Advancing Biopolymer Innovation Through Nanotechnology: Utilizing Machine Learning and Predictive Data Analysis Techniques to Optimize Mechanical and Environmental Properties Using Nanoparticles

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This year’s engineering project puts a focus on improving the BioRegen prototype which is a biopolymer that is completely derived from waste materials that fully biodegrades in natural environments. BioRegen reduces pollution and supports a circular economy by upcycling waste from the seafood and paper industries. This project incorporates three sustainably sourced nanoparticles to enhance the mechanical, thermal, and environmental properties without compromising the eco-friendliness of the polymer. Aligned with United Nations Sustainable Development Goals 9, 12, 14, and 15, this project implements Titanium Dioxide, Calcium Carbonate, and Zinc Oxide nanoparticles, which can be sourced from industrial and natural waste streams. These nanoparticles have significant impacts on the properties of the bioplastic as Titanium Dioxide improves tensile strength by 46.15%, water resistance by 17.07%, and thermal stability, biodegrading within 91.70 days with no toxicity(percentages are an increase from the control group). Calcium Carbonate increases flexibility, maintains strength (48.08%), and biodegrades in 122 days. ZnO achieves the highest tensile strength increase (50.50%) and thermal stability, biodegrading in 100.16 days, although it has reduced flexibility. All nanoparticles passed photodegradation and phytotoxicity tests, ensuring that there was minimal environmental impact. This project shows the feasibility of sustainable nanotechnology in bioplastics. This has a regenerative development model that not only promotes the proper use of waste, but also reduces ecological footprints. These results pave the way for biodegradable plastics and make steps to address global environmental challenges.

Awards Won: