Transformation Of Whole Biomatter To Strong And Stiff Bioplastics
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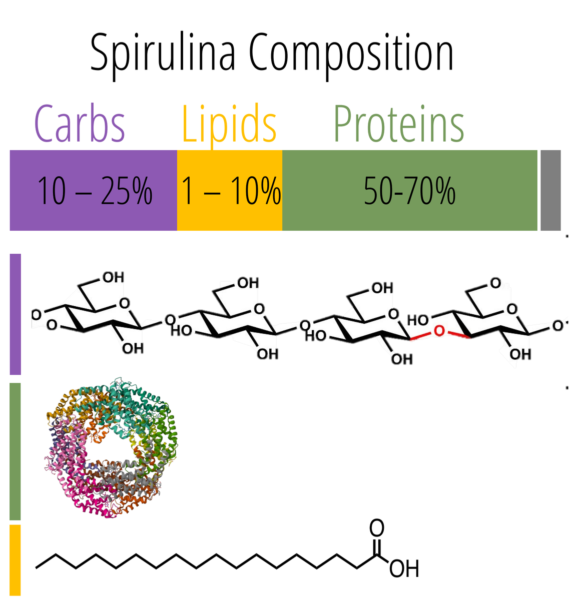
1. Introduction

- Extraction of **monomers & polymers** from biological matter (**biomatter**) provides a range of sustainable polymers as alternatives to petroleum-based plastics[1,2]
- Utilizing whole organisms as polymer without extractions provides a **greener** and **less wasteful** pathway for sustainable polymers production
- **Algae** & photosynthetic bacteria, are **abundant types of biomatter** that can be easily harvested from **non-arable environments** and be used as **a rich biopolymer source** [3,4]
- Here, we study a new class of bioplastics which are formed through thermomechanical processing of "whole" **biomatter** and shed light to their bonding mechanisms

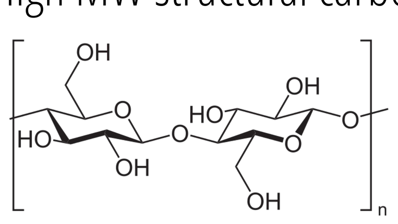
2. Materials & Processing

- Spirulina Biomatter

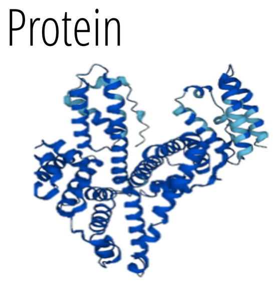


- Biomatter Analogues

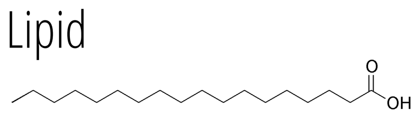
Cellulose
High MW structural carbohydrate



