Designing a Bioplastic Material to Replace Polystyrene and Polypropylene in Single-Use Hard Plastics that Rapidly Degrades in Landfill, Freshwater, and Saltwater Environments

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Plastic cutlery is one of the deadliest plastics for marine life. Forty billion pieces are thrown away each year in the US, ending up in our landfills and waterways. We designed bioplastic materials to replace Polystyrene (PS) and Polypropylene (PP) in single-use items, like cutlery, that would rapidly degrade once discarded. We used materials that were all-natural, non-toxic, renewable, and primarily from waste products. We compared the ultimate tensile strength (UTS) and flexural strength (FS) of our gelatin-based prototypes (generic, beef, and pork) to the PS and PP materials when dry and after short-term exposure to liquids (5–10 min). When dry, our generic and beef gelatin prototypes had a higher UTS and FS than both PS and PP, making them suitable for forks and knives. However, they lost strength when exposed to liquids. New prototypes were made to extend the application of our bioplastics to things like spoons. Adding agar and an enzyme (RM Transglutaminase) significantly increased the UTS and FS when exposed to liquids. Our generic gelatin, agar, and enzyme (GAE) prototype outperformed the PS and PP materials in all testing conditions with a mean UTS of 41.6 MPa (dry), 33.65 MPa (soaked 5 min), 29.28 MPa (soaked 10 min), and a mean FS of 75.37 MPa (dry), 59.55 MPa (soaked 5 min), 48.81 MPa (soaked 10 min). Further, all prototypes, completely degraded in landfill, freshwater, and saltwater environments in < 30 days. Degradation for the GAE prototype was 18.3 days, 26.8 days, and 27.8 days, respectively. All data was analyzed using a two-tailed t test. Our bioplastics materials, with superior strength and rapid degradation in landfill, freshwater, and saltwater environments, are a better alternative for disposable items made from PS and PP, like cutlery.

Awards Won:
Arizona State University: Arizona State University ISEF Scholarship
Sigma Xi, The Scientific Research Honor Society: First Physical Science Award of $2,000
NC State College of Engineering: Award to attend NC State Engineering Summer Camp
NC State College of Engineering: Award to attend NC State Engineering Summer Camp