

By Youn-Kook Kim & Soo-Young Lee

Forward Osmosis & Water Treatment

Understanding self-dosing systems in water filtration devices

Within the field of water treatment, reverse osmosis (RO) is a standard process in which the applied pressure serves as a driving force for mass transport through the semipermeable membrane that is impermeable to salt. According to a recent membrane market report, RO, ultrafiltration (UF) and microfiltration (MF) together account for \$1.8 billion in sales. Approximately \$400 million worth of membranes and modules are sold each year for use in RO worldwide.

Figure 1. Forward osmosis applications
(a) Illustration of water purification hydration bag

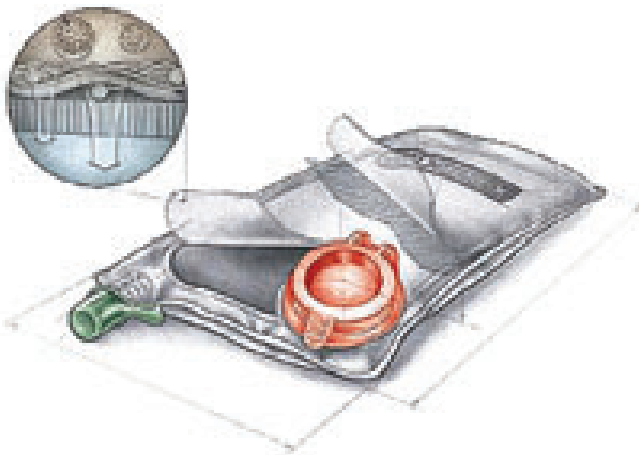


Figure 1. Forward osmosis applications
(b) Cross-section of the implanted DUROS system

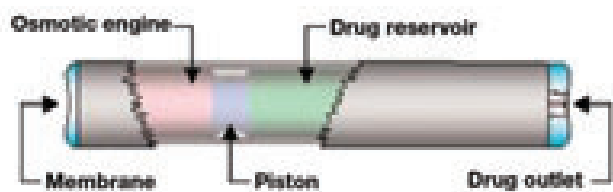
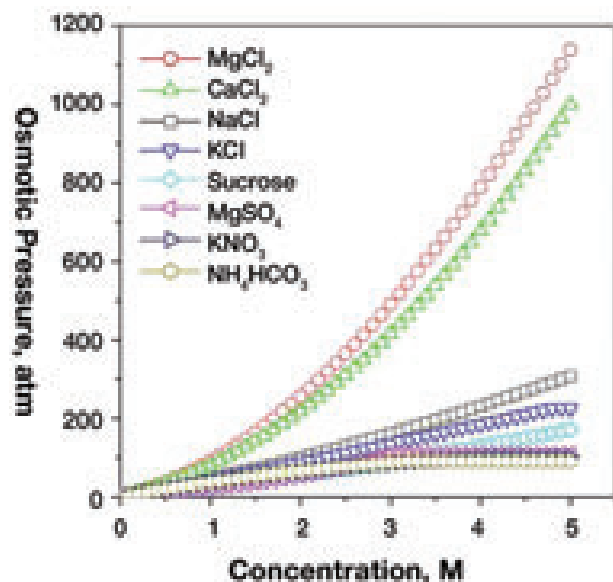


Figure 2. Osmotic pressure as a function of solution concentration at 25°C for various potential draw solutions



There currently is concern surrounding forward osmosis (FO) and its substitution of technology for the RO process because less expensive methods and energy-saving processes are needed to make wastewater treatment, seawater desalination and water purification technologies; therefore, extensive research and applications have been published on this topic.

Figure 1(a) demonstrates the FO applications for the water purification field and the pharmaceutical industry. As shown in the hydration bags, a high-concentration solution such as a sugar or beverage powder is packed inside a sealed bag made of a semipermeable membrane. Upon immersion in an aqueous solution, water diffuses into the bag due to the osmotic pressure difference, creating a diluted high-concentration solution as a sweet beverage consumers can drink.

The most interesting application is the drug-delivery system (DDS) operated by FO as shown in Figure 1(b). The osmotic DDS is able to constantly release drugs through the working of an osmotic pump by the water diffusion from the low-concentration to high-concentration solution.

Current focus exists on the development of a self-dosing system of

antibiotics and cleaning solutions in water filtration devices. By utilizing a self-dosing system in water filtration devices, the system is capable of eliminating bacteria growth in water. In addition to a self-dosing system, a water filtration device—including an auto-cleaning system—will also be introduced in the near future.

Osmotic Process

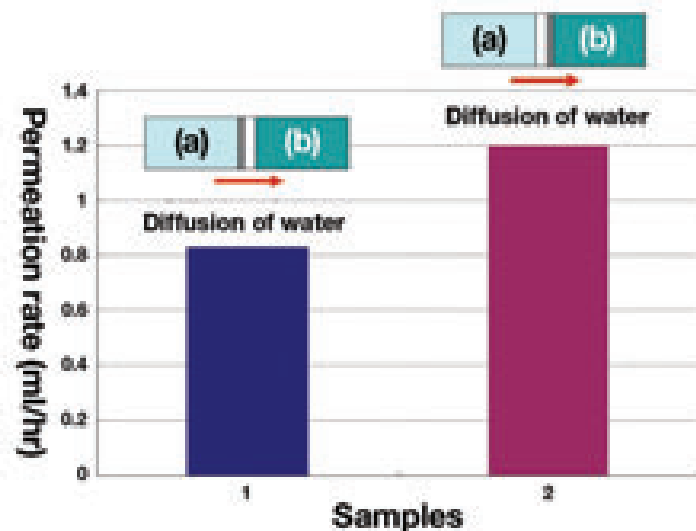
The osmotic process is essentially the transport of water across a selectively permeable membrane from a region of low concentration to one of high concentration. It is driven by a difference in solute concentration across the semipermeable membrane that allows passage of water, but rejects most solute molecules or ions. During the FO process, the water transport is mainly determined by the osmotic pressure and the components of semipermeable membranes. In Figure 2, osmotic pressure is calculated using the OLI Stream Analyzer 2.0 as a function of solution concentration.

