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Journal of Molecular Catalysis B: Enzymatic 5 (1998) 187–189

JOURNAL OF MOLECULAR CATALYSIS B: ENZYMATIC

Highly selective transformation by plant catalysts

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Received 26 September 1997; accepted 29 November 1997

Abstract

This review outlines the recent progress in the biotransformation of foreign substrate by plant cultured suspension cells. The reaction types and stereochemistry involved in the biotransformations are described.

Keywords: Biotransformation; Plant catalyst; Asymmetric reduction; Hydroxylation

1. Introduction

It is well known that plants are the source of valuable products and some useful basic materials such as cellulose, wood and rubber. In addition, secondary products such as terpenoids, cardenolides, coumarins, anthraquinones, flavonoids, glucosinolates and alkaloids are also produced by plants and are used as drugs, flavours, pigments (food ingredient) and agrochemicals. Hitherto, some secondary metabolites from plant cultured suspension cells have been produced [1,2]. However the formation and accumulation of several secondary metabolites does not normally occur in the plant cultured suspension cells and it has proven difficult to harness this potential to industrial processes.

To overcome these problems we have studied the biotransformation of foreign substrates by plant cultured suspension cells. These cells have the ability to specifically convert cheap and plentiful substrates into more useful compounds. More recently, many studies have focused on the ability of plant cultured suspension cells to transform foreign substrates. This paper summarizes the selectivity in the biotransformation of foreign substrate by plant cultured suspension cells.

2. Biotransformation of β-keto ester [3]

In the biotransformation of ethyl 2-methyl-3-oxobutanoate by the cultured suspension cells of *Marchantia polymorpha* and *Glycine max*, ethyl 2-methyl-3-oxobutanoate was reduced diastereo- and enantio-selectively to the corresponding *anti*- and *syn*-(*S*)-hydroxyester by the cultured suspension cells of *M. polymorpha* and *G. max*, respectively (Fig. 1).

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1381-1177/98/$19.00
PII: S1381-1177(98)00032-0

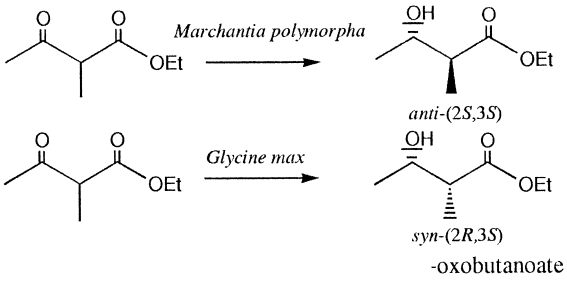

Fig. 1. Biotransformation of ethyl 2-methyl-3-oxobutanoate.

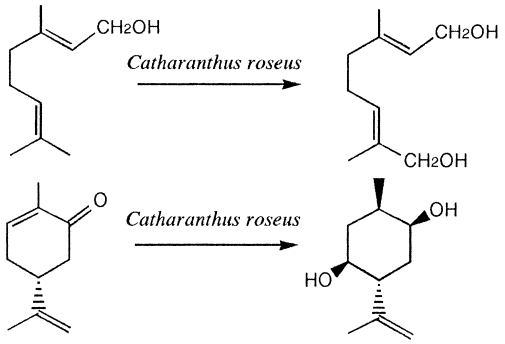

Fig. 2. Biotransformation of geraniol and (−)-carvone.

3. Biotransformation of terpenoids

We studied the biotransformation of carvones and geraniol by the cultured suspension cells of *Catharanthus roseus* and we found that they hydroxylate allylic positions of (−)-, (+)-carvones and geraniol and reduce double bonds and ketones [4]. The main product of geraniol is 10-hydroxygeraniol and the main products of (−)- and (+)-carvones are 5β-hydroxyneodihydrocarveol and 5α-hydroxycarvone, respectively (Fig. 2). From the study of biotransformation of monoterpenoids by the cultured suspension cells of *C. roseus* (periwinkle) it was found that the cultured suspension cells of *C. roseus* have the ability to hydroxylate regioselectively at 10-position of geraniol and C-4 and C-5 positions of carvones.

