

Membrane Technology The Future of Water Purification

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Battelle Beginnings

Battelle was founded in 1923 by the will of Gordon Battelle as a non-profit, charitable trust to provide for “the greatest good to humanity”. Battelle is governed by a self-perpetuating Board of Directors that interprets the Will in light of today’s needs and conditions.



Founding Purpose

- Conduct scientific discovery
- Translate discoveries into practical applications that benefit the economy and society
- Apply proceeds to improve education of men and women for employment



Battelle Overview

- Global enterprise that generates over \$5.5 billion* per year in R&D projects
- Manages over 20,000 employees* in more than 100 locations around the world
- Instrumental in the development of: xerography, no-melt chocolate, cut resistant golf balls, liquid correction fluid, automobile cruise control and universal product code system

* Including National Laboratories Managed by Battelle



Corporate Headquarters
Columbus, Ohio



Ocean Sciences Laboratory
Duxbury, Massachusetts

Battelle Organization

○ **Global Businesses**

We apply science and technology through Global Businesses

- National Security
- Energy Technology
- Health and Life Sciences

○ **Global Laboratory Operations**

We manage scientific discovery and innovation through Global Laboratory Operations

○ **Battelle Ventures, L.P.**

We create commercial value through Battelle Ventures

Managed National Laboratories



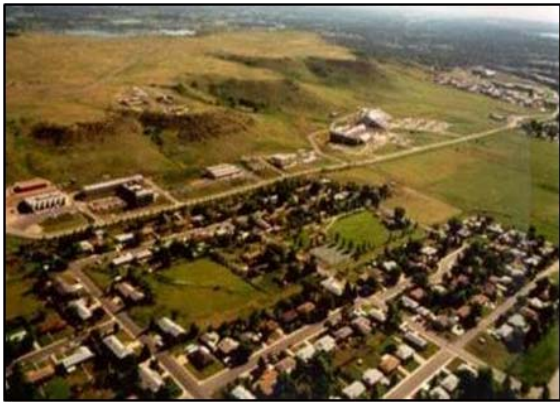
Oak Ridge National Laboratory
Oak Ridge, Tennessee



Pacific Northwest National Laboratory
Richland, Washington



Brookhaven National Laboratory
Upton, New York



National Renewable Energy Laboratory
Golden, Colorado



Idaho National Laboratory
Idaho Falls, Idaho



Lawrence Livermore National Laboratory
Livermore, California

Past Drivers

Membrane Innovation

Background

Increasing and more affluent populations placed pressure on existing raw water sources leading to water scarcity and reliance on lower quality raw sources, including wastewater, brackish water and sea water, while at the same time regulations increased for higher quality drinking water.

Regulatory Driver (USEPA) - Drinking Water

- 1974 Safe Drinking Water Act
- 1989 Surface Water Treatment Rule
- 1998 Enhanced Surface Water Treatment Rule
- 1994 First Large Scale MF Drinking Water Treatment Plant
5.0 MGD Drinking Water Memcor MF Plant

Past Drivers

Membrane Innovation

Water Scarcity Driver - Wastewater Reuse

Orange County Water Factory 21

1976 5 MGD RO system with conventional pretreatment system

2008 75 MGD RO system with microfiltration pretreatment system

Water Scarcity Driver - Seawater Desalination

Tampa Bay Water (TBW) Big Bend Seawater Desalination Plant

1999 TBW awards contract to build 25 MGD seawater desalination plant

2004 American Water Services/Pridesa takes over remediation contract

2007 Desalination plant fully operational

Current Drivers Membrane Innovation

Background

Membrane technology has become an established unit operation for water and wastewater treatment. Innovation focused on improved membrane materials and product configurations to reduce equipment and operating costs.

