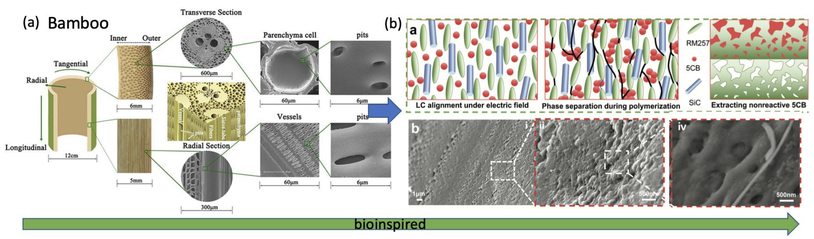
3D Printing of Membranes with Bioinspired Porous Structures for Water Treatment

Emily Hudson, Chemical Engineering
Mentor: Dr. Xiangjia Li, Assistant Professor
School of Matter, Transport, and Energy

1. Introduction

Polymerization phase induced separation is where an initially miscible, single-phase mixture undergoes decomposition during the polymerization of one component, and then transforms into a phase separated blend. To break this down, the polymerization process is where relatively small molecules, monomers, combine chemically to produce a very large chainlike molecule. The phase separation is the creation of two distinct phases from a single homogeneous mixture. This phase separation takes place at a constant temperature and is driven by polymerization instead of being thermally induced. Due to the increasing molecular weight of the reactive component, this causes one or more of the components to be immiscible in one another resulting in spontaneous phase separation. This process is commonly used for membrane formation and other polymer morphology objectives.



2. Abstract

With limited water resources readily available it is pertinent to discover new ways of filtering water to provide clean water resources to communities. To filter water more efficiently, crosslinked liquid crystals leave pores after exposure to light creating high hierarchical porous structures. These pores are then categorized through image processing which can measure the area, diameter, direction, and porosity. The purpose of this project is to achieve selective filtration of particles in the field of water treatment.

3. Research Challenges

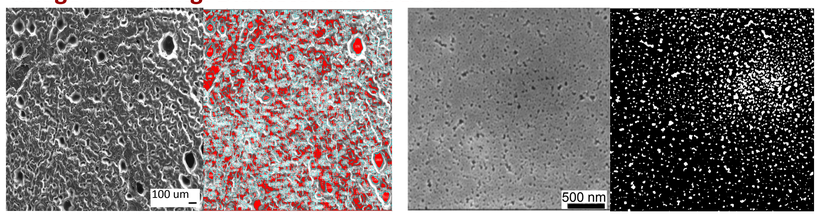
For building membrane with bioinspired porous structures, however, two significant challenges yet to be further addressed, which are the following:

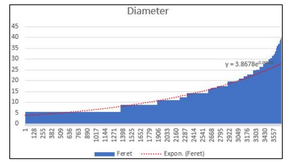
(i) How to accurately achieve bioinspired gradient porous structures in Z direction in the layer-based nanocomposite printing?

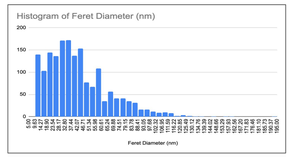
(ii) How to effectively form the aligned porous structures in each layer during layer-based nanocomposite printing for enhanced water purification properties?

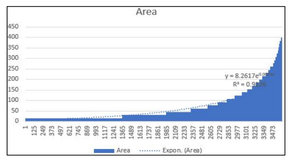
4. Results & Discussion

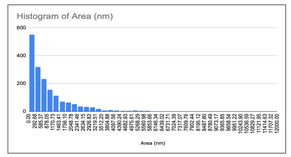
Image Processing: Diameter and Area of Pores





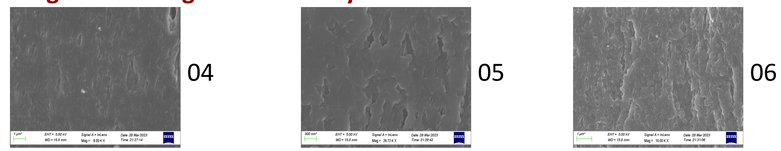






The software ImageJ was used to process the images. ImageJ was able to calculate the diameter and area of each pore as well as counting the total number of pores within each image. ImageJ was also able to determine the overall porosity. The grayscale on each image can greatly impact this data as the shading can impact how the pore is perceived by ImageJ making it seem bigger than it actually is. Below are graphs showing the results of the area and diameter of for both images

Image Processing: Directionality of Pores



The plots displayed above show the directionality of the pores in the membranes. Direction of the pores is important to the filtration aspect of the liquid crystals. These properties determine the molecular structure and rigidness of the liquid crystals.

5. Future Work

1.Continue to study the photopolymerization induced phase separation.
2.Understand gradient porous structures distribution
3.Identify the electrical field assisted liquid crystal templating.
4.Property measurement and validation of 3D printed membrane.

6. Acknowledgements

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Reference: Tang, T., Zhang, B., Liu, X. et al. Synergistic effects of tung oil and heat treatment on physicochemical properties of bamboo materials. Sci Rep 9, 12824 (2019). https://doi.org/10.1038/s41598-019-49240-8

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Ira A. Fulton Schools of Engineering
Arizona State University