Ultrafiltration & Microfiltration
How Membranes Work

Ultrafiltration (UF) and microfiltration (MF) membranes are used to remove a large majority of contaminants from water and process feed streams. This bulletin explains the basics behind ultrafiltration and microfiltration technology, how they work and their various applications.

WHAT IS A MEMBRANE & HOW DO THEY WORK?

What is a membrane?

A membrane is a semi-permeable barrier that allows some molecules or components to pass through while retaining (or rejecting) others.

How do UF & MF Membranes Work?

Filtration is defined as the process of separating suspended solid matter from a liquid. As described in **Reverse Osmosis & Nanofiltration – How Membranes Work** (TSG-B-016), reverse osmosis (RO) and nanofiltration (NF) membranes pass and reject molecules primarily based on charge characteristics. In terms of ultrafiltration (UF) and microfiltration (MF) however, the membrane rejects particles based on size.

Depending on the pore size of the UF or MF membrane and the size of the particles suspended in the feed water, certain particles will pass through the membrane while others are rejected (Figure 1). Particles in the feed water will be rejected if they are larger in size than the UF/MF membrane pore size; the particles are physically unable to fit through the small pores of the membrane. Particles that are smaller than the membrane pore size will pass through the membrane.

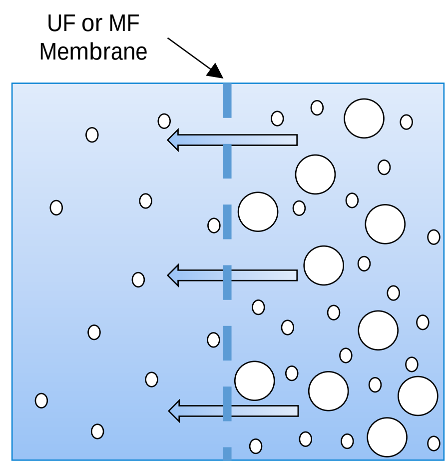

Figure 1. Particles that are larger than the UF or MF membrane pore size will be rejected. Particles that are smaller than the pore size will pass through the membrane.

Due to their unique chemistries and rejection mechanisms, RO, NF, UF and MF membranes permit and reject different molecules/particles. Figure 2 illustrates a filtration spectrum between RO, NF, UF and MF membranes and what each of the membranes typically reject. RO and NF membranes are generally used to remove dissolved salts whereas UF and MF membranes are utilized for their capability to remove bigger components such as proteins, bacteria and suspended solids. As such, the membranes are used in a variety of unique applications.

Figure 3 illustrates a classification of various separation processes based on particle or molecular size. The spiral-wound membrane separation processes—RO, NF, UF and MF—cover a wide range of particle/molecular sizes and applications. UF retains only macromolecules or particles larger than about 1,000 Daltons whereas MF is designed to retain particles in the micron range (typically 0.10 to 5 micron). In addition to removing suspended solids, UF is often used as a method for purifying, concentrating and fractionating macromolecules or fine colloidal suspensions whereas MF is mainly used as a clarification technique, separating suspended solids from dissolved solids (provided the particles are larger than the membrane pore size).

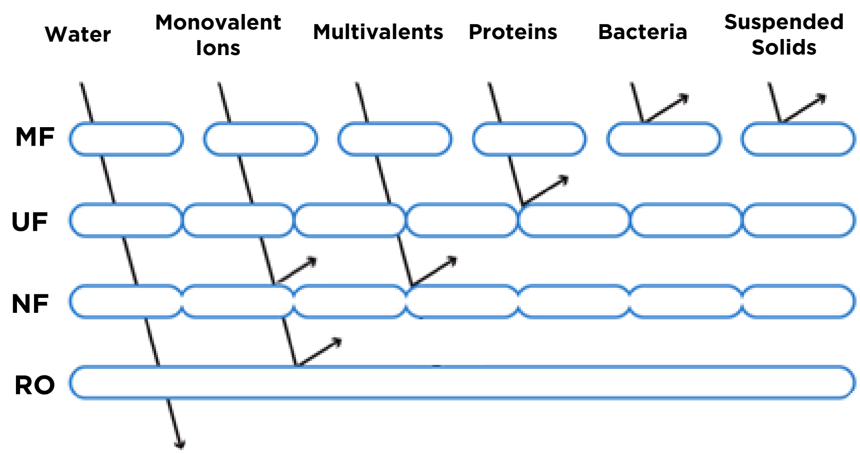

Figure 2. The filtration spectrum between RO, NF, UF and MF membranes.