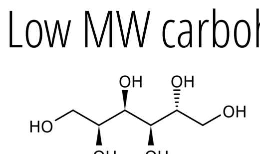
Bovine serum albumin
Protein



Stearic acid
Lipid

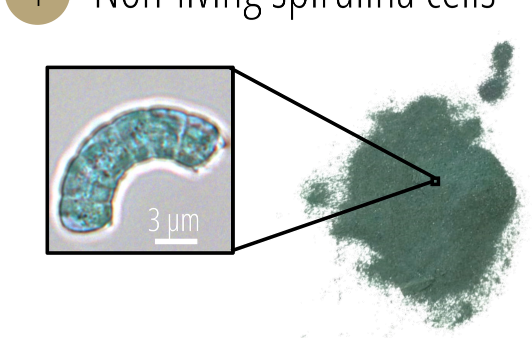


Sorbitol
Low MW carbohydrate

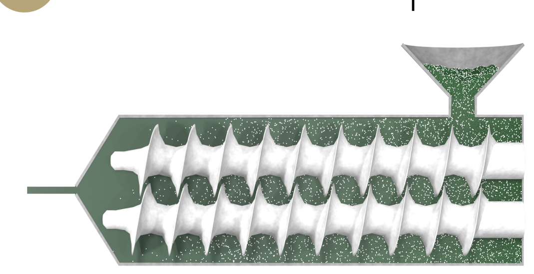


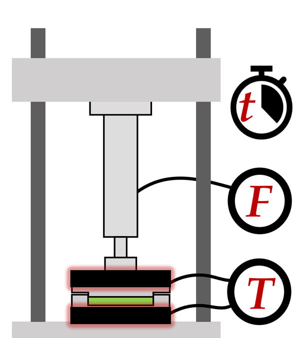
