“ SEPERATION PROCESS”

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Introduction

- **Separation** is simply the process of dividing material into its component parts.
- Separation techniques are essentially methods of purification.
- Homogeneous and heterogeneous mixtures can be **separated** into their components by several physical methods
- The choice of **separation** techniques is based on the type of mixture and difference in the chemical properties of the constituents of a mixture.

Classification of Separation Process

Based on the nature or physical mechanism of separation, various separation processes can be classified into,

1) **Mechanical separations**: separations based on size and/or density differences of different components in a mixture, for separation of solid from liquid (*e.g. filtration and centrifugation*).

2) **Diffusional separations** (mass transfer operations): separations based on molecular movement toward a favourable phase, for separation of dissolved components *(e.g. distillation, absorption, extraction*). ("Mass transfer is the transfer of solute molecules from one point to anther or from one phase to another.")

3) **Membrane separations**: use of a semipermeable membrane to separate molecules with difference in size or some other properties.

Various types of separation processes are:

- Separating Funnel
- Centrifugation
- Evaporation
- Crystallization
- Magnetic separation
- Filtration
- Sedimentation
- Distillation
- Membrane Separations
- Chromatography

SEPARATING FUNNEL

A separating funnel is used for the separation of components of a mixture between two immiscible liquid phases. One phase is the aqueous phase and the other phase is an organic solvent. This separation is based on the differences in the densities of the liquids. The liquid having more density forms the lower layer and the liquid having less density forms the upper layer.

Applications:

- To separate a mixture of oil and water.
- To separate a mixture of kerosene oil and water.

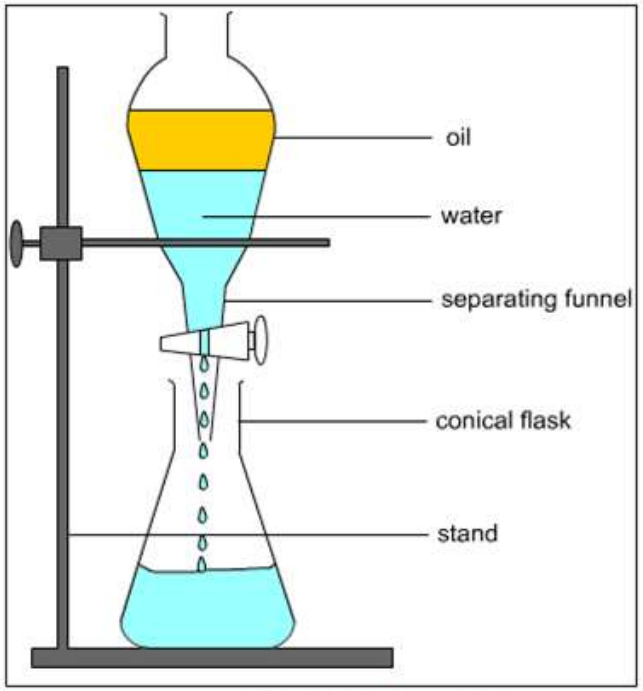


Diagram of Apparatus

CENTRIFUGATION

centrifugation is the process of separation of insoluble materials from a liquid where normal filtration does not work well**.** The centrifugation is based on the size, shape, and density of the particles, viscosity of the medium, and the speed of rotation. The principle is that the denser particles are forced to the bottom and the lighter particles stay at the top when spun rapidly.

The apparatus used for centrifugation is called a centrifuge. The centrifuge consists of a centrifuge tube holder called rotor.

