Available online at www.sciencedirect.com
ScienceDirect
Tetrahedron 63 (2007) 1721–1754
Tetrahedron

Tetrahedron report number 786

Trends in lipase-catalyzed asymmetric access to enantiomerically pure/enriched compounds

Ashraf Ghanem*

Biomedicinal Chemistry Unit, Biological and Medical Research Department (MBC-03-95), King Faisal Specialist Hospital and Research Centre, PO Box 3354, Riyadh 11211, Saudi Arabia

Received 26 September 2006
Available online 1 November 2006

Abstract—Over the last few years, there has been a dramatic increase in the number of publications in the field of lipase-catalyzed reactions performed in common organic solvents, ionic liquids or even non-conventional solvents. A fairly large percentage of these publications have emerged from organic chemists who have recognized the potential of biocatalysis as a viable and popular technique in organic synthesis. Considerable research has shown that reactions catalyzed by enzymes are more selective and efficiently performed than many of their analogues in the organic chemistry laboratory. This review article focuses on some of the recent developments in the rapidly growing field of lipase-catalyzed asymmetric access to enantiomerically pure/enriched compounds. The literature search is dated back to the last five years and covers some comprehensive examples.

Contents

* Tel.: +966 1 4647272x39914; fax: +966 1 4427858; e-mail addresses: ghanem@kfshrc.edu.sa; ashraf_ghanem@yahoo.com

0040–4020/$ - see front matter © 2006 Elsevier Ltd. All rights reserved.
doi:10.1016/j.tet.2006.09.110

1. Introduction

1.1. Enzymes: historical development

Living cells are extraordinary complex systems where a vast number of chemical reactions occur.[1] The catalysts that enable such chemical reactions to occur are called enzymes. Without their existence, the chemistry performed by living cells, called metabolism, would happen at too slow rate for the organism to stay alive.[2]

The history of enzymes and applied biocatalysis goes back thousands of years to ancient Egypt. Thus, enzymes from microorganisms were used in ancient cooking, baking, brewing, alcohol production and cheese making. This has been demonstrated in an old Egyptian papyrus showing methods used to preserve food and alcoholic drinks. Of particular interest is the two-part process used to produce beers, where the grains are deliberately sprouted and heated to provide sugar and flavour. The cooking made the grain more susceptible to attack by the enzymes that convert starch into sugars. This batch was then mixed with sprouted, but unheated, grains in water. Finally, yeast was added to the combination of sugar and starch in solution, and this was fermented to make beer (Fig. 1).

During the 18th and 19th century, applied biocatalysis has been developed on a more scientific basis. In 1833, Payen and Persoz (from France) isolated an enzymatic complex from malt, naming it 'diastase' (a mixture of amylases).[3] A few years later (1835), the Swedish chemist, Jöns Jacob Berzelius, described the first enzymatic hydrolysis of starch using diastase, which has been used in the production of dextrins from the 1830s onwards.[4] In 1836, Theodor Schwann (from Germany) isolated a substance responsible for albuminous digestion in the stomach and named it 'pepsin', the first enzyme prepared from animal tissue. The fermentation of sugar to ethanol by yeast is a process that has been known for very long time. In 1839, the German chemist, Justus von Liebig, developed a mechanistic explanation for the role of yeast in the fermentation process. He viewed the yeast present in the fermentation mixture as a decomposing matter that emitted certain vibrations ['the sugar atoms suffer a displacement; they rearrange themselves in such a way as to form alcohol and carbon dioxide (spontaneous reaction)'].[4]

About two decades later, the French chemist and biologist, Louis Pasteur (1858), proved that fermentation occurs only in the presence of living cells.[5] This divergence in the understanding of the role of yeast in the fermentation process caused a heated debate between Liebig and Pasteur.[6] In 1897, the German chemists, Eduard Buchner and Hans Buchner, discovered that a cell-free extract of yeast could cause alcoholic fermentation. The yeast cell produces the enzyme, and the enzyme brings about fermentation.[7] In 1883, Johan Kjeldahl from Copenhagen developed a method

Figure 1. Enzyme-catalyzed beer manufacturing in ancient Egypt.