ERA CoBioTech

BioTech Research & Innovation Hack

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ERA CoBioTech Funded Projects at A Glance: BESTER

Bioprocesses for the optimized, integrated production of butyl esters from sustainable resources

PART OF
EUROPEAN BIOTECH WEEK
INNOVATION IS IN OUR GENES

BESTER

Biotech-based production of butyl esters from lignocellulosic sugars

Project partners from transdisciplinary ERA-CoBioTech project BESTER developed bioprocesses for the optimized, integrated production of butyl esters from sustainable resources for the commodity chemicals market

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Project duration:

1 April 2018 - 30 June 2021

Total budget: 2.8 €M

Efficiently producing butyl ester from sustainable resources

Industrial Biotechnology is a key enabling technology to produce a plethora of different bio-based products from sustainable resources and a driver for developing the bio-based economy in Europe. Systems biology and Synthetic biology are recent additions to the biotechnology toolbox that in interplay with bioprocess and chemical process technology can help developing competitive industrial bioprocesses for new valuable product manufacturing.
The ERA-CoBioTech project BESTER aimed to establish clostridial bioprocesses for an optimized integrated production of a range of different butyl esters for the commodity chemicals market. Efficient organic acid production using lignocellulosic sugars as a sustainable feedstock should be developed, linkable to ABE fermentation processes on similar feedstock as a source of butanol. BESTER thereby addressed in a coordinated way the two key handles for efficient production of three different organic acids, i.e. a) Systems biology guided strain engineering using Synthetic biology principles to establish new acid production in suitable clostridial chassis strains and mitigate key metabolic bottlenecks hampering high productivity, and b) smart process design and integration to prevent inhibitory effects of the acids produced and the BuOH added in efficient bioprocesses with continuous enzymatic ester product formation and recovery.

Combining Synthetic biology, Systems biology, Process development, and Environmental and Social assessments to make a difference

The BESTER project was performed by seven project partners from Norway, UK (2), Germany (3), and France to maximize output of this substantially industry-driven project and share risks, costs and skills. An optimized integrated biotechnological production of three different butyl esters was targeted, using lignocellulosic hydrolysates as a sustainable feedstock from woody biomass. Aim was the optimized biotechnological production of a range of organic acids from this feedstock, which through enzymatic esterification and linking to ABE fermentations as a source of biobutanol could be converted into the corresponding butyl esters. Systems biology guided strain engineering and Synthetic biology principles were applied to establish metabolic pathways and mitigate key metabolic bottlenecks towards three different short-chain organic acids. Smart process integration with continuous acid removal by enzymatic esterification and ester recovery should ensure viable continuous ester production by simultaneously solving inhibitory effects of the acids and the added butanol, low acid productivity, and unfavourable cell yield. Aim was to develop a set of scalable, robust, and highly productive manufacturing processes for selected butyl esters from sustainable resources. The engineering efforts were supported in an interactive way by comprehensive techno-economic, environmental, and social assessments performed in the project.

Main results

The BESTER consortium has made great progress towards the project's ambitious primary objective. Significantly improved production of two organic acids by engineered Clostridium strains was achieved, while enzymatic esterification of these acids with biobutanol was extensively studied to enable the efficient production of the corresponding butyl esters in two different solvent systems and with options for enzyme recycling for cost reduction. Production of a third acid was for the first time established in a heterologous Clostridium host strain through design and transfer of a synthetic metabolic pathway. A new genome scale metabolic model (GEM) of *Clostridium saccharoperbutylacetonicum* was developed, including with a new software tool for GEM generation, and later refined by integrating absolute proteomics data. Key metabolic bottlenecks towards butyric acid and acetic acid were mitigated through rational metabolic engineering. Comprehensive process development was performed in the project, leading to process flowsheets for two alternative integrated processes, considering continuous acid removal by esterification and extraction, and ester recovery by distillation.

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Biotech and process work in BESTER was complemented and guided by full LCA, water footprint, ethical, legal and social assessment, and application of a responsible research and innovation (RRI) framework. With this, the BESTER project has been in full support of the ongoing and urgently needed transition to a more sustainable production of commodity chemicals from renewable resources, while strengthening the role of industrial biotechnology and the position of systems and synthetic biology as powerful tools in the engineering of bacterial production strains for optimised productivity and process stability. The project has enabled new, solid connections across academia, the institute sector, and industry in Europe based on complementary competences and common interest in a more sustainable future.

Future prospect

BESTER made large progress in developing systems biology tools and applying systems scale studies to previously underdeveloped Clostridium strains, opening up their potential future use as additional microbial cell factories for new and urgently needed bio-based production processes. Insight into the metabolism of these organisms has been largely expanded and their genetic accessibility improved, as has been in the enzymatic esterification of clostridial-produced organic acids with biobutanol. The development of the new GEM construction and omics data integration tools will be valuable for the research field of systems biology in general. The already achieved publications and the four additional publications still jointly targeted post-project will have significant impact in the relevant research fields of bacterial systems biology, clostridial bioprocesses, and biocatalytic esterification. All partners improved and expanded their competence in their respective field of expertise through performing their project activities, and due to the highly transdisciplinary layout of the project plan with significant RRI, environmental, and industrial components, the project clearly expanded competence building well beyond the industrial biotechnology core of the project. The process flowsheets developed in the project and the comprehensive economic, socioeconomic and environmental assessments performed in the project will be a solid basis for further development of the BESTER process towards pilot and demonstration scale, which can ultimately contribute to rendering biobutanol production economically viable through derivable high-value products in an integrated biorefining approach.
Finally, BESTER provided necessary input to developing the bio-based industry in Europe, a key to achieving the ambitious European Green Deal goals for mitigating climate change, while securing future employment and wealth of European citizens in a safe and healthy environment.
The BESTER project has produced a wealth of different results, and many of them have already been communicated and disseminated to a broad range of stakeholders during the project period through conference contributions, courses, stakeholder interviews and a workshop organised by the project towards the end of the project period. Five scientific papers have already been published, and the immediate aim after the end of the project period is to finalize the remaining four scientific publications to summarize and clearly document our project results and disseminate them to the scientific community and potential industrial stakeholders interested in building on our achievements.

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Figure 1: BESTER Partners at the project's kick-off meeting.

Website: https://bester-project.eu/
Twitter: https://twitter.com/BESTER_project
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