Classification of Centrifuge

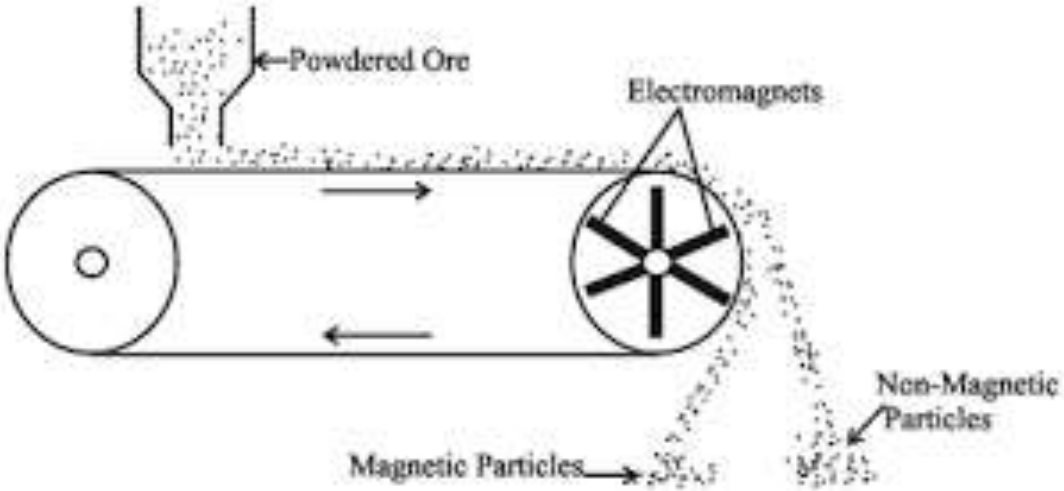
1. Low speed Centrifuge
2. Hight Speed Centrifuge
3. Ultra Centrifuge

EVAPORATION

The general definition of evaporation is the loss or disappearance of a liquid due to vaporization. In the process industry, evaporation process is to concentrate a solution (of a non-volatile solute) or to separate a volatile solvent from a non-volatile solute, by vaporizing and removing part of the solvent (mostly water). In an evaporation process, the liquid solution is usually heated to boiling by steam.

Magnetic separation

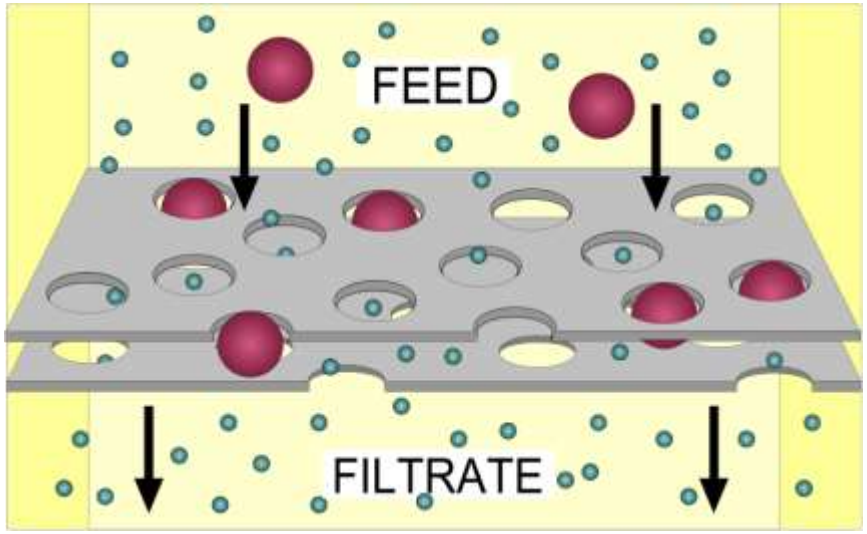
Magnetic separation is a process in which magnetically susceptible material is extracted from a mixture using a magnetic force. This separation technique can be useful in mining iron as it is attracted to a magnet.



FILTRATION

Filtration is the mechanical separation of solid particles from a fluid by passing the fluid through a filtering medium,on which the solids are deposited. The most common filtering medium is fabric cloth with strong mechanical properties.

Filtration is any of various mechanical, physical or biological operations that separate solids from fluids (liquids or gases) by adding a medium through which only the fluid can pass.



- **Hot filtration** method is mainly used to separate solids from a hot solution.

- **Cold Filtration** method is the use of ice bath in order to rapidly cool down the solution to be crystallized rather than leaving it out to cool it down slowly in the room temperature

- **Vacuum Filtration** technique is most preferred for small batch of solution in order to quickly dry out small crystals. This method requires a Büchner funnel, filter paper of smaller diameter than the funnel, Büchner flask, and rubber tubing to connect to vacuum source.

