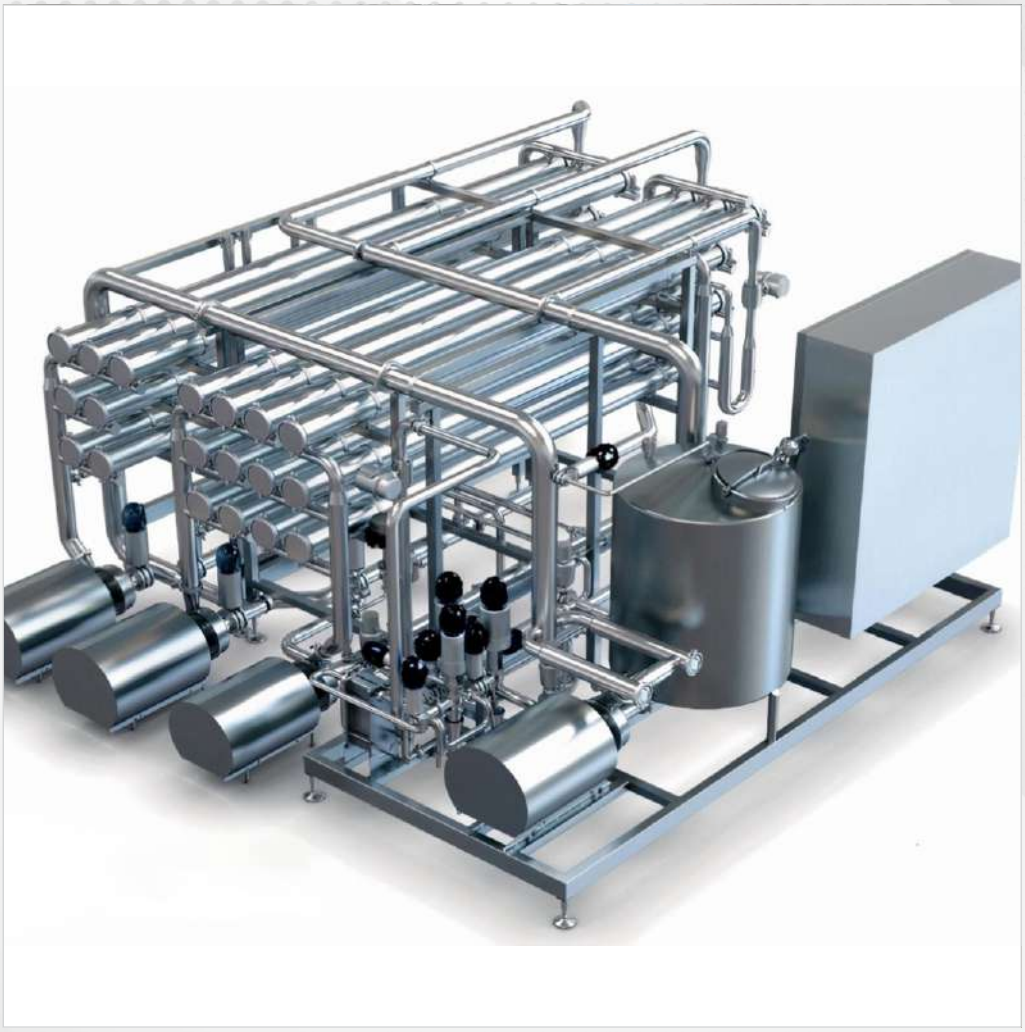
FOOD & BIOTECH ENGINEERS (I) PVT. LTD.



FBE

Fbe Membrane
FILTRATION
SYSTEM

MEMBRANE FILTRATION TECHNOLOGY OVERVIEW

- Membrane filtration is a separation process which separates a liquid into two streams by means of a semi-permeable membrane.

- The two streams are referred to as retentate and permeate. By using membranes with different pore sizes, it is possible to separate specific components of milk and whey. Depending on the application in question, the specified components are either concentrated or removed/reduced.



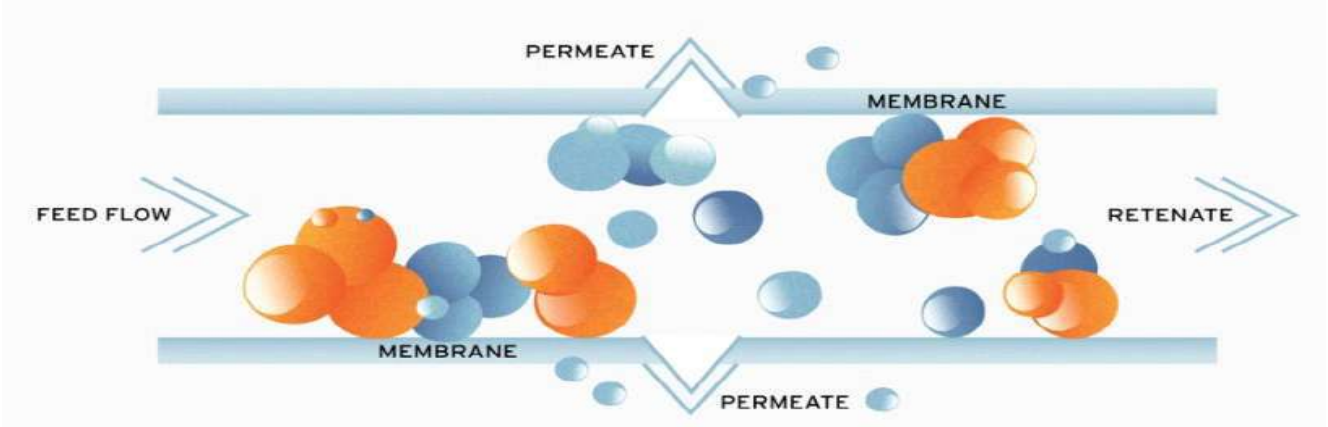

DAIRY APPLICATIONS

CROSSFLOW FILTRATION

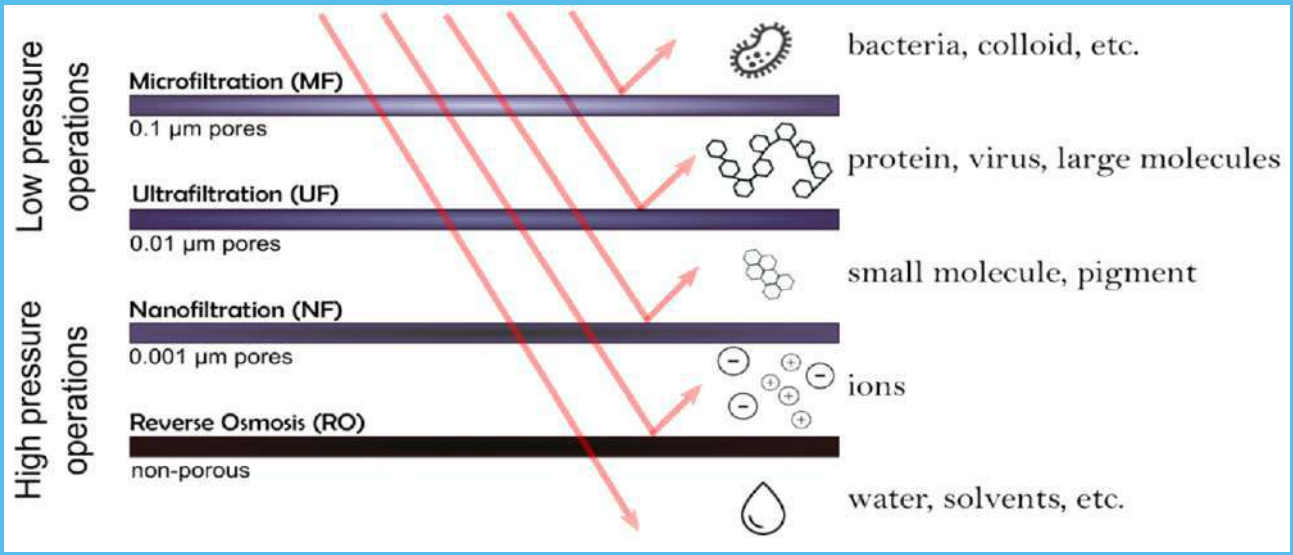
- Crossflow filtration is a process where product is separated through a porous membrane while the feed solution flows rapidly across the surface of the membrane.

