Membranes With Superhydrophilic Zwitterionic Polymers For Water Purification

Kaipin Huang, Shizhong Zhao, Shawreen Manish Shah and Haiqing Lin

Department of Chemical and Biological Engineering, University at Buffalo (SUNY), Buffalo, NY 14260, USA

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Overview

Background:

Increasing need for reusing wastewater due to:

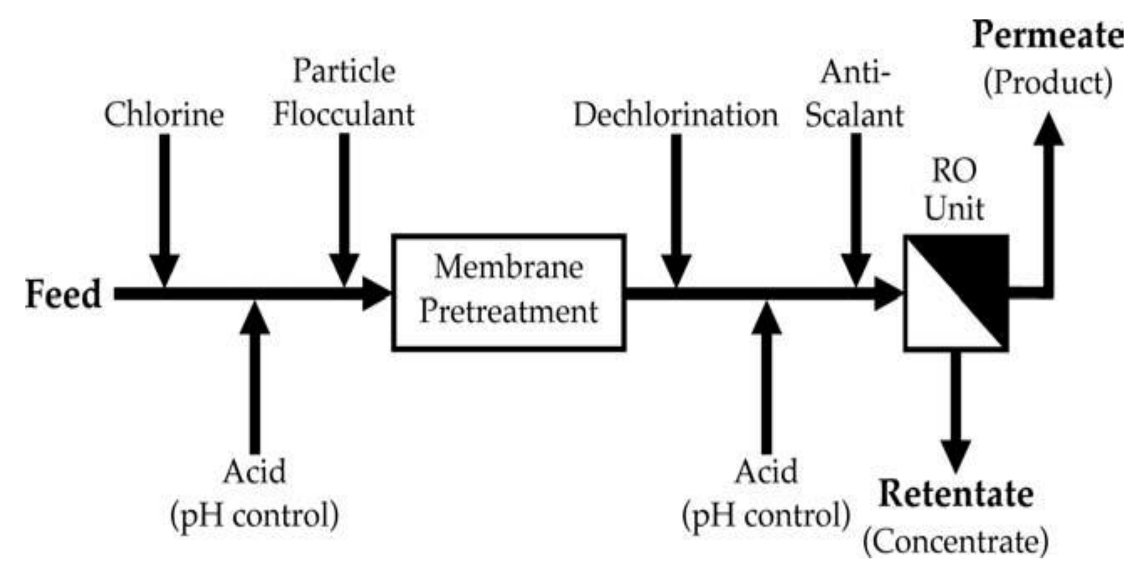
- Population increases rapidly
- Living quality improves
- Excess consume fresh water reserved

Potential Method:

Polymeric Membranes because of :

- High energy efficiency
- Low cost

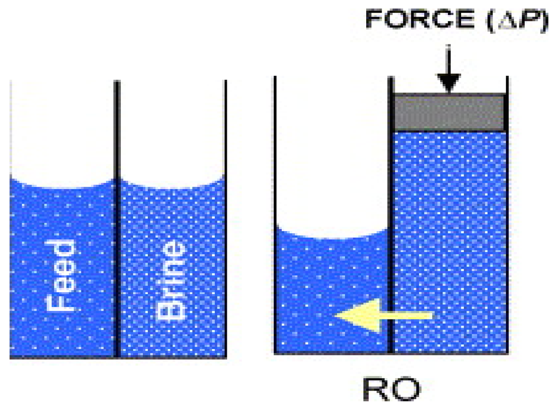
Reverse Osmosis is a widely-use method in wastewater purification.



Water Purification Process

Reverse Osmosis

Reverse Osmosis Membrane System in IDE Hadera Plant.