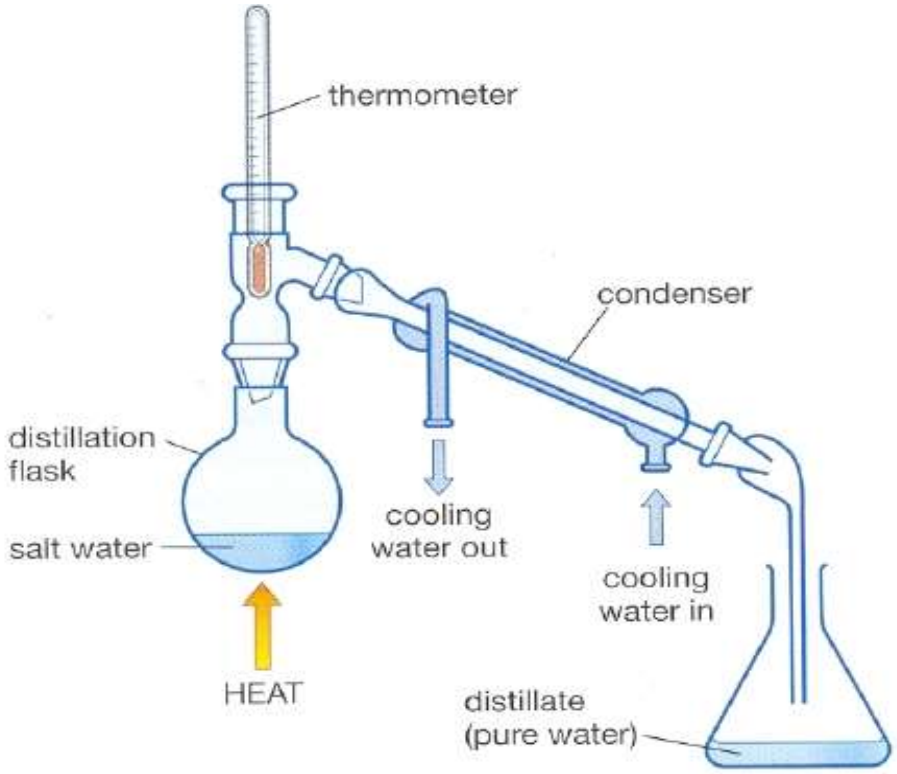
SEDIMENTATION

Sedimentation relies on **gravity** to separate suspended solids from fluids. It is accomplished by decreasing the velocity of the fluid being treated to a point below which the particles will no longer remain in suspension. When the velocity no longer supports the transport of the particles, gravity will remove them from the flow.

DISTILLATION

Distillation is a process of separating the component or substances from a liquid mixture by selective evaporation and Condensation.

The application of distillation can roughly be divided in two groups: laboratory scale, industrial distillation.



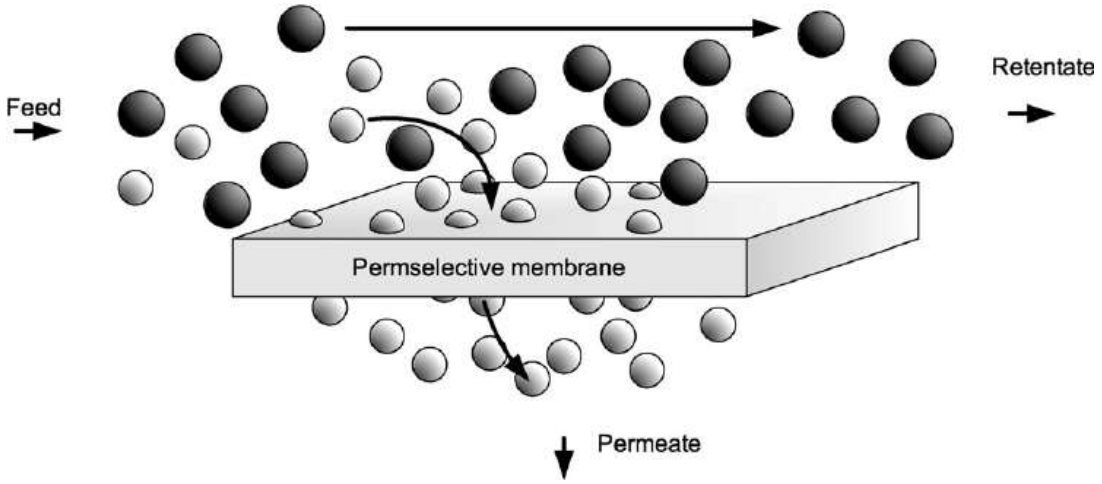
The main difference between laboratory scale distillation and industrial distillation is that laboratory scale distillation is often performed batch-wise, whereas industrial distillation often occurs continuously.

Type of distillation

- Simple distillation.
- Fractional distillation.
- Steam distillation.
- Vacuum distillation.

