Self Cleaning Membranes in Sea Water Desalination

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Jamie Durham
Anterjot Bains
Aaron Tang
Rajesh Swaminathan

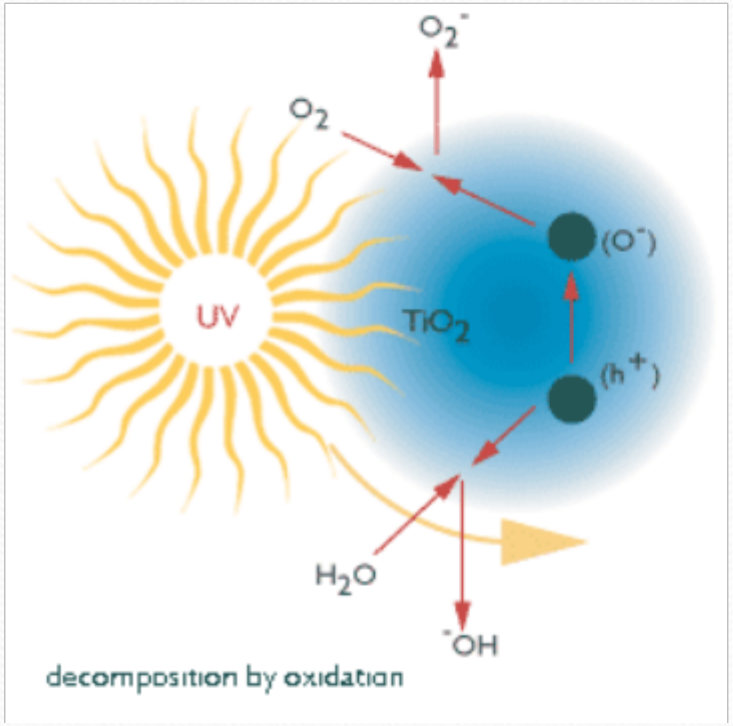
Consultant:
Dr. Christine Moresoli

Design Overview

- Membrane fouling -- main barrier to effective desalination
- Improve membrane filtration throughput
- Current methods require:
  - stopping the flow
  - cleaning mechanism with periodic reverse flow
- Self cleaning membranes:
  - removes the need for a cleaning step
  - prevent flow rate decline

What is Self-Cleaning?

- TiO_2 + UV rays = pair of e^- and p^+
- e^- + O_2 = super oxide radical ions
- p^+ + H_2O = OH^- radicals
- These two groups are extremely strong oxidants that remove contaminants, especially organic compounds



Design/Customer Requirements

Primary:

- Desalination membrane that cleans itself as filtration occurs
- Use TiO_2 nanoparticles to implement this requirement

Secondary:

- Improve membrane hydrophilicity and efficiency using SiO_2 nanoparticles

Tertiary:

- Small scale portable flow system that scales up for industrial use

Design Purpose

Organic contaminants:

- plug pores and reduces flow
- introduce periodic downtime
- make membranes hydrophobic
- contaminate the flow

Design Purpose

Advantages of self-cleaning membranes:

- No downtime between flows
  - Increases throughput
  - Reduces costs
- Filtration process is simplified -- only requires UV light

