(048)

Cracking Plastic: Molecular and AI Driven Insights into Enzymatic PET Breakdown

Thaamiran, P.[1,2*], Mathusan, N.[3,4*], Anisha, S.[5], Nivetha, S.[6], Ellilan, Y.[7], Sivanujan, S.[8]

[1] *Jaffna Hindu College, Jaffna, Sri Lanka*

[2] *Faculty of Science, University of Jaffna, Jaffna, Sri Lanka*

[3] *St. Patrick's College, Jaffna, Sri Lanka*

[4] *Department of Biochemistry & Molecular Biology, University of Colombo, Colombo 03, Sri Lanka*

[5] *Department of Mathematics & Statistics, University of Jaffna, Jaffna, Sri Lanka*

[6] *School of Environmental & Rural Science, University of New England, Australia*

[7] *School of Pharmacy and Biomolecular Science, Liverpool John Moores University, UK*

[8] *Purdue, IN, United States*

**panchu05sagu@gmail.com, *mathushann1324@gmail.com*

Abstract

Microplastic pollution, particularly from polyethylene terephthalate (PET*)*, poses a growing environmental challenge. Among various mitigation strategies, enzymatic degradation has emerged as a promising and sustainable approach. However, the molecular mechanisms governing enzymatic PET breakdown remain poorly understood, limiting our ability to optimize or engineer more efficient biocatalysts. A deeper mechanistic understanding is essential not only for advancing plastic biodegradation technologies but also for enabling scalable, targeted interventions in real-world environments where conventional recycling methods fail. In this study, we computationally investigate the molecular-level interactions between PET and two key plastic-degrading enzymes: PETase and MHETase. Using molecular docking, we explore the binding conformations and interaction profiles of these enzymes with PET oligomers of defined lengths and monomeric compositions. Our analysis reveals stable enzyme–substrate complexes mediated by secondary-level interactions. Despite strong binding affinities, the catalytic degradation mechanisms remain partially unresolved. To further elucidate these mechanisms, we incorporate deep learning-based reaction prediction models trained on organic chemistry reaction data to identify plausible bond cleavage pathways and intermediate states. The AI-driven predictions suggest stepwise hydrolysis of monomer linkages, consistent with mechanistic features observed in similar hydrolases. This integrative computational framework offers new insights into the structural and mechanistic basis of PET biodegradation and supports the rational design of improved enzymatic systems for plastic waste management and removal of oil pollutants.

Keywords: *Microplastic, PET, Degradation, Modeling, Artificial intelligence*