MEMBRANE SEPARATION

Separation by the use of membranes has been increasingly used in the chemical and bioprocess industry. In membrane separation, the membrane acts as a semipermeable barrier which only allows for certain molecules to pass through it



1. Ultrafiltration

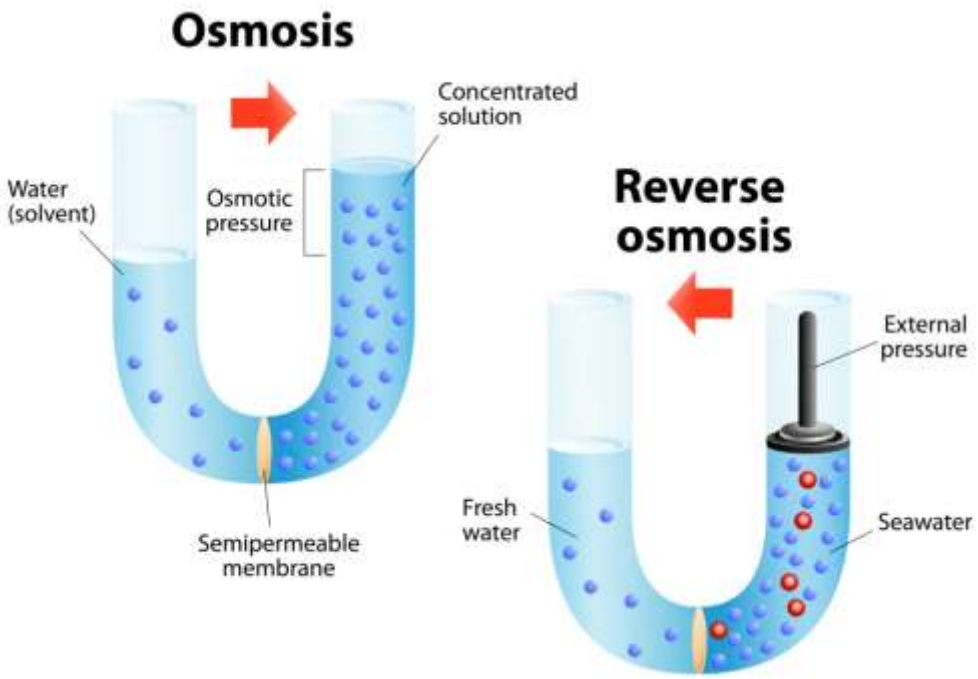
Ultrafiltration (UF) is used for the separation of macromolecules (polymers) such as proteins, with molecular weights 1000-50,000. It is a high-pressure membrane process, up to 145 psi (10 bar).

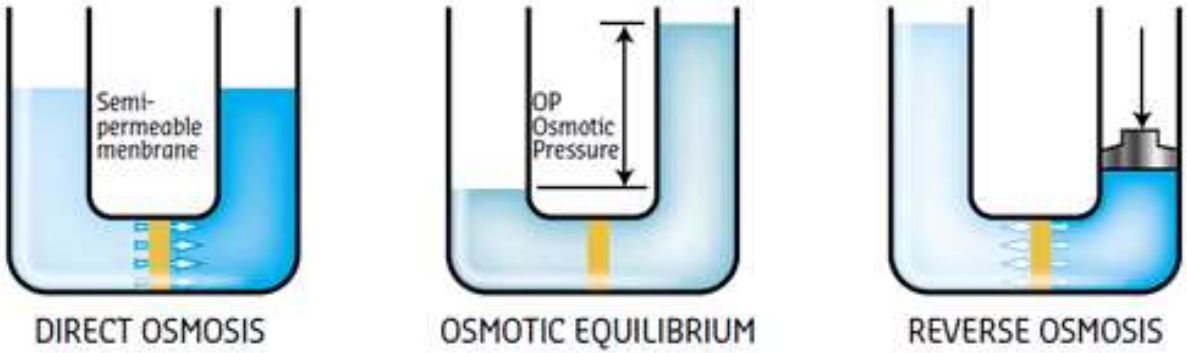
- Molecular weight of particles : 10^3 10^5 Pore size: 20 – 1000 A^0
- Pressure: 6 – 8 atm.
- Transport Mechanism: Convection (main) + diffusion
- Example: Filtration of protein, Red blood cells, polymers, etc.

2. Reverse osmosis

Osmosis (as a natural phenomenon) is the flow (diffusion) of water molecules through a semi-permeable membrane from low-solute concentration side to high-solute concentration side of the membrane.

