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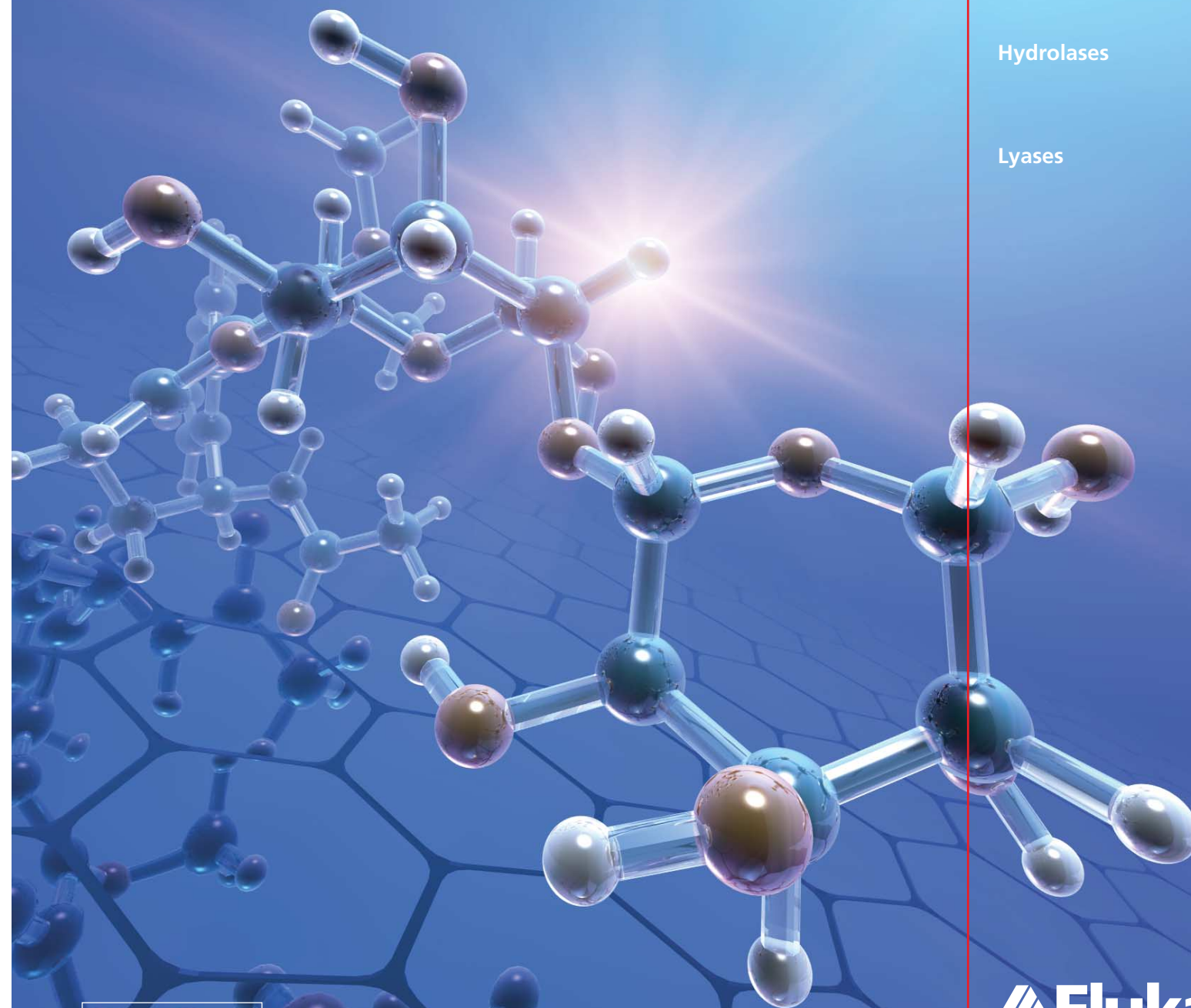
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# ChemFiles Enzymes in Organic Chemistry

