Spring 2015

Development of Anti-Fouling, Anti-Microbial Membranes by Chemical Patterning

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Development of Anti-Fouling, Anti-Microbial Membranes for Wastewater Treatment

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Introduction

- Over **1 billion people** lack access to clean drinking water.
- Treatment of impaired waters exposes membranes to feed waters containing biological and abiotic species, which leads to **fouling and loss of membrane productivity over time**.
- Fouling is one of the **largest costs** associated with membrane processes in water treatment.

Hypothesis

Combining **chemical coating** (Figure 1) **and patterning** (Figure 2) will yield membrane surfaces that are **more effective** at fouling control than either method alone.

Resists live microorganisms (PASSIVE) and releases dead microorganisms

Kills adsorbed microorganisms (ACTIVE)

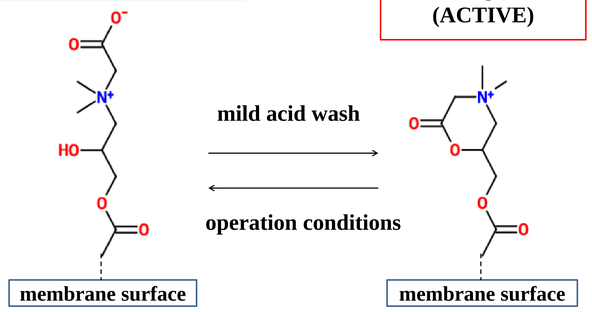


Figure 1. Reversible coating chemistry. **Our strategy differs fundamentally from most other surface modification strategies** that rely solely on passive control or active control (e.g., adding biocides).

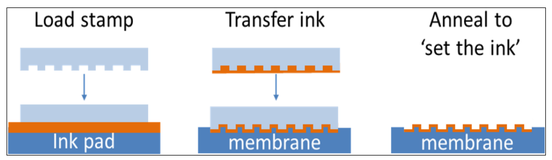
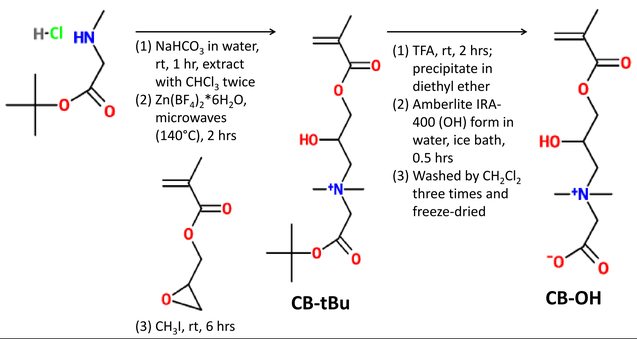


Figure 2. Methods of combining chemical coating and patterning on a membrane surface by deformation (i.e., embossing) of the membrane substrate. Test ink is a poly(ethylene glycol) diglycidyl ether solution in water.

Enabling Chemistry



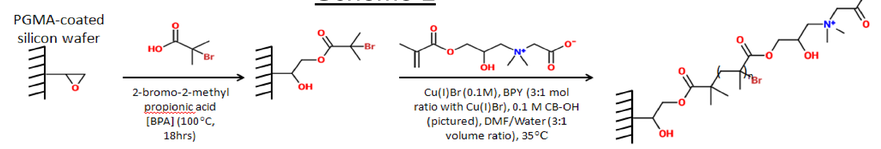
Overall Project Objectives

- Prepare and characterize membranes with surfaces that can switch reversibly between passive and active modes
- Evaluate surface chemistry effects on membrane performance
- Evaluate anti-fouling, anti-microbial function of membranes
- Prepare membranes that are patterned uniformly with chemical coatings that are chosen to limit fouling
- Evaluate the effects of patterning on membrane performance
- Evaluate the anti-fouling function of the chemical patterns

Surface Modification Fundamentals

- Scheme 1 illustrates the surface modification strategy that uses surface-initiated ATRP

Scheme 1



- Figure 3 illustrates the surface modification strategy that uses a stamp.