$$J_W = A\cdot(\Delta p - \Delta\pi) \quad (\Delta p > \Delta\pi)$$

J_W = Water Flux

A = Water Permeability Coefficient

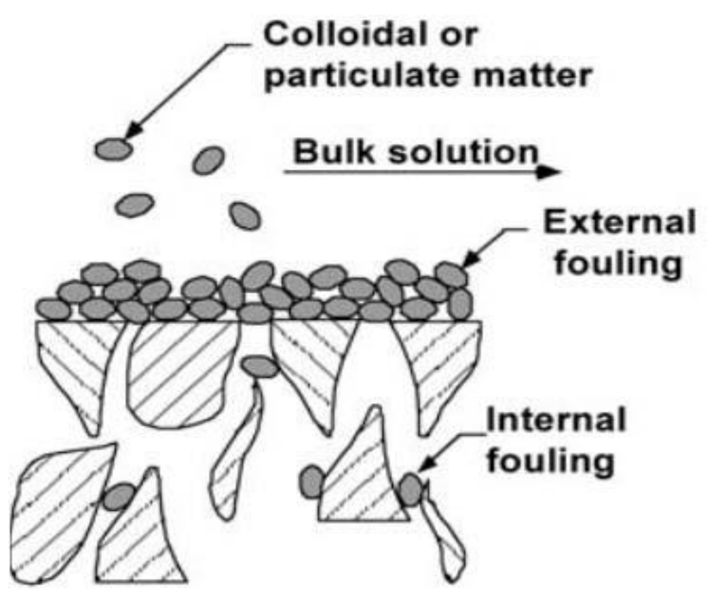
Δp = Pressure Difference

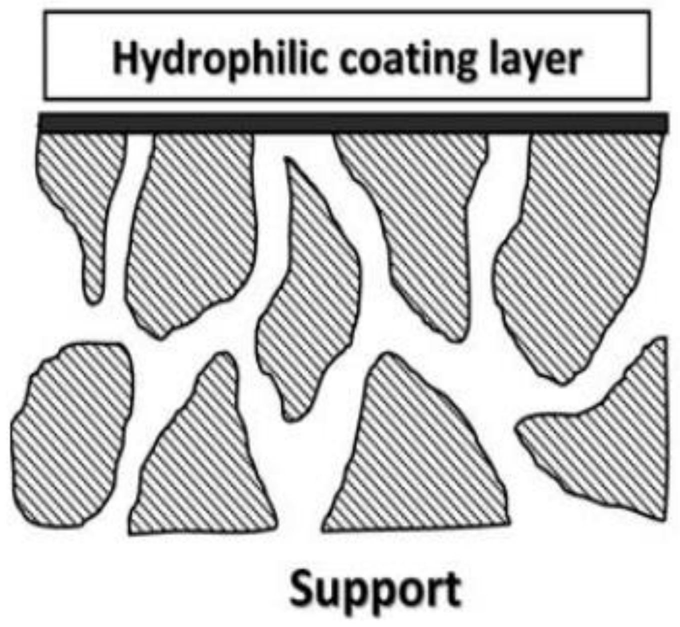
$\Delta\pi$ = Osmotic Pressure Difference

Current Membranes limitation and Potential Solution

Limitation: Membrane external and internal fouling after long term run. Fouling reduces the water flux and further reduces the efficiency

Solution: Hydrophilic coating layer on the surface to reduce fouling.



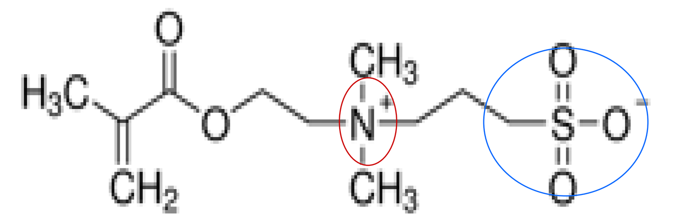


Approach: Free-standing Membranes

Materials:

- **Solute** (**Mass ratio is varied between Zwitterionic Monomer and PEGDA**)

1.Zwitterionic Monomer:



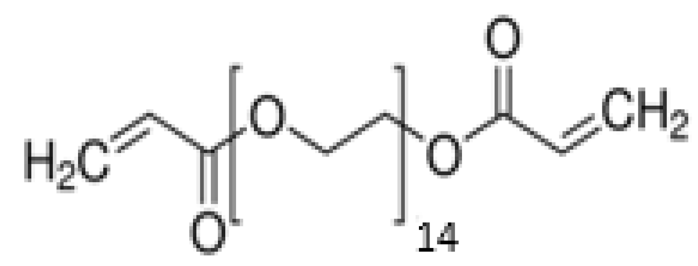
[2-(Methacryloyloxy)ethyl]dimethyl-(3-sulfopropyl)ammonium hydroxide

Zwitterionic Monomer contains both:

- Cationic Group
- Anionic Group

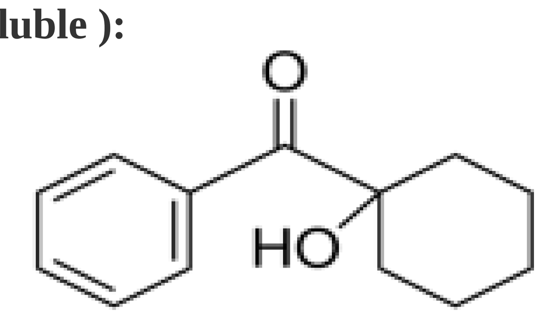
It is a good candidate of **hydrophilic** materials. It is **water** soluble but insoluble in organic solvent.