## SPECIAL FEATURE: New Glycosyltransferase Kits



Vol. 3 No. 6

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## Fluka

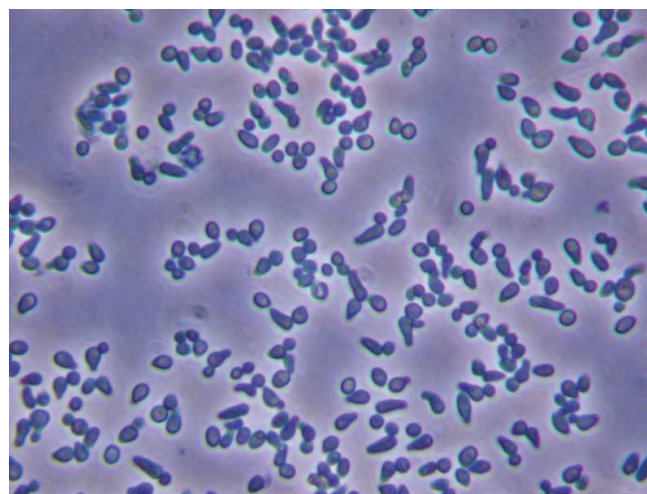
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## CUSTOM MANUFACTURING AT FLUKA

### Biocatalysts and Biotransformations

The recognition of biocatalysts as important manufacturing tools has increased within the chemical and pharmaceutical industries in recent years. Biocatalysts can simplify, or in some instances even enable, the production of complex chemicals and drug intermediates. They can add stereospecificity to the process, eliminating the need for complicated separation and purification steps.

Within Sigma-Aldrich's array of organic and biochemical capabilities, fermentation has had a long tradition with locations in the USA, Israel, and Switzerland. At our Fluka facility located in Buchs, Switzerland, a wide range of chemical knowledge is combined with biotechnological expertise. Fluka both develops and produces biocatalysts on small and large scales, and can subsequently perform the synthesis of the target molecule via biotransformation in-house.



**Rhodococcus Rc2 is among the organisms we utilize in our fermentation processes**

At our newly expanded facility, bioreactors of up to 300 liters in capacity (2 x 20 L, 1 x 75 L and 1 x 300 L) are currently in operation. All fermentation reactors are completely computer-controlled. The Paragon Process Control System allows us a continuous, 24 h operation with complete documentation of the fermentation or biotransformation process. Process optimization is performed with a miniaturized multifermenter system, which allows to follow 6 experiments simultaneously.

The fermentation process at Fluka is in compliance with ISO-9001/2000. Regular internal and external audits guarantee a consistently high standard of operation.

Biosafety is established according to Good Industrial Large Scale Practice (GILSP).

We use both natural and recombinant microorganisms (bacteria, yeasts, and fungi). Recombinant technology allows overexpression of biocatalysts, thereby resulting in higher yields and diminished biological waste. At the customer's request, development and formulation of a custom biocatalyst can take place as well.

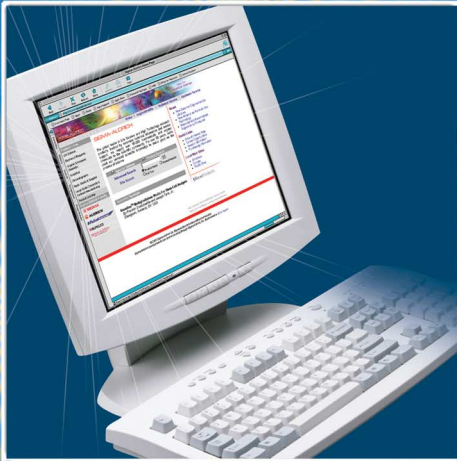
On the downstream processing side, we apply a wide range of highly qualified technologies, such as bioseparation, expanded

bed adsorption, two-phase separation and membrane chromatography. With these technologies the reproducible production of biocatalysts is achieved in highest yields.

In order to fully satisfy the customer's demands, the production of the biocatalyst can be combined with its direct application in a biotransformation. We have experience in routinely performing more than a hundred biocatalytic processes and are ready for large-scale production using reactors with total volumes of up to 1600 L.