Reverse osmosis is the use of high pressure to force the flow of solvent (e.g., water) molecules in the reverse direction of osmotic pressure. Applications of reverse osmosis include: water purification, sterilization, dewatering and the separation of components in a mixture





Reverse Osmosis operating principle

Novel separation processes

The separation processes those are not conventional and routine fall under this category. Therefore, some of the equilibrium and rate governed separation processes are included this.

Some of the processes are identified as,

(i) Membrane based separation processes

(ii) Chromatographic separation processes

(iii) Supercritical Fluid Extraction

(iv) Electric field assisted separation processes

(v) Ion exchange processes, etc.

Chromatographic Separation Processes:-

i. Chromatography is an extremely powerful analytical tool for separating and analyzing complex mixture.

ii. Different types of chromatographic techniques such as column chromatography, TLC, paper chromatography, and gas chromatography.

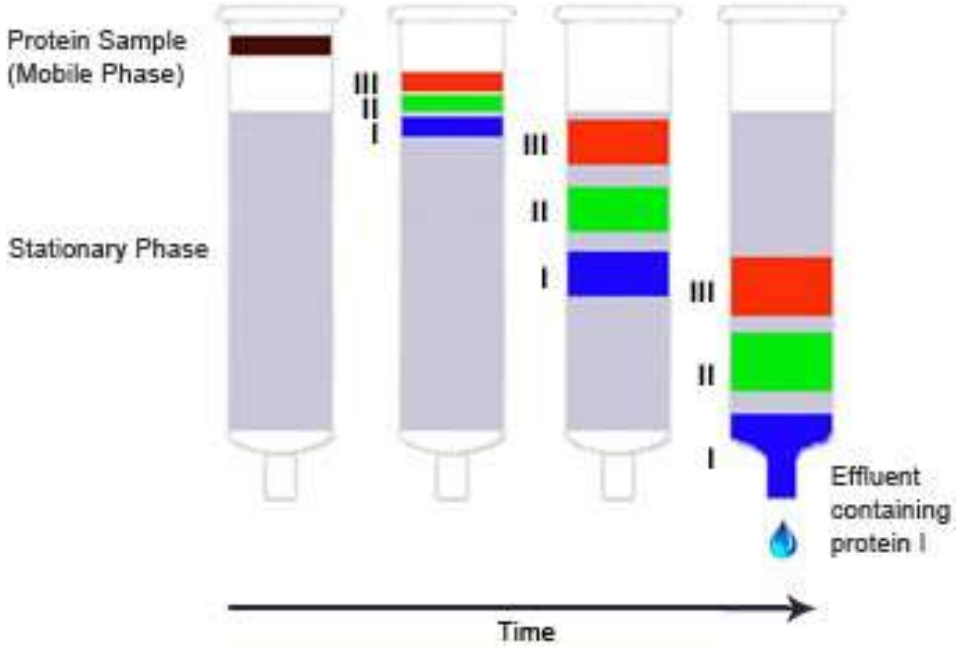


Fig:- Chromatography Separation Technique

Applications:

- To separate colors in a dye.
- To separate pigments from natural colors.
- To separate drugs from blood.

- **Paper chromatography** is one of the important chromatographic methods. Paper chromatography uses paper as the stationary phase and a liquid solvent as the mobile phase. In paper chromatography, the sample is placed on a spot on the paper and the paper is carefully dipped into a solvent. The solvent rises up the paper due to capillary action and the components of the mixture rise up at different rates and thus are separated from one another.

