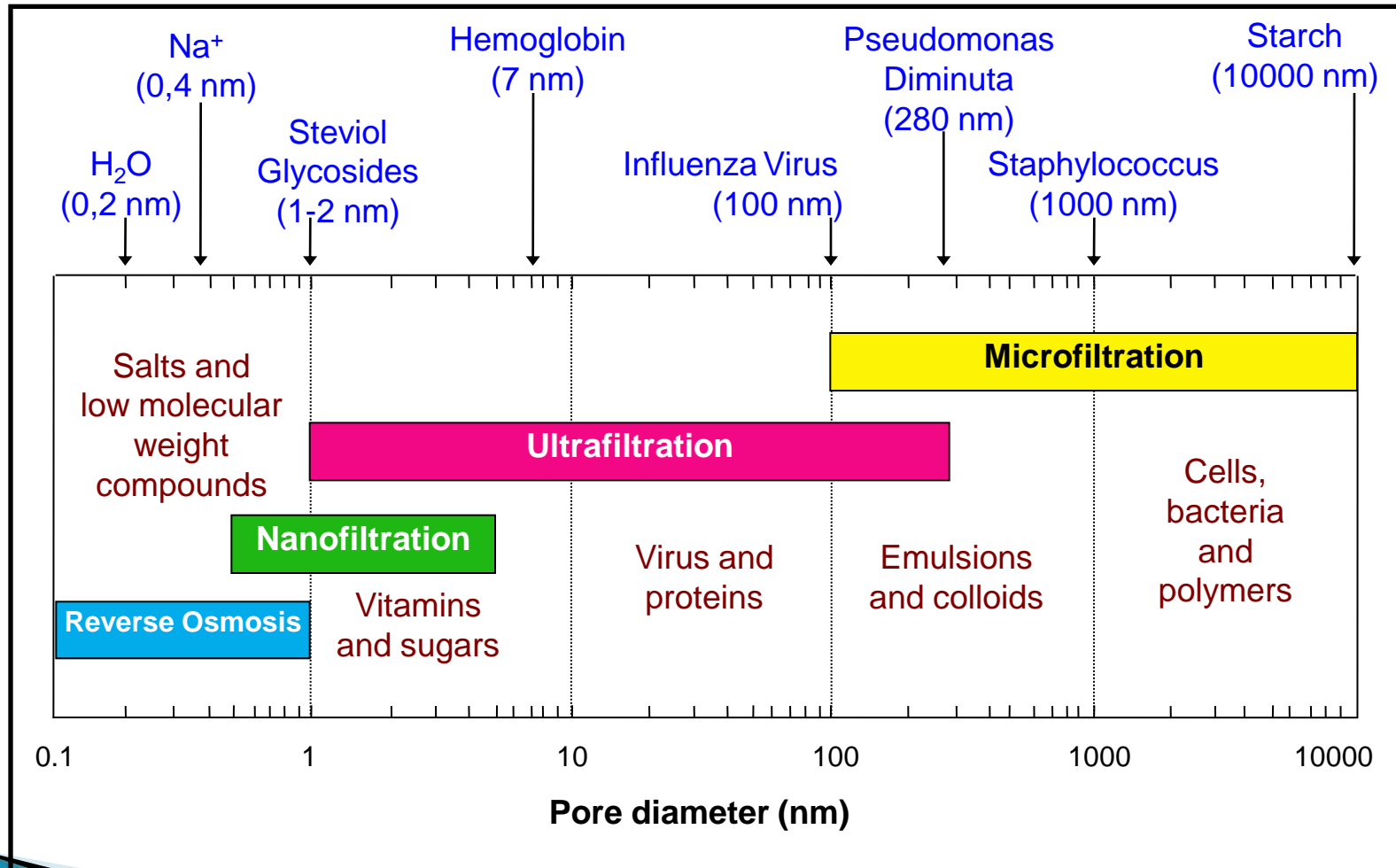
Selective

The selectivity is due to:

