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Development and scale-up of an enzymatic process for 2,5-furandicarboxylic acid (FDCA) synthesis.

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PURPOSE OF THE ABSTRACT

The production of bio-based plastics has become an important area of research due to the negative environmental impacts associated with fossil-based polymers. Polyethylene 2,5-furandicarboxylate (PEF) is a bioplastic with superior performance properties, compared to today's widely used petroleum-based packaging material PET. However, the industrial production of PEF is hampered by the challenges associated with the synthesis of its main building block: 2,5-furandicarboxylic acid (FDCA). A promising alternative to the traditional multi-step chemical routes is the one-step enzymatic oxidation of the biomass-derived 5-hydroxymethyl furfural (HMF) to FDCA.

In this study, we report the development, optimization, and scale-up of a process for the production of a FAD-dependent enzyme, which can oxidize HMF to FDCA. A fed-batch fermentation and the associated downstream process (DSP) were developed and optimized at 7 L scale. The fermentation and DSP were scaled up to 1500 L. Finally, the produced enzyme was used for the bioconversion on 150 L scale. After 47 hours, 99.3% of HMF was converted into FDCA, achieving a product concentration of 39.1 g/L.

This work demonstrates the feasibility and potential of bio-based process development for the production of PEF and offers an effective and industrially relevant alternative to the chemical synthesis of FDCA.

FIGURES

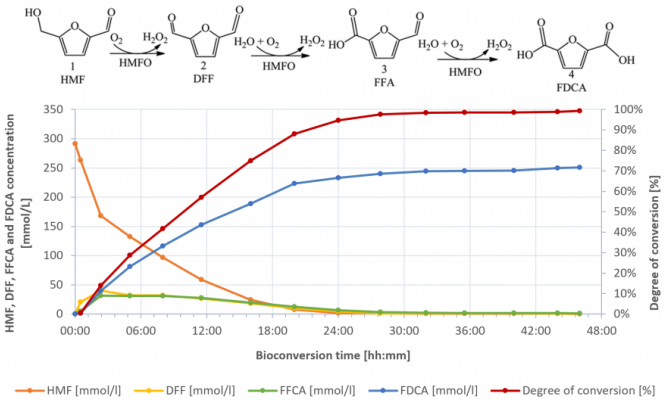

FIGURE 1

BBEPP process scale-up.

Bioreactor (Frings 150 L) used for the enzymatic conversion of HMF to FDCA.

FIGURE 2

Enzymatic bioconversion of HMF to FDCA (150 L scale).

Concentration [mmol/L] of HMF substrate (orange), FDCA product (blue), and the reaction intermediates FFCA/FFA (green), and DFF (yellow) over the time. The degree of HMF conversion [%] over the time is also reported (red).

KEYWORDS

Biocatalysis | 2,5-furandicarboxylic acid (FDCA) | Enzyme production | Process intensification

BIBLIOGRAPHY