Functionality of Bioplastics: Investigating the Physical and Mechanical Properties of Algal Bioplastics for Sustainable Applications

Yew, Chloe Yaan Yuit (School: Norwood International High School)

The accelerating depletion of fossil fuel reserves and the escalating crisis of plastic pollution, underscore the critical need for sustainable, biodegradable alternatives to conventional petroleum-based plastics. This study explores the development and material characterization of algae-based bioplastics as renewable polymer substitutes. Bioplastics were synthesized using agar, glycerine, and water through thermo-mixing, mold casting, and drying processes. The effects of varying agar and glycerine concentrations on key mechanical and physical properties, including tensile strength, flexibility, water permeability, absorbency, and thermal response, were systematically evaluated. Results showed that higher agar concentrations increased tensile strength, stress, and modulus of elasticity, enhancing material rigidity. Conversely, increasing glycerine content improved flexibility and strain but reduced tensile strength and stiffness, demonstrating its role as a plasticizer. Results for water permeability and absorbency were inconclusive, suggesting areas for further investigation. Elevated temperature accelerated the biodegradation rate of the polymers. Based on the optimized formulations, prototype single-use products were developed to demonstrate real-world applicability. This research highlights the potential of algae-derived biopolymers as sustainable alternatives to conventional plastics, particularly in single-use applications, and provides valuable insights into how formulation adjustments can tailor material properties, improving their commercial viability. By addressing both mechanical performance and practical use cases, this study contributes to advancing biodegradable polymers in support of reducing plastic pollution and promoting a circular, bio-based economy.

Awards Won: