MEMBRANES APPLICATIONS

Ultrafiltration (UF) is a variety of membrane filtration in which forces like pressure or concentration gradients lead to a separation through a semipermeable membrane. Suspended solidsand solutes of high molecular weight are retained in the so-called retentate, while water and low molecular weight solutes pass through the membrane in the permeate. This separation process is used in industry and research for purifying and concentrating macromolecular (103 - 106 Da) solutions, especially protein solutions.
Ultrafiltration is not fundamentally different from microfiltration. Both of these separate based on size exclusion or particle capture. It is fundamentally different from membrane gas separation, which separate based on different amounts ofabsorption and different rates of diffusion. Ultrafiltration membranes are defined by the molecular weight cut-off (MWCO) of the membrane used.
Ultrafiltration is applied in cross-flow or dead-end mode.

Applications

Industries such as chemical and pharmaceutical manufacturing, food and beverage processing, and waste water treatment, employ ultrafiltration in order to recycle flow or add value to later products. But also blood dialysis belongs to ultrafiltration.

Drinking water
UF can be used for the removal of particulates and macromolecules from raw water to produce potable water. They have been used to either replace existing secondary (coagulation, flocculation, sedimentation) and tertiary filtration (sand filtration and chlorination) systems employed in water treatment plants or as standalone systems in isolated regions with growing populations.
[1] When treating water with high suspended solids, UF is often integrated into the process, utilising primary (screening, flotation, filtration) and some secondary treatments as pre-treatment stages.

Drinking water treatment 300 m^3/h using ultrafiltration in Grundmühle waterworks (Germany)

[2] UF processes are currently preferred over traditional treatment methods for the following reasons:
No chemicals required (aside from cleaning)
Constant product quality regardless of feed quality
Compact plant size
Capable of exceeding regulatory standards of water quality, achieving 90-100% pathogen removal
[3] UF processes are currently limited by the high cost incurred due to membrane fouling and replacement.
[4] Additional pretreatment of feed water is required to prevent excessive damage to the membrane units.

In many cases UF is used for pre filtration in reverse osmosis plants to protect the RO. Ultrafiltration is an effective means of reducing the silt density index of water and removing particulates that can foul reverse osmosis membranes. Ultrafiltration is frequently used to pretreat surface water, seawater and biologically treated municipal water upstream of RO.

Principles

The basic operating principle of ultrafiltration uses a pressure induced separation of solutes from a solvent through a semi permeable membrane. The relationship between the applied pressure on the solution to be separated and the flux through the membrane is most commonly described by the Darcy equation:

$$J = \frac{TMP}{\mu R_t}$$

where J is the flux (flow rate per membrane area),
TMP is the transmembrane pressure (pressure difference between feed and permeate stream), μ is solvent viscosity,
Rt is the total resistance (sum of membrane and fouling resistance).

Hollow fibre module

Depending on the shape and material of the membrane, different modules can be used for ultrafiltration process. Commercially available designs in ultrafiltration modules vary according to the required hydrodynamic and economic constraints as well as the mechanical stability of the system under particular operating pressures.

The main modules used in industry include:

- Tubular modules
- Hollow Fibre
- Spiral-wound modules