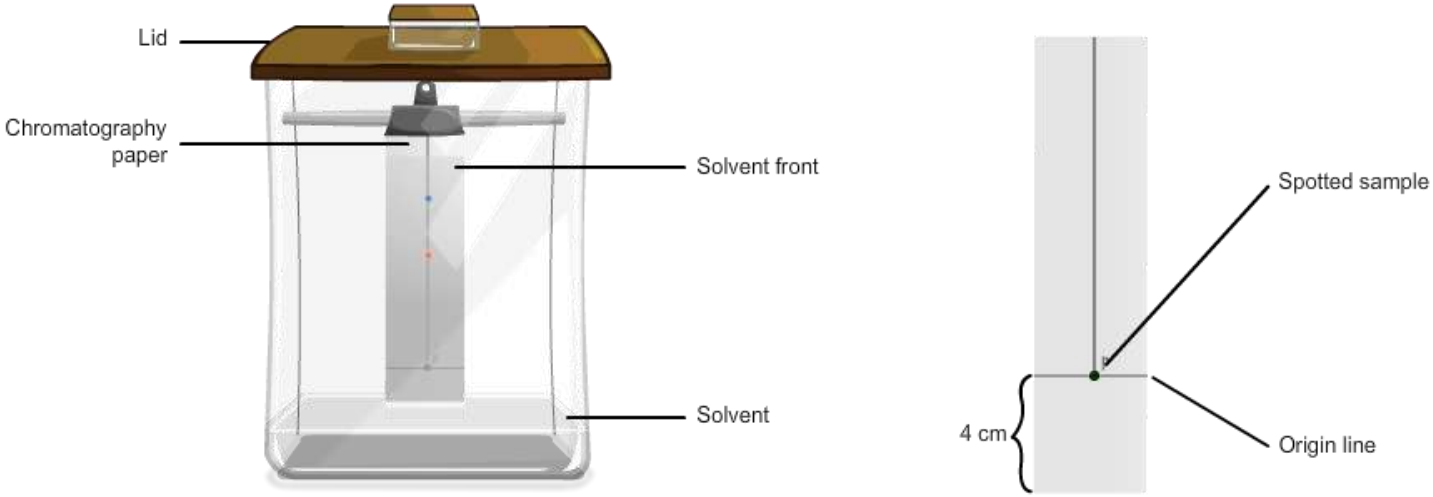


Fig:- Paper Chromatography

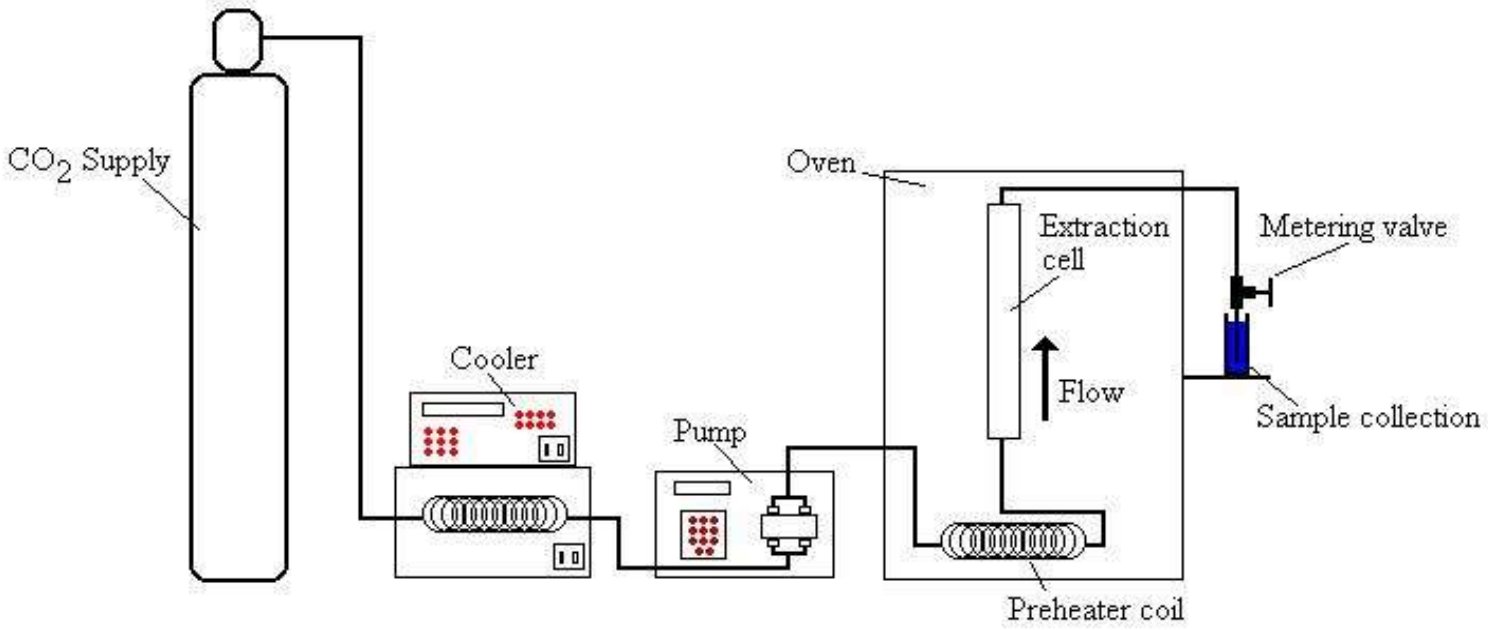
Supercritical Fluid Extraction

- Supercritical Fluid Extraction (SFE) is the process of separating one component (the extractant) from another (the matrix) using supercritical fluids as the extracting solvent. Extraction is usually froma solid matrix, but can also be from liquids.

