BIOTRANS
LA ROCHELLE 2023

N°500 / OC / PC
TOPIC(s) : Industrial biocatalysis / Enzyme production, immobilization

SCALE-UP OF AN ENZYMATIC PRODUCTION OF CYRENE FROM LEVOGLUCOSENONE (LGO)

AUTHORS
Kévin AMRANI / URD ABI, 3 RUE DES ROUGES TERRES, POMACLE
Florent ALLAIS / URD ABI, 3 RUE DES ROUGES TERRES, POMACLE
Louis MOUTERDE / URD ABI, 3 RUE DES ROUGES TERRES, POMACLE

PURPOSE OF THE ABSTRACT
SCALE-UP OF AN ENZYMATIC PRODUCTION OF CYRENETM FROM LEVOGLUCOSENONE (LGO)

This work is part of the European BBI JU Flagship ReSolute project. The overall project objective is to build the first-of-its-kind industrial plant and downstream value chain for the adoption of 99% pure Dihydrolevoglucosenone (CyreneTM). CyreneTM is a clear, colorless-to-light-yellow liquid with a slight ketone odor and has proven to be a multi-purpose aprotic solvent that can be a high-performance alternative to NMP, DMF, DMSO, DMAc etc. The Resolute plant feedstock is locally sourced renewable cellulosic biomass waste meaning manufacture is close to net-zero, sustainable and circular.

The ReSolute plant will produce its CyreneTM offtake via the reduction of the platform molecule Levoglucosenone (LGO) which itself is a product of the flash pyrolysis of wood cellulose (FuracellTM process). The CyreneTM reduction is carried out using a heterogeneous catalyst and, although it is efficient in terms of yield and cost, there can be limitations. For example, whilst tests have proven essentially zero-to-minimal presence of metal ion impurities, even the idea of a low 100 parts per billion (ppb) metal ion presence can be unpalatable for certain high-value industry applications, such as electronics or pharmaceuticals.

Therefore, to give downstream end-users from all industry sectors – including those sensitive to metals – full commercial access to CyreneTM as a bio-based, environmentally-benign solvent, a biocatalytic process has been developed. It involves an alkene reductase from Pichia stipitis – the OYE 2.6 (Old Yellow Enzyme family) - and has produced a guaranteed metal-free CyreneTM material with the potential for large scale manufacture.

The aim of this work is to adapt and scale-up this enzymatic reaction to prove its feasibility at a pilot scale. Several difficulties must be addressed, such as LGO solubility in the aqueous medium, its inhibition on the OYE 2.6 at certain concentrations and the denaturation of the cofactor regeneration enzyme, the Glucose Dehydrogenase (GDH), at a certain concentration of CyreneTM. In the course of this work, we went from milliliter scale in a microplate to liter scale in a bioreactor by multiplying the final concentration of CyreneTM by 30 and from an overnight reaction to a few hours. Improvement in productivity allowed us to reach a 1483-fold scale-up.

FIGURES

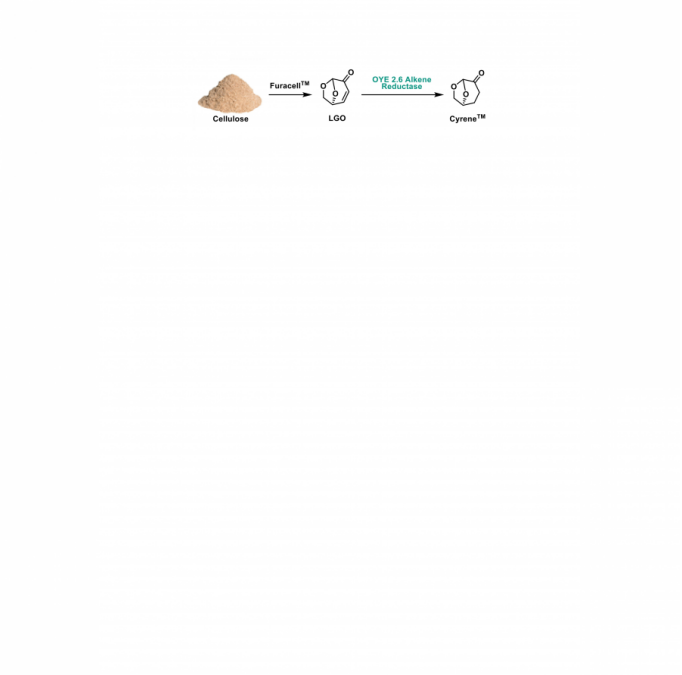

FIGURE 1

Enzymatic production route of CyreneTM from LGO

This figure describes the enzymatic production route of CyreneTM from wood cellulose.

FIGURE 2

KEYWORDS

CyreneTM | Levoglucosenone (LGO) | Biocatalysis | Scale-up

BIBLIOGRAPHY

G. R. Court, C. H. Lawrence, W. D. Raverty and A. J. Ducan, US 20120111714, 2011

Mouterde L. M. M.; Allais F.; Stewart, J.D. Green Chem. 2018, 20 (24), 5528-5532.

Patterson-Orazem A, Sullivan B, Stewart JD. Bioorganic & Medicinal Chemistry. 2014 Oct;22(20):5628-5632.