Developing a cyanobacteria-based pretreatment for speeding biodegradation of “compostable” polylactate bioplastic

Belle Ehrmantraut, Joseph Lin and Michael F. Cohen

Department of Biology, Sonoma State University

Waters Collaborative Research Grant

Summary

Background: Replacing petroleum-based plastics with zero-carbon plastics will be essential for creating a sustainable society. Polylactate (PLA) bioplastic technically meets the non-toxic and biodegradable standards to be labeled “Compostable” but cannot currently be processed by most commercial composting facilities or in home compost piles due to its slow rate of degradation.

System design: We have begun a project to investigate the ability of photosynthetic nitrogen-fixing cyanobacteria to initiate the degradation of PLA and thereby make it suitable for wide scale composting. Alkaline conditions initiate the breakdown of the PLA polymers, making them accessible to microbial degradative enzymes. In our system, during daylight hours photosynthesis by cyanobacteria naturally raises the pH of the surrounding water to as high as pH 11 causing PLA to become markedly brittle, a telltale sign that the molecular weight of the composite polymers has been substantially reduced. The pretreatment system consists of two parallel shallow channels that are stocked with cuttings of manufacture-rejected PLA salad bowl lids (donated to us by World Centric, which supplies Sonoma State Culinary Services with the containers, utensils, plates and cups that are used across campus).

Experimental analyses: The parallel design allows for optimization experiments in which an operational parameter will be varied in one channel while keeping the other constant. The effect of that change on system performance will then be monitored. Our experiments at Sonoma State will measure (1) the time-dependent physical changes, including weight loss, that occur to PLA in our system, and (2) the rate of biological degradation of the pretreated PLA in a vermicompost maintained at Sonoma State and under composting conditions utilized by a local company that is partnering with us. Experiments conducted with international partners will investigate potential uses of cyanobacterial products to be harvested from our system.

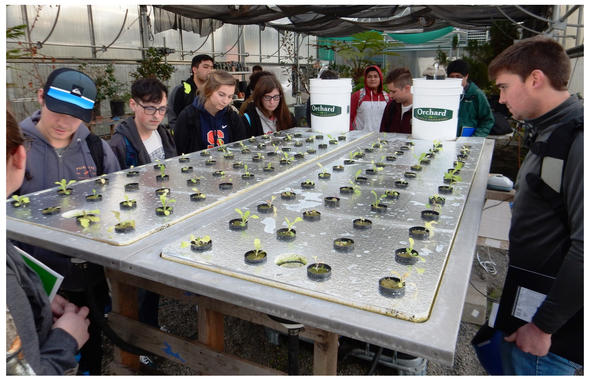
Project objectives: In carrying out this project, our goal is to remove a current bottleneck on wider usage of sustainable PLA bioplastic while serving our mission to engage students in research and community service.

System construction

Materials for the building the system were purchased with funding from School of Science and Technology Innovation and Strategic Priorities Award

Initial operations: Aquaponics, 2018-2020

From 2018 to 2020 the circular flow system supported the healthy co-cultivation of crop plants and fish



Conversion to a photosynthetic PLA pre-treatment system

In early 2021 modifications were made to the system to allow for growth of photosynthetic microorganisms in contact with cut pieces of PLA bioplastic.

Cultivation of cyanobacterial inoculum

System inoculation, February 12, 2021

A simple aqueous medium is cycled through the system

Initiation of vermicomposting, April 19, 2021

Project partners

Businesses:

- **World Centric, Inc., Rohnert Park, CA**

Donation of PLA for use in experiments

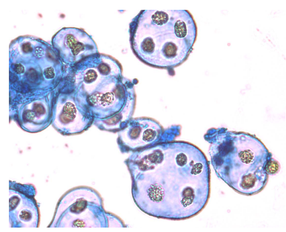
- **The Ranch at Sonoma Mountain, Penngrove, CA**

Use of wood chipper to shred experimental PLA material

Universities:

- **Dr. Nina Kamennaya, Ben-Gurion University of the Negev, Israel**

Composition and metal-binding capacity of cyanobacterial polysaccharides harvested from the system (stained blue here)



- **Dr. Seiko Ito, Baika Women’s University, Japan**

Characterization of molecular alterations to pre-treated and composted PLA

Acknowledgements

We are grateful for the invaluable assistance of the Department of Biology Instructional Support Technician Stephanie Thibault.

Funding was generously provided by Sonoma County Water Agency through the Watershed Academics To Enhance Regional Sustainability (WATERS) Collaborative program.