- Rapid crossflow causes turbulence at the surface of the membrane, which serves to keep the membrane from becoming plugged. As a result, a large volume of solution can be filtered in a short period of time.

  Crossflow filtration is often referred to as tangential flow filtration because the feed solution flow is tangential to the surface of the membrane. The clarified solution is termed the filtrate or permeate. The concentrated solution that exits the membrane device is termed the concentrate.



TYPE OF MEMBRANE FILTRATION SYSTEM

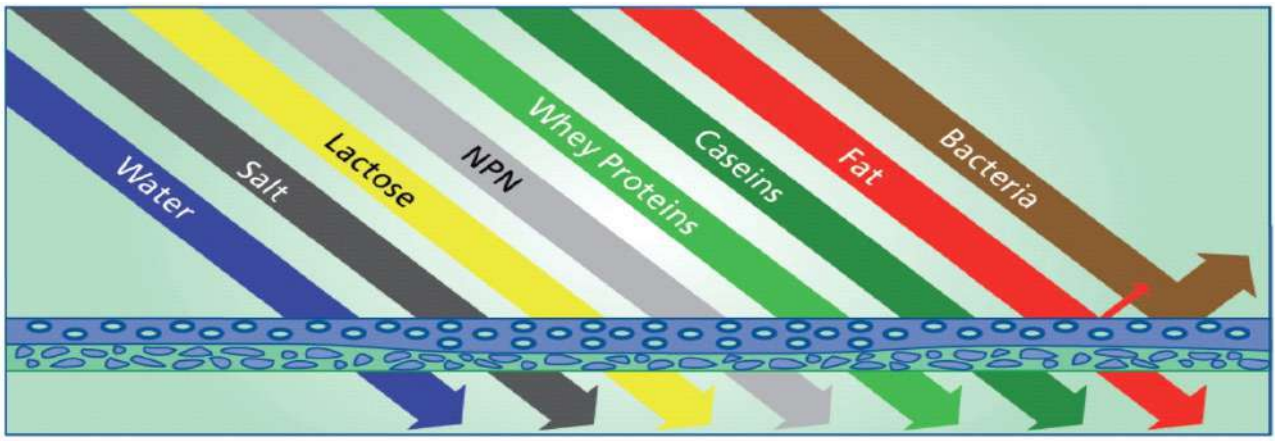


1. MICROFILTRATION (MF)

- Microfiltration is a low pressure-driven membrane filtration process, which is based on a membrane with an open structure allowing dissolved components to pass while most non-dissolved components are rejected by the membrane.

Advantages of FBE MF System

- Higher permeability of Native Whey Proteins
- Lower space requirements
- Less Diafiltration water
- Lower cost



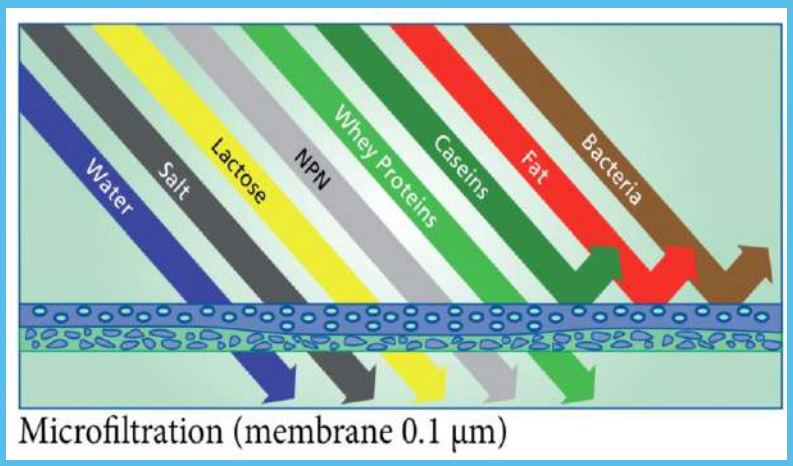
Microfiltration (membrane 1.4 µm)

1.1 APPLICATIONS OF MF SYSTEM

- **Bacteria and spore removal**
  - Cheese milk
  - Market milk (ESL)
  - Powder milk
  - Cheese whey
- **Protein fractionation**
  - Cheese milk
  - Powder milk
  - Market milk
- **Defatting of whey**
  - For WPI 90 Production
- **Cheese brine clarification**

1.2 APPLICATIONS OF MF SYSTEM

MICELLAR CASEIN PRODUCTION VIA MF (ACHIEVING PURITY LEVELS OF 95/5)



Microfiltration (membrane 0.1 µm)

During the last couple of decades, industry has been turning to microfiltration techniques that can extract casein in its native, micellar form, without the use of acids or enzymes. Micellar casein extracted using microfiltration is heat stable, and has a much milder flavor and texture, so it is ideal as a high-quality ingredient for nutritional formulas, powders and health drinks and snacks, as well as for its more traditional use in cheese making.

Retentate Fraction is concentrated to produce Micellar casein Concentrate (MCC) Permeate fraction containing Native Whey Proteins - NWP (also called Serum Protein, Ideal Whey Protein, Virgin Whey Protein) Further concentrated to produce Native WPI (NWPI)

1.2 APPLICATIONS OF MF SYSTEM

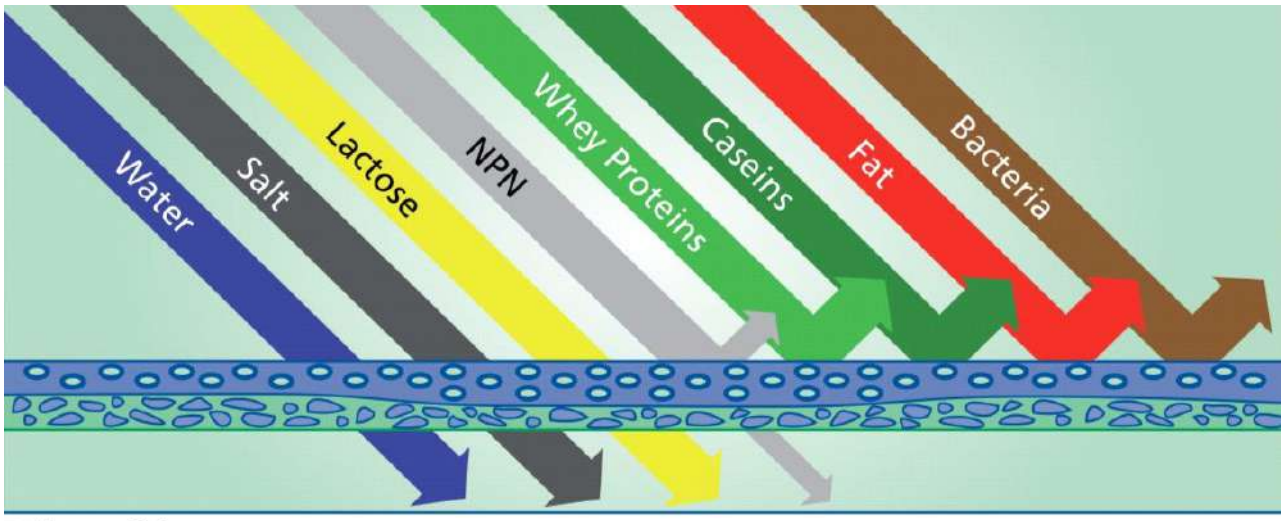
(CHOOSING CERAMIC MEMBRANES OVER POLYMEMRIC MEMBRANES FOR MICELLAR CASEIN PRODUCTION VIA MF)