1. Size
2. Shape
3. Electrostatic charge
4. Diffusivity
5. Physicochemical interactions
6. Polarity

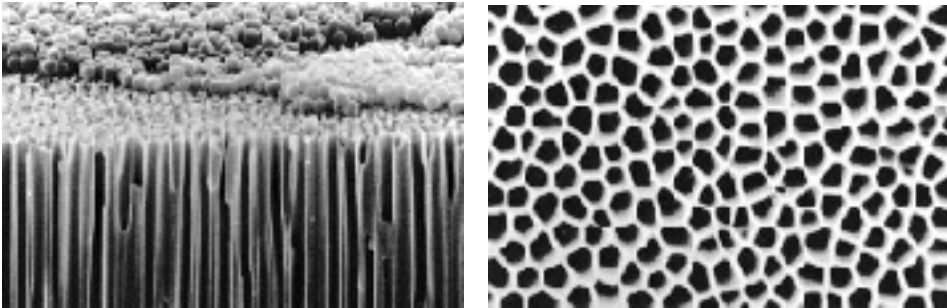


Membrane Classification (Pore Size)

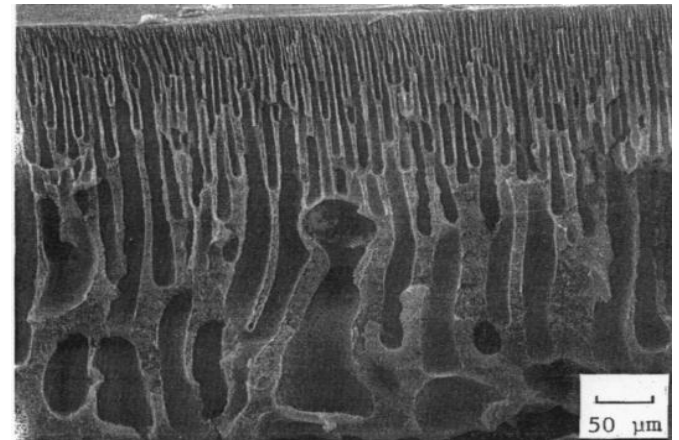


Membrane Classification (Structure)

- Symmetric. Also called homogeneous. A cross section shows a uniform porous structure.
- Asymmetric. In a cross section, one can see two different structures, a thin dense layer and below a porous support layer.