- Contaminant concentration minimized

- Longer lasting membrane

Design Criteria/Verification

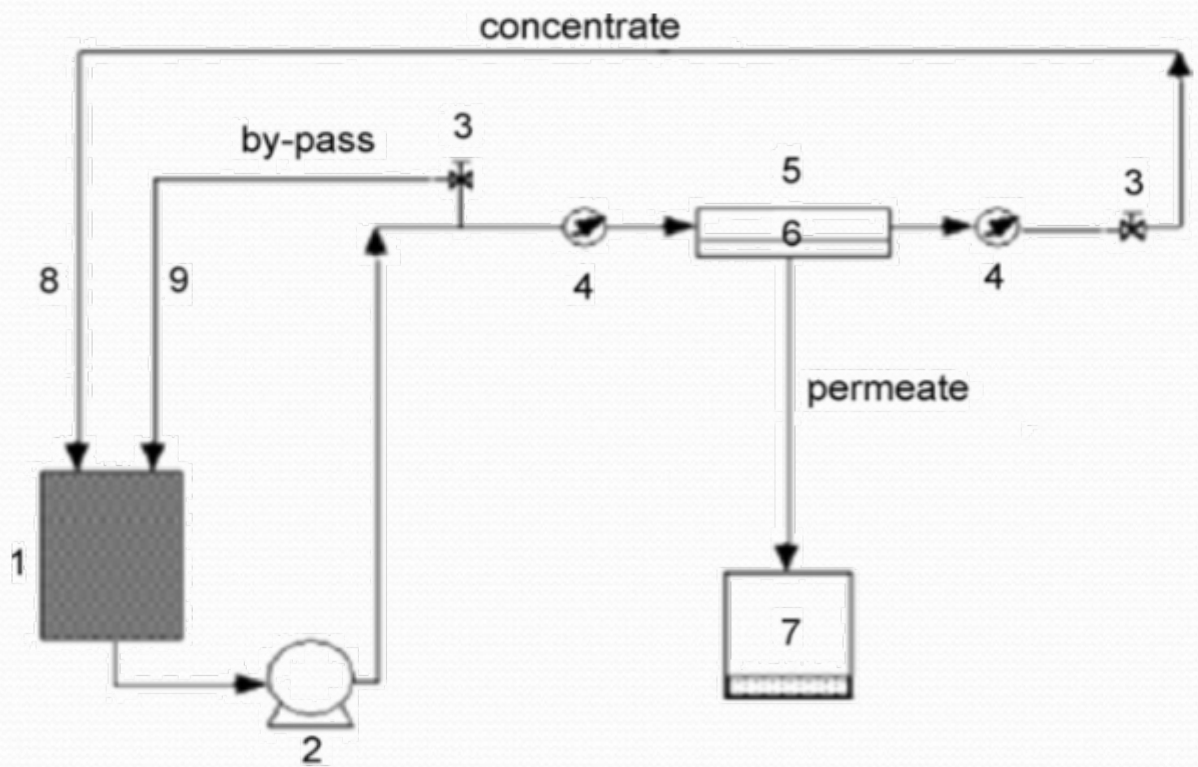
- Performance Criteria
  - Flow rate
  - Concentration of organic contaminants
  - Selectivity
  - Efficiency to TiO_2 weight ratio

- Test variable: Simulated sea water
  - DI water as control
  - 3.5% salinity
  - Phenols, PCBs, Halogenated compounds

Design Trade-offs

Parameter	Good	Bad
1. Increased UV light duration	Increases self-cleaning properties	Increases cost
2. Increased Particle Concentration	Increases self-cleaning properties	a. Increases deposition time b. Decreases flow rate c. Increases cost
3. Decreased particle size	Increases surface area which increases catalytic performance	Increases Cost

Reverse Osmosis Schematic



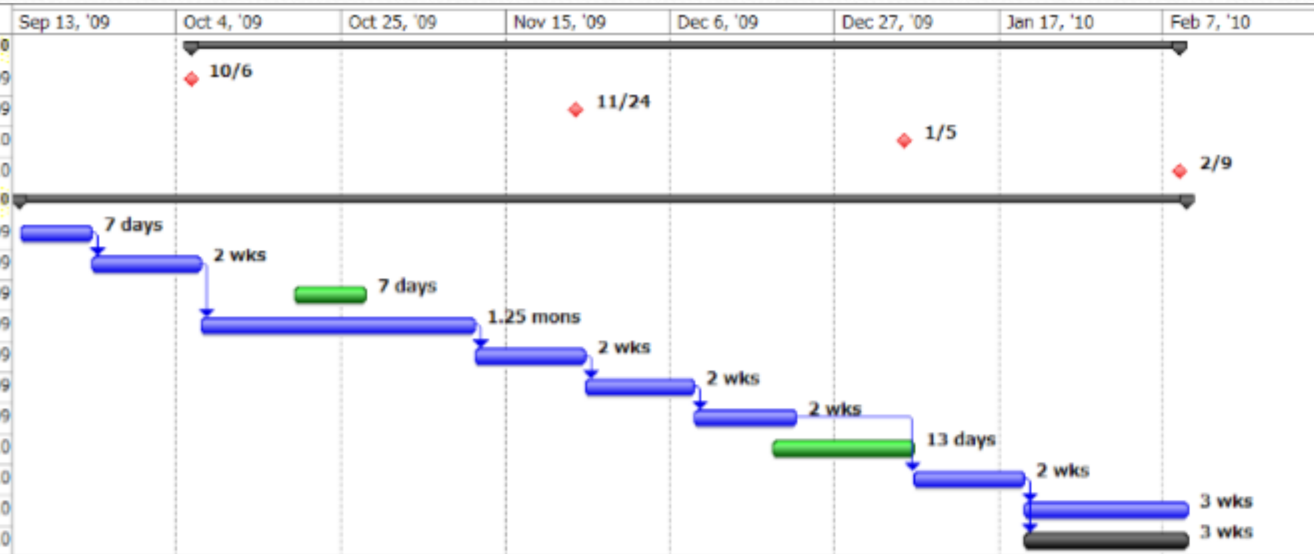
1. Feed Tank
2. Pump
3. Valve
4. Pressure gauge
5. Crossflow cell
6. Membrane
7. Permeate
8. Concentrate
9. By-pass