Membrane Materials

- Composite polymer membrane with nanoparticles (energy/production)
- Modified polymers w/grafting, blending, surface modifications (fouling)
- Oxidation resistant RO membranes (fouling/useful life)

Membrane Product Configurations

- Larger membrane cartridge/element size for economies of scale
- Membrane bioreactors
- Packaged water and wastewater treatment plants

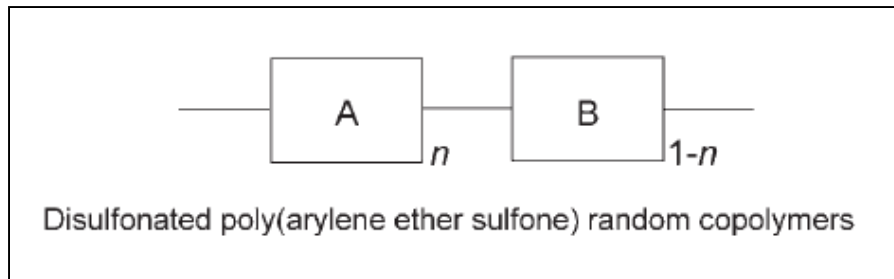
Current Drivers

Membrane Innovation

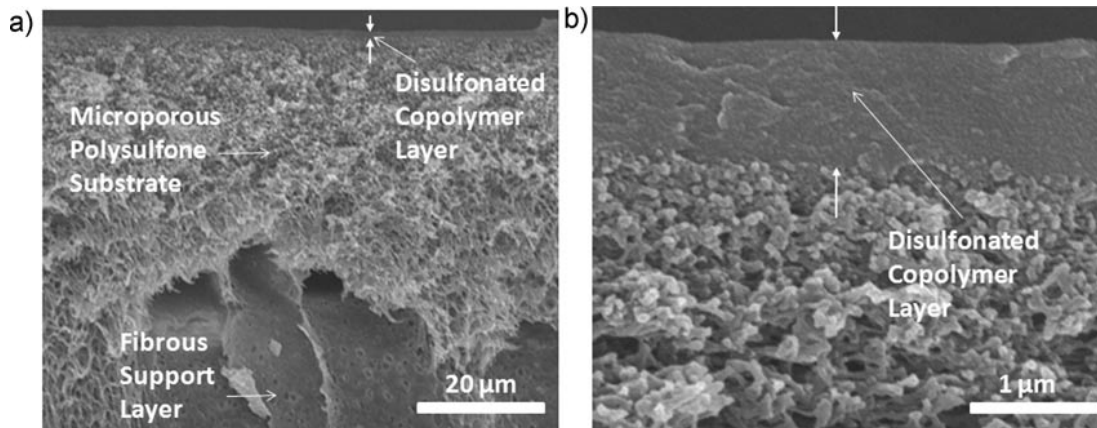
Membrane Polymer