Comparison	Spiral Wound	Ceramics
Running cost	Low	High
Investment	Low	High
Sensitivity suspended solids	High	Low
Sensitivity viscosity	Medium	Low
Permeate flux	Low	Medium
Membrane life	1 – 2 years	10 Years
Resistance chemicals and temperature	Medium	High

Comparison	Ceramic MF (50°C)[2]	Spiral Wound MF (50oC)	Spiral Wound MF (10oC)
Casein in Permeate [1]	"Low"	"Low"	"High"
Expected max. running time	8 - 10 hours	8 - 10 hours	20 hours
Reachable CAS/TOP ratio (95%)	"High"	"High"	"High"
SP Permeability	"High"	"Medium"	"Medium"
"Heat and hold" stabilisation	Yes	No	No
Expected max. VCF	VCF 4	VCF 4	VCF 4

2. ULTRAFILTRATION (UF)

- Ultrafiltration is a medium pressure-driven membrane filtration process.
- Ultrafiltration is based on a membrane with a medium-open structure, allowing most dissolved components and some non-dissolved components to pass, while larger components are rejected by the membrane.
- Ultrafiltration will remove: High molecular weight substances, Colloidal materials, Organic polymeric molecules, Inorganic polymeric molecules
- This separation process is used in industry and research for purifying and concentrating macromolecular (103 - 106 Da) solutions, especially protein solutions. Pore diameters in the 10-1000 A range.



Ultrafiltration

2.1 APPLICATIONS OF UF SYSTEM

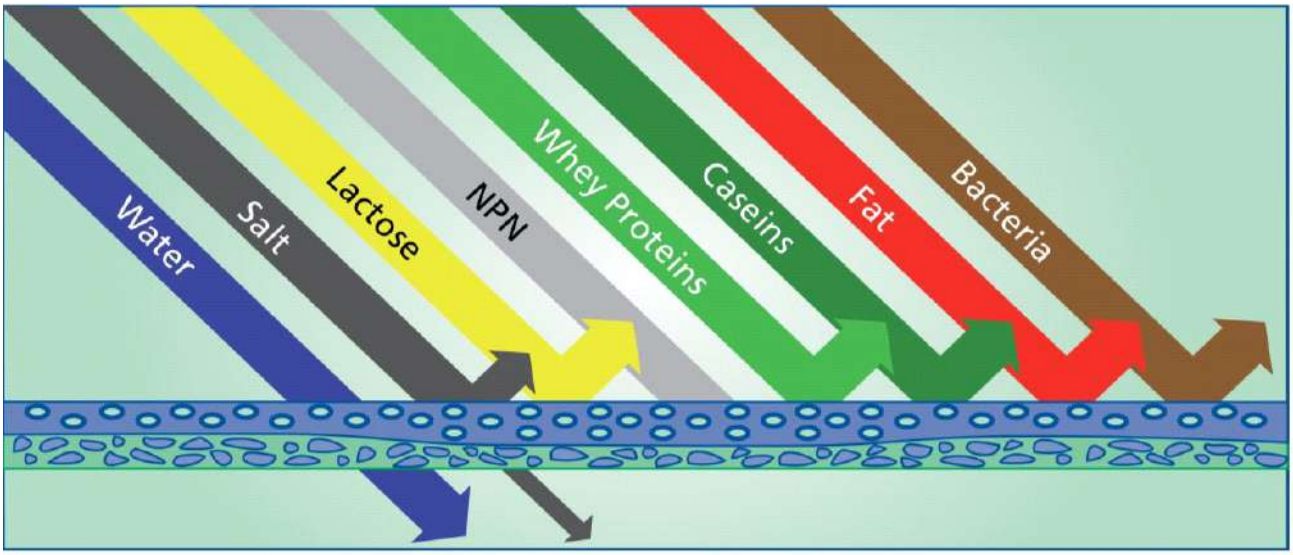
- Protein Concentration / Standardization of:
  - Cheese milk
  - Milk Protein Concentrate
  - Whey Protein Concentrate WPC 35, WPC 50, WPC 65, WPC80, WPI 90

- De-Calcification (Calcium removal)
  - Decalcification of RO/NF concentrated Permeate for lactose Production

- Lactose Reduction (Lactose Free milk)

3. NANO FILTRATION (NF)

Nanofiltration is a medium to high pressure-driven membrane filtration process. Generally speaking, nanofiltration is another type of reverse osmosis where the membrane has a slightly more open structure allowing predominantly monovalent ions to pass through the membrane. Divalent ions are - to a large extent - rejected by the membrane. In the dairy industry, nanofiltration is mainly used for special applications such as partial demineralisation of whey, lactose-free milk or volume reduction of whey.



Nanofiltration

3.1 APPLICATIONS OF NF SYSTEM

- Demineralisation and concentration of:
  - *Milk*
  - *Whey*
  - *UF permeate*

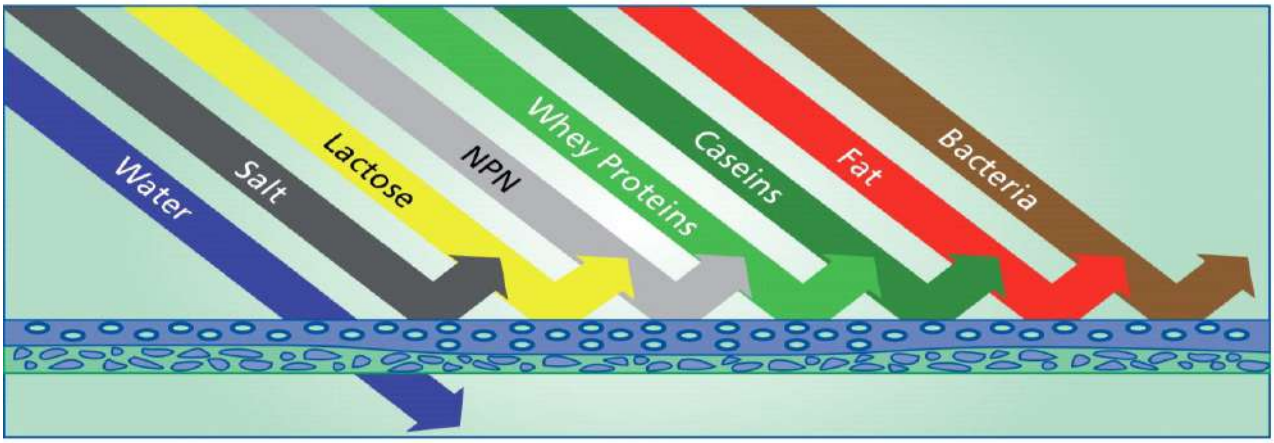
- Lactose Reduction
  - *Lactose-free Milk*

- Detergent Recovery
  - *Purification of CIP (Cleaning-In-Place) Solutions*

4. REVERSE OSMOSIS (RO)

- Reverse Osmosis is a high pressure-driven membrane filtration process which is based on a very dense membrane. In principle, only water passes through the membrane layer.