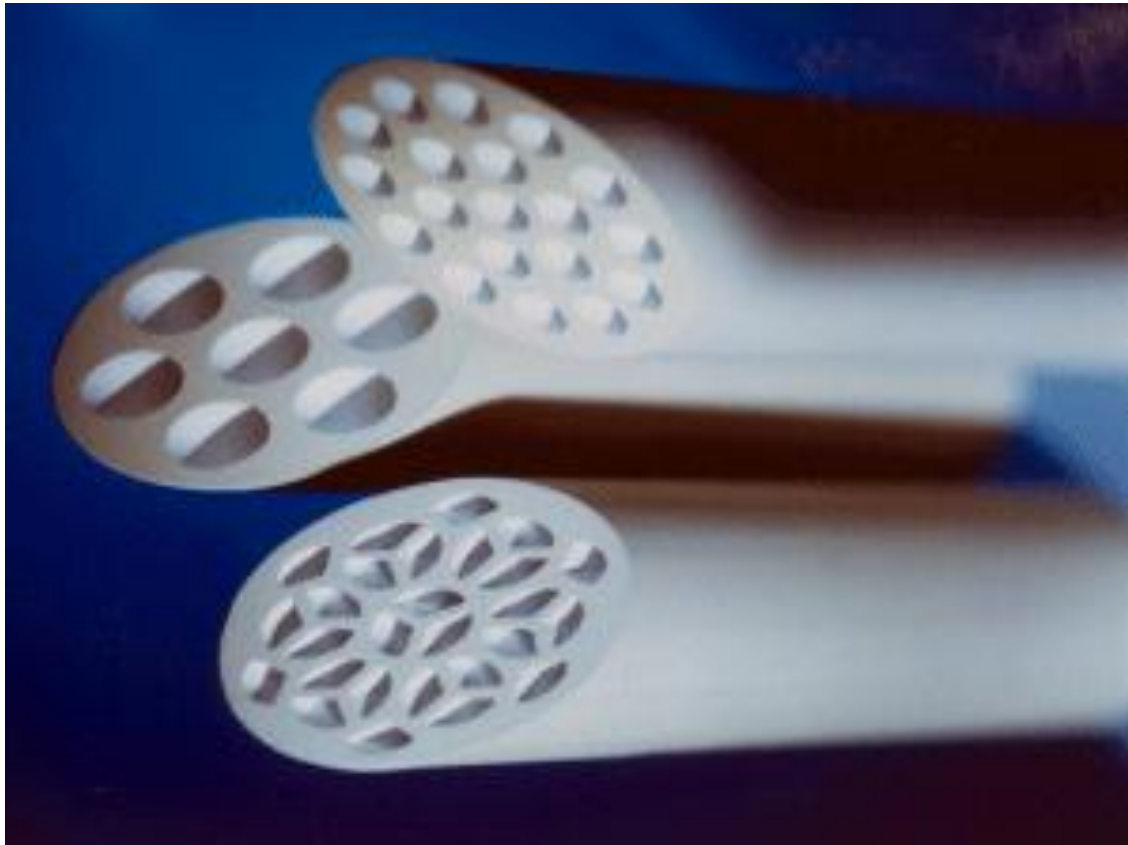
Symmetric-ceramic membrane



Asymmetric-polypropylene membrane

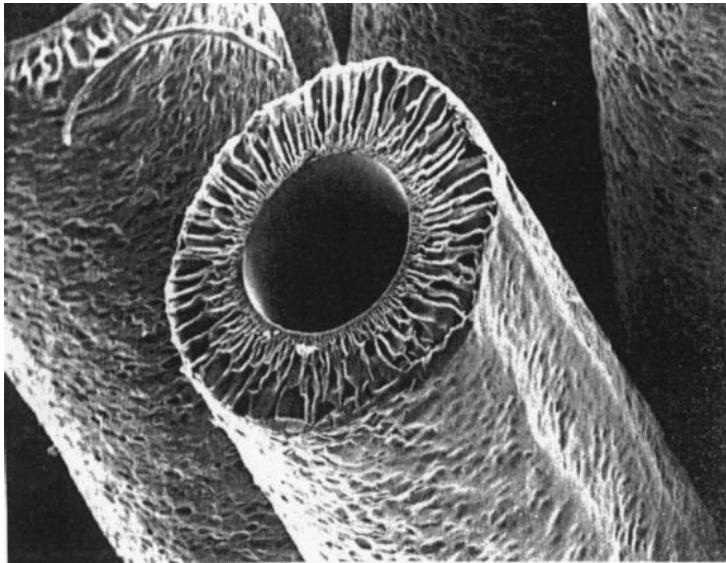
Membrane Classification (configuration)

Tubular -mostly used Microfiltration and Nanofiltration



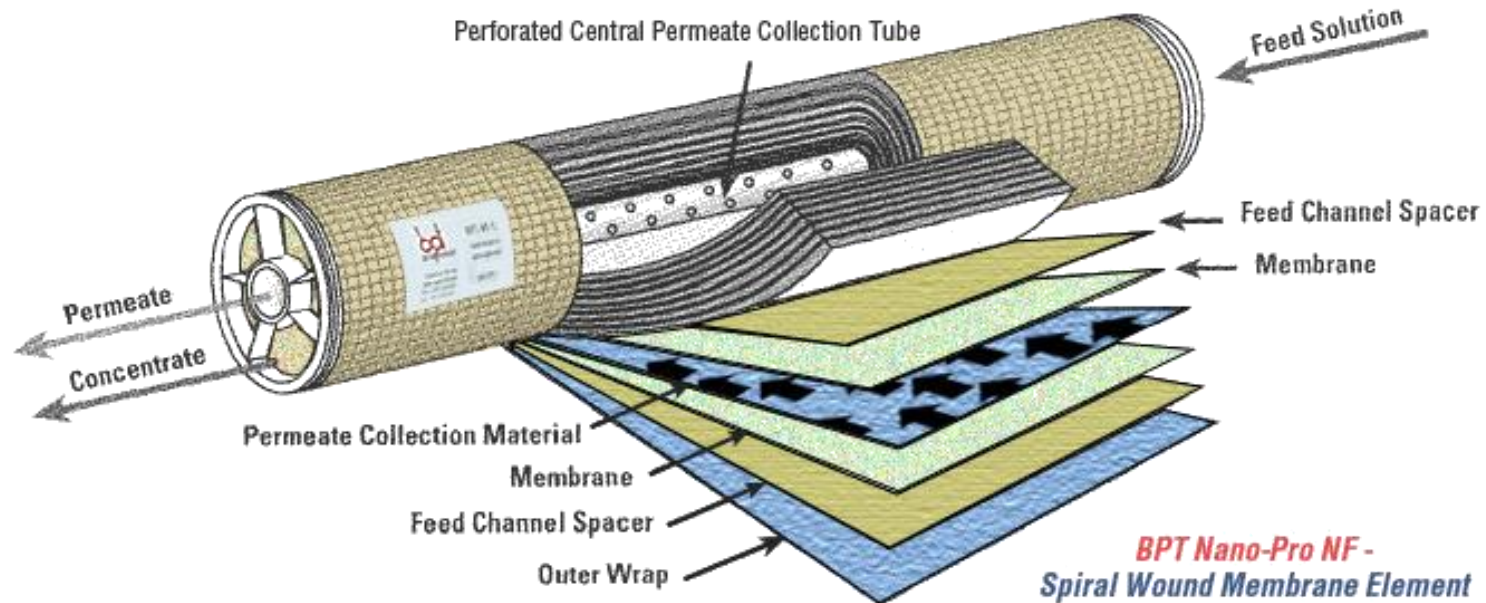
Membrane Classification (Configuration)

