Innovative Sustainable Bioplastic Production: Unleashing the Potential of Crustacean Waste Through a Novel Microbial Synthesis

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Fossil fuel-derived plastics, including microplastics, cause significant environmental pollution, necessitating sustainable solutions. While biodegradable plastics are key for sustainability, their limited degradation conditions pose challenges. Polyhydroxyalkanoates (PHAs), synthesized from sugars and oils by microorganisms, offer a promising solution for degradation in diverse environments, including marine and cold soils. However, high cost of microbial feedstocks hinders economic viability of PHA production. Approximately 8 million tons of crustacean shells are discarded annually worldwide. The widespread and low-cost availability of these shells, which are rich in polysaccharide chitin, suggests their potential as viable feedstock for PHA production. This research aimed to discover and analyze microorganisms capable of producing PHA from crab shells, originating from soil with high crab shell accumulation in Toyooka City. For the first time, GC-MS confirmed a bacterium that synthesizes PHA from crab shells and powdered chitin, classified as a previously unidentified species through genome analysis. Furthermore, the discovery of two distinct long circular contig with significantly different GC contents in the bacterial genome suggests that it is composed of two symbiotic bacteria. Detailed gene analysis has revealed a mechanism whereby one symbiont depolymerizes chitin into sugars, while the other not only shares this depolymerization capability but also utilizes these sugars for efficient PHA synthesis. This highlights the intricate synergistic interaction that underpins efficient PHA production from crustacean shells. These discoveries offer ecologically novel insights, present an innovative approach to PHA production, and significantly advance a circular society.