The techniques we use on the application side vary widely from simple batch biotransformations over membrane reactors to whole-cell biotransformations.

Welcome to the  
**SIGMA-ALDRICH**  
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Your valuable research assistant  
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## 1. NEW! GLYCOSYLTRANSFERASE KITS FROM FLUKA

- **Are you working on glycosylations and synthesis of oligosaccharides and glycoconjugates?**
- **Do you like to complement your synthetic techniques using biocatalysts?**
- **Do you like to avoid laborious multistep procedures?**
- **Are you interested in high stereo- and regioselectivity?**

**The unique Fluka Glycosyltransferase Kits include sufficient amounts of enzymes, nucleotide sugar donors, buffers and reagents, necessary for successful glycosylations on preparative scale.**

As part of our commitment to the progress of biocatalysis in synthetic chemistry, Fluka has, in the past few years, developed and produced new glycosyltransferases for preparative carbohydrate synthesis as part of our commitment to the progress of biocatalysis in synthetic chemistry. Several recombinant glycosyltransferases are now available from well-established fermentation processes and can be offered for synthetic applications. Employing metabolic pathway engineering researchers at Kyowa Hakko Kogyo Inc. (Tokyo, Japan) recently developed a large scale production system for many nucleoside mono- and diphosphate sugar donors.<sup>[41-44]</sup> This technological breakthrough can be expected to enable industrial scale economic synthesis of oligosaccharides and glycoconjugates in the near future.<sup>[7]</sup>

In order to support and stimulate scientific research in enzymatic carbohydrate synthesis, Fluka and Kyowa Hakko have agreed to cooperate in the development of various glycosyltransferase kits. Each kit is designed to offer the enzyme, the corresponding nucleotide sugar donor and further components for the transfer of a specific monosaccharide moiety to an acceptor substrate on a small preparative scale. To provide greater flexibility in research applications, each enzyme is supplied in aliquots for multiple reactions on a scale, sufficient for product characterizations.

### 1.1 GLYCOSYLTRANSFERASES - INTRODUCTION<sup>[1-7]</sup>

Oligosaccharides and polysaccharides are ubiquitous in nature as components of a broad range of molecular structures. They function as structural scaffolds, to regulate viscosity, for energy storage, and as key components of cell surfaces. Intense studies in recent years have revealed the vital role of carbohydrate moieties of cell surface glycoproteins and glycolipids in cellular communication processes and physiological responses.<sup>[8-11]</sup> Cell-surface glycoproteins and glycolipids act as protein ligands providing anchors for intercellular adhesion. They also provide points of attachment for antibodies and other proteins, and they function as receptor sites for bacteria and viral particles.<sup>[12,13]</sup> Altered cell surface glycosylation patterns are associated with cellular

differentiation, development and viral infection and are diagnostic in certain cancers.<sup>[14]</sup> Oligosaccharides and glycoconjugates, which serve as competitive ligands, represent valuable tools in biological studies and potential drug targets in infectious diseases, inflammation and cancer. Glycosylation of proteins and other bioactive molecules may serve in site specific and controlled drug delivery, to increase solubility of hydrophobic molecules,<sup>[15,16]</sup> alter uptake and residency time in vivo<sup>[17,18]</sup> and decrease antigenicity.<sup>[19]</sup>

The growing recognition of the roles of carbohydrates in fundamental biological processes and their potential as new therapeutics has accentuated the requirement for a general availability of larger amounts of varying carbohydrate structures.