Hollow fiber - mostly used for Ultrafiltration




Membrane Classification (Configuration)

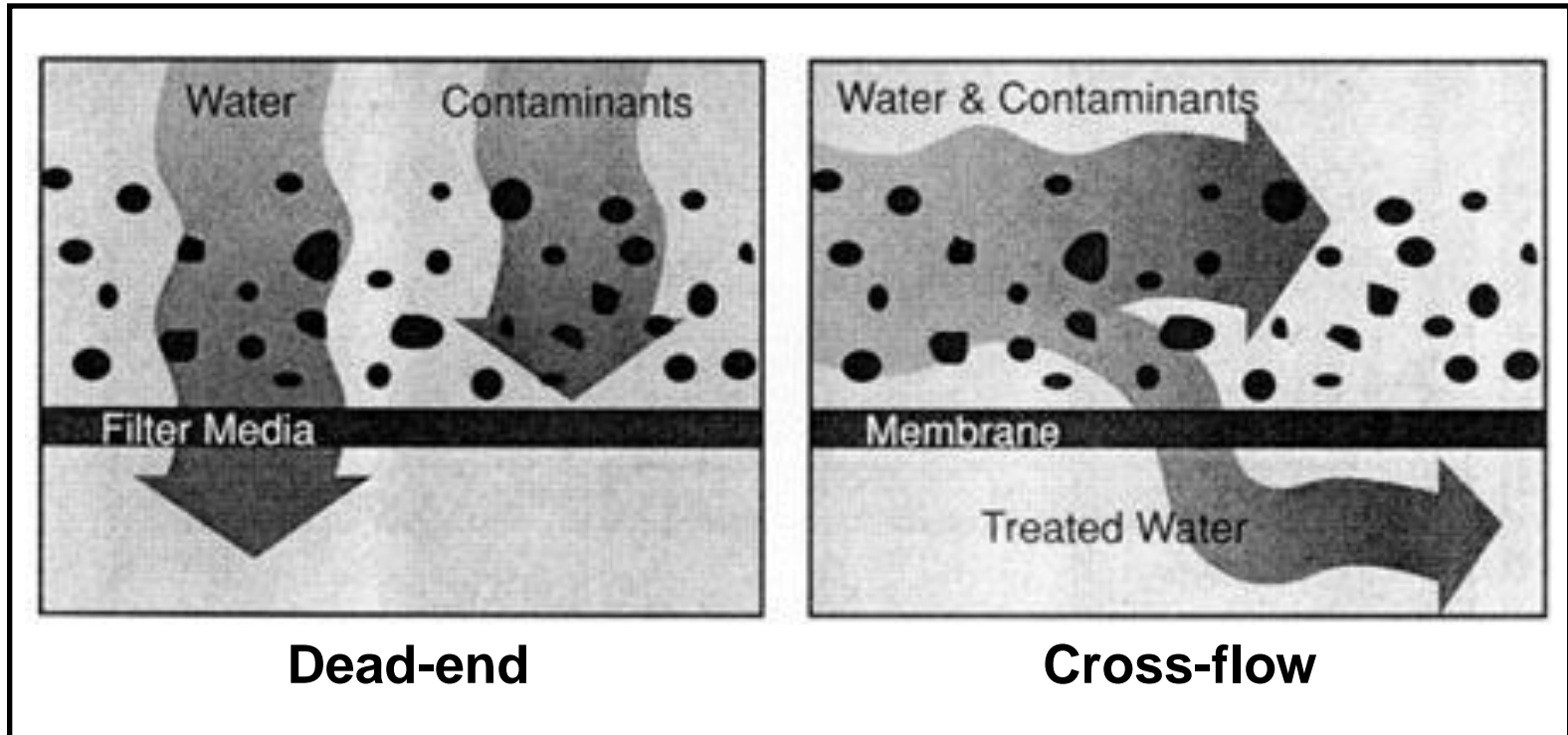
Spiral wound - mostly used for Nanofiltration and Reverse Osmosis



