Taming Osmosis

By Charlie He

New membranes work with nature to solve water and energy challenges

Unlike dissolving table salt in water, removing salts from water pays the cost for going against nature. Laws of nature govern the chemical phenomenon of osmosis—the natural movement of pure water from an area of low solute concentration, through a semi-permeate membrane, to an area of high solute concentration. The pressure generated by the movement of pure water to equalize solute concentrations on each side of a membrane is called osmotic pressure. First documented in 1748, osmosis was a phenomenon observed only in the laboratory for the following 200 years.

In the 1950s, reverse osmosis (RO) membrane technology was invented. By applying an external pressure that overcomes the osmotic pressure, RO reverses the natural flow to recover water from a saline source. As a fully developed technology, RO is the finest water filtration method known and produces water with superior quality. Advances in recent years have changed the way public utilities view this technology: They now consider it a safe, energy-efficient and cost-effective solution to meet critical water needs through desalting seawater and brackish water sources. Energy consumption, membrane fouling and scaling, and concentrate disposal, however, still limit RO performance and its implementation potential.

Advancements in membrane technologies continue to lower energy usage and the costs associated with desalination. Extensive research and development of new fouling-resistant and energy-efficient membranes are underway. Other recent work has focused on integrating RO with electrodialysis (ED) to improve recovery of valuable deionized products or to minimize concentrate volume requiring discharge or disposal.

One example is a brackish groundwater desalination turnkey pilot project completed by Carollo Engineers for California's Indian Wells Valley Water District. Besides an RO-ED hybrid, the project utilized a specially designed reversible RO skid. This unit incorporates an advanced automated system that allows reversal of flow in the first and second stages with an intermediate concentrate blowdown step. The study demonstrated that flushing of particles and biological growth in the lead elements and dissolving scale on tail elements improves fouling control and prolongs membrane life, thereby improving overall performance.

In the last decade, the most exciting achievement in taming osmosis has been the development of the forward osmosis (FO) membrane. Like RO, FO uses a semi-permeable membrane. Unlike RO, which requires high operating pressure to work against the osmotic pressure, FO uses a solution with high osmotic potential to draw clean water through the membrane from a solution of low osmotic potential, as plants do. FO offers unique potential benefits (e.g., reduced pretreatment complexity, low-pressure operation and low fouling propensity). It has been shown to effectively concentrate a variety of feed streams.

FO is a developing technology for most municipal applications and requires demonstration scale testing to prove its feasibility and long-term reliability. Carollo is collaborating with Hydration Technology Innovations to conduct demonstration scale testing on reclaimed water RO concentrate for the Arizona cities of Phoenix, Scottsdale, Tempe, Mesa and Glendale. This project will create new municipal applications of FO membranes as an energy-efficient, fouling-resistant alternative to RO. MT

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