The isolation of glycoconjugates from natural sources provides only minute quantities, limiting carbohydrate structure and function studies to the characterisation of glycan chains isolated from glycoproteins.<sup>[10]</sup> Moreover, it is nearly impossible to obtain homogeneous glycoproteins from overexpression systems.<sup>[20,21]</sup>

The presence of multiple functional groups and stereocenters in carbohydrates makes them challenging targets for the organic chemist. Decades of synthetic research have not yielded robust, automated protocols comparable to those developed for the preparation of peptides and oligonucleotides. Major issues for the economic, large-scale, chemical synthesis of carbohydrates and glycoconjugates are: <sup>[1,6,22-24]</sup>

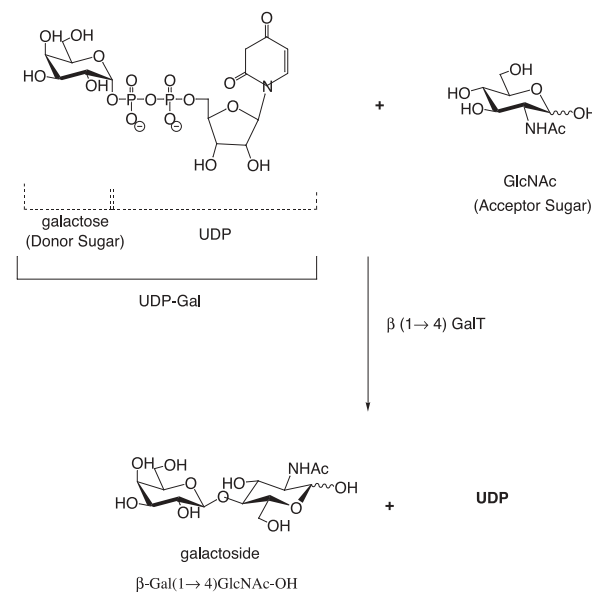
- **Multiple hydroxyl functionalities, which exhibit similar reactivities, must be suitably differentiated in order to obtain the desired glycosidic linkages with suitable levels of regioselectivity and stereospecificity. Therefore, laborious protecting group manipulations and complex synthetic schemes are required.**
- **The high diversity in linkages between specific monosaccharide units present in oligosaccharides and glycoconjugates still requires effective, regioselective, and stereospecific activation of either glycosyl donors or acceptors. This diversity in joints between monomer subunits even in simple oligosaccharides exceeds that of other biopolymers.**
- **Due to the fact that many carbohydrates are only soluble in water, their manipulation requires either an adaptation of organic reactions to aqueous media or a reversible modification of the carbohydrates to achieve solubility in non-aqueous solvents.**

Biocatalysts, namely glycosyltransferases from the Leloir pathway,<sup>[25-27]</sup> responsible for the synthesis of most cell-surface glycoforms in mammalian systems, have been proven as viable alternatives in the preparation of oligosaccharides.<sup>[11-27]</sup> As more and more of these transferases are isolated or produced from recombinant sources, chemists have recognized enzymatic glycosidation as the method of choice to complement their classical synthetic techniques. Leloir glycosyltransferases are highly regio- and stereospecific with respect to the glycosidic linkages formed. They use unprotected sugar precursors, thus avoiding tedious chemical elaborations, and provide products in high yields.

For questions about the pricing or to order, please contact your local Sigma-Aldrich Office (see back cover)

## 1.1 GLYCOSYLTRANSFERASES - INTRODUCTION CONTINUED

The biosynthesis of oligosaccharides, catalysed by glycosyltransferases from the Leloir pathway, resembles the corresponding chemical procedure (see **Figure 1**). A donor sugar is activated in a first step, followed by the transfer of the activated moiety to an appropriate acceptor sugar. These enzymes utilize primarily eight different glycosyl esters of nucleoside mono- or diphosphates as activated monosaccharide donors to build a new glycosidic bond, such as UDP-Glc, UDP-GlcNAc, UDP-Gal, UDPGalNAc, GDP-Man, GDP-Fuc, UDP-GlcUA, and CMP-NeuAc.<sup>[26]</sup>