Membrane Application

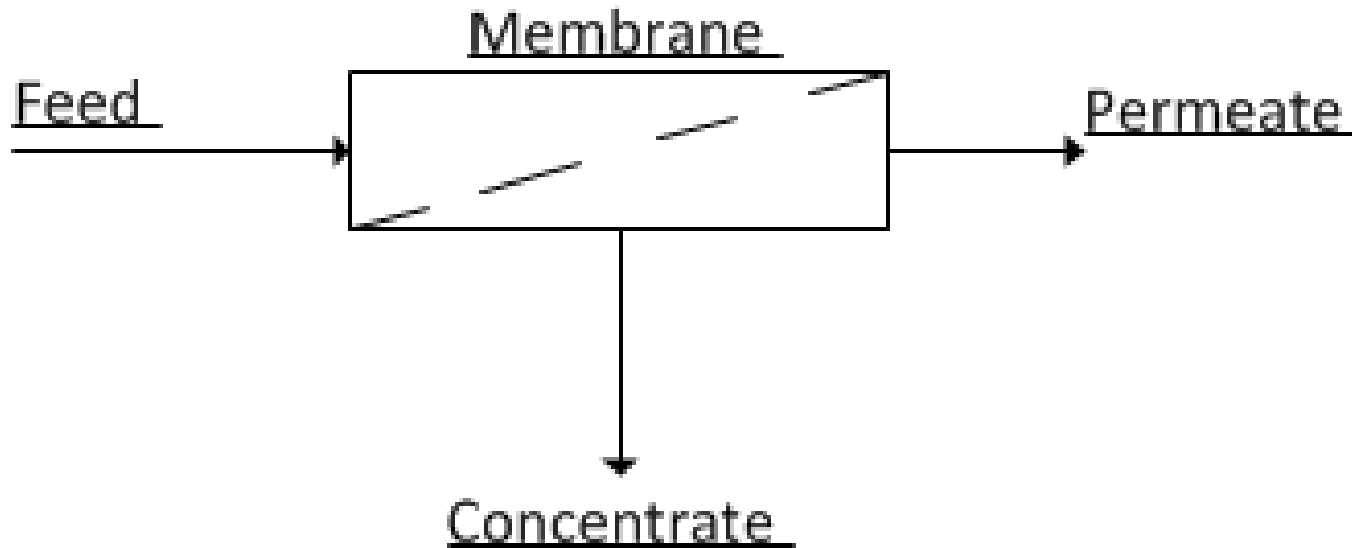
- Microfiltration (MF)
 - Mainly used for particle-fluid separation.
 - Pretreat water for R.O and nanofiltration.
 - Ultrafiltration (UF)
 - Used for: concentration, clarification and fractionation.
 - Pretreat water for R.O and nanofiltration.
 - Turbidity reduction.
 - Macro molecules separation.
 - Nanofiltration (NF)
 - Organic particles concentration.
 - Softening of water.
 - Multivalent ions concentration.
 - Reverse osmosis (RO)
 - Highly pure water.
 - Desalination.
 - Monovalent ions concentration.
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Operations (type of filtration)



Operations

(recovery and rejection)



$$\bullet \text{Rejection} = \frac{\text{concentration Permeate}}{\text{concentration Feed}} \times 100[\%]$$

$$\bullet \text{Recovery} = \frac{\text{flow Permeate}}{\text{flow Feed}} \times 100[\%]$$

$$\bullet \text{Flux} = \frac{\text{flow}}{\text{Area}} \text{ (LMH)}$$

Operations (Pressure and flux)

Process	Driving force	Typical flux
Microfiltration	0.1-3 Bar	100-1000 LMH
Ultrafiltration	0.35-6 Bar	30-300 LMH
Nanofiltration	6-40 Bar	20-150 LMH
Reverse Osmosis	7-70 Bar	10-35 LMH

