Multistep bioreaction engineering of an enzymatic production process for 1,3-propanediol from glycerol

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Description

1,3-propanediol is an important bulk compound e. g. for the production of polymers and synthetic materials for the chemical industry[1]. So far, two general production methods are established in the industry today: Chemical synthesis and various fermentation processes[2]. Nevertheless, these two methods exhibit a number of disadvantages especially concerning yield and environmental compatibility. Chemical synthesis requires harsh conditions as extreme temperatures and pH-ranges on the one hand. Fermentation does not require these conditions; however, a maximum yield of 60% can be reached and several byproducts are generated within the applied microorganisms.
By developing a completely new method as an enzymatic, cell free biotransformation system, both disadvantages can be erased in order to reach 100% conversion at moderate conditions. Therefore, a combination of selected enzymes from different organisms is established to form a multistep bioproduction system.

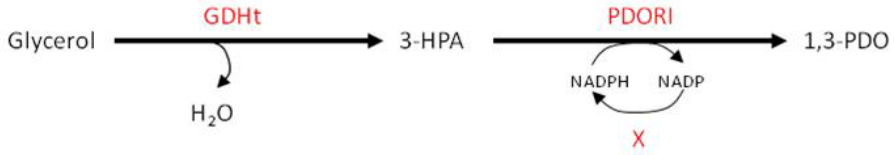

Fig. 1: Example for the partly realized enzymatic production process

While glycerol is converted to 3-hydroxypropionaldehyde (3HPA) by the enzyme Glycerol Dehydratase (GDHt) in a first step, 3-hydroxypropionaldehyde is secondly transformed to 1,3-propanediol (1,3PDO) by the enzyme Propanediol Oxidoreductase-Isoenzyme (PDORI). For integrated cofactor regeneration a third enzyme “X” is used. Since all enzymes applied in this system are not commercially available strategies for enzyme production via high cell density fermentation and purification of these partly recombinant, partly natural enzymes had to be established first.
The understanding and controlling of general engineering aspects of multistep bioreactions with their dynamics and kinetics will help to establish industrial enzymatic production processes in the near future. Furthermore, the found results and the gained knowledge of this still young research field of Biosystems Engineering can be transferred to other enzymatic production systems.

References

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[2] Xiu Z.-L. and Zeng A.-P. (2008) Present state and perspective of downstream processing of biologically produced 1,3-propanediol and 2,3-butanediol. Appl Microbiol Biotechnol. 78(6):917-26.

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