2.Crosslinker:



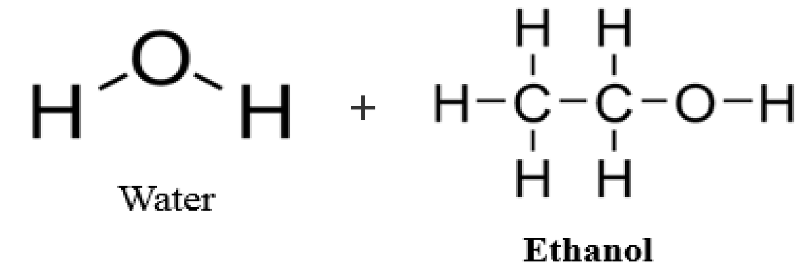
PEGDA: Poly(ethylene glycol) diacrylate

3.Initiator(**0.2 wt. % used not water soluble**):



HCPK:1-Hydroxycyclohexyl Phenyl Ketone

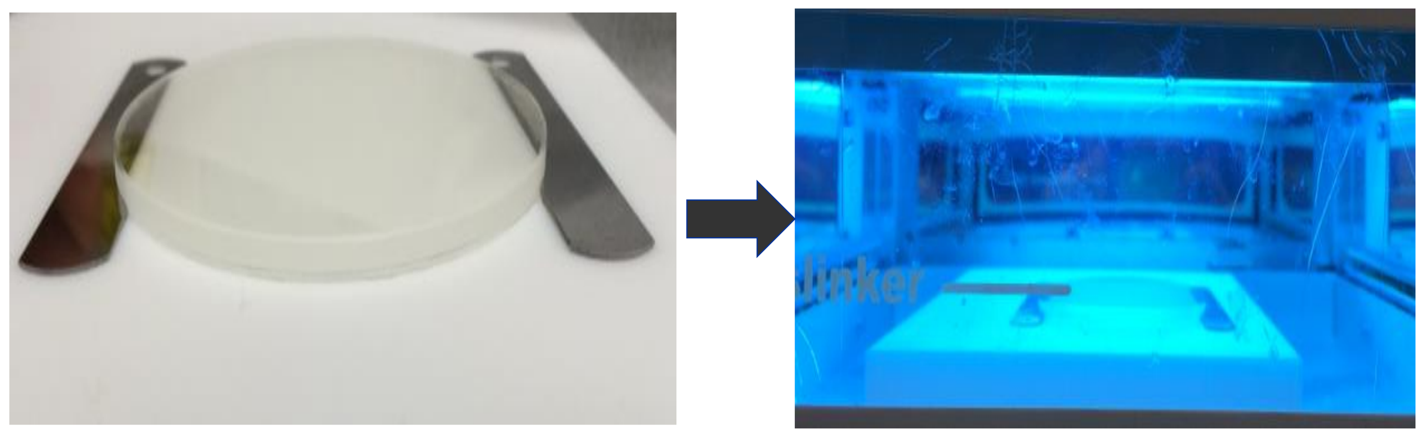
- **Solvent** (**Mass ratio between Water and Ethanol is kept as 1:1**)