Operations

Specifications

Size	Glucose Rejection (%) ⁽¹⁾	26 mil spacer ⁽²⁾	
		Flux (LMH)	Active Membrane Area (m ²)
8040	98	125±8	27.8

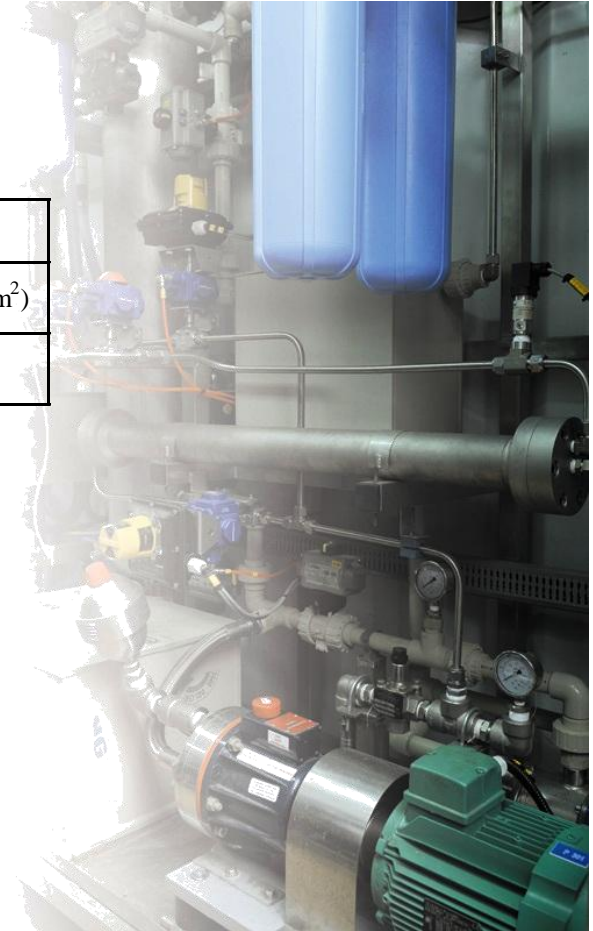
⁽¹⁾ Test Conditions: RO water at 580 psi (40 bar), 86°F (30°C),
Feed solution for rejection test is 3% glucose in RO water

⁽²⁾ 1 mil (1/1000th) of an inch = 25 microns

$$\bullet \text{Rejection} = \frac{\text{concentration Permeate}}{\text{concentration Feed}} \times 100[\%]$$

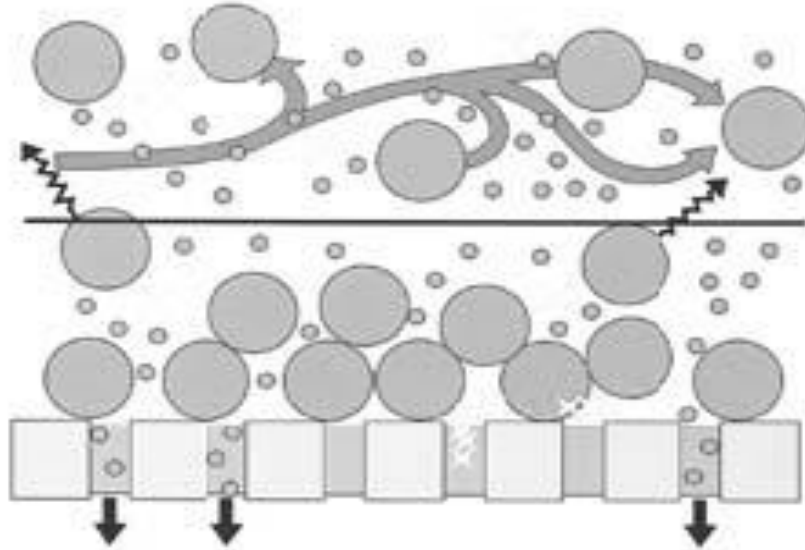
$$\bullet \text{Recovery} = \frac{\text{flow Permeate}}{\text{flow Feed}} \times 100[\%]$$

$$\bullet \text{Flux} = \frac{\text{flow}}{\text{Area}} \text{ (LMH)}$$



Operations (fouling)

- Fouling of membranes due to accumulation of solute/particulates at the membrane interface has to be addressed for economic reasons. The membranes are too expensive to be replaced for reasons of fouling.
- All membranes are subject to fouling, no exception.
- Fouling is acceptable as long as it is reversible and manageable .

