Protein-Coated Fiber Mats for Aqueous Microplastic Capture

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1. Background

- Microplastics (MPs) are micron-scale plastic particles
  - Polystyrene (PS) is a common type of MP
- MP accumulation in the environment is increasing, especially in aquatic ecosystems
- MPs are linked to health issues in animals and humans

2. Goals

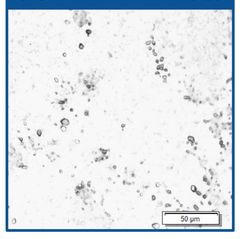
- To create cost effective protein cross-linked polypropylene mats that remove a quantifiable amount of MPs from water
- To determine a method to quantify the microplastic capture performance of a mat

3. Experimental

Polystyrene Microplastic Preparation:

- Cryogenic ball milling of PS
- <10 µm PS MPs suspended in water

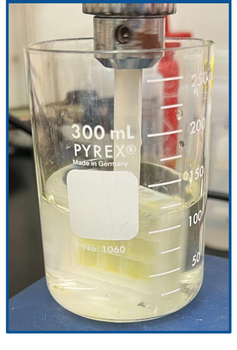
Cryogenically Ball Milled PS MPs (optical microscopy)



Mat Preparation:

- Lysozyme or bovine serum albumin (BSA) proteins are denatured
- Denatured proteins are absorbed onto polypropylene mats
- The proteins are cross linked to coat the mat

Carberry Reactor Setup



Cloud Point Characterization:

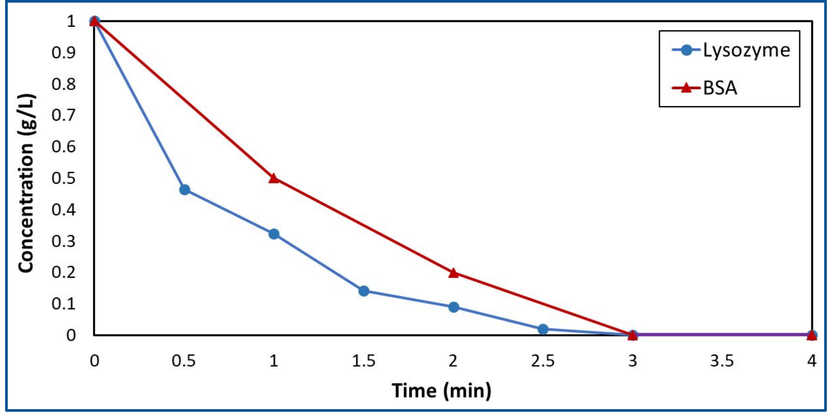
- Measures solution turbidity
- Measured a laser's power after passing through the PS MP solution

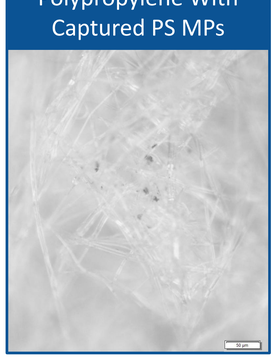
Mat Efficiency Testing:

- Mat stirred in the PS MP solution using a Carberry reactor
- Cloud point measurements taken over time and converted to concentration

4. Results

Mat Efficiency Testing: PS MP Solution Concentration Over Time Being Filtered by Lysozyme or BSA Cross-Linked Polypropylene Mats



Untreated Polypropylene	Lysozyme Cross-Linked Polypropylene	Lysozyme Cross-Linked Polypropylene With Captured PS MPs
		

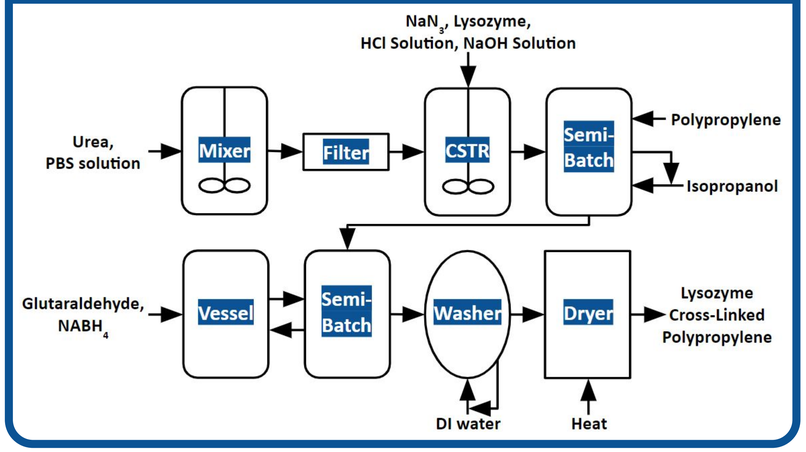
Conclusions:

- Cloud point measurements can be used to monitor mat MP capture performance by measuring MP concentration
- Lysozyme and BSA cross-linked polypropylene mats are able to capture PS MPs in water
  - Lysozyme mats are initially quicker at PS MP removal than BSA mats

5. Future Work

- Testing additional types of proteins and substrates for the mat
- Testing the mats for the capture of different types of MPs
- Exploring the effects of stream properties such as pH, salinity, flow rate, etc. on mat performance

6. Scale-Up

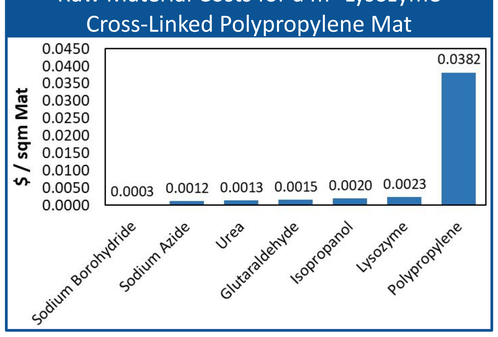


7. Cost Analysis

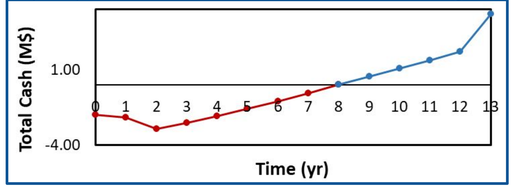
Lysozyme Cross-Linked Polypropylene Mat Costs:

- Raw materials: $0.05 per m^2
- Cost of manufacture: $0.18 per m^2

Raw Material Costs for a m^2 Lysozyme Cross-Linked Polypropylene Mat



Total Cumulative Cash Flow Diagram for Lysozyme Mat Production Sold at 25% Margins



Other Metrics:

- Payback period: 8 years
- ROROI: 4.2% after depreciation

Recommendation: These mats are a good investment

8. Acknowledgements

We would like thank our mentors Dr. Jan Genzer (NCSU), Dr. Kirill Efimenko (NCSU), and Dr. Leah Johnson (RTI International) for their guidance throughout the project. We also thank Dr. Lisa Bullard and Dr. Matthew Cooper