Direct polymerization of di-sulfonated block co-polymers

McGrath, Virginia Tech/Freeman, University of Texas



A = Hydrophilic monomer
B = Hydrophobic monomer



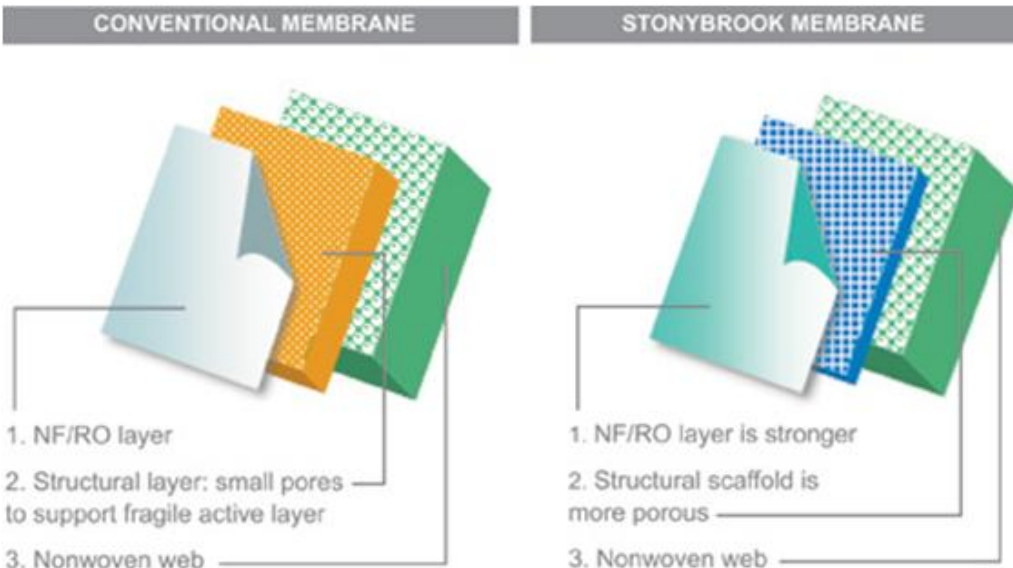
Current Drivers

Membrane Innovation

Membrane Structure

Membrane support layer modification

Stonybrook Purification



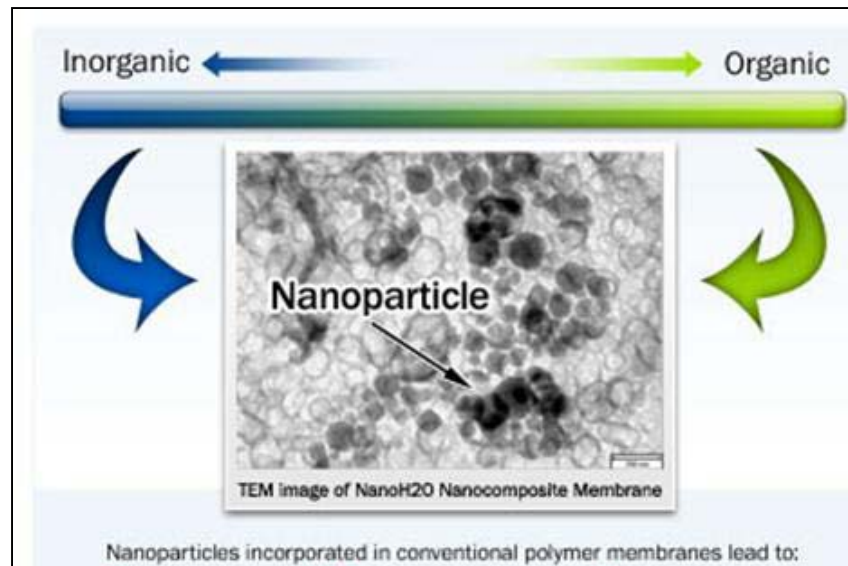
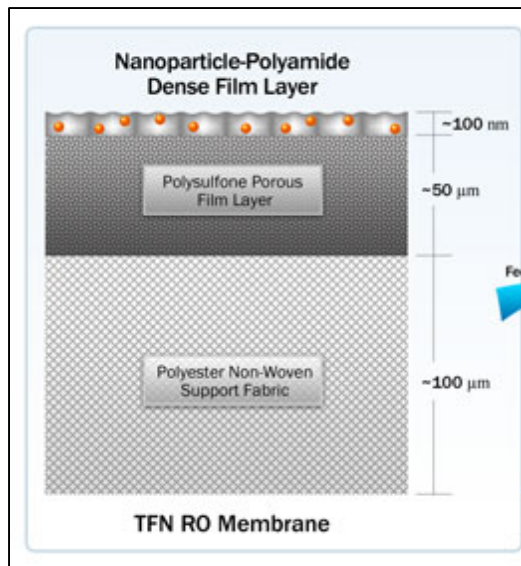
http://www.stonybrookpure.com/membrane_technology.html

Current Drivers Membrane Innovation

Membrane Composition

Composite polymer w/nano-particle

NanoH2O Inc.



