

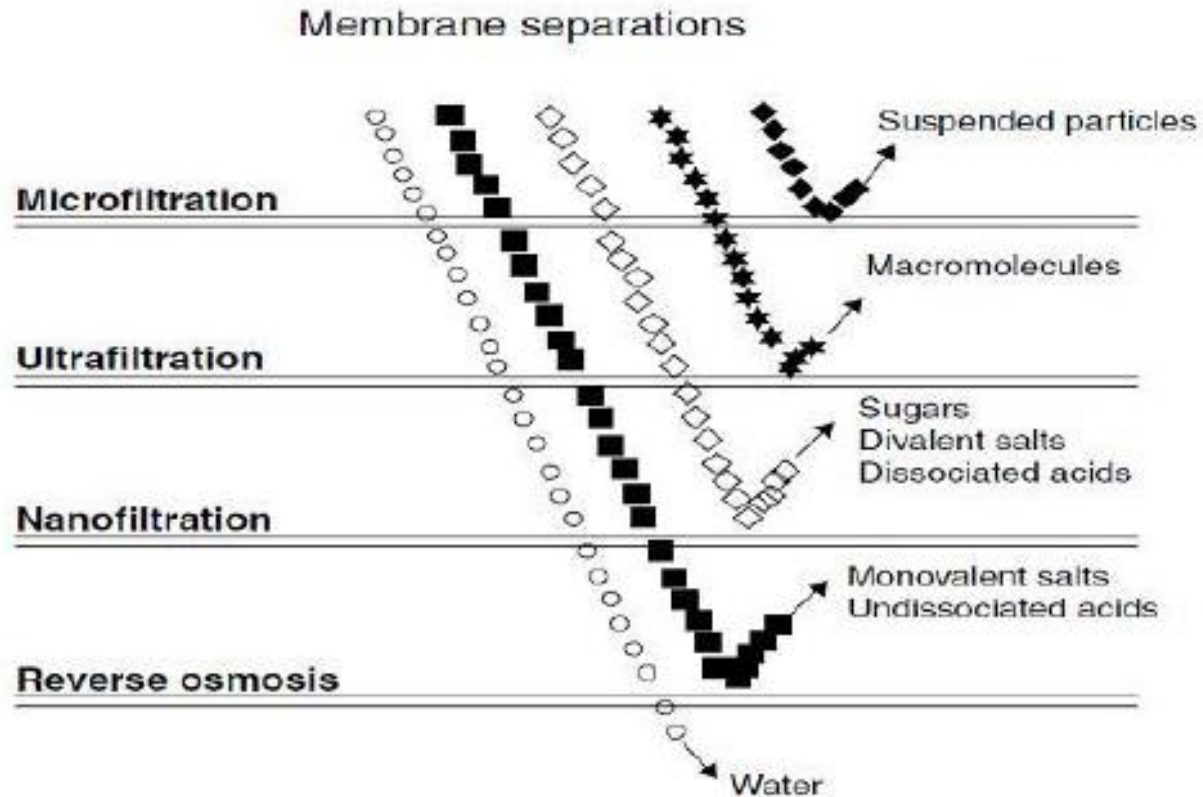
Ultrafiltration

Membrane processing is used in the dairy industry for **non-thermal processing**, to retain most of the nutrients and is mainly used for manufacture of health and functional foods, through concentration and fraction of various components. This involves, Ultra Filtration, Reverse Osmosis, Micro Filtration and Electrodialysis.

