Membrane Makeover

By Isabelle Duchemin

Growing range of applications spans the water treatment spectrum

Membrane processes can be classified in many ways, based on nature, structure or driving force. Hydrostatic pressure differences are used in microfiltration (MF), nanofiltration (NF), reverse osmosis (RO) and gas separation as the driving force for mass transport through the membrane.

Ultrafiltration (UF) is a membrane process based on pressure difference as its driving force. It is basically a pressure-driven separation process, governed by a screening principle, dependent upon particle size. UF membranes have pore sizes between 1 and 100 nm, allowing retention of compounds with a molecular weight of 30,000 to 500,000 Dalton. Typically, the process is suitable for retaining biomolecules, bacteria, viruses, polymers, colloidal particles and sugar molecules.

UF can be considered as a method for simultaneously purifying, concentrating and fractionating macromolecules or fine colloidal suspensions. In the beginning, most UF applications were in the medical sector, e.g., kidney dialysis operations. Today, UF applications in water and wastewater treatment encompass a wide variety of sectors. The recent global increase in the use of membranes in water applications can be attributed to several factors, such as increased regulatory pressure to provide better water quality, increased demand for water requiring exploitation of water resources of lower quality than those previously relied upon, and market forces surrounding the development and commercialization of membrane technologies.

In this context, organic hollow-fiber MF or UF membranes are economical and cost-effective choices. The performances and features of the polymeric materials used in hollow-fiber membrane manufacturing now are well known, allowing strategic adaption for speciality applications.

Medical Applications

Polymeric membranes have become widely used as components of medical devices and implants, drug delivery systems, diagnostic assays, biosensors and more. Membrane processes are used effectively for treatment of patients with various pathologies for the removal of toxins from blood (e.g., hemodialysis) or for gas exchange with blood (e.g., blood oxygenation). The most important application is dialysis, for which millions of dialyzers are manufactured each year.

Hollow-fiber UF membranes—thanks to their ability to ensure retention of greater than log 4 for bacteria, viruses, *Legionella* and possibly endotoxins—also meet the requirements of a growing market: the production of sterile water in the medical environment. Thus, UF showers and taps are commonly used in hospitals for caregivers (for hand washing) and immune-deficient patients.

Residential Treatment & Reuse

In many parts of the world, tap water does not meet all criteria for drinking water standards. UF cartridges at the point of entry (POE) or point of use (POU) are used to secure water supply. Hollow-fiber UF is an option for POU/POE filtration for the safe and cheap production of drinking water.

Residential reuse of greywater or rainwater also is an emerging and growing market for reducing tap water use. These water sources offer an alternative, which, once clarified and purified by UF (possibly before RO or other treatment for dissolved matters removal), may be reused in homes for applications such as flushing toilets, washing clothes and dishes, or lawn irrigation.

Municipal Treatment & Reuse

UF is a competitive option for municipal drinking water treatment and offers an alternative for the removal of waterborne pathogens. Today, hollow-fiber UF is used to replace the clarification steps of coagulation, sedimentation and filtration in conventional water treatment plants.

The main advantages of low-pressure hollow-fiber UF membrane processes compared with conventional clarification (direct filtration, settling/rapid sand filtration or coagulation/sedimentation/filtration) and disinfection (post chlorination) processes are that they eliminate the need for chemical additives, offer precision size-exclusion filtration, provide consistent and constant water quality in terms of particle and microbial removal, allow for process and plant compactness, and use simple automation.

Water resources are becoming increasingly scarce in many regions of the world due to population development and increased demand. Besides seawater, tertiary treated wastewaters are becoming alternative sources of water for several applications, including drinking water production. UF permeate—cleared of suspended solids, bacteria, viruses and large organic compounds—is ideal for reuse purposes.

Public Water

Pools. In large community swimming pools (such as in municipalities or hotels), UF provides treatment to make the water safe, as well as reclaim water from backwashes of conventional media-based pool filters. Using UF for backwash drain water treatment saves energy and provides water for reuse in other applications. Soon, UF also will reach the market for private swimming pools.

Water Care. Water purification systems are required in commercial hotels, club spas, balneotherapy and thalassotherapy centers, all of which need to maintain a superior level of water quality. Regardless of the water source, UF provides water that is super clarified and bacteria free.

Water Features. If the temperature of the water reaches 25°C or higher and the water is sprayed, fountains can be ideal spreaders of microorganisms such as bacteria, the worst of these being *Legionella*. This bacterium is dangerous when little droplets or aerosols are inhaled by people with impaired immune defenses. Sunlight also causes algae growth, which can turn water green and allow growth of a biofilm layer, which is an ideal breeding place for *Legionella* bacteria. UF secures the sprayed water while retaining *Legionella* bacteria in a compact and easy-to-maintain filter inside the fountain.

Aquariums. Large municipal aquariums and zoos disinfect water in order to protect the various species in their care from infection from waterborne viruses and bacteria. Because UF requires no chemical additives, the animals are protected from the irritation often associated with chemical disinfectants.

Desalination

Recently, UF has been recognized as a competitive pretreatment for desalination RO systems. The application of UF as pretreatment for RO is mandatory for sites requiring extensive conventional pretreatment or where wide fluctuations of raw water quality are expected. Several studies have proven that UF pretreatment can produce a consistent high level of water quality, regardless of raw water quality fluctuations. Due to competitive pricing forces and advanced developments in UF manufacturing, it now is a viable RO pretreatment alternative to conventional filtration.

Industrial Process Water

In industrial processing, water is used in numerous applications requiring a variety of water qualities. Examples include food and beverage process water, cooling water, water for rinsing and chemical production, boiler feedwater, purified water and injection water. UF technology already is used in many industrial applications.

Food & Beverage. Water used during the food preparation step must be treated to a potable level. UF can be used for this purpose as standalone treatment or as part of a treatment chain. Many bottling companies rely on UF to meet ever-increasing legislative and consumer quality demands.

Power Generation. Power generation industries convert other forms of energy (water power, fossil fuels, nuclear power and solar power) into electrical energy. Much of this market is associated with membrane filtration, specifically UF for water filtration and clarification.

Aquaculture. Recently, membrane technology has been considered as an alternative water treatment in aquaculture. A sufficient supply of high-quality water is essential to any aquaculture operation, because it affects the reproduction, growth and survival of aquatic organisms. To increase the quality of water input, UF retains pathogens and generates highly pathogen-free water. At the same time, UF pore structure allows ions to pass through the membrane, which is extremely beneficial in applications such as farm-raised shrimp or crayfish.

Reuse. UF not only enables the removal of products from complex material streams, but also allows other useful substances or pure water to be separated out. Recirculation techniques then can be employed to re-insert these materials into the production process to enable them to be reused.

Oil & Gas Extraction. A new application for UF is seawater pretreatment before desulfation in offshore oil exploration. Seawater desulfation is provided by the NF membrane process, which requires total solids (turbidity) pretreatment. UF accounts for high production flow, low weight and small footprint, as well as continuously excellent treated water quality.

Every day new applications are discovered for UF technology. It is a technology designed for efficiently and economically clarifying and purifying water. Wherever clarifying and purifying filtration is necessary, one can consider UF membrane technology. *wqp*

Isabelle Duchemin is commercial manager for Polymem. Duchemin can be reached at i.duchemin@polymem.fr. Additional reporting was provided by Richard Mest, president of Master Water Conditioning Corp. Mest can be reached at richard@masterwater.com.

For more information on this subject write in 1003 on this issue's reader service card.