- In the dairy industry, reverse osmosis is normally used for concentration or volume reduction of milk and whey, milk solids recovery and water reclamation



Reverse Osmosis

4.1 APPLICATIONS OF RO SYSTEM

- **Concentration of**
  - Milk
  - Whey
  - UF permeate
  - Butter milk

- **Polishing of:**
  - RO permeate
  - NF permeate
  - Evaporator condensate

MEMBRANE TYPE

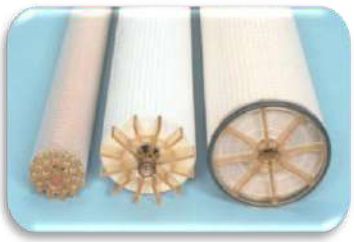
1. **Polymeric**
   - Polymeric membranes include a range of different membrane types such as spiral wound, hollow fibre and flat sheet (plate-and-frame) membranes - all of which are made from organic materials. Polymeric spiral wound membranes provide a high membrane area per element leading to smaller and less expensive plant designs.

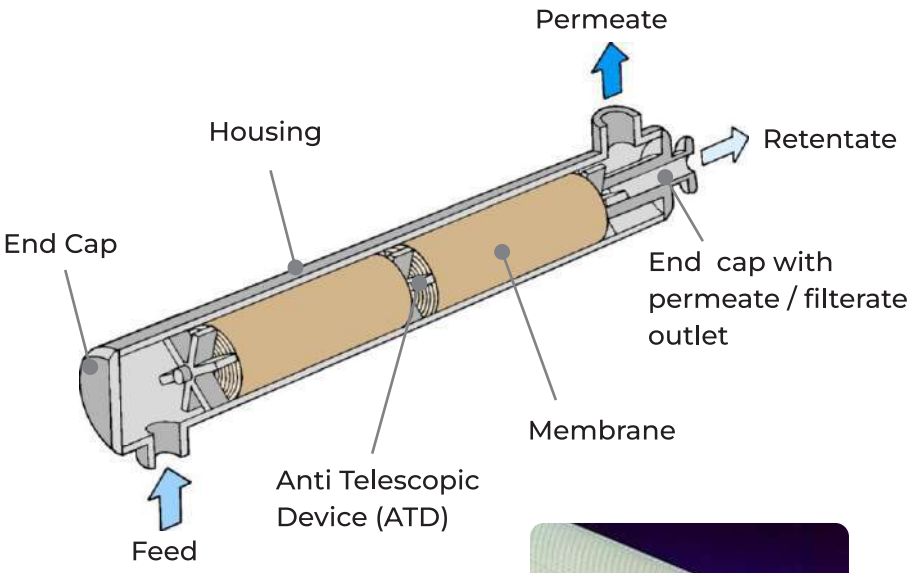
- Cleaning of this type of membranes is, however, complicated, and the lifetime of polymeric membranes is consequently relatively short.

- As polymeric membranes come in a wide range of pore sizes, they can be used for a large number of dairy filtration applications from RO to MF.

2. **Ceramic**
   - Ceramic membranes include a number of membranes which are all made from inorganic materials. As ceramic membranes are Highly resistant to temperature and chemicals, they are easy to clean. The lifetime of ceramic membranes is longer than that of polymeric membranes. However, due to the limited membrane area per element, ceramic membranes are relatively expensive. Ceramic membranes come in a limited range of pore sizes, and are normally only used for microfiltration and in some cases ultrafiltration processes.

UNDERSTANDING POLYMEMRIC MEMBRANES





ADVANTAGES OF MEMBRANE FILTRATION SYSTEM

- **High flexibility:** Membrane filtration has a wide range of applications, from removing large particulate material to removing dissolved compounds. This means that no matter your separation challenge or application needs, different membrane filtration products are available to address them.

- **Lower production costs:** Unlike other technologies, membrane filtration is usually less expensive. This is because of its lower installation costs, lower energy costs, and fewer processing steps. At the same time, it produces a greater degree of purity and higher overall yields. Membrane filters don't result in a filter cake, effectively eliminating costs due to residue disposal.

- **No need for chemicals:** To address the demand for limiting chemical concentrations used in water treatment, membrane filtration is an optimal solution because it doesn't require any chemical additives. Instead, membrane filtration physically removes pathogens and eliminates the need to add chemicals, such as in chlorination.

- **Removes pathogens:** Membrane filtration can remove 90% to 100% of pathogens from the process fluid.

- **Energy efficiency:** Membrane filtration has considerably low energy requirements. For example, using ultrafiltration before nanofiltration and reverse osmosis saves energy by 20%.

- **Keeps proteins intact:** Membrane filtration is one of the most effective methods of separating proteins without denaturing them. Because it does not introduce chemical reagents or heat input, membrane filtration preserves the integrity of proteins.

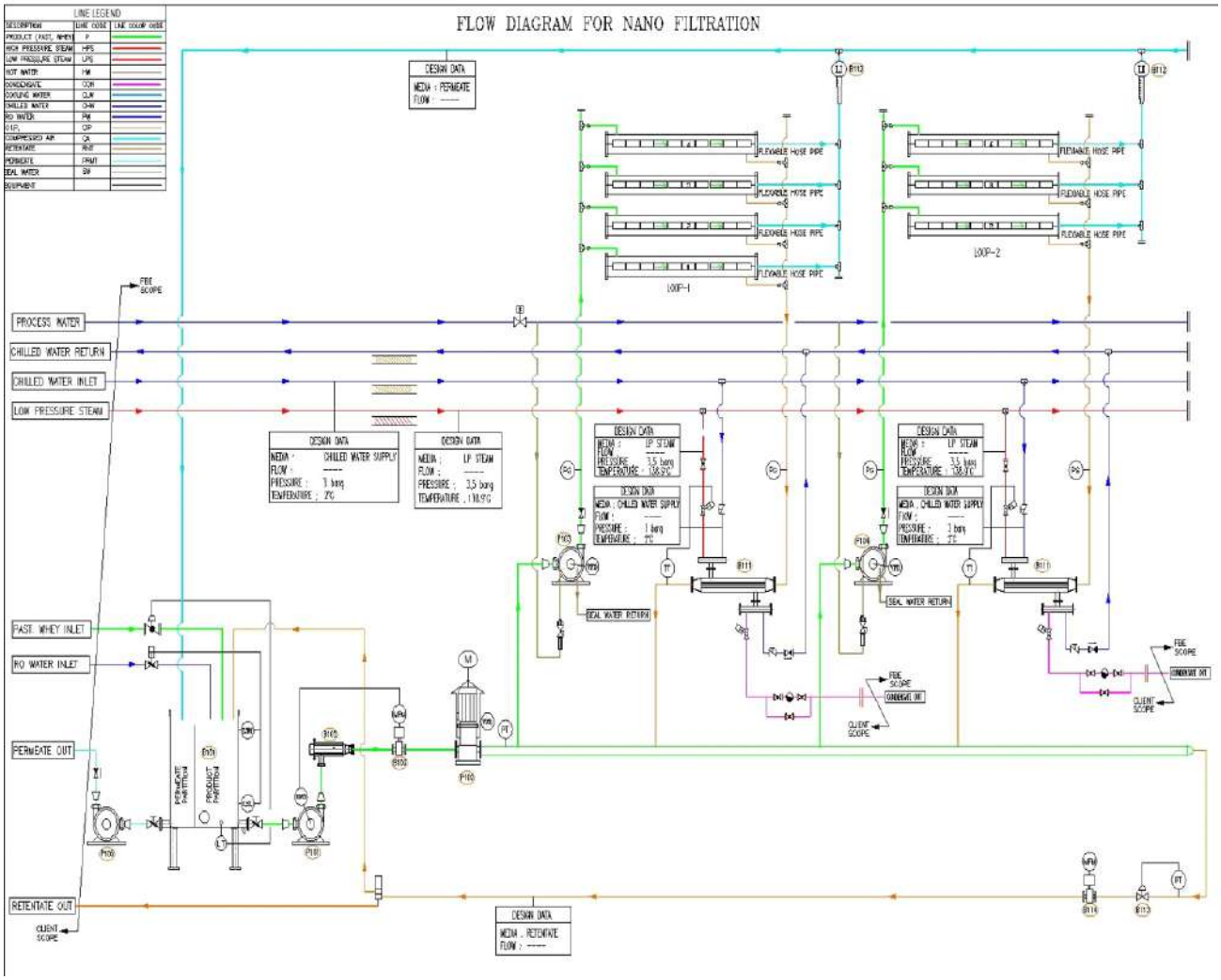
- **Ideal for testing:** Membrane filtration is an effective method of assessing fluid samples for various types of contamination. By transferring the membrane filter from one medium to another, it can isolate and enumerate various bacterial colonies.

