RECLAMATION
Managing Water in the West

U.S. Department of the Interior
Bureau of Reclamation

Forward Osmosis Water Purification

Improvements to FO membranes and process can significantly reduce capital and energy costs for water desalination plants

What Is The Problem?

Commercial desalination technologies used to desalinate seawater and inland brackish waters — including electrodialysis, reverse osmosis (RO), multistage flash distillation, and vapor compression — can be cost-prohibitive due to high capital and energy costs.

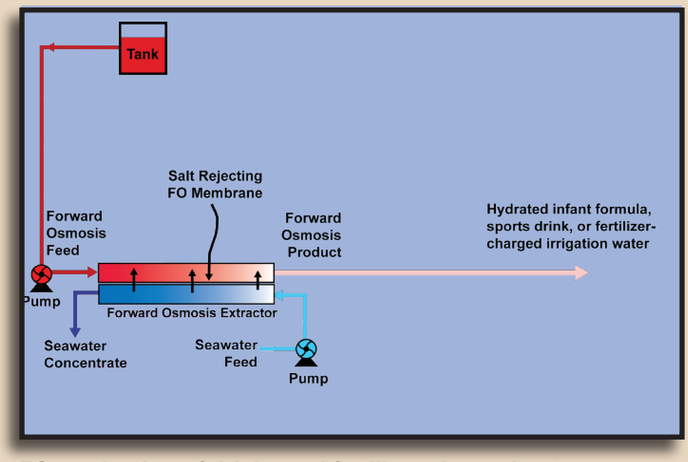
Desalination using forward (direct) osmosis (FO) has the potential to significantly reduce both capital and energy costs.

What Is The Solution?

Traditional RO uses high-pressure pumps to force seawater (or other contaminated water) thru a semi-permeable membrane. The membrane allows only pure water to pass thru as the salt and other contaminants are held back by the membrane.

FO employs a membrane similar to RO, but the saltwater is not pressurized to force it through the membrane. If two solutions are placed on either side of a semi-permeable membrane, water will move toward the side with the higher concentration of solutes. Thus, if a concentrated solution of water and fertilizer ("driving solution") is placed opposite a volume of seawater ("source water") the natural force of osmosis will pull pure water out of the seawater and through the membrane, resulting in a larger volume of fertilizer-charged irrigation water ("FO product"). Similarly, baby formula powder or liquid concentrate can extract fresh water from a contaminated source water, producing a large diluted volume of liquid baby formula. In FO, selecting the proper driving solute determines the end use of the FO product, and the salinity of the source water determines its maximum dilution.

The advantage of using FO compared to pressure-driven membrane processes like RO is that it operates at low pressures, translating into less energy used. FO's primary energy consumption occurs if the driving solute must ultimately be separated from the FO product. For example, to produce drinkable water from saltwater, a concentrated driving solution is formulated using water and a chemical that can be efficiently removed from the resulting FO product, thus leaving pure water.

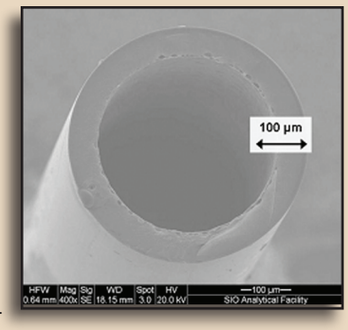


FO production of drinks and fertilizer-charged water

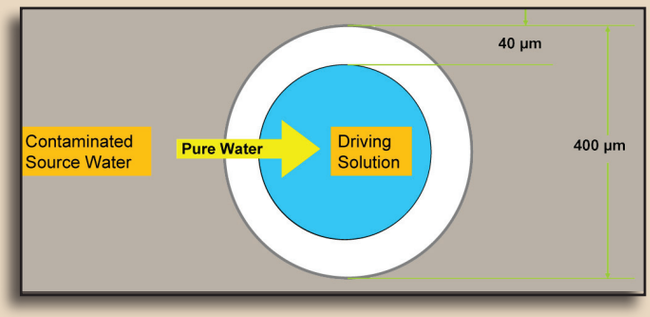
The Bureau of Reclamation is filing a patent for a driving solute and a 2-stage process that removes and recycles the driving solute back to the FO extractor producing potable water that is free of salt and the driving solute. The Bureau of Reclamation and Separations Systems Technologies have also developed cellulose ester hollow-fiber FO membranes that are thin, strong, and offer more desalting surface area per unit volume as compared to flat sheets.

Who Can Benefit?

Efficient membranes and an engineered 2-stage FO process offer the potential for low-cost seawater desalination. As desalination plants become more affordable, FO may be a new alternative to the drinking-water shortages in many areas.



Hollow fiber cellulose ester membrane.

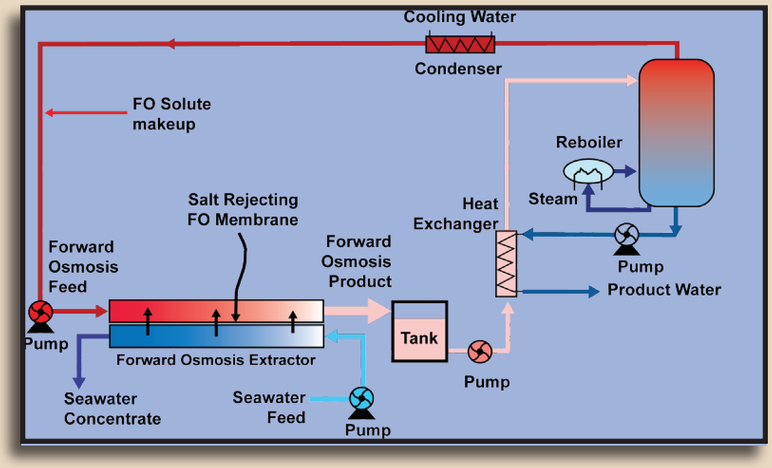


Driving solution pulls purified water from contaminated source waters across thin, strong, hollow fiber membrane.

Future Development Plans

The next steps consist of pilot testing and maturing the FO process and driving solution and further development of hollow-fiber membranes with the following properties:

1. High permeability to water
2. High rejection of dissolved contaminants
3. Chemical compatibility with driving solutes
4. High rejection of driving solutes
5. Thin backing to minimize concentration polarization
6. Strength for handling and operation at low pressure



2-stage FO process for production of potable water from saltwater

Reclamation is currently seeking a qualified industry partner to cooperate in further testing and commercialization.

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Collaborators

Reclamation's Science and Technology Program and Reclamation's Yuma Area Office, Separation Systems Technologies, and University of Denver.