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ENZYCLE - Microbial ENZYmes for the valorization of non-recyCLEd plastic fractions

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Introduction

Packaging is the main plastic waste fraction representing about 63% of the total plastic waste generated in Europe. Thus, it is necessary to develop new processes for recycling the currently not valorized plastics, especially packaging multilayer plastics (i.e. PET/PE), post-consumer polyethylene terephthalate trays, clamshell containers and microplastics present in wastewater to reach the European targets (European strategy for plastics aims to achieve the 100% of packaging recyclable or reusable by 2030) and reduce the amount of plastics ending up in the ocean (8 million tonnes each year).

Since mechanical recycling is not always an option or leads to down-grading of the material, i.e. for multilayer and plastic mixes, biochemical or enzymatic recycling of recalcitrant plastic fractions might form a powerful alternative.

The use of enzymes for plastics recycling benefits from their extremely high substrate specificity, high catalytic power, as well as their sustainability, due to enzymes operate under mild conditions of temperature, pH and pressure and often in aqueous media. The advances in the understanding of microbial functions from an enzyme to pathways, and entire metabolic networks now allow the engineering of complex metabolic functions in microbes. ENZYCLE is encompassing the plastic enzymatic recycling from a holistic point, approaching all the development stages from the identification and selection of new enzymes, through the development of new systems for continuous enzyme production, to the development of recycling and valorization processes.

Project objectives

ENZYCLE' overall objective is to valorize and upgrading non-recycled plastic fractions through enzymatic processes to obtain high value-added products. For this, research is focused on the identification of enzymes with hydrolytic activity on polyesters (PET) and on polyolefins (PE and PP), to establish efficient production processes and to develop recycling processes on plastic fractions that are currently not recycled. Additionally, ENZYCLE is also dealing with the problem with microplastics and their high environmental and health impact. In summary, within ENZYCLE project, new processes for enzymatic recycling of multilayer packaging, post-

consumer PET trays and clamshell and microplastics are being developed with the aim of enhancing the sustainability of these wastes, within a framework of circular economy, so as to save material and economic resources, creating new value chains by turning them into valuable products and closing the loop value chain by introducing the final obtained products back in the production process for plastic polymers.

Current status

To date, ENZYCLE has been a milestone in the development of biotechnological tools for implementation in the recycling of fossil-based polymers that cannot be recycled today.

In this sense, potential microorganisms have been identified and isolated for the treatment of polyolefins, where synergies with certain oxidative treatments are being explored to increase the degradation rates of these polymers of fossil origin, and also to increase the efficiency of the enzymatic depolymerization of polyesters such as PET.

Technologies are also being developed to enable more cost-effective enzyme production, as well as the development of new processes for the depolymerization of PET containers and multilayers composed of polyesters and polyolefins, and the treatment of microplastics in wastewater streams.

This project is deepening the scientific and technical understanding of these developments, and exploring new industrial sectors for enzyme applications by creating new sectoral interconnections.

In environmental terms, the environmental impact will be reduced by reducing GHGs and energy consumption. Likewise, these types of processes are positioned as safer technologies.

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Biography

Juan Antonio Tamayo-Ramos is Project Specialist in the Industrial Biotechnology Unit at ITENE Research Center (Valencia, Spain), acting as Project Coordinator of the ENZYCLE project. He obtained a PhD in Microbial Molecular Biology at IATA-CSIC (Spain), having completed 6 years of Postdoctoral appointment in the Laboratory of Systems and Synthetic Biology at Wageningen University (Netherlands), and 6 years as Head of the Toxicology Research Unit at the ICCRAM Research Center-University of Burgos (Spain). He holds over 20 years of experience in microbial biotechnology, food science, toxicology and materials science. He has been the PI of 7 EU funded projects, is co-author of over 50 papers in peer-reviewed journals and 2 patents.