- **Saves time:** When obtaining quantitative data, membrane filtration provides quicker results than the MPN (most probable number) method. It only takes 24 hours for membrane filtration to yield results.

- **High-quality end product:** Membrane filtration is a clean, green technology that offers reliable, relevant results. The separation process is based only on molecular size, eliminating the need for additives. This results in a high-quality end product, which more easily complies with the high standards of consumers and strict requirements of regulators.

APPLICATION OF MEMBRANE FILTRATION SYSTEM ACROSS INDUSTRIES

- Food & Beverage
- Dairy
- Sugar
- Pharmaceutical
- Chemical
- Wastewater
- Sweeteners & Starches



WHY CHOOSE FBE

- We offer solutions and guidance for all stages from development through pilot trials to full- scale systems.
- We understand the technology and processes and match them to your needs and requirements.
- We have decades of experience.
- We are open to new ideas and opportunities.
- We are easy to communicate with in all respects.
- We innovate based on customer challenges and cross-industry experience.
- We are independent and do not represent any specific manufacturers

G. ELECTRODIALYSIS IN DAIRY INDUSTRY

Food & Biotech
Engineers (I) Pvt.Ltd.

FBE HAS A JOINT VENTURE WITH SEPARIONICS

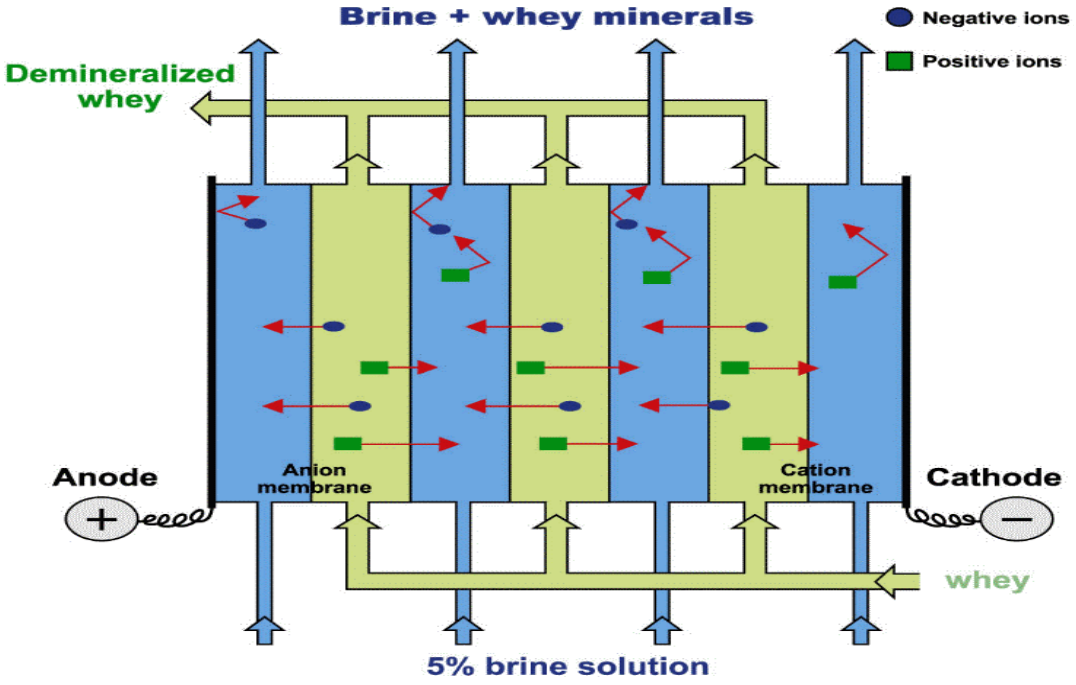
SEPARIONICS

- Company established in November, 2021.
- Joint-venture of companies "BKG Water Treatment" and "Nevox". This partnership enables Separionics to design strongly enhanced solutions, through collaborative product and process development.
- Core business is development, manufacturing and supply of customized engineered systems and solutions based on membrane processes like electro-sorption, electrodialysis, electrodeionization, etc.

OVERVIEW OF ED

- Electrodialysis (ED) is an electro-chemical membrane filtration used to demineralize/desalinate ionized solutions. Under an electric field, ions migrate through ion-exchange membranes from the dilute (feed) compartment to the concentrate (brine) compartment.

- Electrodialysis is used as the most effective process for removal of minerals and organic acids. ED Provides almost complete removal of monovalent ions and a considerable part of the divalent ions such as calcium, magnesium and phosphates.



THREE SOLUTIONS IN ED

- **E-Sorp** is an advanced electro membrane process based on capacitive deionization technology for highly efficient ion removal with lowest energy consumption and high recovery. Perfect for process water desalination, drinking water desalination, energy efficient and environmentally friendly softening and denitrification.

- **E-Sep** is electromembrane separation and synthesis process based on electrodialysis and bipolar electrodialysis for targeted removal of ions from highly saline or complicated liquids, concentration of electrolytes or conversion of salt solutions to basic chemicals.

- **HMS** (Hybrid membrane systems) - combination of pressure-membrane and electro-membrane processes in one technology to achieve the highest product quality and efficiency, as well as the highest added value.

