

# Q&A Polymeric Membrane Filtration

The when, where and how treatment is applied.

**P**olymeric membrane filtration encompasses the use of micro-filtration (MF), ultrafiltration (UF), nanofiltration (NF) and reverse osmosis (RO) technologies, each with its own unique variations and applications. Polymer filtration is a membrane-based technology that uses water-soluble polymers that bind with metal ions to prevent the metals from entering wastewater streams and from causing sludge formation.

The following interview is with Robert Huehmer, who currently is process manager with USFilter's (a Vivendi Water company) Memcor, Microfloc and General Filter products division, located in Timonium, Md. He possesses a bachelor of chemical engineering degree and master of environmental engineering degree from McMaster University in Hamilton, Ontario, Canada. Specializing in membrane treatment for the past six years, Huehmer has designed and commissioned MF, NF and RO membrane systems for use in the pharmaceutical, petrochemical, and power generation industries—in addition to his work in the wastewater reuse and potable water markets. Huehmer has performed numerous pilot studies investigating the use of membrane technologies to reuse municipal wastewater and produce potable water from surface water.

**WQP:** What are polymers and how does polymeric membrane filtration work?

**Rob Huehmer:** The word 'polymer' comes from the Greek language: poly means 'many' and mer means 'parts.' Polymeric comes directly from the Greek word polymeres, meaning having many parts. A polymer consists of many small molecules of plastic—referred to as monomers—which have undergone a chemical reaction to form large molecules consisting of repeating sequences of monomer.

A variety of different polymers typically is used to manufacture membranes. Most commercially available MF or UF membranes are manufactured using polyvinylidene fluoride (PVDF), polypropylene (PP), polysulfone (PS) or cellulose acetate (CA). RO membranes typically are manufactured using CA or thin-film composites of various polymers.

MF is a pressure-driven, size exclusion membrane process with a typical effective pore size of 0.1–1 µm. MF is predominantly applied for particulate and microbial removal from surface water and ground water. MF effectively has been used in various industries to remove particulate from a liquid stream. Typical operating

pressures range from 5 to 30 psig. MF membranes usually are manufactured in a hollow-fiber configuration, although tubular MF membranes are available.

UF also is a pressure-driven, size-exclusion membrane process with a typical molecular weight cutoff of greater than 50,000 daltons. The principle application of "loose" UF processes is for removal of particulate and microbial matter greater in size than the molecular weight cutoff. These systems usually are constructed in either the hollow fiber or tubular membrane configurations—although they are available in a spiral wound configuration for specialty applications such as in the dairy industry. The operating pressure typically ranges from between 7 and 35 psig.

NF is a pressure-driven, diffusion-based membrane process capable of removing multivalent ions such as calcium, sulfate and nitrate. Unlike MF and UF, mass transfer of water occurs via diffusion through the membrane rather than via flow through discrete pores in the membrane. NF commonly has been applied in the United States for the removal of pesticides, sulfate, hardness and nitrates from surface water. NF membranes also provide approximately 2 log removal of disinfection byproduct precursors. Relative to MF, UF and RO, NF has been applied to potable water production relatively recently. The use of NF in the production of potable water supply will increase markedly in the next decade. NF provides the ability to treat multiple water quality contaminants while requiring little water conditioning prior to distribution of the treated water.

**Hyperfiltration (RO)** is a pressure-driven, diffusion-based membrane process capable of removing monovalent ions such as sodium and chloride. Similar to NF, mass transfer of water occurs via diffusion through the membrane rather than via flow through discrete pores in the membrane as in MF and UF. RO frequently is used for desalination of brackish water or seawater for potable use. It also frequently is used to provide high-quality permeate for use as boiler feed water and pharmaceutical water.

The application of polymeric membrane filtration is very specific to the type of application and the size of the contaminant that you wish to remove.

