Degradation of Polyethylene Terephthalate (PET) With New Thermoalkaliphilic Recombinant Esterase Enzyme: Free and Immobilized on Chitosan-Halloysite Beads

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Polyethylene Terephthalate (PET) has become one of the most widely produced and utilized plastics due to its durability and versatility. Over time, PET is released into the environment through processes such as breakdown and washing. Unfortunately, it eventually accumulates in ecosystems and enters the food chain, contaminating seafood, drinking water, and other consumer products. In this study, a novel thermoalkaliphilic esterase enzyme was extracted from recombinant E. Coli, and its optimum working conditions were determined experimentally. To enhance its stability and prolong usability, the enzyme was immobilized on chitosan-halloysite (CTS-HNT) beads. Comparative experiments were conducted to evaluate PET degradation using both free and immobilized enzyme forms. Various analytical techniques, including SEM, TEM, FT-IR, TG-DSC, CD, RAMAN, and LC-MS were employed to characterize CTS-HNT, PET or its degradation products. Additionally, computational methods such as molecular dynamics (MD) simulations and quantum mechanics (QM) modelling provided insights into PET-enzyme interactions, offering valuable guidance for future enzyme modification studies. The results demonstrated that the esterase enzyme effectively degrades PET under optimal conditions (55 ºC, pH 8). The immobilized enzyme retained significant activity over 7 cycles, while a few activators (MgSO4, CaCl2) significantly enhanced enzyme performance. Raman analysis confirmed structural changing in PET. This study is the first application of esterase immobilized on CTS-HNT beads in PET degradation and shows promising results, compared with literature findings. Additionally, the use of the enzyme as a green approach in PET degradation makes this study important in terms of sustainable plastic waste management.

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