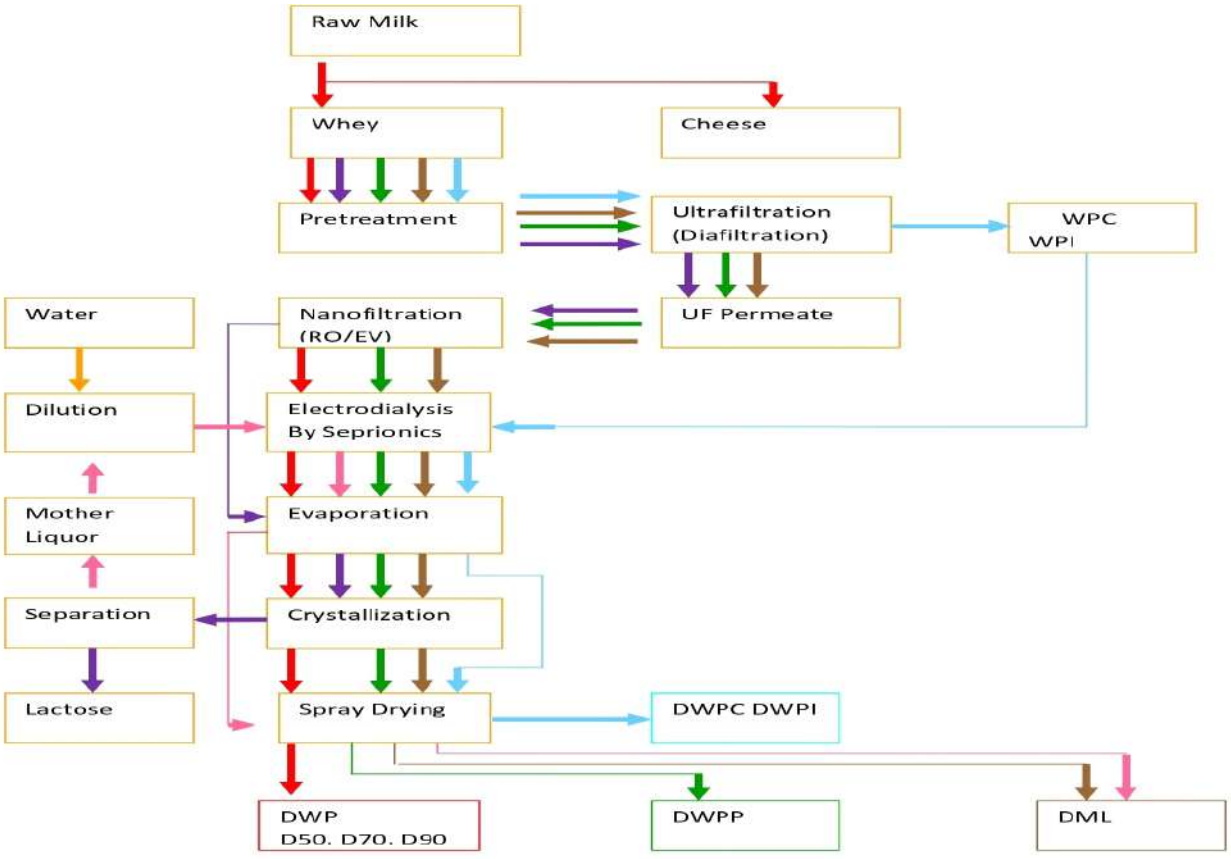
COMPARED TO OTHER DEMINERALIZATION TECHNIQUES, SUCH AS ION-EXCHANGE

- ED significantly reduces the amount of chemical consumption that is associated with resin regeneration (the membrane functional groups are continuously regenerated by the electrical field applied). Time for return of investment decreases with increasing salt content.

- ED systems can be tuned from 0 to 100% capacity to control a constant product quality even with variable feed quality. Process is better controlled allowing a wide range of demineralisation from D50 to D90.

- ED systems proposed by Separionics are modular and easily expandable for future increase of capacity

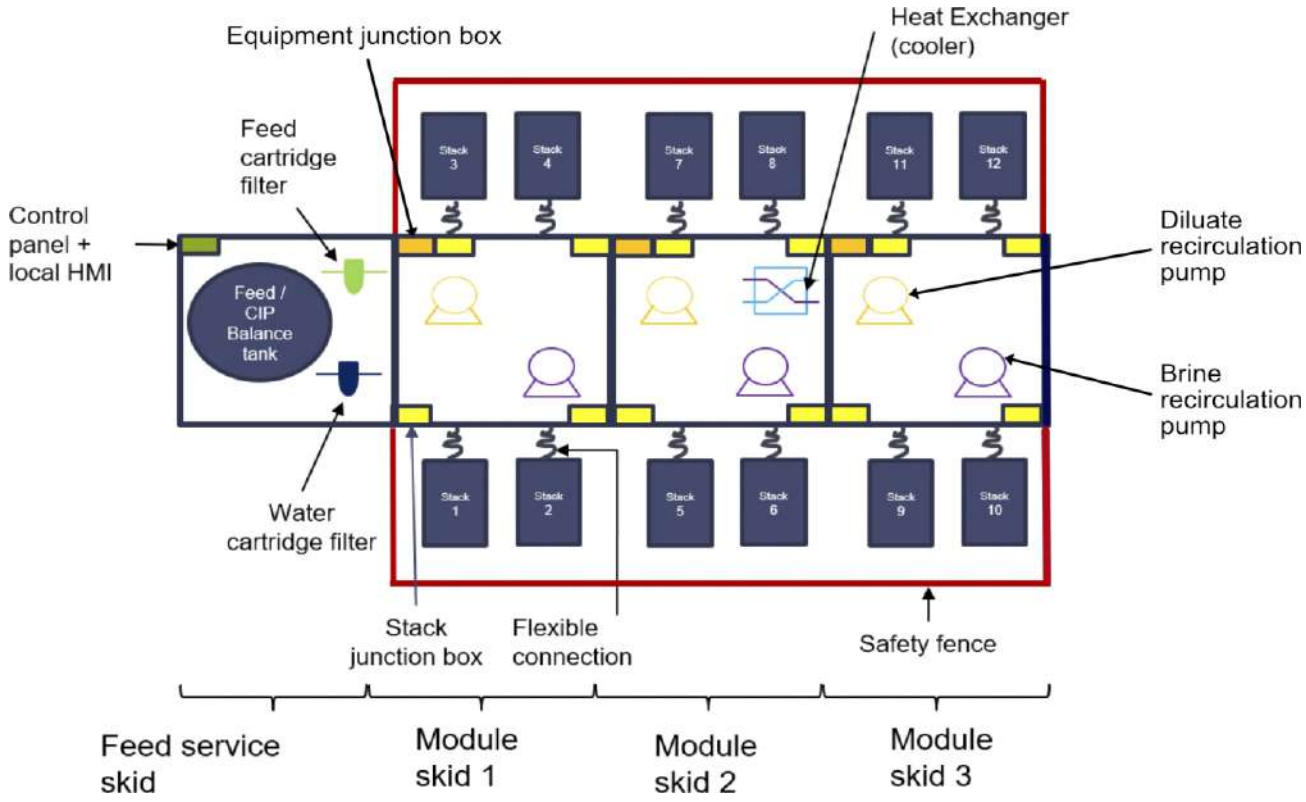
APPLICATIONS OF ED IN DAIRY



1. Demineralization of whey
2. Demineralization of UF permeate
3. Production of lactose with mother liquor as a by product
4. Demineratization of mother liquor
5. Demineralization of UF permeate to produce DML & lactose
6. Demineralization of WPC or WPI

DWP- demineralized whey powder
DWPP- demineralized whey permeate powder
DWPC- demineralized whey protein concentrate
DWPI- demineralized whey protein isolate
DML- demineralized mother liquor
WPC- whey protein concentrate
WPI- whey protein isolate

GA DRAWING FOR ED SYSTEM



BENIFITS OF WHEY DEMINERILIZAION BY ED

- Standardization of whey for following production steps:
- Regulation of mineral content (50%–90%)
- Regulation of acidity (decrease of acidity)
- Minimizing drying process difficulties due to high levels of minerals and lactic acid
- Decreasing of crystallization period
- Increasing the yield of valuable products (e.g.lactose)
- Preserving the product quality
- Lower operating costs

ED-TREATED WHEY PRODUCTS

- Demineralized whey and whey powder
- Demineralized Whey Protein Concentrate
- Demineralized Delactosed Whey
- Concentrated dairy products
- Beverages on whey basis
- Substituted ingredients for ice cream
- Fermented milk products
- Yoghurt
- Lactose, lactulose
- Glucose – galactosis syrups
- Breastmilk substitutes (Infant formula)
- Nurse nutrition products