Furthermore we investigated the biotransformation of menthols and β-thujaplicin (hinokitiol) by the cultured suspension cells of *Eucalyptus perriniana* (eucalyptus) [5–7]. In the bio-

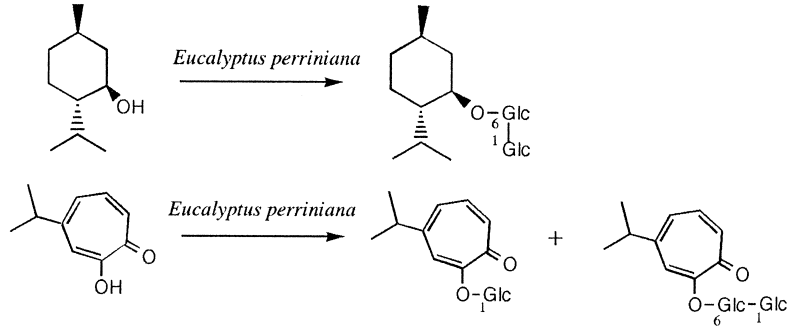

Fig. 3. Biotransformation of (−)-menthol and β-thujaplicin.

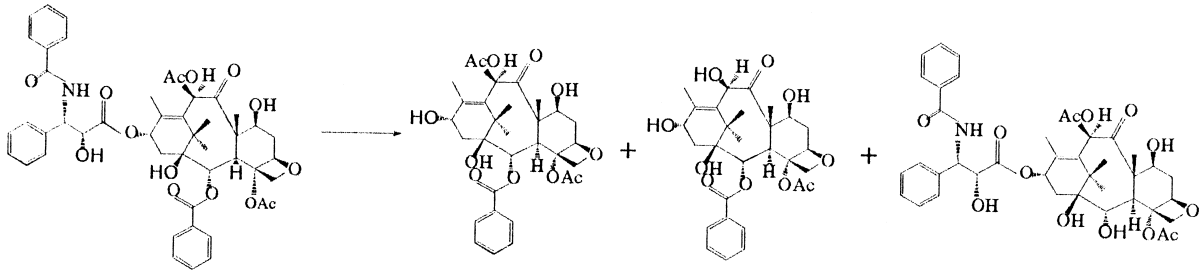

Fig. 4. Biotransformation of taxol.

transformation of menthols the main products of (−)- and (+)-menthols are (−)- and (+)-menthol 3-*O*-β-D-gentiobiosides, respectively. In the case of β-thujaplicin, the cultured cells of *E. perriniana* glycosylate the hydroxyl group of β-thujaplicin. From these results it was found that eucalyptus cultured suspension cells perform regioselective glycosylation, terpenoids, e.g., (−)-, (+)-menthols and β-thujaplicin (see Fig. 3).

4. Biotransformation of taxol

Taxol, a highly functionalized diterpenoid secondary product derived from yew (*taxus* species) which is now recognizing as the best anticancer drug against human breast cancer. More recently we studied biotransformation of taxol by *E. perriniana* cell suspension cultures. As shown in Fig. 4, taxol was converted to baccatin III, 10-deacetylbaccatin III and 2-debenzoyltaxol [8]. From this result, it is found that *E. perriniana* cultured suspension cells hydrolyze the ester group at C-13 and then the acetyl group at C-10 of the produced baccatin III. On the other hand, the cells regioselectively hydrolyze the benzoyl group at C-2 of taxol.

The reaction types and stereoselectivity in biotransformation depends on the functional group in the foreign substrates. Therefore, biotransformation by plant cultured suspension cells (plant catalysts) can be considered as an important tool for commercial and/or large scale production of secondary products and food ingredients.

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