Uses of Membrane filtration

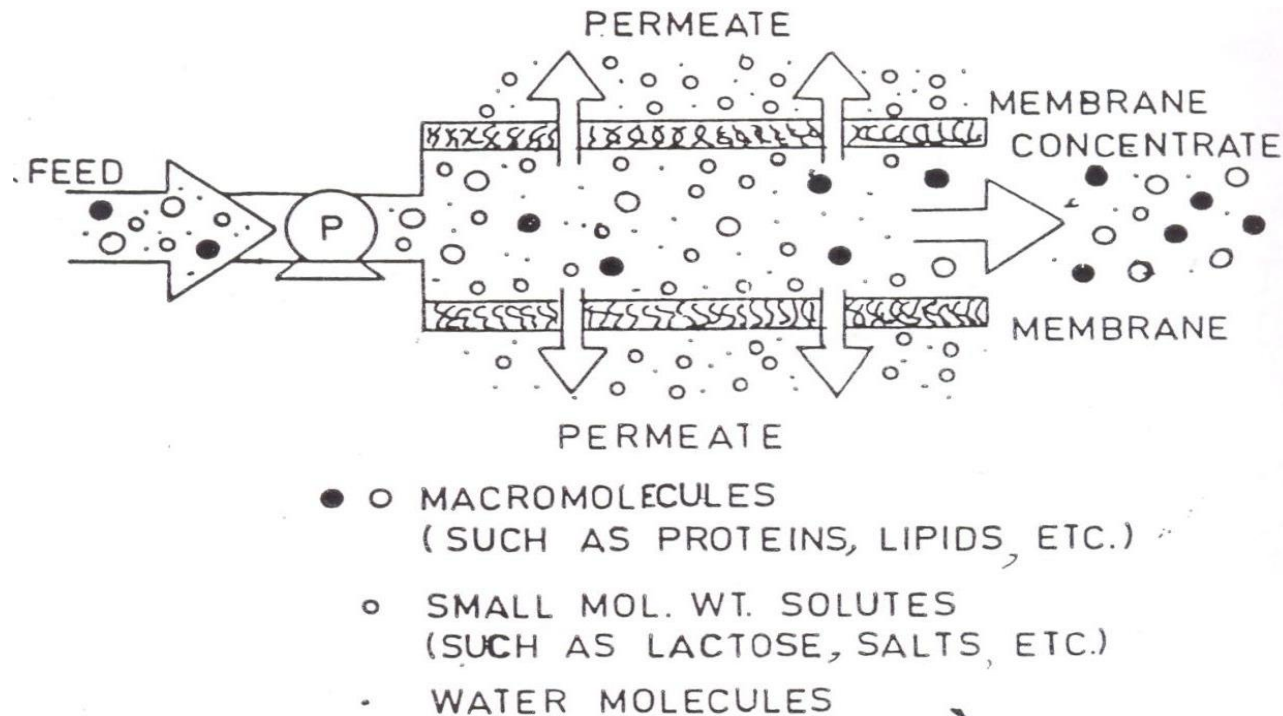
1. Whey can be efficiently concentrated from protein which has high BOD.
2. Cheaper method than drying as it involves pumping as against evaporation of moisture
3. Possibility of incorporating whey proteins into cheese.
4. Milk also can be concentrated without damage to protein or changing flavor unlike in concentration and drying.
5. Other industrial uses, like water purification, fractionation and concentration in food and pharmaceuticals, recovery of various components of waste for further use.

Types of Membrane separation



The various membrane processes have different range of conditions under which they operate as well as the basic principle of drive. However, the heart of the membrane process is the membrane itself.

Terminology



Membrane: A membrane can be defined as a phase which acts as a barrier to flow of molecular or ionic species between other phases that it separates. It is either dry solid, a solvent swollen gel, or a liquid that is immobilized.

Semipermeable membrane: A membrane which allows some molecules to pass and retains other according to their size.

Composite membrane or thin film: Thin filtering layer built on to the support layer and the two layers are of different materials.

- **Asymmetric Membrane:** Chemically of the same material throughout but physically is of different structure on its two sides.
- **Membrane cut off:** Molecular weight above which 100 % (in practice 95%) of a solute is retained by the membrane.
- **Permeate:** The filtrate, the liquid passing through the membrane.
- **Concentration Factor:** The volume reduction achieved by concentration.
- **Retention Factor:** It specifies the ability of a membrane to retain that molecule.
- **Separation Factor (s)** a measure of performance of the membrane in separating solvent and solute.
- **Concentration Polarization :** Increase in concentration of solids in the direction towards the membrane due to the extraction of permeate through the membrane.
- The rediffusion of concentrated solids back into the feed is governed by Fick's law. This law describes molecular diffusion .

$$J_{AB} = -D_{AB} \frac{d_{CA}}{dz}$$

- **Flux:** Rate of extraction of permeate, measured in litres/sq. h.
- The flux or the flow rate in the membrane under laminar flow is governed by Hagen Poiseuille equation. This equation relates the pressure drop, path geometry and viscosity of fluid flowing through membrane under laminar condition.

