Repurposing fungal plant biomass-hydrolyzing enzymes for the degradation of polyethylene terephthalate

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ABSTRACT

Plastic pollution is a widespread global challenge, affecting ecosystems, wildlife, and economies. Following the principles of a circular economy, innovative strategies are essential to address plastic pollution, involving the recovery, recycling, and reuse of plastic waste [1]. Polyethylene terephthalate (PET), a widely used plastic, is also a major pollution contributor, as a significant amount of PET waste, especially bottles, remains poorly collected [2]. In the context of green chemistry, microbial enzymes able to decompose biomass can play also a vital role in plastic breakdown due to structural and physicochemical similarities between natural and synthetic polymers [3]. Especially fungal enzymes, cutinases, and plant biomass-hydrolyzing esterases, show promise in PET hydrolysis, as these enzymes are known to act on crystalline and/or hydrophobic substrates such as hemicellulose.

For this reason, this study aimed to repurpose microbes' enzymatic arsenal mimicking the mechanism of biomass degradation. Specifically, different enzyme mixtures, including a cutinase and three esterases from *Fusarium oxysporum* and *Thermothelomyces thermophilus* (synonym *Myceliophthora thermophila*), were chosen to synergistically contribute to polymer degradation. At the same time, surfactants with different charge were introduced into the reaction mixture, as their role can be correlated with surface-active proteins produced by filamentous fungi known as hydrophobins. Similar to hydrophobins, surfactants can interact with enzymes to improve their accessibility and/or prevent nonspecific adsorption on the polymer surface. Notably, *F. oxysporum* cutinase combined with anionic surfactants exhibited heightened efficacy, emerging as an efficient alternative for PET degradation in mild reaction conditions. Regarding enzyme synergies, cutinases and ferulic acid esterases such as *Fo*FaeC and *Mt*Fae1 resulted in complete conversion of PET intermediate products to TPA, while the glucuronyl esterase *St*Ge2 demonstrated significant potential for improving degradation yields in crystalline PET.

KEYWORDS: plastic biodegradation; cutinase; polyethylene terephthalate; surfactants; esterases;

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