- *Carbon dioxide (CO_2)* is the most used supercritical fluid, sometimes modified by co-solvents such as ethanol or methanol. Extraction conditions for supercritical carbon dioxide are above the critical temperature of 31 °C and critical pressure of 74 bar.

- The system must contain a pump for the CO_2, a pressure cell to contain the sample, a means of maintaining pressure in the system and a collecting vessel.

- The liquid is pumped to a heating zone, where it is heated to supercritical conditions. It then passes into the extraction vessel, where it rapidly diffuses into the solid matrix and dissolves the material to be extracted. The dissolved material is swept from the extraction cell into a separator at lower pressure, and the extracted material settles out. The CO_2 can then be cooled, re-compressed and recycled, or discharged to atmosphere.



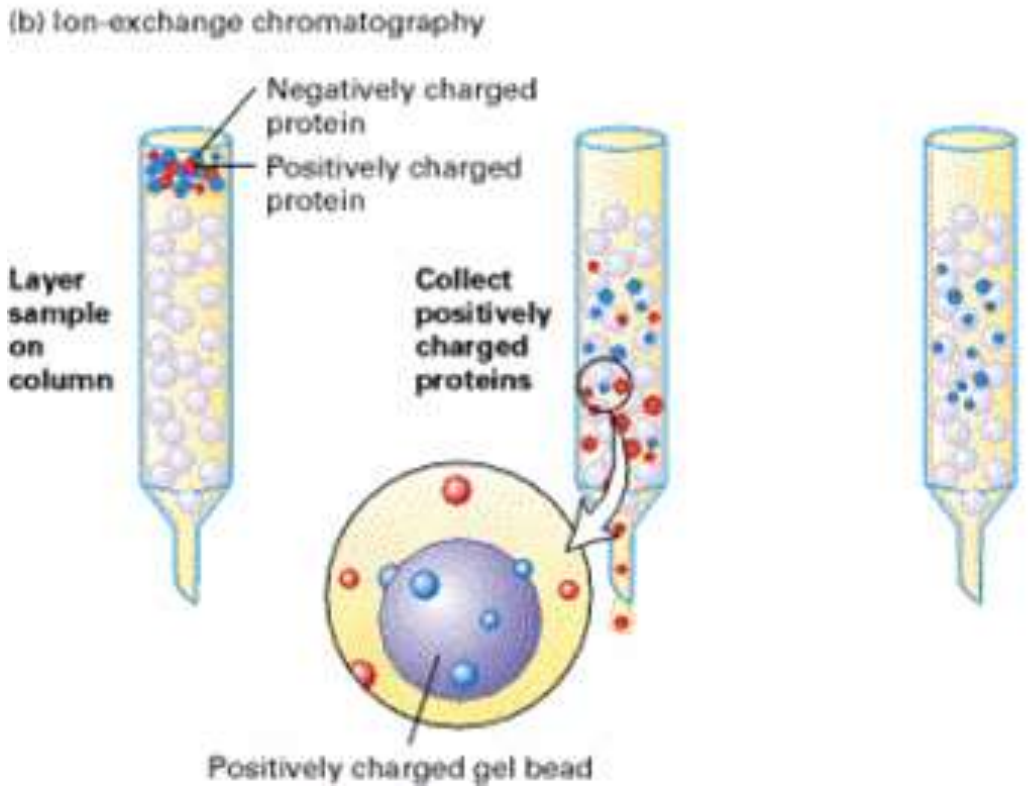
Ion Exchange Chromatography

The most popular method for the purification of proteins. IEC can be divided into two different sub types.

a. Cation exchange chromatography positively charged molecules are attracted to a negatively charged.

b. Anion exchange chromatography, negatively charged molecules are attracted to a positively charged.

After the molecule of interest has been adsorbed, the column is washed to remove any residual unbound species from the solid phase.



Application :

- Used for biopurification
- Used in downstream processing platforms.

Thank You