- Rejection = $1 - (\text{solute conc. in Permeate} / \text{solute conc. in Retentate})$
- Volume concentration ratio (VCR) = Initial feed volume / Retentate volume
- Weight concentration ratio (WCR) = Initial feed weight / Retentate weight
- Volume reduction % = $\{1 - (1 / \text{VCR})\} \times 100$
- Transmembrane Pressure: Pressure gradient between Retentate side and permeate side.
- Retentate: Fraction of feed stream not passing through the membrane.
- Permeate: Fraction of feed stream passing through the membrane.
- Hold up volume: volume of concentrate remaining in the module.
- Concentration polarization (CP): A higher concentration of retained solute species adjacent to the membrane surface than in the bulk stream.

Microfiltration (MF) :

- MF is a pressure-driven employing pressures considerably lower than others especially Reverse Osmosis. In fact the distinction between UF and MF is somewhat arbitrary and there is no distinction on purely theoretical grounds.
- The distinction lies in the size ranges of the materials which are separated. **UF is considered to involve the processing of dissolved macromolecules, while MF involves separation of dispersed particles such as colloids, fat globules or cells.**
- MF can be considered to fall between UF and conventional filtration, although there is overlap at both ends of the spectrum.

Ultra Filtration(UF):

- Ultra filtration can be defined as a pressure driven membrane process that can be used in the separation and concentration of substances having a molecular weight between $10^3 - 10^6$ Dalton.
- UF is a process where the high molecular weight component, such as protein, and suspended solids are rejected, while all low molecular weight component pass through the membrane freely. There is consequently no rejection of mono and disaccharides, salts, amino acids, organics, inorganic acids or sodium hydroxide.

Characteristics of Ultrafiltration:

- Membrane: Asymmetrical
- Thickness: 150 – 250 μm
- Thin film: 1 μm
- Pore size: 0.2 – 0.02 μm
- Rejection of: Macro molecules, proteins, polysaccharides
- Membrane materials: Ceramic, PSO, PVDC, CA, thin film
- Membrane module: Tubular, hollow fibre, spiral wound, plate-and-frame
- Operating pressure: 1-10 bar
- Mechanism of membrane retention: Molecular screening
- Typical flux: 30 – 300 $\text{lit}/\text{m}^2\text{h}$
- **Polymers used in membrane manufacturing:**
 - Cellulose Acetate
 - Polyamide membranes
 - Polysulfone membranes
 - Ceramic Membrane

Fouling of membrane:

Fouling is termed as decline in flux when all operating parameters like pressure, flow rate, temperature and feed concentrations are kept constant. It can be avoided by:

- Pretreatment of feed.
- Maintain minimum axial velocity.
- Dynamic pressure of flow should be higher.
- For proteinaceous feed, pH far away from iso- electric point is maintained.

U.F. membrane preparation methods:

- Phase inversion
- Thermal inversion
- Dynamic membrane
- Ultrathin composite membranes
- Track – etched membranes

Disadvantages:

- As the surface of membrane is not smooth, building of scale leads to idle environment for bacterial growth.
- The voids provide space for growth of micro-organisms.
- Disassembly of the UF equipment for manual cleaning is not practical due to high surface area involved.
- Membrane materials like cellulose acetate have high sensitivity to several cleaning and sanitizing solutions.

Applications

- Separation and fractionation of individual milk proteins from lactose and minerals.
- Enzyme recovery in various operations like lactose hydrolysis using lactase.
- Fractionation of cheese whey
- Pre – concentration of milk for cheese manufacturing.
- Sugar refining
- Vegetable protein processing. e.g. soy proteins
- Concentration of egg white
- Animal products industry. e.g. gelatin
- Biotechnology applications
- Fruit juices & other beverages.