The water flux (J) across the semipermeable membrane in forward osmosis is described with the water permeability coefficient (A) and the osmotic pressure difference ($\Delta\pi$) as the equation: $J=A(\Delta\pi)$.

The water permeability coefficient (A) is dependent on the semipermeable membrane thickness, solubility of water into the membrane and diffusivity of water within the membrane. The osmotic pressure difference ($\Delta\pi$) is the difference in osmotic pressure across the semipermeable membrane between the high-concentration solution and the low-concentration solution.

The rejection of NaCl in FO

Figure 3. Permeation rate of water by the different contact side of high-concentration solution on TFC polyamide membrane



is calculated with the equation: $R(\%) = (CF - CP) / CF \times 100$, where CF and CP are the concentration of feed and permeate solutions, respectively.

Self-Dosing Systems

The reported findings by M. Elimelech, et. al., reveal the results of FO performance using AG and CE membranes. In general, AG and CE are used for brackish water in the RO process. The AG membrane is a polyamide synthesized by the interfacial polymerization on the polysulfone support layer. The CE membrane is composed of a cellulose acetate asymmetric membrane. According to the results, the AG membrane showed the water flux of 21 gal per day (gpd) while the CE membrane showed the water flux of 17 gpd at the hydraulic pressure of 20 atm.

Membranes can be classified by the morphological properties as a dense and composite membrane. The polyamide RO membrane is primarily composed of the asymmetric porous layer and the polyamide thin layer. The asymmetric porous layer provided mechanical stability, while the polyamide thin layer determined water permeability and salt rejection.

To prepare the self-dosing system, a thin film composite (TFC) polyamide RO membrane was used. Generally, the TFC polyamide membrane was prepared by the interfacial polymerization method. The performance of the TFC polyamide showed the permeability of 80 LMH and the average salt rejection of 98% at the operating pressure of 225 psi, the feed solution of 2,000 ppm NaCl and the operating temperature of 25°C.

The self-dosing system was operated by the osmotic pressure between the region of low-concentration solution (100 ppm) and the region of high concentration of NaCl (300,000 ppm). To design a self-dosing system, the concentration profile in the region of high-concentration solution should be used to release the antibiotics or the clean solution constantly.

Figure 3 represents the different water permeation rates from the side of a low-concentration solution to the side of a high-concentration solution. Based on the results, Sample 2 shows the higher permeation rate in comparison to Sample 1. The difference of Sample 1 (porous support side) and Sample 2 (polyamide side) is the different contact side of the porous support layer and polyamide layer with the high-concentration solution.

Applications

Compared to RO, FO systems and the principle of osmotic pressure have a wide range of applications in the areas of wastewater treatment

and water purification systems; sea-water desalination and brackish water processes; concentration of solutions of food products, pharmaceutical solutions and chemical streams; and power generation.

The self-dosing system of antibiotics and clean solution enables the design of water filtration devices including the auto-clean system used in homes and industrial water filtration systems.

In the near future, the FO system will be applied as a general technology in various fields. *wqp*

Youn-Kook Kim, Ph.D., and Soo-Young Lee are senior researchers for the Research Div./Environment Technology Institute of Woongjin Coway, Ltd., Coway USA, Inc. Both can be reached at 213.480.1600 or by e-mail at dealer@coway-usa.com.

WEB RESOURCES

Related search terms from www.waterinfolink.com:
POE/POU, disinfection, filtration

For more information related to this article, visit www.wqpmag.com/lm.cfm/wq010904

For more information on this subject write in 1014 on the reader service card.

Ozone Systems

*Performance Guaranteed...
You Will Never Fail*

Whole-House Water Treatment Systems
Complete trouble-free removal of :

- Iron • Sulfur • Manganese • Bacteria
- Greatly improve taste
- Competitively priced
- Chemical and maintenance free

Bottled Water

- Improved taste • Increased shelf life
- Bacteria free • Increased profit margin
- Compliance with health regulations

Under Sink Systems

Laundry

Cooling Towers





800-633-8469

Tel 830-367-4030
Fax 830-367-4050
Kerrville, Texas

tecsales@ozonepurewater.com
www.ozonepurewater.com

Same Day Shipping • Assistance Always Available
Residential / Commercial • Low Cost / High Profit
Full Service Water Treatment Supplier Since 1980



UNITED FILTERS INTERNATIONAL




The Force in Filtration

901 S. Grand Avenue TX 79101 (800) 373-8386
www.unitedfilters.com
*MSD42 available upon request.

write in 771

More than just a pretty face.



Inside that sleek exterior is the most precisely engineered tank head in the industry. Machined from solid PVC bar stock for maximum reliability, our exclusive TOUGH STUFF® Tank Heads are ready to ship in a full range of standard sizes and configurations. Need something a little different? We custom design and manufacture to your specifications and materials, including CPVC, polypropylene, Teflon and PVDF.

TOUGH STUFF Tank Heads from Mattson/Witt.
Proof that beauty is more than skin deep.

www.mattsonwitt.com | 1.800.663.4371



write in 761