Membrane Helps To Replenish The World's Fresh Drinking Water Supply

University of California, Los Angeles (UCLA)

In April of 1961, at the dedication of a desalination plant in Texas, President John F. Kennedy said: *No water resources program is of greater long-range importance than our efforts to convert water from the world's greatest and cheapest natural resources — our oceans — into water fit for our homes and industry.*

He went on to say that:

Such a breakthrough would end bitter struggles between neighbors, states and nations.

While there may be less hope for the end of struggles between nations, Kennedy's assertion that extracting freshwater from saltwater is one of the greatest scientific breakthroughs in history couldn't be truer today. More than 97 percent of the earth's water is too salty for human consumption. Water use has been growing at more than twice the rate of population growth in the last century.

The World Health Organization reports that as populations rise, urbanization grows and there is an increase in household and industrial uses for water, the world is running out of clean, drinkable water. Water scarcity affects 1 in 3 people on every continent. According to United Nations statistics, at least 1 billion people live in areas where water is scarce, and the numbers are reported to reach 1.8 billion by 2025.

Around the time President Kennedy made that speech, researchers at the University of California at Los Angeles (UCLA) were developing a new technology that forced water molecules across a semipermeable barrier at a much faster rate than salt ions, producing a freshwater stream. The process became known as *reverse osmosis* (RO) and has since become the most popular method of separating salt water from seawater, or desalinated water. Over time, the UCLA team developed this technology into tubular membrane modules that produced freshwater from ocean and brackish groundwater.

It was a watershed event in addressing seawater desalination.

> *Over the next 30 to 40 years, manufacturers improved membrane material as well as module and process designs and, as a result, the cost to produce freshwater from seawater was reduced by 4 percent between 1980 and 2000.*

But there were two challenges. The first: the process remained energy-intensive and costly. And second, modern RO membranes were prone to fouling when rejected particles and bacteria accumulated on the surface.

By early 2000, though it was only one of a few options available to address severe water shortages, the still-expensive process of RO seawater desalination was gaining global acceptance.

Making Over a Membrane

Eric M.V. Hoek, Ph.D., was in his first year as an assistant professor of environmental engineering at UCLA when he began working on a new RO membrane material that he envisioned would perform better in desalination applications.

"[I thought,] what if we could integrate a nanoparticle into an RO membrane to make it more productive and resistant to bacteria?" says Hoek. "I imagined the properties of such a material, and then one day learned in a presentation by a colleague's student that something like it existed but in a different form."

That material, known as a zeolite, or molecular sieve, due to its internal molecular pores, takes up water like a sponge. The pores are just big enough to let water through but just small enough to reject salt. An extra advantage was that these materials could also be modified to exhibit antimicrobial functionality.

Hoek's hypothesis was that synthesizing zeolite nanoparticles and embedding them within the RO membrane could reduce the overall energy demand in the desalination process.

When it worked, Eric Hoek had built a better membrane.

That's when, with startup funds provided by UCLA's Henry Samueli School of Engineering and Applied Sciences, thin-film nanocomposite (TFN) membrane technology flowed from the tributary of great water desalination discoveries from the university. A second stream of funding came from the UCLA's California NanoSystems Institute (CNSI) and from the company that ultimately would commercialize the technology, NanoH_2O Inc.

The material was named, says Hoek, "for its unique structure where a 100- to 200-nanometer thin film contains both nanoparticles and polymers working together to produce a better material than either could alone." It attracted water and rejected salt and other particles that can obstruct the flow of water.

Hoek says the TFN membrane demonstrates a 50- to 100-percent increase in permeability when compared to conventional RO membranes while maintaining the same level of salt rejection. It also inhibits the adhesion of bacteria and other organic materials that tend to foul up membranes over time.

All of this significantly reduces the cost of desalinated water, making it a more economically viable option to increase global water supply. In 1980, for example, the cost of desalinating water with conventional membranes was $2 to $3 per cubic meter. In 2010, with the new membrane, the cost was .50 to $1 per cubic meter.

A Sustainable Technology and a Company Surface

Discovery and commercialization came together in 2005 when Hoek met Jim McDermott, an experienced technology entrepreneur, and Bob Burk, Ph.D., a scientist with many years of experience in environmental technologies. Within weeks of their initial meeting, a deal was struck.

"It was an exciting agreement," says Emily Loughran, director of licensing at the UCLA Office of Intellectual Property about the licensing. "I had heard from a colleague that there was an investor interested in clean energy and sustainable technologies. Our objective is to bring technology with a clear and demonstrable effect to the marketplace for public benefit. This project encompassed all the things we like to see. It's very rewarding to be a part of a deal like this one."

Jeff Green, who founded Archive Inc. and Stamps.com with Jim McDermott, was brought in as chief executive officer, and Burk was named chief scientific officer. The excitement of the union between Hoek, UCLA and Green was further heightened by the fact that not only did the original technology come out of the UCLA, but Green and McDermott are graduates of the UCLA Anderson School of Management.

In late 2005, after receiving $900,000 in angel funding, NanoH_2O set up its office in one of the CNSI incubator laboratories. Two years later, a $5 million investment came from Khosla Ventures and, in 2008, another $20 million came from Oak Investment Partners and Khosla.

NanoH20 opened a 26,000-square-foot research and manufacturing and corporate facility in nearby El Segundo, Calif., in late 2009.

The company received an additional $10 million in 2010 from PCG Asset Management and CalPERS, along with a $400,000 research grant from the United States Office of Naval Research to explore military applications for this RO membrane technology now marketed under the QuantumFlux brand name.

"Eric's membrane improves the economics and energy efficiency of desalination while it increases the world's fresh water supply," says Green. "The more productive the membrane, the lower the energy consumption of the desalinization process. In retrofit installations, NanoH_2O's QuantumFlux membranes can significantly increase water production or drastically decrease energy consumption. For new system designs, utilizing QuantumFlux membranes can enable engineers to build smaller plants due to the higher efficiency of the technology.

"This will help improve the quality of life for drought-stricken areas of the world and ensures a potable water supply for future generations," Green adds.

Freshwater: A Continuing Flow

Nano$H_2O$was recently selected as one of top 100 companies for a Global Cleanteach list out of more than 4,000 nominations. Global Cleantech 100 recognizes companies that offer solutions to the planet's most pressing environmental challenges.

“I never intended to file a patent or start a company,” Hoek says. The fact that our ideas have inspired other people is tremendous, and now there’s a company that is poised to lead the membrane desalination industry.”

First commercial sales for NanoH_2O’s seawater RO membrane occurred in the fourth quarter of 2010. As of spring 2011, multiple desalination plants around the world are benefiting from this advanced technology.

NanoH_2Ocontinues to advance the research conducted at UCLA, allowing an expanded portfolio of products that will further lower the cost of desalination and directly address the worldwide water scarcity issues that President Kennedy foresaw so clearly.

***Upd*ate:** According to “LG Chem to Acquire U.S. Desalination Membrane Innovator NanoH2O,” by Randall Hackley, published on March 16, 2014 by Bloomberg, NanoH2O Inc. is being purchased by Seoul-based LG Chem Ltd. for $200 million.

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