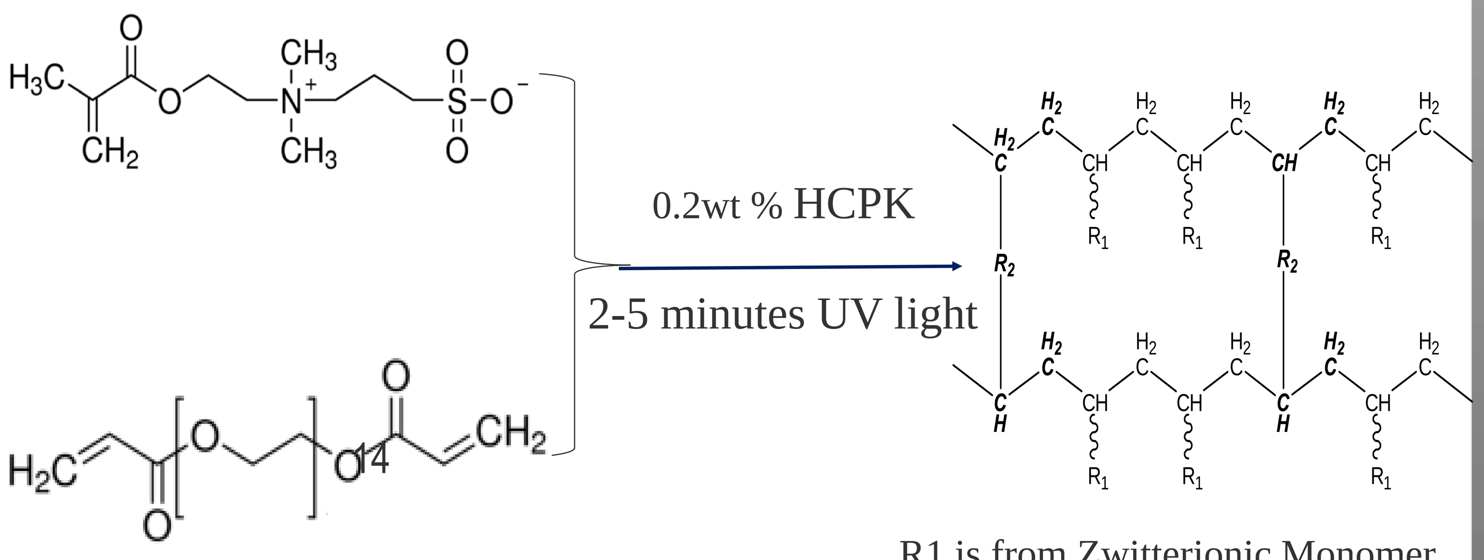
- Water is the solvent for Zwitterionic Monomer
- Ethanol is the solvent for Initiator

Method:

- "Sandwich" (from top to bottom) -Quart plate +Solution +Spaces +Teflon plate.
- Under UV light for up to 5 minutes.



Reaction:



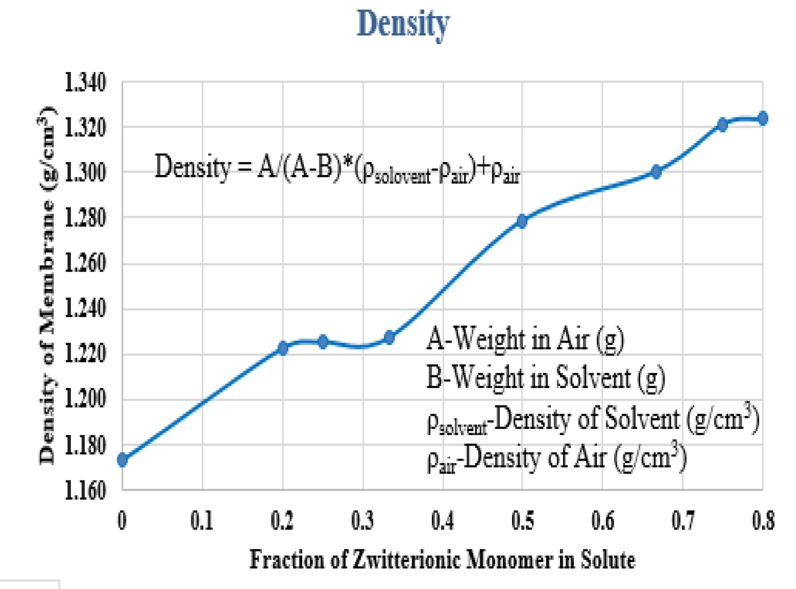
R1 is from Zwitterionic Monomer, R2 is from PEGDA