- Processing to Bioplastics

1 Non-living spirulina cells



2 Thermomechanical processing

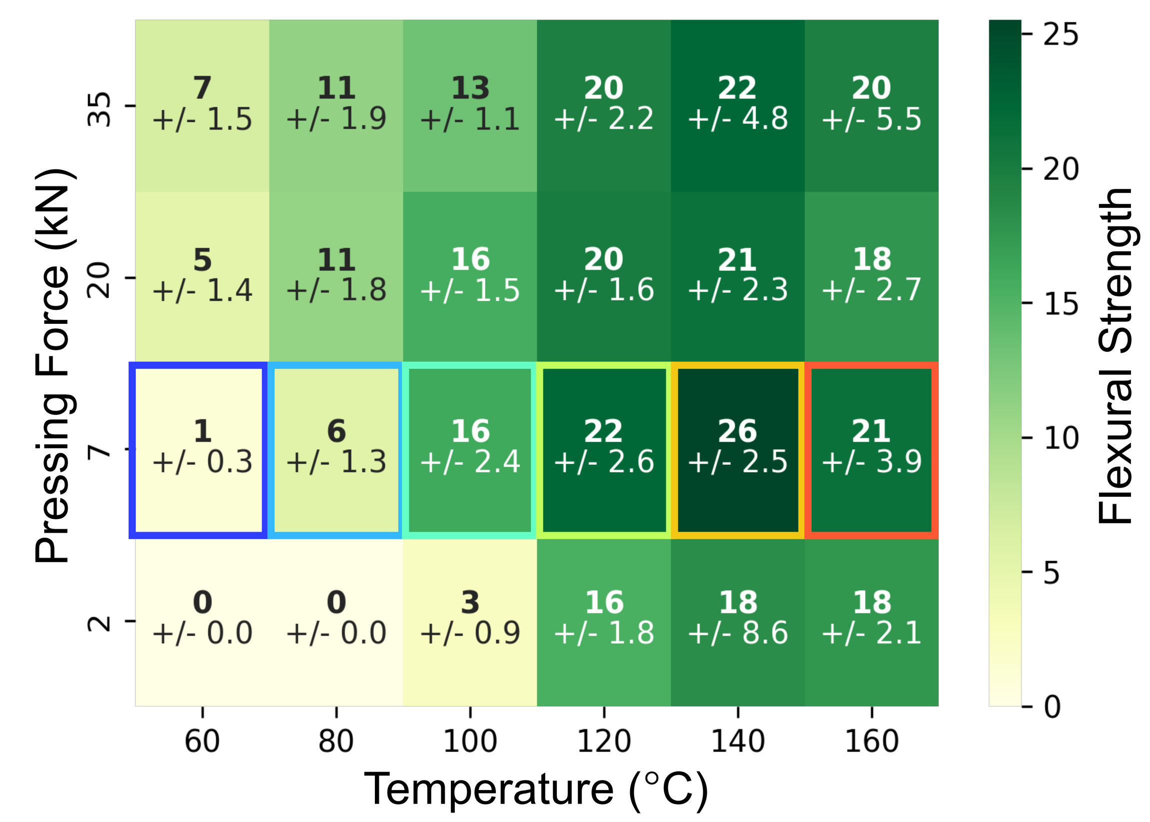


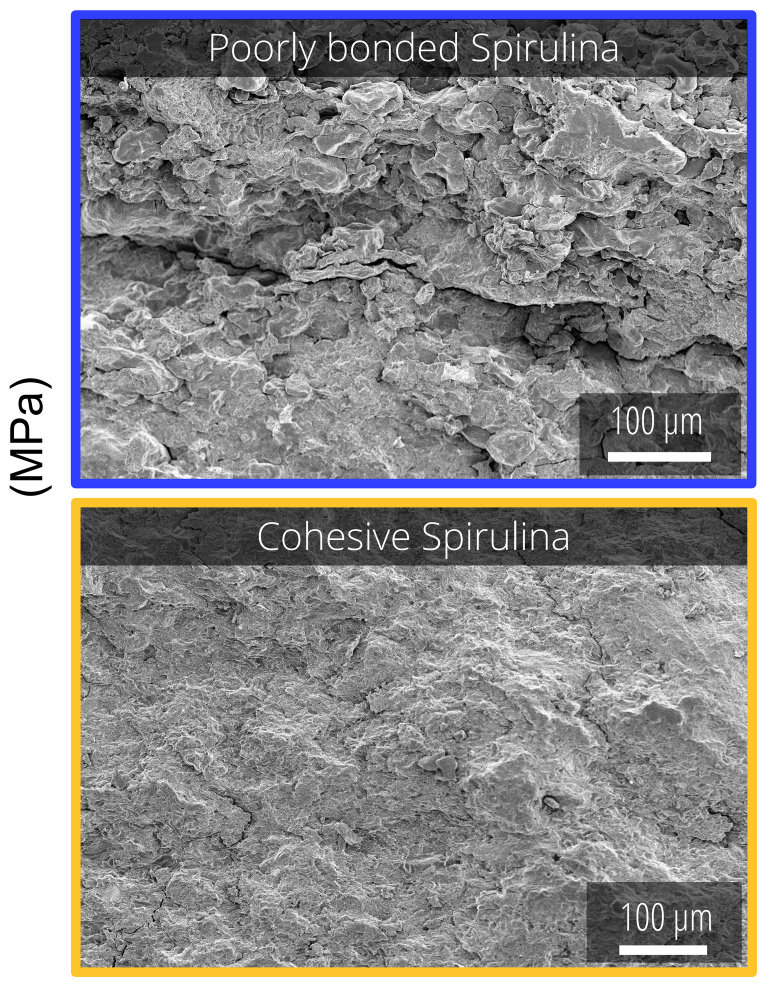


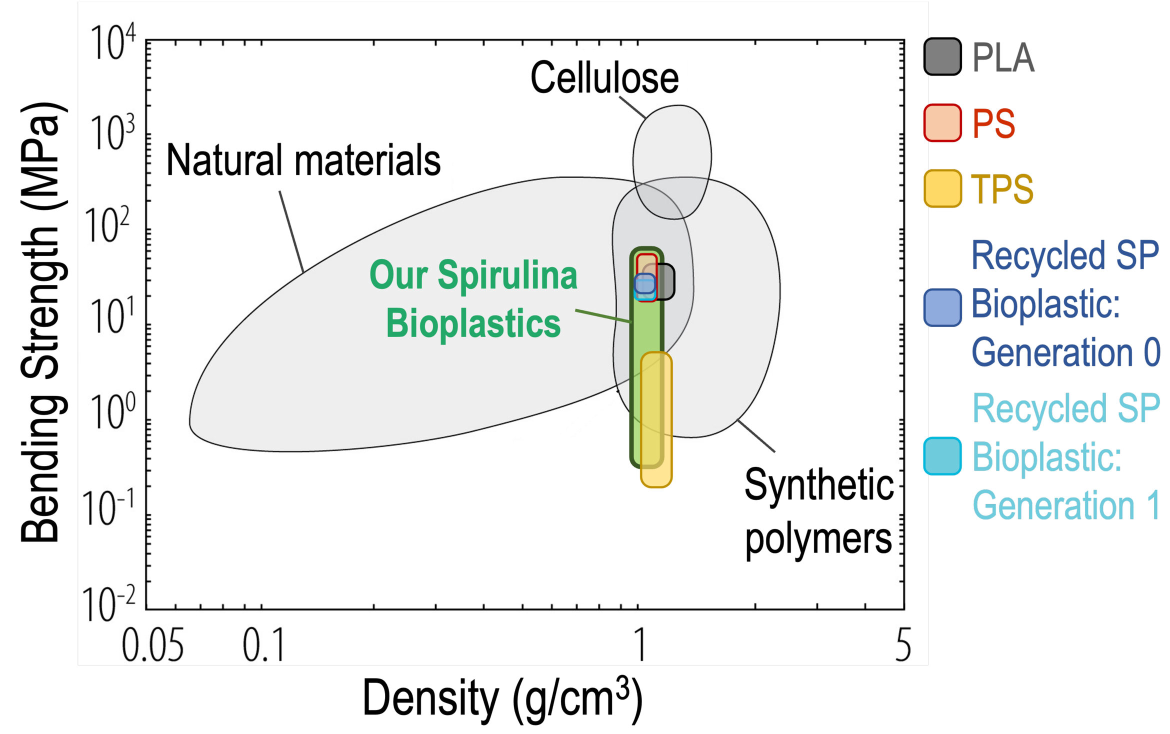
3 Cohesive Bioplastics

