What is Membrane separation?

It is a process of separating food components by using semi-permeable membranes, basing on the molecular size & molecular weight of the components.

The driving forces of the separation process are, for example, differences in concentration or pressure between the two sides of the membrane.

Membrane separation processes remove much smaller substances, such as viruses and dissolved ions, from the water.
Principle of operation

Membrane Processing

Semi-permeable membrane
Pressure applied

Permeate
Retentate

Retentate
Feed
Permeate
Membrane processing Technologies

- Reverse osmosis
- Nano filtration
- Ultra Filtration
- Microfiltration
- Pervaporation
- Ion exchange
- Electro dialysis
Different Membrane concentrations

- Microfiltration
- Ultrafiltration
- Nanofiltration
- Reverse Osmosis

WATER

Bacteria, Fats
Macromolecules
Colloids, Proteins
Sugar, Pigments
Salts
Monovalent Ions
Range of Concentration in various filtration systems

- **Reverse Osmosis**
  - 0.001 μm (1 nm)
- **Ultrafiltration**
  - 0.01 μm (10 nm)
  - 0.1 μm (100 nm)
- **Nanofiltration**
  - 1 μm (1,000 nm)
- **Microfiltration**
  - 10 μm (10,000 nm)

- **Log scale**
  - 2 nm
  - 20 nm
  - 200 nm

- **Particles and Molecules**
  - Ions
  - Virus
  - Pyrogen
  - Sugar
  - Colloidal silica
  - Dyes
  - Albumin Protein
  - Bacteria
  - Paint pigment
  - Yeast
  - Suspended particles

- **Approx. Molecular Weight**
  - 200 D
  - 20,000 D
  - 100,000 D
  - 500,000 D
Reverse osmosis (RO)
Concentration of solution by removal of water

Nanofiltration (NF)
Concentration of organic components by removal of part of monovalent ions like sodium and chlorine (partial demineralisation).

Ultra filtration (UF)
Concentration of large and macro molecules

Microfiltration (MF)
Removal of bacteria, separation of macromolecules
Reverse osmosis...

A membrane separation process, driven by a pressure gradient, in which the membrane separates the solvent (generally water) from other components of a solution. Solvent flow is opposite to the normal osmotic flow.

The membrane pore size is very small allowing only small amounts of very low molecular weight solutes to pass through the membranes.
Reverse osmosis...APPLICATIONS

Broadly used to separate water from **low molecular weight solutes (salts, aroma compounds etc.)**, which have high osmotic pressure.

- Concentrate & purify fruit juices, enzymes, fermentation liquors & vegetable oils; Pre-concentrate juices & dairy products before evaporation.
- Concentrate wheat starch, citric acid, egg white, milk, coffee, syrup, natural extracts & flavors.
- To clarify wine & beer (De-alcoholisation for low alcohol wines & beers)
- To determine & purify water from boreholes or rivers or desalination of sea water.
- Water & waste water purification.
- Concentration of whey during cheese manufacture.
RO Materials & Equipments

- Polymer having high permeability for water, high rejection for soluble salts and durability.
- Cellulose acetate is outstanding being inexpensive.
- Polyacrylo-nitrile, polyamides, polyurethans are also used, but they have low temperature resistance and low pH range.
- Polysulphones and ceramic materials can withstand high temperature and wider pH range.
- Operating pressure ranging from 40 to 80 bar @ 450 to 2400 lit/h of flux.
Advantages of Reverse osmosis

• Very economical

• Low operating cost

• Ability to avoid heat treatment process
Nano filtration (NF)

- New class of pressure-driven membrane processes that lies between RO and UF
- Pressure range: 10-50 bar (lower pressure than RO)
- Rejects ions with more than one negative charge (such as SO42-, CO32-)
- Also known as loose reverse osmosis
- Removes materials having molecular weight between 300 to 1000 Da.
- Employed for pre concentration for R.O.
Nano filtration

- Removal of inorganic salts
  - Na, K, Cl, urea, lactic acid,
- Partial demineralization
- Membranes that leak particle species with a radius in the nanometer range
- Reduce salty taste
- Pretreatment for electro dialysis, ion exchange
- Acid removal
- Reduce salt from cheese making
- Dispersed particles such as colloids, fat globules etc. are separated.
Ultrafiltration is similar to reverse osmosis with low pressure of operation.

