Switchable Polarity Solvent Forward Osmosis (SPS FO)

High-recovery treatment for turning wastewater into a resource

Award-winning INL technology dramatically lowers the cost of water purification, offering new solutions for treating industrial wastewater.

Water shortages for domestic, agricultural and industrial uses are an ever-present concern, and squeezing value out of every drop has become a global challenge. That's why Department of Energy research in water treatment and security remains a priority.

Each year in the U.S. alone, workers produce more than 2.94 trillion gallons (70 billion barrels) of water from oil and gas development, according to the National Energy Technology Laboratory. Hydraulic fracturing ("fracking") operations in the oil and gas industry use 3 million to 5 million gallons of water to establish each well. Improved treatment, recycling and reprocessing could make this water available for industrial reuse and ease the tension on valuable water resources such as aquifers and arterial river systems.

A NOVEL SOLUTION

Idaho National Laboratory researchers have harnessed natural osmotic forces to extract freshwater from wastewater by having a more concentrated switchable polarity solvent on the other side of a membrane. The concentrated solution pulls the water through the membrane, leaving the contaminants behind, using the same forces that nature uses to regulate water and nutrients in human cells. Then the water can be extracted from the solution with low-cost, low-grade heat.

The approach combines the qualities of specialized new materials (called switchable polarity solvents) with forward osmosis processes (SPS FO) and special membranes. Compared to competing technologies, the patent-pending SPS FO process costs less and recovers more freshwater from saltwater, industrial wastewater and virtually any other feed solution.

The primary methods of removing dissolved materials often drive the costs of treating industrial water. Typically, these methods involve pretreating high-

Idaho National Laboratory

INL researcher Aaron Wilson led development of the SPS FO technology.

Josh McNally characterizes membrane performance on a lab-scale FO system.

fouling solutions (at times more than 60 percent of the entire process costs) or brine product disposal (which can be more than 75 percent of the entire process costs).

FO processes allow for simplified and less costly pretreatment processes, greatly lowering many overall industrial water treatment costs. SPS FO's high recovery capabilities make it possible to address very concentrated solutions and reduce the volume of brine byproduct, often by a factor of five (75 percent to 95 percent recovery). Smaller brine volumes can greatly reduce the cost of many industrial water treatment processes.

HOW IT WORKS

The SPS FO process begins when saline "wastewater" is pumped past one side of a membrane. Simultaneously, the SPS solution is pumped past the other side of the membrane. The SPS solution — a combination of amines, water and a carbon dioxide trigger — creates a solution more concentrated than the wastewater, making it possible for natural osmosis to pull out clean water.

To separate the pure water from the SPS solution, the team simply applies heat, which releases the CO2 and turns the remaining SPS solution into an oily liquid that naturally separates from water.

The technology earned a 2013 R&D 100 Award and other technology awards. Several licenses and development agreements have been signed and are forthcoming to pursue and refine SPS FO for various applications.

WHAT'S NEXT

Initial focus for this new technology is to refine the process for a variety of industrial applications. In many manufacturing processes, additional processing may or may not be required to reuse the recovered water. So researchers are taking a modular systems engineering approach to couple SPS FO with other mature technologies. This will let them achieve the desired quality of water and optimize each module for productivity and cost.

Preliminary applications are focusing on refining the process for capturing water for reuse in industrial processes, such as fracking in oil and gas exploration. More research is planned to investigate other applications, such as creating potable water for human consumption from processes such as seawater desalination.

FOR MORE INFORMATION

Technical contact
Aaron D. Wilson
208-526-1103
aaron.wilson@inl.gov

General contact
Abby Todd
Communications Liaison
208-526-6166
abby.toddbloxham@inl.gov

www.inl.gov

A U.S. Department of Energy National Laboratory

20-50443-009-R3 (Updated: 2021)