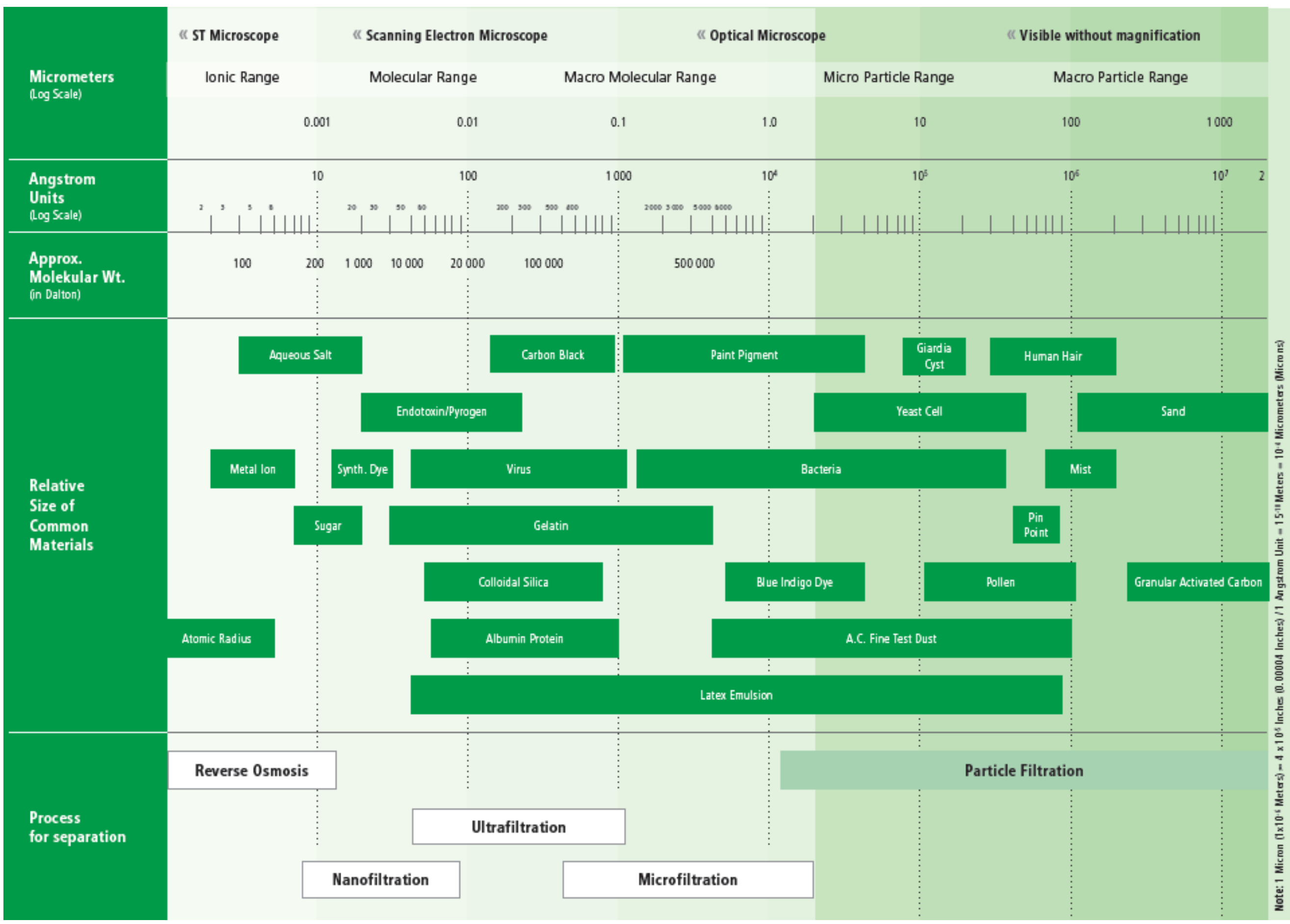

Figure 3. This chart illustrates various common RO, NF, UF and MF separation processes and the average particle/molecule size found within these applications.