COMPOSITION OF CONCENTRATED DEMINERALIZED WHEY AND ASH REMMOVAL BY ED

PARAMETERS	RAW WHEY (FROM NF)	50% ASH REMOVAL	70% ASH REMOVAL	90% ASH REMOVAL
Nature protein	1,92	2,02	2,05	2,07
Non-protein nitrogen	0,45	0,43	0,42	0,40
Lactose	11,42	11,85	11,92	12,05
Acid	2,33	1,21	0,77	0,43
Ash content	1,72	0,66	0,39	0,15
Fat	1,16	0,17	0,17	0,17
TS	18.00	16,34	15,72	15,27

ELECTRICITY CONSUMPTION (KWH) PER 1 TON OF DEMINERALIZED WHEY

Level of demineralization, %	Acid		Sweet	
	TS=6%	TS=20%	TS=6%	TS=20%
50	8,40	14,85	4,91	5,87
70	-	20,71	-	10,64
90	-	36,15	-	19,17

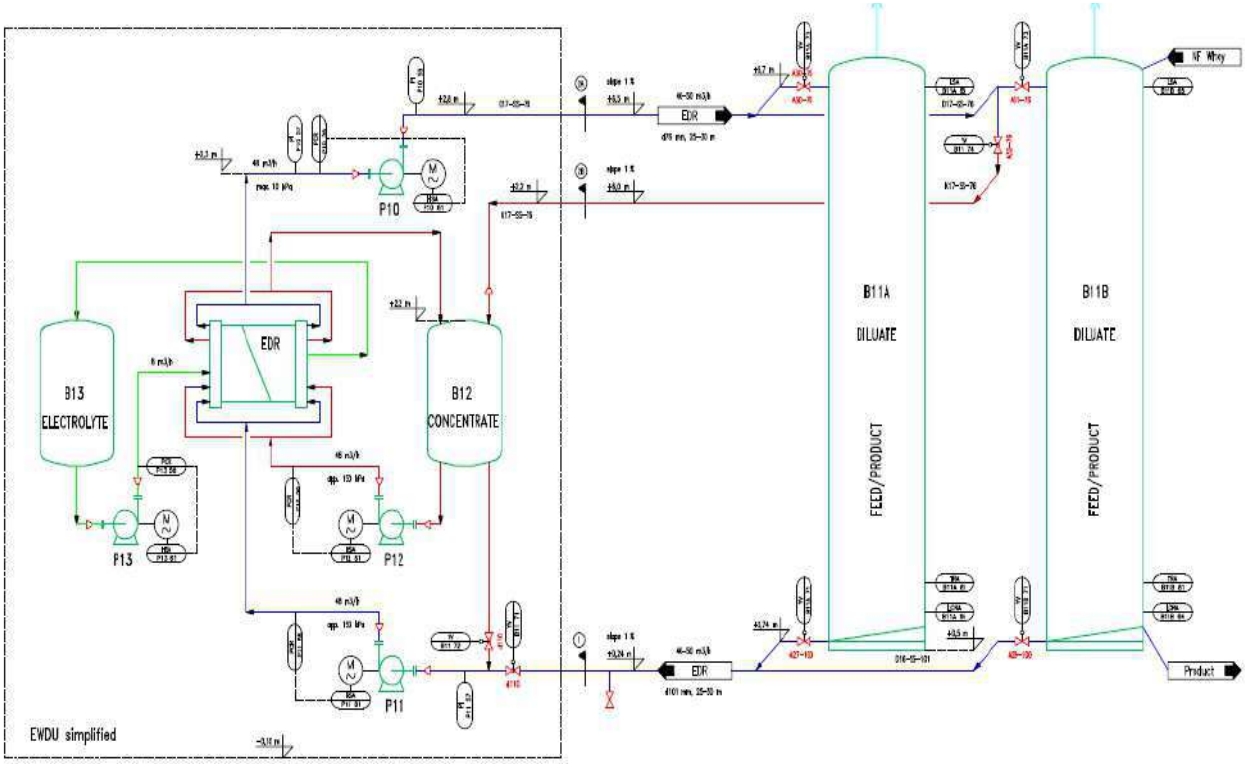
WATER CONSUMPTION (M3) PER 1 TON OF DEMINERALIZED WHEY

Level of demineralization, %	Acid		Sweet	
	TS=6%	TS=20%	TS=6%	TS=20%
50	0,40	0,73	0,35	0,55
70	-	1,01	-	0,80
90	-	1,48	-	1,14

CHEMICAL REAGENTS CONSUMPTION (KG) PER 1 TON OF DEMINERALIZED WHEY

Level of demineralization, %	Acid				Sweet			
	TS=6%		TS=20%		TS=6%		TS=20%	
	NaOH	HNO3	NaOH	HNO3	NaOH	HNO3	NaOH	HNO3
50	0,9	0,71	0,9	0,71	0,9	0,71	0,9	0,71
70	-	-	0,9	0,71	-	-	0,9	0,71
90	-	-	0,9	0,71	-	-	0,9	0,71

PROCESS DIAGRAM FOR EDR

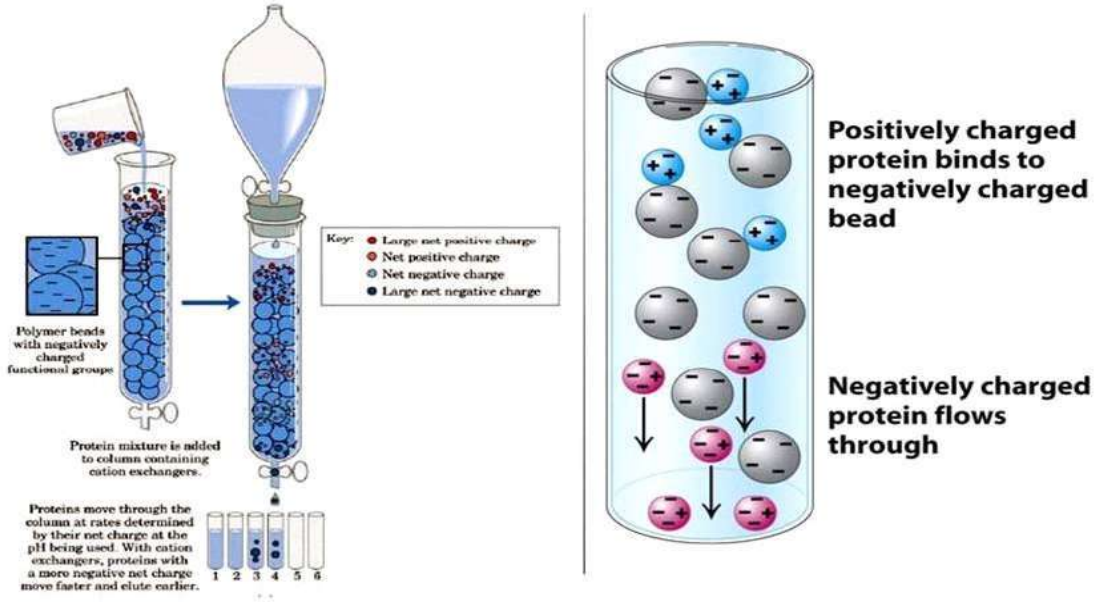


ION EXCHANGE OVERVIEW

- Ion- exchange chromatography is based on electrostatic interactions between charged protein groups, and solid support material (matrix). Matrix has an ion load opposite to that of the protein to be separated, and the affinity of the protein to the column is achieved with ionic ties.

