Optimizing Crosslinking of Thin Film Bottlebrush Polymer for Use in Antifouling Membrane Coatings

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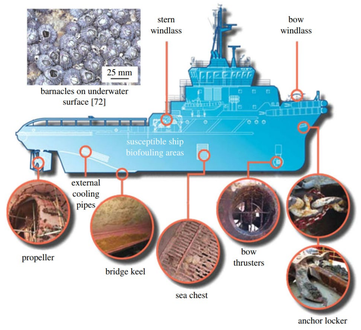
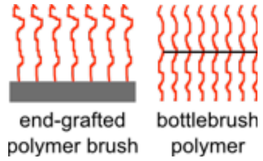
Introduction

Surface fouling is a significant impediment to efficient and effective water filtration. Fouling results from the adsorption of an undesired layer of particulates onto a surface and can decrease the efficiency of water filtration and degrades the quality of water.[1]

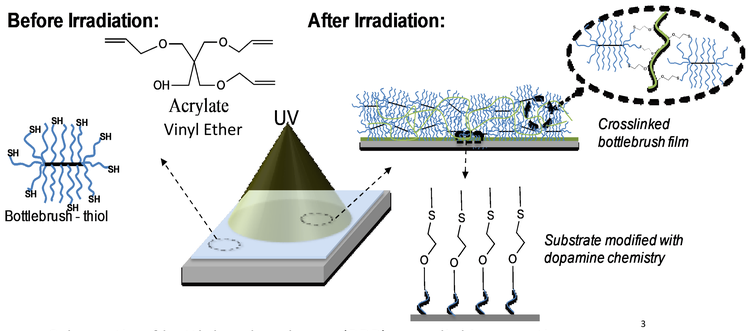




(Left) Schematic of various examples of fouling in a marine setting. These examples depict biofouling—the fouling caused by living organisms, but fouling can also be organic or inorganic compounds. (Right) Schematic for a polymer brush and bottlebrush polymer (BBP). Both contain dense, brush-like chains that can reduce fouling. [2]

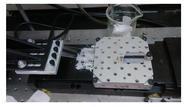
Polymer brushes are a potential solution to reduce fouling. Polymer brushes are dense layers of polymers tethered to a surface. However, these are impractical to deposit over large areas. Brush-like macromolecules known as bottlebrush polymers (BBP) have the potential to function as fouling resistant surfaces that can be coated using conventional, low-cost techniques. However, scalable methods for coating surfaces with BBPs have not been developed.

In this study, we investigate the parameters for depositing and crosslinking a layer of BBPs onto an arbitrary surface through flow coating. Ellipsometry is used to analyze BBP film thickness and stability. This work demonstrates a simple, light-activated approach to produce BBP coatings.

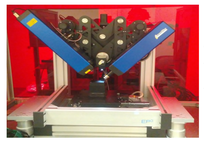


Schematic of bottlebrush polymer (BBP) crosslinking reaction process [3]

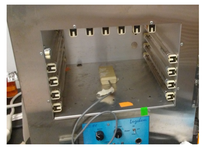
Equipment Utilized



A flow coater is used in casting[4] of BBP onto silica substrates. This can be used to deposit nanoscale-thin films with precise control over film thickness.



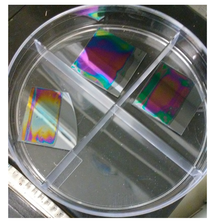
An optical ellipsometer is used for measuring thickness of thin films through analysis of the phase difference of light that is reflected from the surface.



A UV reactor initiated the crosslinking reaction. The intensity of the light is determined by the number of bulbs placed in the reactor.

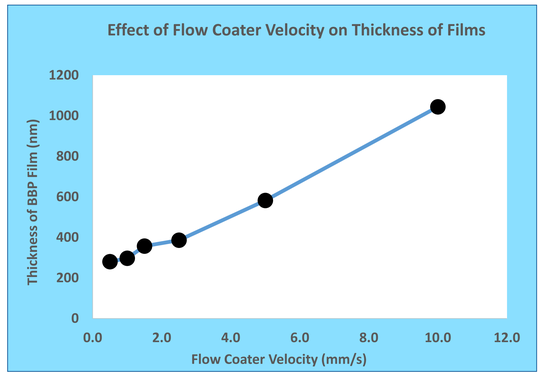
General Crosslinking Methodology

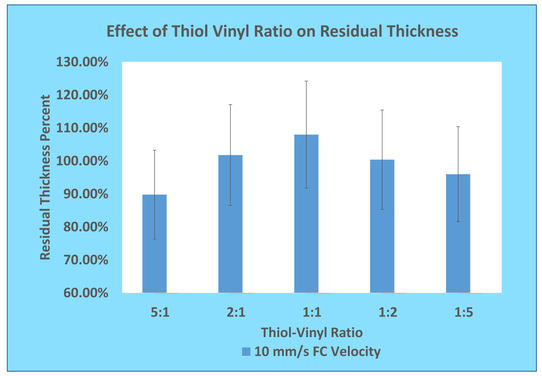
- BBP is placed into a solution with vinyl ether with a photo initiator.
- BBP is cast onto silicon wafer substrate via flow coater set to a specific velocity.
- BBP with silicon substrate is placed in a UV reactor for 2 hours.
- Initial thickness of the BBP film is measured with the ellipsometer.
- Samples are washed in toluene for 10 minutes.
- Final sample thickness is obtained again to determine residual thickness.
- Crosslink effectiveness is inferred by residual thickness of BBP after toluene wash. A 100 % residual thickness indicates a stable film.

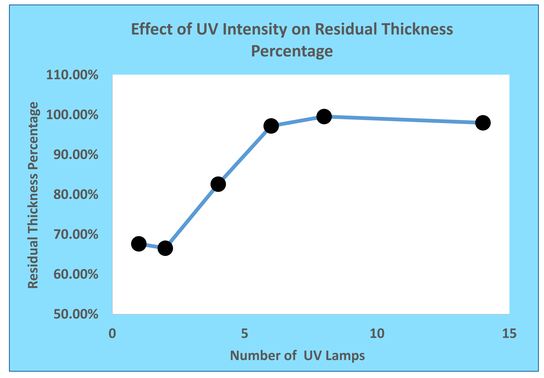


BBP coating on silicon wafers. Different colors can give an approximation n film of thickness.[4]

Crosslinking Outcomes







Conclusions

- Uniform and stable bottlebrush films can be deposited through flow coating. These materials can be crosslinked under UV light.
- BBP film thickness can be precisely controlled by flow coater velocity, ranging from approximately 100 – 1000 nm.
- At a sufficient level of light intensity the residual thickness is near 100 %, indicating stable BBP films.
- The ratio of thiol-vinyl influences film stability, with optimal stability near 1:1. Crosslinked films can also be formed at 1:5 and 5:1 ratios.

References

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Acknowledgements

We would like to thank Christina Crawford, Dr. Carolyn Nichol and the members of the Verduzco laboratory. CE thanks Dr. Nduka Enemchukwu for feedback and support during her time in the lab. She is also thankful to God for the opportunity. This work was funded by NSF Nanotechnology Research Experience for Teachers, National Science Foundation Grant EEC-1449500.