ULTRAFILTRATION & MICROFILTRATION MEMBRANES

Ultrafiltration

Because UF and MF membranes reject particles based on size exclusion principles, they are often classified according to the size of the separated components.

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UF membranes may be classified by molecular weight cut off (MWCO) in Daltons (1 Dalton is equivalent to 1 atomic mass unit) or by pore size in micron. UF membranes are typically classified by a range from about 1,000 to 500,000 Daltons (Da), but as the membrane becomes more open (greater than 100,000 Da), it is common to see UF membranes classified by pore size.

Since UF and MF membranes deal with the separation of fairly large molecules including proteins, starch and gums, clays, paints, pigments, suspended solids, etc., the osmotic pressures involved in UF and MF processes are extremely low. Because of this, UF and MF systems require much lower operating pressures than RO or NF systems.

UF membranes are asymmetric, characterized by a thin "skin" on the surface of the membrane. The layers underneath the skin may consist of voids, serving as a support for the skin layer. Because rejection occurs at the surface of the membrane, retained particles or macromolecules above the nominal MWCO do not enter the voids or main body of the membrane. As a result, asymmetric membranes rarely get "plugged". However, they are susceptible to fouling.

Asymmetric UF membranes are given "nominal" ratings. These ratings refer to the molecular size or molecular weight above which a certain percentage of the solute in the feed solution (of a specific molecular size or weight) will be retained by the membrane.

Microfiltration

MF membranes are typically classified according to pore size, typically rejecting particles in the 0.10 to 5 micron range. TRISEP® polymeric MF membranes are classified as asymmetric microporous, designed to retain particles above their ratings. For example, a 0.10 micron MF membrane implies that it will not allow particles larger than 0.10 micron to pass through it. In fact, there is a distribution of pore sizes on the membrane surface. Because of this, particles that are approximately the same size as the pores may partially penetrate the pores and block them, resulting in a drop in flux. It is important to have a cleaning regime in place to keep the membrane surface free of pore-plugging particles. If enough of the membrane pores get blocked, it may become irreversibly plugged.

UF & MF MEMBRANE CHEMISTRIES

Polyethersulfone

Polyethersulfone (PES) membrane is widely used in MF and UF spiral-wound elements as well as hollow-fiber designs and is commonly used for process applications including food & dairy. Although PES membrane is hydrophilic in nature, membrane manufacturers offer PES membranes of varying degrees of hydrophilicity. PES membranes are widely available in a wide range of MWCO and pore sizes ranging from 1,000 Da to 0.2 micron.

Polyvinylidene Fluoride

Polyvinylidene fluoride (PVDF) membrane exhibits extremely low protein and color binding. Because of this, it has been known to be a more fouling-resistant membrane. It is a very popular material for MF and UF elements in wastewater treatment applications for this reason and because it has better resistance to chlorine than the polysulfone family. PVDF membrane is used in a variety of configurations including spiral-wound, hollow fiber and tubular designs.

Polyacrylonitrile

Polyacrylonitrile (PAN) membrane is ideal for oily wastewater and applications where tolerance to solvents and oils is required. It is available in spiral-wound and hollow fiber configurations.

Other Chemistries

Due to the many different applications membranes are used in today, membrane manufacturers have produced numerous unique UF and MF membranes to meet specific needs and requirements. Because of this, various other UF and MF membrane chemistries exist on the market today including (and not limited to) regenerated cellulose, ceramic composites, polyvinyl alcohol (PVA), cellulose acetate (CA), cellulose triacetate (CTA), polyamide (PA), polyimide (PI), polytetrafluoroethylene (PTFE), polypropylene (PP) and polycarbonate.

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