- Proteins are separated from the column either by changing pH, concentration of ion salts or ionic strength of the buffer solution. Positively charged ion- exchange matrices are called anion-exchange matrices, and adsorb negatively charged proteins. While matrices bound with negatively charged groups are known as cation-exchange matrices, and adsorb positively charged proteins

ION EXCHANGE CHROMATOGRAPHY PRINCIPLE



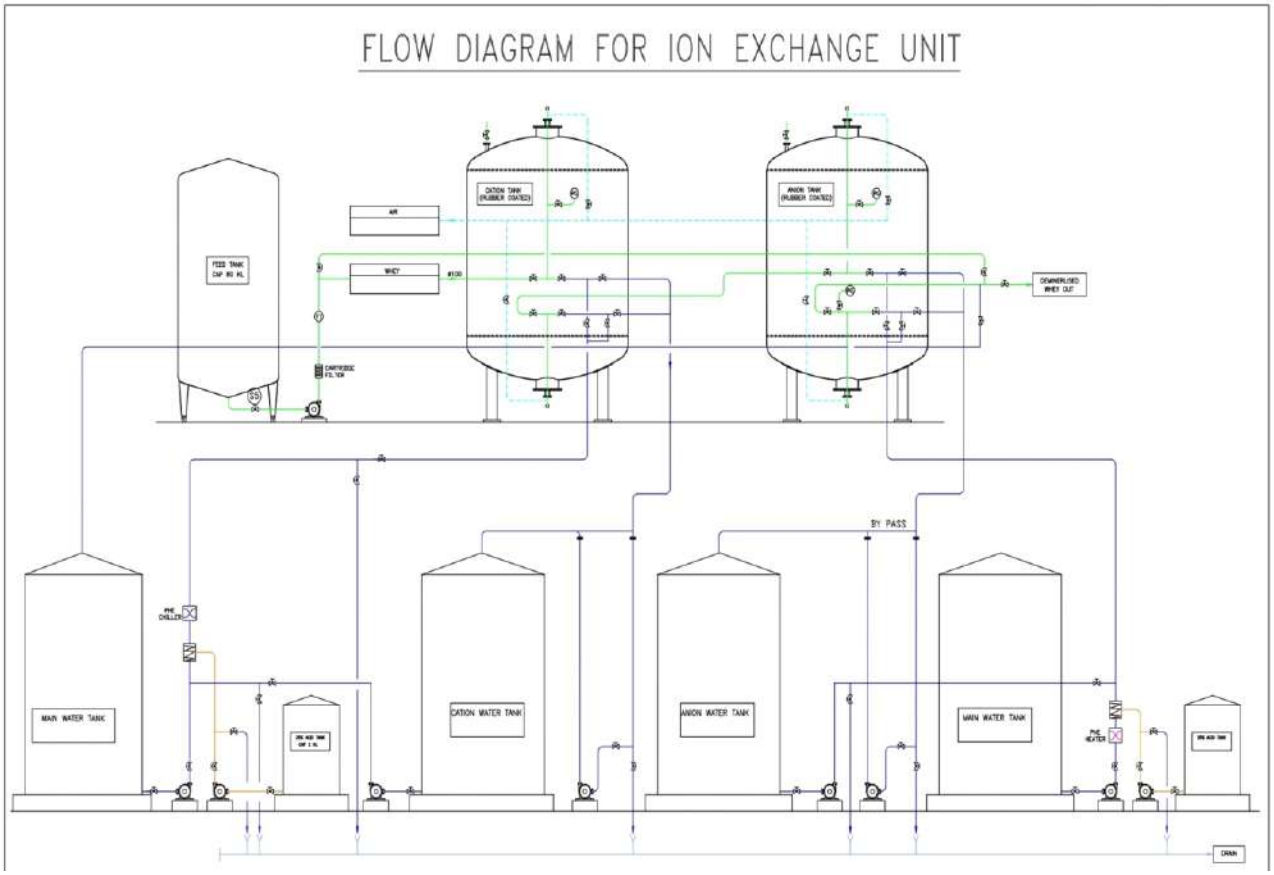
PROCESS DESCRIPTION

- During the demineralization process (production), the product will successively go through a cationic ion-exchange resin and an anionic ion-exchange resin. When the resins are saturated with the removed organic and mineral components, the production is stopped, and each resin bed is regenerated separately:
  - the cationic resin with a diluted solution of strong acid (HCl at 5 % concentration)
  - the anionic resin with a diluted solution of strong base (NaOH at 4 % concentration)

- After regeneration, the resin beds are rinsed with water and are ready again for a new production run.

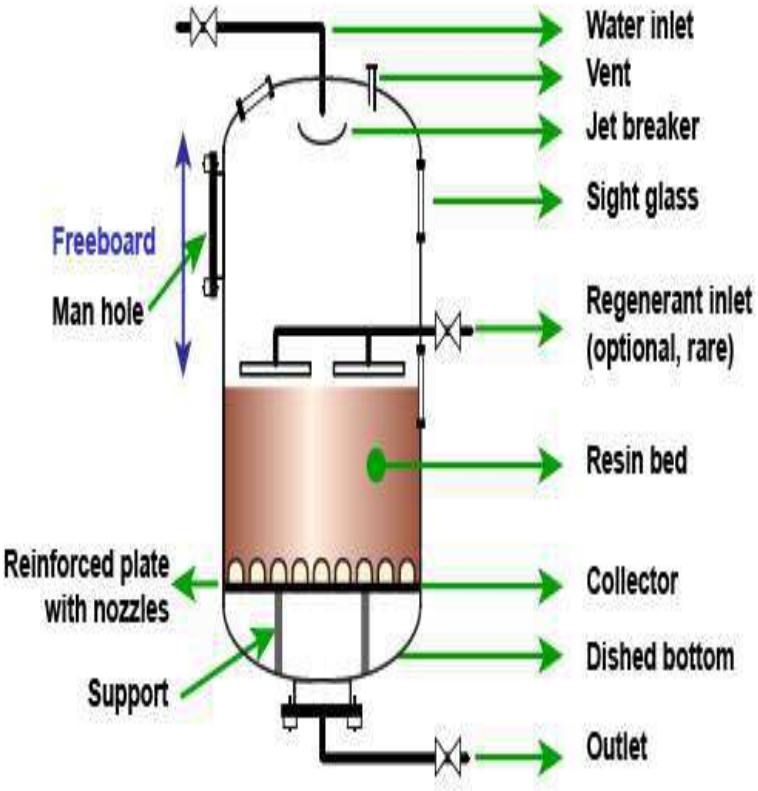
- The streams outgoing from the cationic and the anionic column are fitted with a resin trap. These traps prevent the cationic or the anionic resin from going in other parts of the process.

DEMINERILIZATION VIA ION EXCHANGE



ION EXCHANGE COLUMNS

Ion exchange resins are used in columns. These are pressure vessels, usually made of rubber-lined steel. Small units are made of fiberglass reinforced plastic, and units used in the food industry are often made of stainless steel. A typical ion exchange column with co-flow regeneration is represented below:



ION EXCHANGE CHROMATOGRAPHY

ADVANTAGES

- LONG LIFE OF RESINS
- CHEAP MAINTENANCE
- ENVIROMENTAL FRIENDLY AS IT DEALS ONLY WITH SUBSTANCE OCCURING IN WATER

DISADVANTAGES

- NATURE AND PROPERTIES OF ION EXCHANGE RESINS
- NATURE OF EXCHANGING IONS
- THERE ARE SOME SUBSTANCES THAT CAN FOUL THE RESINS

SOME OF OUR PRESTIGIOUS CLIENTS

And many more !

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