Development of an enzymatic treatment for valorizing (recycling and upcycling) PET-textile waste

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E. Zangelmi[I], J. La Rocca[II], G. Broggini[II], G. Molla[I], L. Pollegioni[I], E. Rosini[I]

[I]Department of Biotechnology and Life Sciences, University of Insubria, Varese, Italy, [II]Department of Science and High Technology, Università degli Studi dell'Insubria, Como, Italy

Since 2000, the textile industry has experienced significant growth, leading to overproduction of waste and environmental concerns. Worldwide textile production currently relies on synthetic fibers, with polyethylene terephthalate (PET) fibers representing 54% of the total annual output, with a production of 61 million tons in 2021. Our work aims to develop a multienzymatic treatment for the degradation of mixed textile waste, with a specific focus on recycling and upcycling PET fibers. While PET-degrading enzymes can selectively convert PET into its monomers, they face considerable challenges, particularly in breaking down substrates with high crystallinity. In this study, we tested the efficacy of an engineered variant of LC-cutinase (S101N/F243T LCC) (previously published in: Pirillo V. *et al.* (2023) The FEBS Journal 290, 3185–3202), on pre- and post-consumer textile wastes at different composition (100% PET or blended, and dyed or undyed). Given the negligible hydrolytic activity in the direct enzymatic treatment of 100% PET textiles, we explored the use of physical pretreatments (thermal, microwave, ultrasound, ball-milling) of the substrate to enhance PET depolymerization. Thermal and ball-milling pretreatments emerged as the most effective, enabling the enzyme to produce a 60% and 6% TPA yield, respectively, after a 4-day incubation at 55 °C in 100 mM phosphate buffer pH 8.0. DSC analysis of the pretreated textiles shows a significant decrease in crystallinity after thermal treatment and no significant changes after ball-milling, suggesting that the improvement in enzymatic depolymerization could be attributed to a reduction in sample crystallinity and an increase in substrate-enzyme interface area. Furthermore, we observed that the end of the depolymerization process seems associated with the unproductive adsorption of the enzyme onto the substrate. In conclusion, the enzymatic degradation of PET-textile waste is close to being a reality.