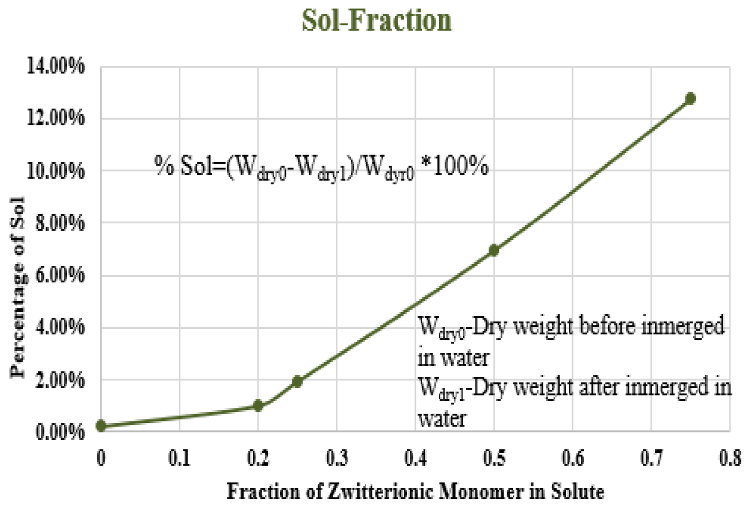
Results

Samples:

Sample (Zwit:PEGDA)	Solute (Monomer+Crosslinker)		Solvent (Water +Ethanol)		Initiator (HCPK) (%)	Get Membrane
	Zwit (%)	PEGDA (%)	Water (%)	Ethanol (%)		
Pure PEGDA	0	50	25	25	0.2	√
1:4	10	40	25	25	0.2	√
1:3	12.5	37.5	25	25	0.2	√
1:2	16.7	32.3	25	25	0.2	√
1:1	25	25	25	25	0.2	√
2:1	32.3	16.7	25	25	0.2	√
3:1	37.5	12.5	25	25	0.2	√
4:1	40	10	25	25	0.2	√
Pure Zwitter	50	0	25	25	0.2	X

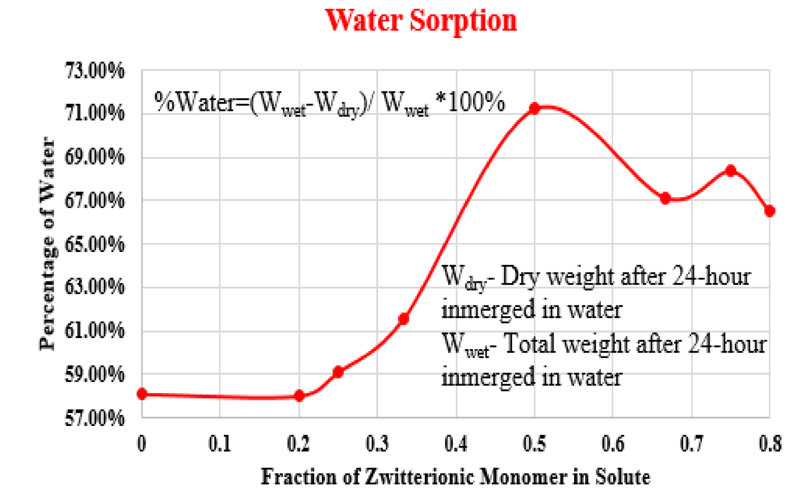
Density decreases with increasing ratio of Zwitterionic Monomer





Sol dissolves in water but gel not.
Sol Fraction increases with increasing ratio of Zwitterionic Monomer.

Water Sorption shows the ability the membrane to hold the water molecules. It maximizes at 1:1 ratio.



Conclusion, Future Work and Acknowledge

Conclusion :

- The density of membrane increases with increasing ratio of Zwitterionic Monomer
- Zwitterionic membranes have appropriate Zwitterion inside.
- Zwitterionic membranes have good ability to hold water molecule.

Future Work:

- Evaluate salt diffusivity of some samples.
- Make flat samples for contact angles.
- Measure water permeability.

Acknowledge:

1. Geise, G. M.; Lee, H. S.; Miller, D. J.; Freeman, B. D.; McGrath, J. E.; and Paul, D. R. Water Purification by Membranes: The Role of Polymer Science, J. Polym. Sci. Part B: Polym. Phys. 2010, 48, 1685-1718.
2. Andrew B. Lowe*,‡ and Charles L. McCormick*,‡, § . *Synthesis and Solution Properties of Zwitterionic Polymers†. Chem. Rev.* **2002,** *102*, 4177-4189.
3. Cath, Childress, and Elimelech, *J. Membr. Sci.*, 2006, *261*, 70-87.