Enzyme biotechnology and industrial biocatalysis

Brief description

Enzymes, as biological catalysts, possess a series of highly valuable characteristics for the industry: they exhibit high specificity, function under mild conditions, are readily accessible, and do not harm the environment. For these reasons, enzymes are being employed in food, detergent, chemical, pharmaceutical, and diagnostic industries. In many cases, enzymatic processes have proven to be highly competitive and efficient on a large scale. Our technology provides the possibility of performing biotransformations to obtain the desired product for the client.

How does it work?

Industrial enzymes are obtained from microorganisms such as bacteria, actinomycetes, fungi, and yeasts, which are pre-selected through screening techniques or genome mining. Once the most promising microorganisms have been identified, they are cultivated under controlled conditions using flask or bioreactor fermentation. The optimization of fermentation processes through culture medium engineering maximizes enzymatic production. After fermentation, the enzymes of interest are extracted from the culture media and undergo a rigorous purification process. This process involves various chromatographic and concentration techniques to ensure a highly pure product. Subsequently, structural characterization of the enzymes is performed using advanced techniques such as electrophoresis, MALDI-TOF, analytical ultracentrifugation, and spectroscopy. Additionally, functional characterization includes stability and activity studies under different pH and temperature conditions, substrate specificity analysis, and determination of kinetic and chemical mechanisms.

Isolation, cloning, and sequencing of the gene encoding the enzyme allow large-scale production. In cases where cloning and expression in Escherichia coli are not viable due to genome-specific issues or the need for post-translational modifications, alternative optimized expression systems are used, such as Streptomyces lividans and Rhodococcus sp. To enhance the catalytic properties and stability of enzymes, protein engineering studies are carried out using directed mutagenesis and directed molecular evolution techniques. Once improved enzyme versions are obtained, immobilization processes are applied to enable their recovery and reuse in industrial applications. Immobilization strategies are tailored to each process and include entrapment in gels, microencapsulation, cross-linking with bifunctional reagents, adsorption, and covalent binding to inorganic or organic supports. Finally, immobilization conditions are optimized to develop efficient and robust biocatalysts, determining optimal process parameters such as pH, temperature, stability, kinetic parameters, and reusability in successive reactions.

What problem does it solve?

Our technology allows the large-scale production of industrial enzymes with high purity through cloning and optimized expression. Additionally, their stability and performance can be enhanced through protein engineering and directed evolution, as well as through different immobilization approaches, reducing costs and facilitating reuse. This enables companies to develop more sustainable, efficient, and cost-effective processes in different areas like biotechnology, food, pharmaceutical, or biofuel industries.

What future products will it develop?

With our technology, a wide range of industrially relevant enzymes can be obtained. Thanks to enzyme immobilization, we ensure more cost-effective, sustainable processes tailored to the specific needs of each industry.

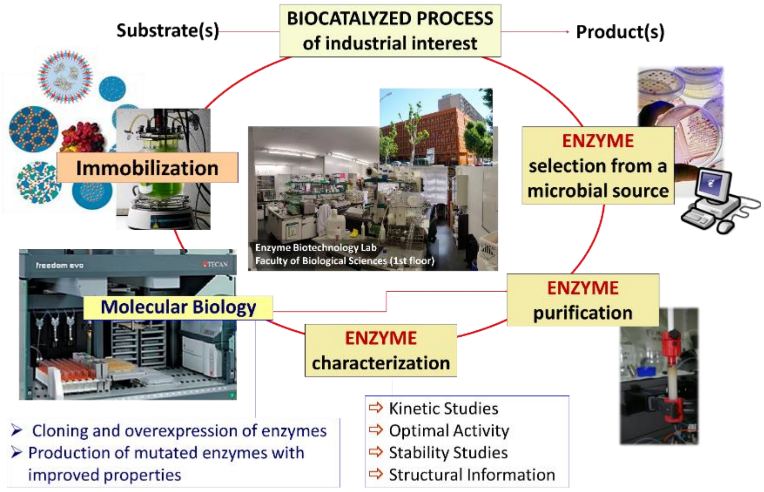

Figure 1. *Topic research areas of the UCM Enzymatic Biotechnology Research Group*

Ventajas competitivas frente a otras investigaciones

- **Advantages of enzymes in industrial processes**

Enzymes offer unique advantages, such as high specificity, high catalytic activity, and the ability to function at moderate temperatures and pressures. Additionally, reactions in organic media provide further benefits over aqueous media, such as increased solubility of reactants, easier product purification, and greater enzymatic stability while preventing bacterial contamination.

- **A more sustainable future with the help of Biocatalysis**

The ability to produce enzymes on a large scale and in reusable formats not only reduces production costs but also minimizes environmental impact. By replacing traditional chemical processes, biocatalysis eliminates polluting waste and removes the need for costly decontamination methods. Thus, biocatalysis is an efficient, cost-effective, and sustainable solution for the industry of the future.

Where has it been developed?

This technology has been developed at the Department of Biochemistry and Molecular Biology at the Faculty of Biological Sciences. The research team has extensive experience in the described methodologies and has worked with various enzymes involved in industrial processes, such as cellulases, β-glucosidases, lipases, D-amino acid oxidases, penicillin acylases, polyhydroxyalkanoate depolymerases, nucleoside deoxyribosyltransferases, and hexosaminidases.

And moreover…

We offer tailored solutions for companies seeking innovative and sustainable biocatalysts in any field of application. The Enzymatic Biotechnology UCM Group provides knowledge and expertise at all stages of industrial enzyme development:

- Production and optimization of enzymes from microbial sources.
- Isolation, purification, and characterization of enzymes.
- Cloning, sequencing, and protein engineering for improved enzymatic performance.
- Optimized expression in host microorganisms.
- Enzyme immobilization for enhanced stability and reusability.

Researcher in charge

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