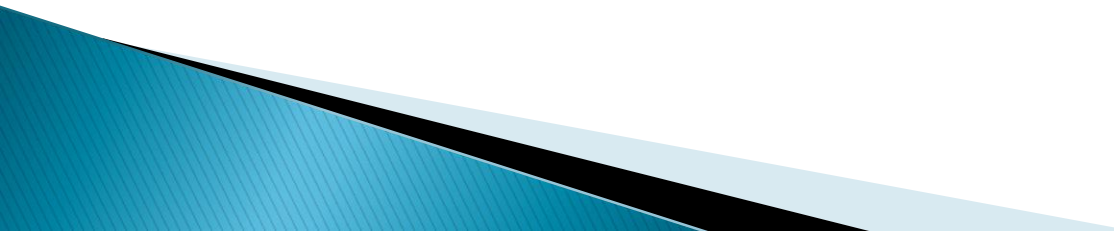


Operations (fouling)

Potential Fouling Material

- Natural organic matter.
- Colloids.
- Inorganic material.
- Synthetic polymers.

Fouling Mitigation

- Pretreatment.
 - Frequent back wash (UF).
 - Frequent chemical cleaning.
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Operations

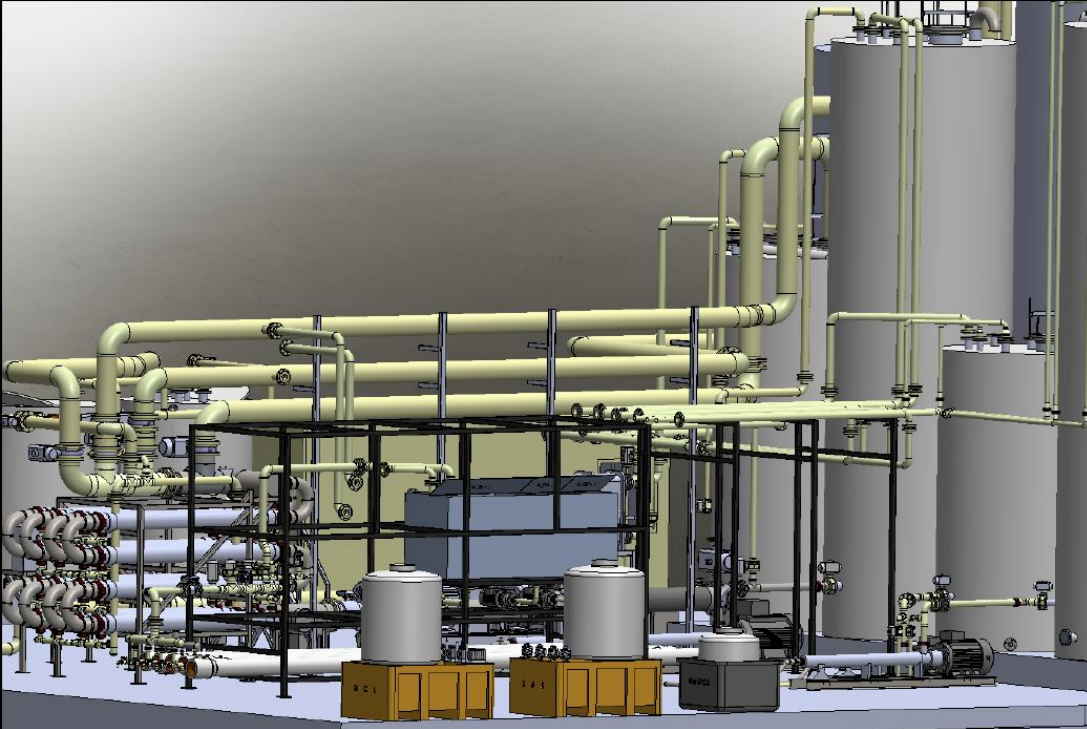
(Pilot Plant for process evaluation)



Operations

(Pilot Plant for process evaluation)





Summary

- Membrane is a Mature Technology
 - Membrane can be used to concentrate Steviol Glycosides
 - A Successful Membrane Operation Depends on:
 - The Selection of an Appropriate System and membrane
 - Optimized Operating Conditions
 - Manageable Membrane Fouling
 - Pretreatment
 - Trained personal
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