**WQP:** How are they used?

**Huehmer:** Polymeric MF and UF membranes have been used to filter water,

beer, sodium hydroxide, wine and metals finishing waste. UF frequently is used to recover paint from industrial paint lines. NF and RO have been used to purify water for industrial or pharmaceutical use, desalinate seawater, remove nitrates from groundwater and concentrate sugar. The applications are extremely varied with new applications emerging on an almost daily basis.

MF is capable of reducing the concentration of pathogens such as *Giardia* and *Cryptosporidium* by greater than 7 logs. It commonly is used as pretreatment for NF or RO systems. MF provides feed water with silt density indexes of less than three and frequently less than one, reducing the frequency of chemical cleaning of the NF or RO system. This effectively extends the life of the NF or RO membranes and decreases the operating cost of the system.

As of the summer of 2000, there were more than 50 drinking water treatment plants in North America using polymeric MF or UF membranes, each treating more than 1 million gallons of water per day.

**WQP:** Which applications are best for MF and UF?

**Huehmer:** MF and UF have been applied to water sources ranging from 0.1 to 1,000 NTU. Most potable water applications have been on groundwater under the influence, surface waters with few contaminants of concern or waters that have been pretreated using chemical coagulation/sedimentation. These membrane processes operate very well under these conditions. Due to the complexity of water chemistry, however, it is recommended that a consultant address each application on a case by case basis. The most prevalent use of MF/UF technology to date is for compliance with the Surface Water Treatment Rule. Under the provisions of the Surface Water Treatment Rule, water utilities must ensure that the system removes or inactivates 3-log of *Giardia* cysts (99.9 percent) and 2-log of *Cryptosporidium* oocysts (99 percent). *Cryptosporidium* is a chlorine-tolerant organism, which means that physical removal of the oocysts must be achieved. Alternately, a disinfectant with high efficacy with respect to *Cryptosporidium* may be used. MF has been shown in numerous independent studies to remove greater than 7 log of *Cryptosporidium* and *Giardia*. MF/UF particularly is suited to high-quality raw water supplies, which possess few contaminants regulated by EPA other than turbidity (particulate) or pathogens such as *Giardia lamblia* (source of 'beaver fever'), *Cryptosporidium parvum* and faecal coliform.

**WQP:** Which other technologies (filter membranes) would MF/UF compare to?  
**Huehmer:** Membranes also may be manufactured of ceramic and metal composites. In many instances these membranes successfully have been used for the filtration of surface waters. These technologies normally are more expensive than polymeric membranes and typically are used in specialty applications. In some instances, the presence of small particles and organic molecules in surface water or wastewater has resulted in rapid fouling of ceramic membranes.

**WQP:** How economical/efficient is this filtration?

**Huehmer:** Only a decade ago, the application of MF and UF technology to produce potable water was limited by the high capital cost of the equipment. Continuing development of the technology combined with a commodity scale of production and new competition in the market has resulted in dramatic cost reductions in this technology.

Membrane systems are being designed that are considered cost comparative to conventional water treatment systems over the total plant life when such factors as labor, power consumption and residuals management are considered.

**WQP:** Why would someone want to use this method?

**Huehmer:** Concentrated research in the industry has greatly reduced both the capital cost and operating costs during the last decade.

Membrane systems used to produce potable water possess advanced control systems that permit the plant to operate automatically. In many cases, the state agencies regulating the production of potable water have issued permits allowing membrane systems to operate without the presence of an operator. In other cases, the membrane plant may be operated remotely using a modem connection.

**WQP:** What is the future for polymer membranes filtration?

**Huehmer:** The future market for polymeric membrane technologies is very bright. With the continued population growth in water-stressed regions in the United States such as California, Nevada and Arizona, the demand for water continues to increase. With demand projected to exceed sustainable supplies, the United States is in a position where severe water shortages will be experienced in the coming decades unless water policies are changed. Better use of the resources that we have, coupled with development of additional resources such as seawater desalination and wastewater, can prevent us from becoming—as Senator Paul Simon describes in his book on the subject—tapped out.

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