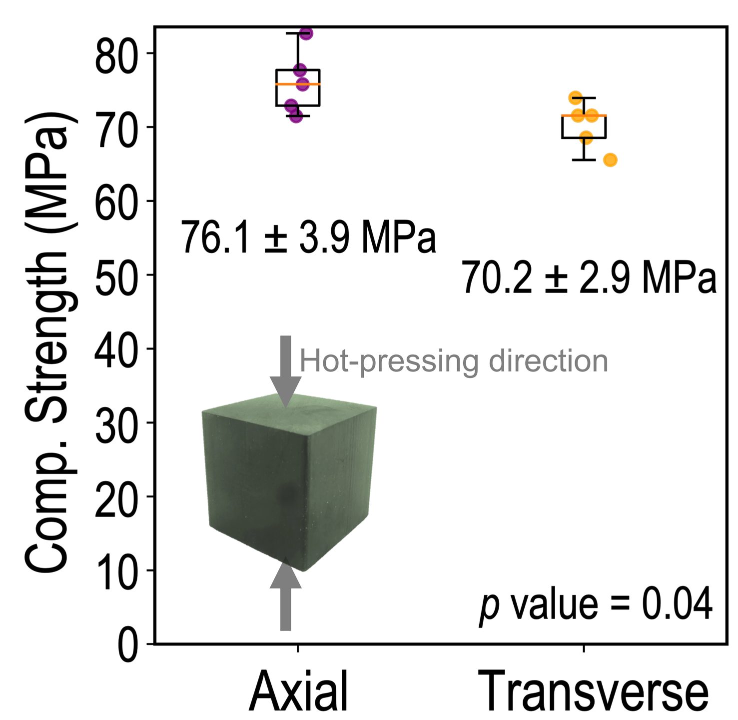
3. Bioplastics

- Varying hot-pressing conditions yields **property differences through changes in bonding and morphology**
- **Design of Experiments** is used to probe effects of processing conditions

