Discovery and Engineering of Improved Biocatalysts for the Synthesis of Biodegradable Plastic Copolymers (BioCat4BioPol)

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Inadequate waste management practices have rendered petroleum-based plastics a global problem. Their accumulation in the environment and their gradual breakdown into micro- and nano-plastics represents a global threat. For this reason, research aims at the production of new polymers derived from renewable sources and new polymerization strategies.

Bioplastics, like polylactic acid (PLA) and poly-hydroxy-alkanoates (PHAs), seem to be a viable solution to mitigate the impact of plastic pollution worldwide. However, both polymers present disadvantages that reduce their widespread commercial adoption: PLA has excellent transparency but has demonstrated inefficient degradation in the environment; on the other hand, PHAs are highly biodegradable but present less resistance and stiffness. For these reasons, the ability to copolymerize different monomers may be the key to obtaining bioplastic with desirable characteristics. [P(LA-co-3HB)] copolymers have been designed to exhibit enhanced properties, both in terms of mechanical strength and biodegradability. To reach this target, recombinant Escherichia coli that expresses lactyl-CoA (LA-CoA)-polymerizing enzymes (LPE) have been employed to prepare [P(LA-co-3HB)] copolymers. This goal has never been achieved enzymatically (in vitro) or with microbial cell factories (in vivo).

The recently launched BioCat4BioPol project has the objective of designing hybrid P3HB-PLA polymerases that can perform the elongation of alternative copolymers in a one-pot/two-enzyme system. For this, we will exploit advanced artificial intelligence (AI) methods to identify target enzymes and predict the mutation that can improve the catalytic features of these biocatalysts, thus demonstrating that enzymatic synthesis of bioplastic copolymers using a rational approach can become attainable and implementable.