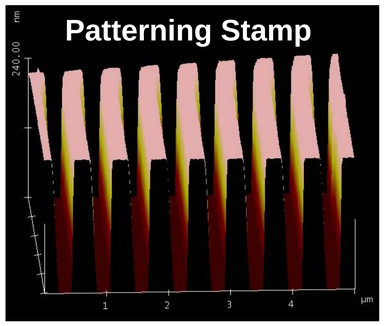


Figure 3. Surface morphology of a linear silicon nanostamp used for patterning membrane surfaces.

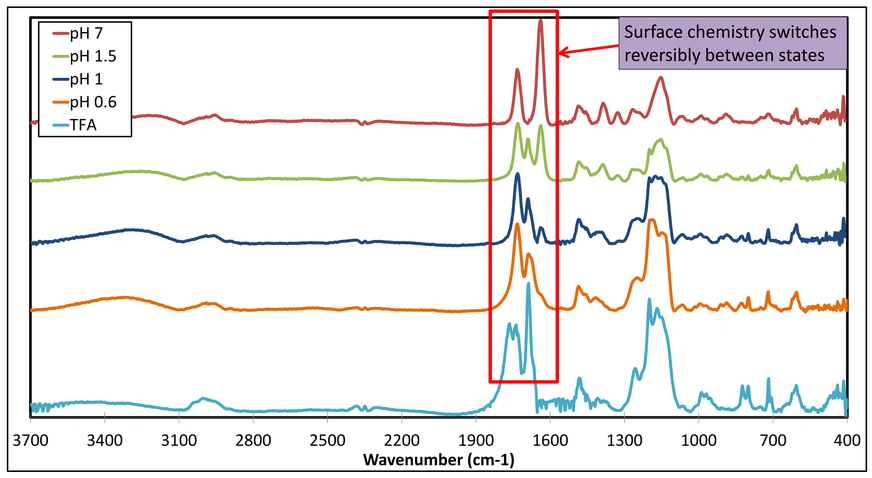
In this example, the stamp dimensions are:

Period: 625nm

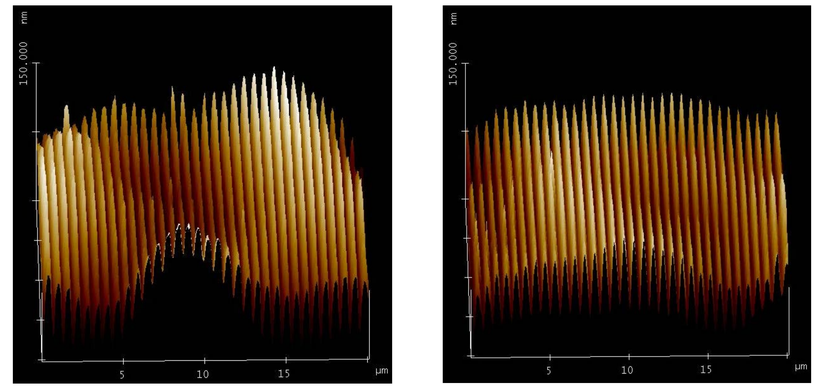
Line width: 215nm

Groove depth: 250nm

Transmission FTIR



Atomic Force Microscopy Images



No reaction, 60°C, 30 min

50 wt%, 60°C, 30 min

Figure 4. Effectiveness of creating a pattern on the membrane while deforming the membrane substrate. Common scale is 20 µm × 20 µm × 150 nm. The left image has an average channel height of 51 ± 19 nm, while the right image has an average channel height of 67 ± 11 nm.

Summary of Current Work

- **CB-OH** was **synthesized** successfully
- **Polymerization** of CB-OH was **successful** from silicon substrates
- FTIR showed **successful, reversible switching** between CB-OH and CB-Ring
- PEGDE test ink was **successfully patterned** onto membranes

Future Work

- **Vary initiator density** and measure resulting polymer chain densities and possible effect on switching pH
- Perform polymerization from **glass and QCM sensors** for bacterial deposition and release studies
- Perform polymerization from **NF and RO membranes** and test performance.
- Develop **polymeric stamp** for patterning membranes
- Test fouling performance with **colloidal particles and proteins**
- Investigate effectiveness of **different patterns and chemical coatings**

Acknowledgements

- This work was supported by the National Science Foundation Graduate Research Fellowship under Grant No. DGE-1246875. Any opinion, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the NSF.
- We thank the US-Israel BARD Foundation for financial support through Research Grant Agreement No. US-4654-13
- 2014 Tiger Grant Award Proposal Award