How Membrane Technology Contributes to Sustainability and Life Sciences

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Outline

- The world 2030
- Energy and water: trends and challenges
- Innovations for optimizing water-energy
- Applications for Life Science
By 2030, the world’s population will reach 8.3 billion
1.8 billion people will live in water-scarce regions by 2025
Basics of Reverse Osmosis

Chemistry

\[
\text{NH}_2 + \text{ClO}_2 \rightarrow \text{NHCO}_2 + \text{H} + \text{NCO}_2 \text{m} \]

MPD in water

TMC in Isopar L

\[
\begin{align*}
\text{NH}_2 & \quad \text{CONH} \\
\text{COH} & \quad \text{COO}_2
\end{align*}
\]

Polyamide

Polysulfone

Ultrathin Barrier Layer

Microporous Polysulfone Substrate

Reinforcing Polyester Fabric

Manufacturing

Oven

PET+PS

Extraction

TMC application

amine application

Rewind

Spiral Wound Element Design

Perforated Product Tube

Anti-Telescoping Cap

Feed Water Carrier

Permeate Carrier Material

Semi-Permeable Membrane

Edges are glued to form Permeate Envelope

Feed Solution

Permeate Flow

Permeate

Concentrate
30% more water
45% more energy
Water Energy Nexus - Sustainability

**Water for Energy**
- Extraction & Refining
- Fuel Production (Ethanol, hydrogen)
- Hydropower
- Thermo electric cooling
- Extraction and Transmission
- Drinking water treatment
- Energy associated with uses of water

**Energy for Water**
- Wastewater treatment
Target - 30% Energy savings, 40% better Quality

Salt Permeability (GFD)

Water Permeability (GFD/psi)

99.0%

99.3%

99.5%

99.7%

99.9%

200 psi

125 psi

100 psi

Ind STD

BW30

OPEX

ECO

Chemical Savings

Energy Savings

ECOnomical ($ over lifetime of element)

ECOlogical (sustainability over the lifetime of element)
Historical Perspective for Energy Efficient Membranes

Commercialization Reality for FT30

Takes Decades to make the next big change – WHY?

Absence of fundamental structure-property relationship
In the last 30 years we are locked in a narrow compositional window- Let’s expand ....
A Terpolymer Approach – An Example

**Functionality**

**Charge**

**Rigidity**

**Flexibility**

**Terpolymer - Structure Designed to Performance**
Our Contribution to World Challenges

DOW FILMTEC™ ECO RO Elements

40% less salt passage  
30% less energy

Saves 2 billion kilo watts of energy and reduces 1.5 million metric tons of CO2 emissions over 10 years
Water Customers Are Being Squeezed on Both Ends

Water/energy scarcity and declining feed water quality

Increasing discharge requirements / Zero discharge

Seawater
Brackish water
Recovered water

Water customers

Municipal WWTP
Receiving body
Fouling and Sustainability - An Emerging Critical topic

1. Energy
2. Cost of cleaning chemicals
3. Reliability

Ref: OCWD, Shu et al AWWA-2015
Innovations in Water Treatment can optimize the Water-Energy Nexus

Research

1. Fouling control and mitigation
2. Understanding 3D structure
3. Computational high throughput research
4. Increasing discharge requirements / Zero discharge
Residential — Higher Productivity, Better Quality and Reduce Footprint

Salt Permeability (GFD)

Water Permeability (GFD/psi)

Ind STD
200 psi
125 psi
70 psi
Tankless

ECO

0.1 0.15 0.2 0.25 0.3 0.35 0.4
0 0.05 0.1 0.15 0.2 0.25 0.3 0.35 0.4 0.45

0.1
0.15
0.2
0.25
0.3
0.35
0.4

0.1
0.15
0.2
0.25
0.3
0.35
0.4

Dow

99.0 %
99.3 %
99.5 %
99.7 %
Market’s Demand - High Recovery Operation

Drinkable (25%) → Waste → Drinkable

Current

Drinkable

High Recovery

Problems
- Scaling of membrane
- System efficiency
- Application knowledge

Approach
- Improved module design
- Fundamental research around scaling
Membranes for Dairy Application

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<th>MW Daltons</th>
<th>Milk Component</th>
<th>Separation process</th>
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<td>Fat globules</td>
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</tbody>
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**Research**

1. High throughput vs Nitrogen rejection
2. Water reuse vs waste water production
3. Cleanability vs life time

Ref: Wisconsin Dairy Institute
Material
✓ x-linked Polyimides, PDMS, Pan support

Advantages
✓ Replace solvent extraction
✓ Replace crystallization
✓ Replace distillation

Challenges
❖ Stability of membrane
❖ Rejection dependent
❖ solvent/solute/membrane interactions
Where Science Can Help

Addressing water availability, water quality, cost and energy efficiency