Degradation-Conversion Mechanism in Thermophile-Driven Upcycling of Biodegradable Plastics into Polyhydroxyalkanoates

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The lack of recycling technologies for biodegradable plastics (BDPs) has led to significant resource wastage and limits its sustainable expansion. The inherent biodegradability of BDPs enables their depolymerization into low-molecular-weight intermediates, particularly under thermophilic conditions, which are subsequently channeled into microbial metabolic pathways for targeted conversion. Polyhydroxyalkanoates (PHA), a category of microbially synthesized BDPs characterized by high economic value and growing demand, offer a promising strategy for upcycling waste BDPs. This study focuses on *Chelatococcus thermostellatus*, a thermophilic PHA-accumulating microorganism that exhibits dual capabilities for simultaneous BDPs degradation and PHA biosynthesis under thermophilic conditions. This project employs thermophiles as chassis microorganisms for BDPs biorecycling. The thermophilic degradation mechanisms and bioassimilation pathways of various types of BDPs for PHA biosynthesis are systematically investigated, accompanied by characterization of the structural configurations and material properties of the synthesized PHA. Subsequently, a synthetic microbial consortium is constructed to regulate metabolic intermediates, with particular emphasis on elucidating the regulatory impacts of carbon source allocation in metabolic pathways on PHA synthesis efficiency. Process optimization is further implemented through the strategic modulation of operational parameters and environmental variables to enhance production performance. Additionally, the synergistic compatibility between mild chemical depolymerization and biological recycling is explored to establish an integrated system for improving PHA recovery efficiency. The findings are anticipated to provide theoretical foundations and technical frameworks to advance the high-value circular utilization of BDPs.

Keywords: Biodegradable Plastics, Upcycling, Thermophile, PHA