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Biological reaction engineering for the preparation of C9 chemicals from oleic acid: n-nonanoic acid, 9-hydroxynonanoic acid, 1,9-nonanedioic acid, 9-aminononanoic acid, 1,9-nonanediol, 9-amino-1-nonanol, and 1,9-diaminononane

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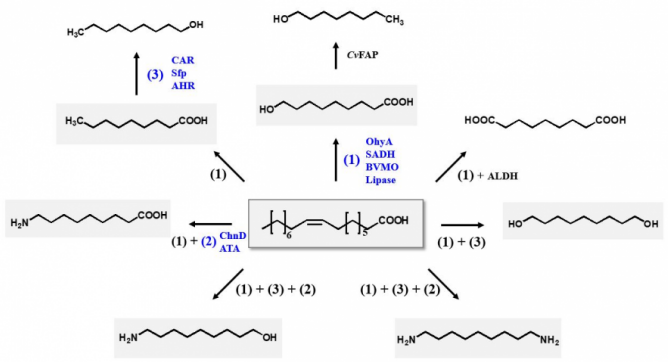
PURPOSE OF THE ABSTRACT

Engineering of native and recombinant enzyme reactions in whole-cell biocatalysis may allow to produce a variety of chemicals. In particular, fine-tuning of the reactions may enable to prepare a desired product to a high conversion. Here, we present that various C9 chemicals such as n-nonanoic acid, 9-hydroxynonanoic acid, 1,9-nonanedioic acid, 9-aminononanoic acid, 1,9-nonanediol, 9-amino-1-nonanol, and 1,9-diaminononane could be produced to a high conversion from C18 oleic acid (Fig. 1).

The C9 chemicals could be prepared as follows;
1) 9-Hydroxynonanoic acid and n-nonanoic acid were produced from oleic acid by using the recombinant Escherichia coli, expressing an oleate double bond hydratase, a secondary alcohol dehydrogenase, and a Baeyer-Villiger monooxygenase, and a lipase from Thermomyces lanuginosus. [1]
2) 9-Hydroxynonanoic acid was converted into 1,9-nonanedioic acid by the recombinant E. coli expressing the primary alcohol dehydrogenase and aldehyde dehydrogenase (ChnDE). [2, 3]
3) 9-Aminononanoic acid was prepared from 9-hydroxynonanoic acid by the combination of the primary alcohol dehydrogenase (ChnD) and ω-aminotransferase from Agrobacterium fabrum (ω-AT_Afab) expressed in recombinant E. coli. Moreover, 9-hydroxynonanic acid was converted into 1,9-nonanediol by carboxylic acid reductase (CAR) and aldehyde reductase expressed in recombinant E. coli. [4]
4) 1,9-Diaminononane and/or 9-amino-1-nonanol were produced from 1,9-nonanediol by the recombinant E. coli expressing ChnD and ω-AT_Afab.

As a representative example, activation of 7 recombinant enzyme reactions and 1 native enzyme reaction with repression of 1 native enzyme reaction in E. coli led to formation of 1,9-diaminononane with the conversion of ca. 70% from oleic acid (Fig. 2). These results suggest that engineering biological reactions allow to produce various industrially relevant chemicals from renewable fatty acids to a high conversion.

FIGURES



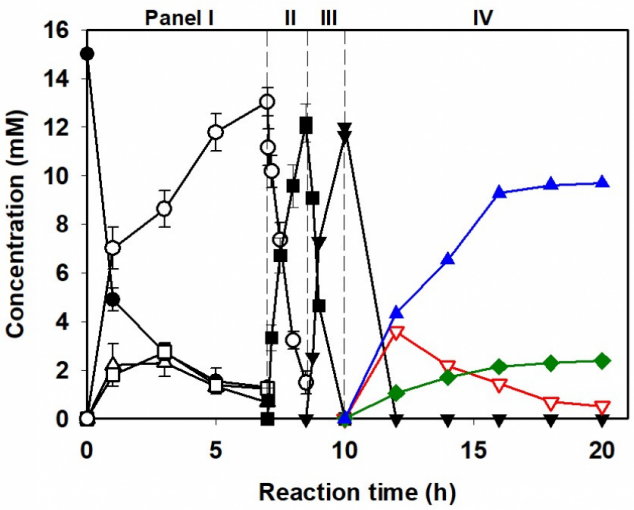


FIGURE 1

Enzymatic preparation of various C9 chemicals from oleic acid

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FIGURE 2

Cascade preparation of 1,9-diaminononane from oleic acid by E. coli-based whole-cell biocatalysts.

The symbols indicate the concentration of oleic acid (closed circle), 1,9-nonanediol (closed down triangle), 9-ANA (closed diamond), 9-amino-1-nonanol (opened down triangle), and 1,9-diaminononane (closed triangle).

KEYWORDS

Enzyme Catalysis | Oleic acid | C9 Chemicals | 1,9-Diaminononane

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