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Exploring Polyester Biodegradation by Filamentous Fungi

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Abstract

Polyesters, such as poly(butylene succinate) (PBS), poly(butylene sebacate) (PBSE) and poly(butylene adipate co-terephthalate) (PBAT) are among the most diffused biodegradable polymers, as they are known to meet the conditions for biodegradation in industrial composting. However, concerns remain regarding their biodegradability in harsh environments, such as lower temperatures and with less diverse microbial populations [1,2]. Moreover, the fate of their degradation products remains poorly investigated. This study aimed to investigate the role of filamentous fungi in the biodegradation of PBS, PBSE and PBAT, at low temperature and in simple cultural media. The goal was to extend existing investigations to less favourable conditions and to gain information on the ability of microorganisms to proliferate in the presence of the polymer as sole carbon source.

Initial biodegradation screening involved 99 fungal strains, isolated from various environments, including landfill soil and wastewater. Subsequently, 37 fungi demonstrating promising degradation abilities were incubated at 24 and 15°C with each polyester in the form of a film, as the sole carbon source, for 2 months. The polymers were characterized by GPC, DSC, and contact angle measurements before e and after biodegradation. Results showed a diverse range of degradation capacities among the tested fungi and varied degradability among the polymers, with PBSE exhibiting the highest resistance attributed to its hydrophobic nature and high crystallinity.

The best performing fungal strains were then employed in liquid trials with monomers and polymer powders, to assess their monomer/oligomer assimilation capacity. At the end of the experiment, biomass and residual polymers were separated from the liquid medium that was furtherly analyzed by HPLC-RI/UV-Vis to quantify the presence of residual monomers or oligomers. Results revealed complete assimilation of succinic and sebacic acids, partial assimilation of adipic acid, and slower assimilation of 1,4-butanediol. Terephthalic acid accumulation was noted, suggesting incomplete assimilation, if any.

Overall, the study demonstrated that the chemical and physical characteristics of the polyesters play a significant role in both the degradation efficiency of microorganisms and their ability to assimilate degradation products.

References

1. Haider, T. P., Völker et al. Angewandte Chemie International Edition, 58(1), 50-62, 2019.
2. H. Jia, M. Zhang et al. Journal of Environmental Sciences, 103, 50–58, 2021.