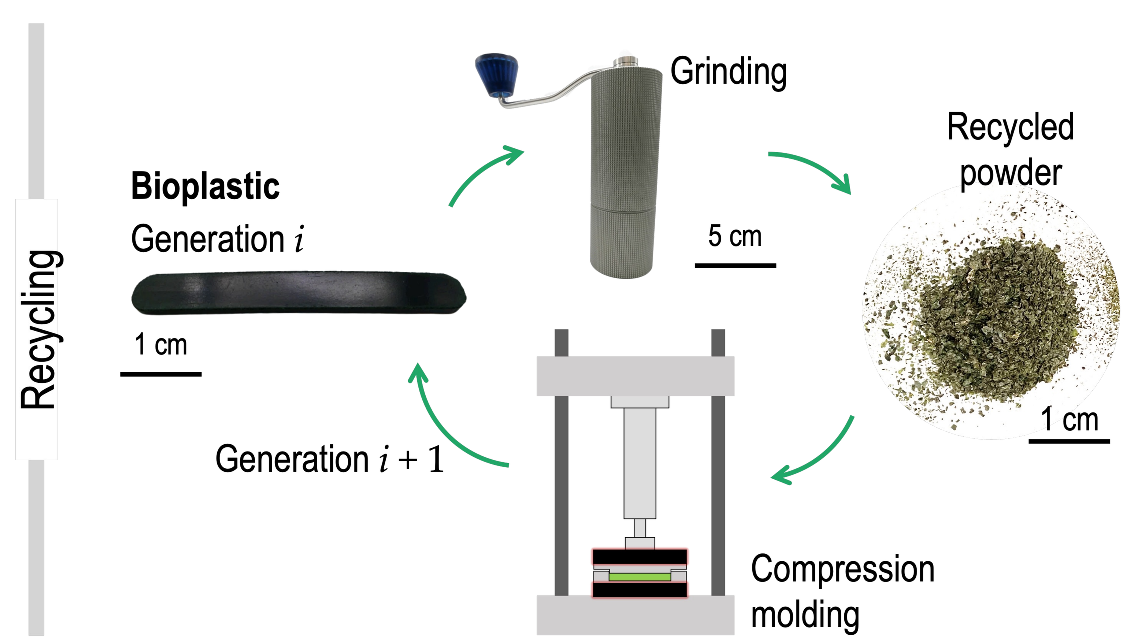


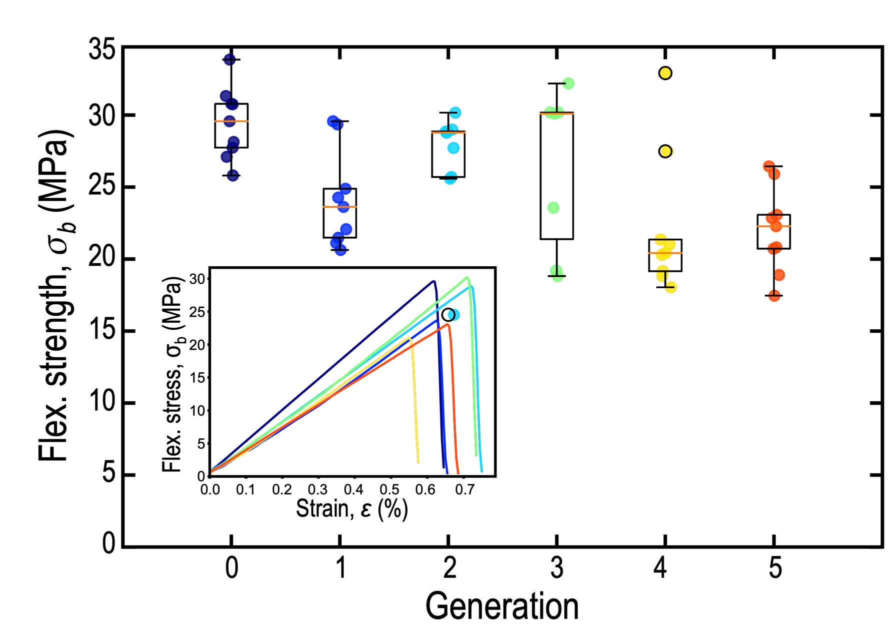


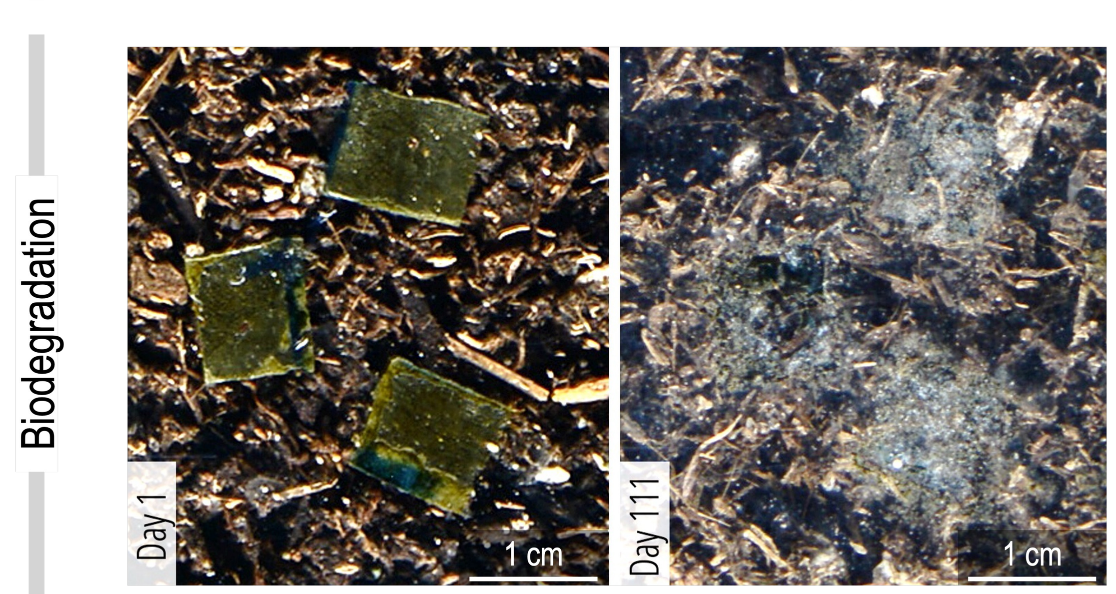


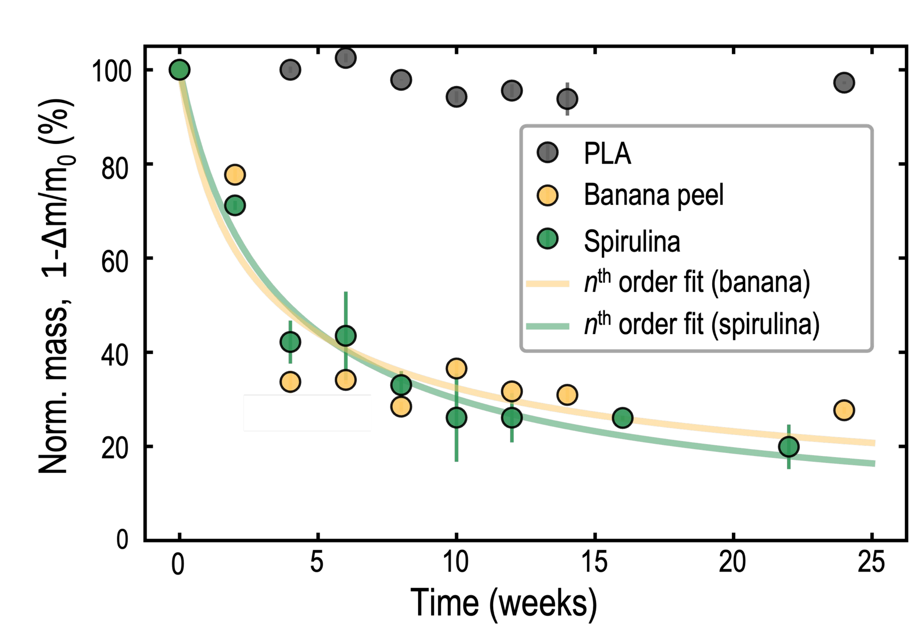


4. End of life



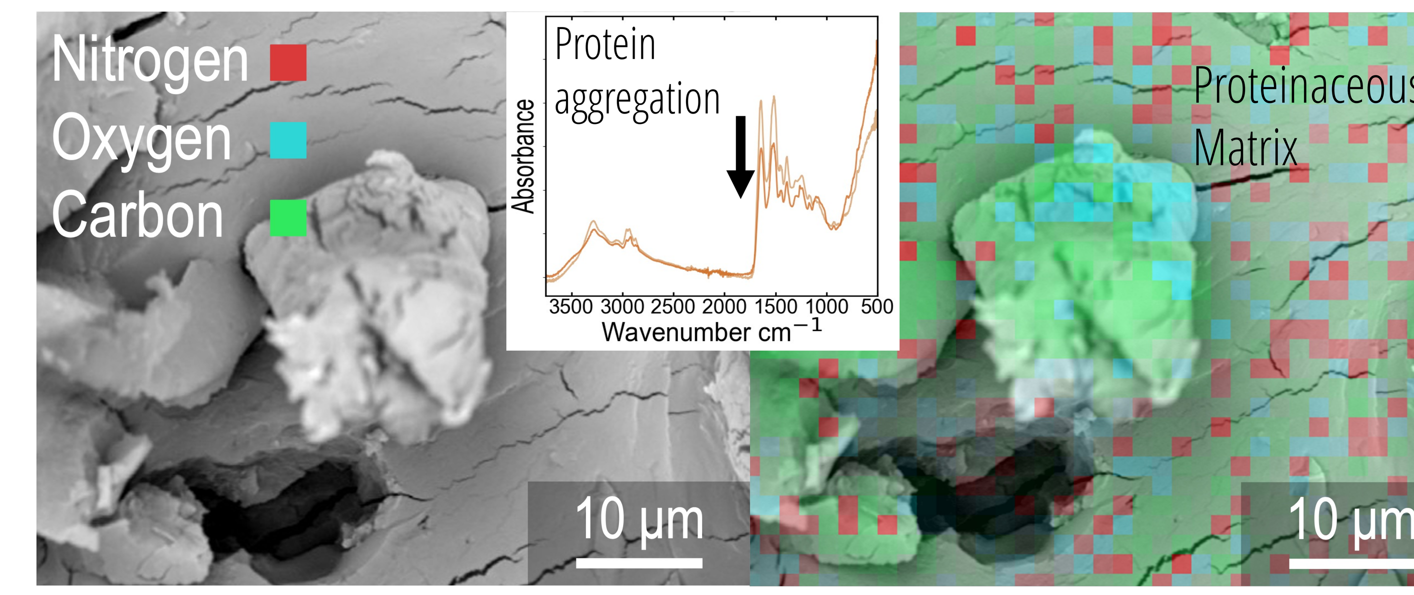




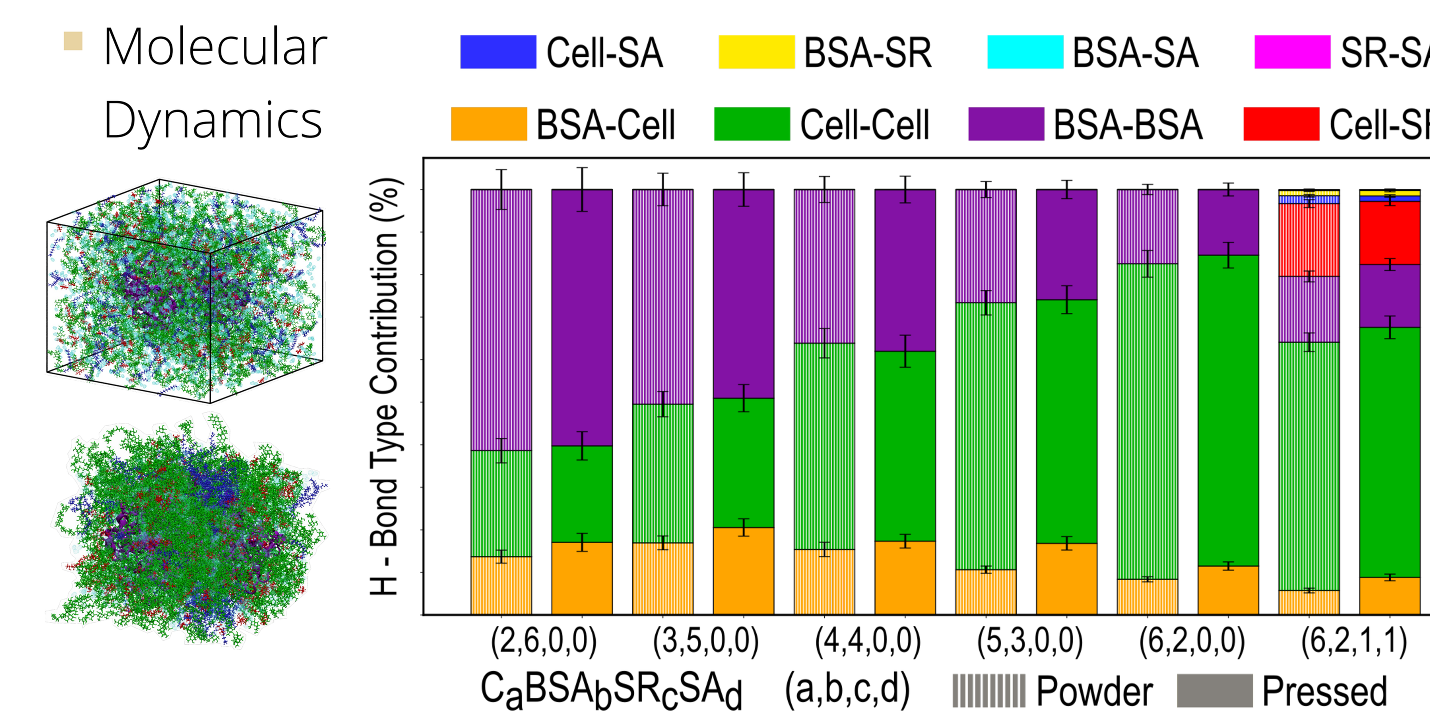


5. Insights into bonding

- Protein serves as binder & undergoes aggregation



- Molecular Dynamics



6. Conclusions & Future Directions

- Strong & Stiff Bioplastics from "whole" biomatter are introduced
- Varying the **temperature** and **pressing** conditions drives changes in the micromorphology & bonding of the biomatter matrix, controlling the mechanical properties
- Formation of a cohesive bioplastic is related to **protein aggregation** and intermolecular **hydrogen bonding**
- Next, **high-throughput** fabrication and **machine learning** to reveal mechanism of bonding & enable accelerated design

7. References

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3. Iyer H. et al. *Strong and Stiff Bioplastics from Spirulina Cells.* Advanced Functional Materials (2023) p.2302067
4. Campbell I. & Lin M.Y. et al. *Progress in Sustainable Polymers from Biological Matter.* Annu Rev Mater Res (2023) Vol. 53:81-104

8. Acknowledgements

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