Design Issues

- Deposition Method (ion assisted deposition)
  - Adapt TiO_2 to work with chosen deposition method
- Prevent aggregation of TiO_2
- Plugging
- Stability -- will TiO_2 actually remain there
- Dispersion of particles/adsorbates (getting uniform distribution)

Timeline

ID	Task Name	Start	Finish
	Milestone: Yes	**Tue 10/6/09**	**Tue 2/9/10**
3	Complete Test Setup	Tue 10/6/09	Tue 10/6/09
7	Complete Osmosis Assembly	Tue 11/24/09	Tue 11/24/09
11	Final System Integration	Tue 1/5/10	Tue 1/5/10
15	Final Delivery	Tue 2/9/10	Tue 2/9/10
	Milestone: No	**Mon 9/14/09**	**Tue 2/9/10**
1	Obtain Membranes	Mon 9/14/09	Tue 9/22/09
2	Assembly of Test Setup	Wed 9/23/09	Tue 10/6/09
4	Midterms	Mon 10/19/09	Tue 10/27/09
5	Trial 1-6	Wed 10/7/09	Tue 11/10/09
6	Filter Integration	Wed 11/11/09	Tue 11/24/09
8	Trials 7-10	Wed 11/25/09	Tue 12/8/09
9	Finalize System Integration	Wed 12/9/09	Mon 12/21/09
10	Winter Break	Sat 12/19/09	Tue 1/5/10
12	Optimization	Wed 1/6/10	Tue 1/19/10
13	Overall Design Review	Wed 1/20/10	Tue 2/9/10
14	Preparation for Final Presentation	Wed 1/20/10	Tue 2/9/10



Critical Milestones:

- Assembly of Test setup – Oct 6
- Filter Integration – Nov 24
- Finalized System Integration – Jan 5
- Overall Design Review – Feb 9

Budget - Materials

Materials	Price
Polymer Membrane	Free – Sponsored by Pall Corporation
TiO_2 Nanoparticles	$225
SiO_2 Nanoparticles	$100
Sea Salt	$10
Various Organic Contaminants (e.g. PCBs, surfactants)	$135
Professional Packaging	$30
SUBTOTAL	$500

Budget - Equipment

Equipment	Price
Sponsored Testing Equipment • Dead-end membrane holder • FE-SEM • XPS • Image Analysis Software	Free
AFM	Free
Excimer UV Lamp	$300
PECVD	Free
Reverse Osmosis Assembly	$300
SUBTOTAL	$600
Contingency (20%)	$220
GRAND TOTAL	$1,320

References

[1] Hyeok, Sung Ho Kim and Sohn Byeong- and Park, Tai Hyun., *"Design of TiO2 nanoparticle self-assembled aromatic polyamide thin-film-composite."* Journal of Membrane Science, 2003, Issue 157-165, Vol. 211.

[2] H. Yamashita, H.Nakao, M. Takeuchi, Y. Nakatani, and M. Anpo., *"Coating of TiO2 photocatalysts on super-hydrophobic porous teflon membrane by an assisted ion deposition method and their self-cleaning performance."* Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, May 2003, Issue 898-901, Vol. 206.

[3] Guan, Kaishu., *"Relationship between photocatalytic activity, hydrophilicity and self-cleaning effect of TiO2 and SiO2 films."* Surfaces and Coating Technology, 2005, Issue 2-3, Vol. 191.

[4] S.S. Madaeni, N. Ghaemi., *"Characterization of self-cleaning RO membranes coated with TiO2 particles under UV radiation."* Journal of Membrane, 2007, Issue 221-233, Vol. 303.