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Mitigating product inhibition via an aqueous two-phase system in a biocatalytic process for p-coumaric acid production

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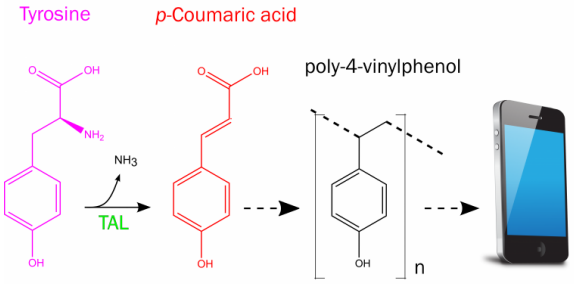
PURPOSE OF THE ABSTRACT

p-Coumaric acid (pCA) is a promising chemical precursor to making thin, flexible, and transparent organic semiconductors, with applications in wearable electronics. pCA can be produced via biocatalysis, but the required tyrosine ammonia lyase (TAL) enzyme suffers from competitive product inhibition, which reduces production titers, rates, and yields [1]. We considered and tested several strategies to mitigate this problem, and we developed a method of in-situ product removal using an aqueous two-phase system (ATPS) consisting of a polymer and salt phase. pCA has a partition coefficient of around 1:20 in the salt:polymer phases, effectively removing pCA into the polymer phase. The implementation of the ATPS into a biocatalytic process still faced a challenge, as the whole cell biocatalyst also partitioned into the polymer phase due to the high density of the salt phase. In order to keep the biocatalyst in the salt phase, we tried immobilized the biocatalyst in a hydrogel and loading the beads into a catalyst basket. However, the common calcium-alginate hydrogel was unstable in the salts used for salt:PEG ATPS, but we found K-carrageenan to be stable in potassium salts. After making further optimizations to the composition of the ATPS, we finally tested the effectiveness of the immobilization procedure and the ATPS at improving pCA production in a rotating bed bioreactor. This work may help in the development of a viable pCA production bioprocess, and it is a case study in using bioprocess engineering to overcome limitations with a biocatalyst.

FIGURES



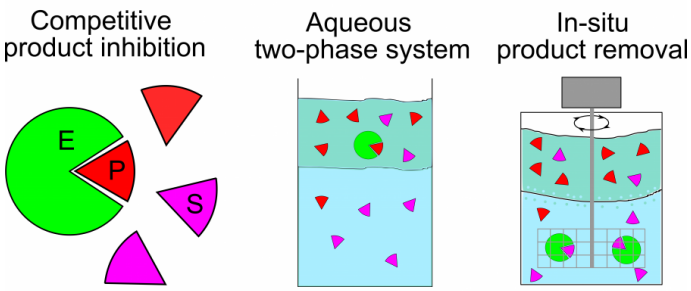


FIGURE 1

Biocatalysis for p-coumaric acid production

TAL, tyrosine ammonia lyase

FIGURE 2

Mitigating product inhibition via in-situ product removal

E, enzyme; P, product; S, substrate.

KEYWORDS

Biocatalysis | Aqueous two-phase system | In-situ product removal | Immobilization

BIBLIOGRAPHY

[1] sariaslani, f. s., ann. rev. microb. 2007, 61(1), 51-69.