University of Massachusetts Amherst

The Impact of Geometric Properties on the Self-Assembly of Mesoscale Polymer Filaments

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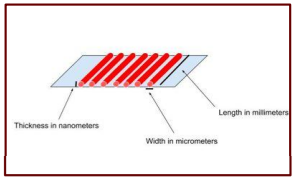
Integrated Concentration in Science

Objective

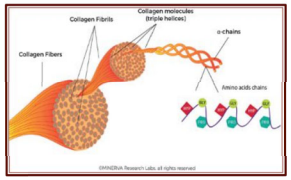
The objective of this research is to see how the length of mesoscale polymer ribbons impact the bundling process especially looking at the percent decrease in length after bundling and the number of ribbons in each bundle.

Background

- Mesoscale Polymers (MSP) → Hierarchical polymer structures inspired by collagen
- The bundling process occurs due to the hinges in the MSPs, allowing for spaces for interaction on the ribbons*



MSPs are defined by their high-aspect ratios with a length in millimeters, width in micrometers, and thickness in nanometers



Collagen inspires increased durability without compromising on flexibility in its bundling process

Hypotheses

- Longer lengths will contain more ribbons per a bundle
- Longer lengths will have a higher percent decrease in length after bundling
- Shorter lengths will contain less ribbons per a bundle
- Shorter lengths will have a higher percent decrease in length
  - Note: previous research used a length of 4mm as standard length

Results

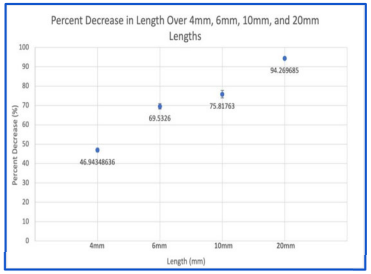


Figure 1: The Average Number of Ribbons As a Function of Length

The average number of ribbons per bundle increases from 4mm to 20mm lengths from an average 3.75 ribbons per a bundle to 12 ribbons per a bundle.

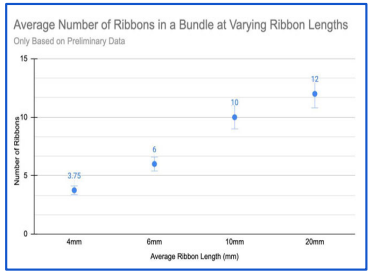


Figure 2: The Percent Decrease in Length Before and After Bundling

The percent decrease increases with length going from a 46.9% decrease for the 4mm length to a 94.3% decrease for the 20mm length

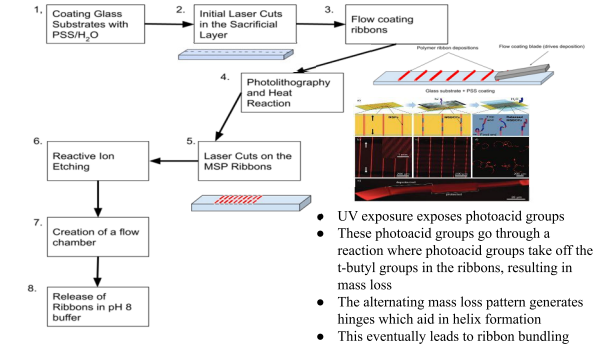
Discussion

- The average number of ribbons per bundle increases from 4mm to 20mm in Figure 1
  - As the length of the ribbon increases, the prospects of bundling increase due to length of the ribbon and scope for more bundling interaction
- In Figure 2, the percent decrease in length increases over the lengths of 4mm to 20mm
  - Longer lengths may increase the amount of ribbon bundling and can lead us to more experimentation with understanding ribbon defects

Future Steps

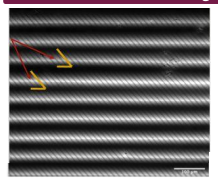
- Experimenting with lengths between 10-20mm to see how the defect patterns change (organized vs. disorganized self-assembly)
- Exploring the role of width and thickness in MSP bundling by finding ways to control from them in the flow coating process

Methods

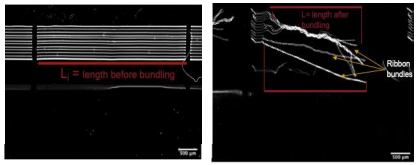


- UV exposure exposes photoacid groups
- These photoacid groups go through a reaction where photoacid groups take off the t-butyl groups in the ribbons, resulting in mass loss
- The alternating mass loss pattern generates hinges which aid in helix formation
- This eventually leads to ribbon bundling

Quantification of Results



Hinge Angle Formation: Images taken from the fluorescence optical microscopy using 20x lens and ImageJ is used to measure the angle.



Length of the Ribbons and Ribbon Bundles: These images were taken on the fluorescence optical microscopy with a 2.5x lens. ImageJ is used to measure the length of ribbons and the bundles.

Acknowledgements

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- Dr. Dylan M. Barber → Previous graduate student in Crosby Group
- Demi Moed → PhD Candidate in the Crosby Group

If you would like to learn more about my thesis, please watch this video.

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