In UF, the membrane pore size is larger allowing some components to pass through the pores with the water. It is a separation/fractionation process.
Dia-filtration

Dia-filtration is a specialized type of ultra-filtration process in which the retentate is diluted with water and re-ultra filtered, to reduce the concentration of soluble permeate components and increase further the concentration of retained components.
Equipments

- U.F. membranes have higher porosity.
- They operate under low pressure (0.05 to 10 bar @ 2400 lit/hr of flux).
- Polymers like poly-sulphones, poly-amides, PVC, poly-styrene, poly-carbonates and poly-ethers are normally used.
Applications of Ultra filtration

- Most commonly used to pre concentrate milk prior to preparation of other range of dairy products
- Concentration of sucrose & tomato paste.
- Separation & concentration of enzymes, other proteins or pectin.
- Treatment of water to remove bacteria and contaminants greater than 0.003 µ dia.
- To selectively remove lactose and salts from the whey.
- Removal of protein hazes from honey & syrups.
- Pretreatment for R.O. to prevent fouling by organic and colloidal material
Integrated Membrane filtration system comprising UF plant for WPC & RO plant for Lactose concentration

Source: DSS-Internet
Large membrane filtration installation for whey processing.
Microfiltration

- Microfiltration (MF) designates a membrane separation process similar to UF but with even larger membrane pore size allowing particles in the range of 0.2 to 2 micrometers to pass through.

- The pressure used is generally lower than that of UF process.

- MF is used in the dairy industry for making low-heat sterile milk.
<table>
<thead>
<tr>
<th>Process</th>
<th>Permeate</th>
<th>Concentrate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RO</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>dyeing effluent</td>
<td>clean water</td>
<td>BOD, salt, chemicals, waste products</td>
</tr>
<tr>
<td>water</td>
<td>low salinity water</td>
<td>salty water</td>
</tr>
<tr>
<td>whey</td>
<td>low BOD permeate</td>
<td>whey concentrate</td>
</tr>
<tr>
<td>antibiotics</td>
<td>salty waste product</td>
<td>desalted, concentrated antibiotics</td>
</tr>
<tr>
<td>dyeing effluent</td>
<td>clean, salty water</td>
<td>BOD/COD, color</td>
</tr>
<tr>
<td>water</td>
<td>softened water</td>
<td>waste product</td>
</tr>
<tr>
<td>whey</td>
<td>salty waste water</td>
<td>desalted whey concentrate</td>
</tr>
<tr>
<td><strong>NF</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>antibiotics</td>
<td>clarified fermentation broth</td>
<td>waste product</td>
</tr>
<tr>
<td>bio-gas waste</td>
<td>clarified liquid for discharge</td>
<td>microbes to be recycled</td>
</tr>
<tr>
<td>carrageenan</td>
<td>waste product</td>
<td>concentrated carrageenan</td>
</tr>
<tr>
<td>enzymes</td>
<td>waste product</td>
<td>high value product</td>
</tr>
<tr>
<td>milk</td>
<td>lactose solution</td>
<td>protein concentrate for cheese production</td>
</tr>
<tr>
<td>oil emulsion</td>
<td>oil free water (&lt;10 ppm)</td>
<td>highly concentrated oil emulsion</td>
</tr>
<tr>
<td>washing effluent</td>
<td>clarified water</td>
<td>dirty water (waste product)</td>
</tr>
<tr>
<td>water</td>
<td>clarified water</td>
<td>waste product</td>
</tr>
<tr>
<td>whey</td>
<td>lactose solution</td>
<td>whey protein concentrate</td>
</tr>
<tr>
<td>xanttan</td>
<td>waste product</td>
<td>concentrated xanttan</td>
</tr>
<tr>
<td>Type of membrane</td>
<td>Advantages</td>
<td>Limitations</td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>-------------------------------------------------</td>
<td>------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Cellulose acetate</td>
<td>High permeate flux, good salt rejection, easy to manufacture</td>
<td>Operates below $30^\circ$C and pH range 3 to 6. broken down by chlorine</td>
</tr>
<tr>
<td>Poly sulphones, poly amides, PVC, poly styrene, poly carbonates, poly ethers</td>
<td>Better temp. resistance</td>
<td>Don’t withstand high pressure-restricted to U.F., Poly amides are more sensitive to chlorine than cellulose acetate</td>
</tr>
<tr>
<td>Composite or ceramic membranes (porous carbon, zirconium oxide, Alumina)</td>
<td>Inert, very wide range of operating temp. and pH, resistance to chlorine and easily cleaned</td>
<td>Expensive</td>
</tr>
</tbody>
</table>
Thank You!