<http://www.nanoh2o.com/Technology.php5>

Current Drivers

Membrane Innovation

Membrane Product Configuration

Larger membrane products for economy of scale



Membrane Bioreactor Cassette



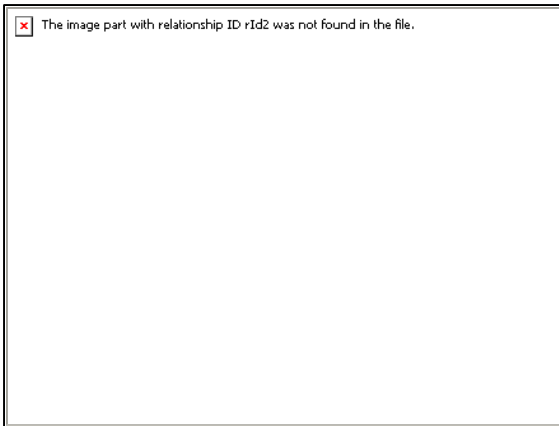
Reverse Osmosis Membrane Element

Current Drivers

Membrane Innovation

Membrane Product Configuration

Packaged Deployable Water Treatment Plant



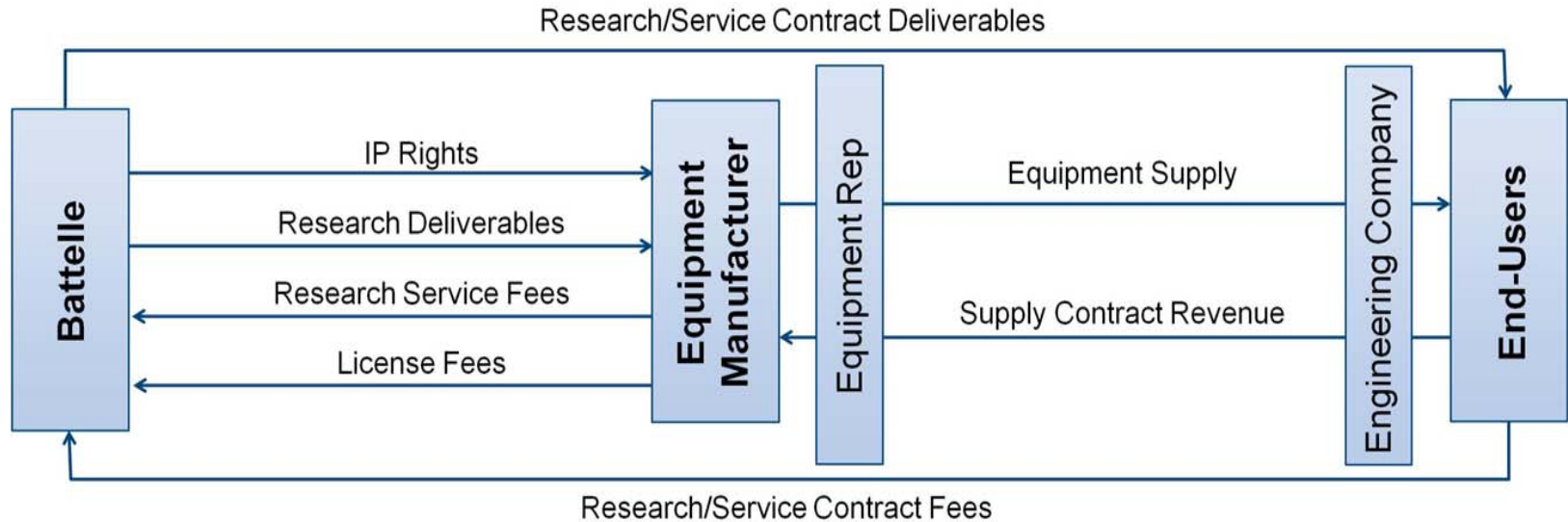
Current Drivers

Membrane Innovation

Membrane Product Configuration
Extremely Large Membrane Systems



Path to Market Water Technology



Engineering Companies

CH₂M HILL
AECOM
CDM
Malcolm Pirnie

Equipment Suppliers

Siemens
ITT
Degremont
Veolia

End Users

Industry
Municipalities
Private Water Companies
Government

Worldwide Market Opportunity

Taiyuan Steel, China