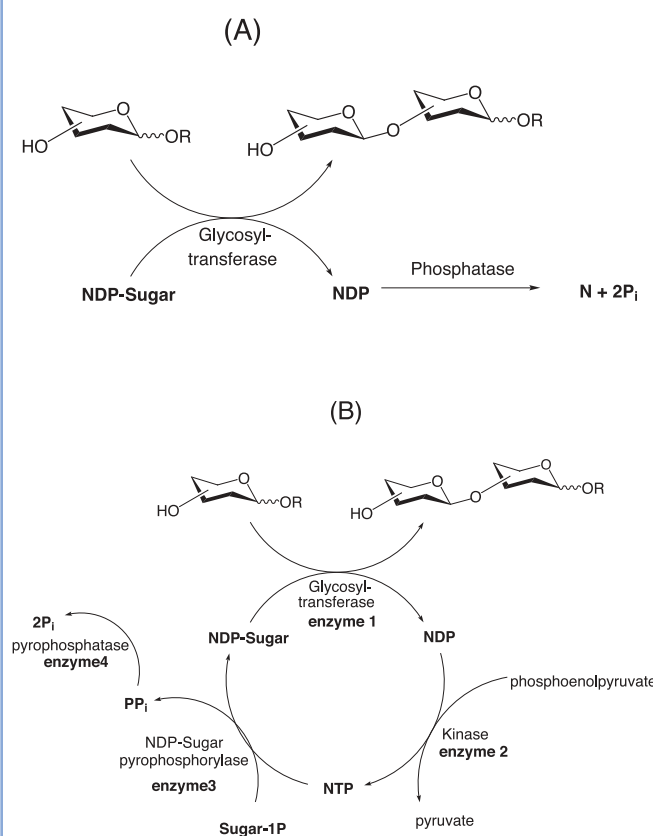
**Scheme 1. Glycosyltransferase-catalysed glycosidation using  $\beta(1\rightarrow 4)$ -Galactosyltransferase [ $\beta(1\rightarrow 4)$ GalT].**

Glycosyltransferases are specific for the type of linkage ( $\alpha$  or  $\beta$ ), and the linkage position of the glycoside bond formed [e.g.  $\alpha(1\rightarrow 3)$  or  $\beta(1\rightarrow 4)$ ]. Also, they are considered to be specific for a given glycosyl donor and acceptor, which led to the "one enzyme–one linkage" concept.<sup>[28,29]</sup> A number of recent observations have defeated the theory of absolute specificity regarding donors or acceptors:

- **The transfer of analogues of some nucleoside mono- or diphosphate sugar donors by glycosyltransferases has been described.**<sup>[30-36]</sup>
- **The enzymes tolerate a certain range of modifications in the acceptor substrate, as long as specific structural requirements (e.g. appropriate stereochemistry and availability of the hydroxyl group involved in the glycosidic bond) are met in the acceptor molecule.**<sup>[1-5]</sup>

A major issue in glycosyltransferase-catalysed glycosidations is the fact, that the nucleoside diphosphates generated during reaction are potent glycosyltransferase inhibitors. Two strategies have been described to prevent product inhibition:

- **The addition of phosphatase to remove nucleoside diphosphates [Scheme 2(A)].**<sup>[37]</sup>
- **Employing multienzyme regeneration systems, nucleoside diphosphates can be recycled to the appropriate nucleoside diphosphate sugars. Although several different enzymes and expensive cofactors are involved in these in situ regeneration systems, they are supposed to avoid the use of stoichiometric amounts of expensive sugar nucleotides [Scheme 2(B)].**<sup>[38-40]</sup>



**Scheme 2. Methods for avoiding product inhibition in glycosyltransferase-catalyzed synthesis: (A) Addition of phosphatase. (B) Recycling of sugar nucleotides (NDP = nucleoside diphosphates, NTP = nucleoside triphosphates, N = nucleoside, Pi = phosphate).**

**For more information about the complete range of glycosyltransferases and glycosyltransferase kits offered by Fluka, please take a look at the product listing in section 2.2 or visit our website at [www.sigma-aldrich.com/fluka](http://www.sigma-aldrich.com/fluka).**

## 1.2. $\beta(1\rightarrow 4)$ GALACTOSYLTRANSFERASE

### 59505 $\beta(1\rightarrow 4)$ -Galactosyltransferase Kit **NEW!**

Cat. No.	Name	Amount
48279	$\beta(1\rightarrow 4)$ -Galactosyltransferase from bovine milk ~ 1 U/mg <sup>1)</sup> , E.C. 2.4.1.22	5 x 1 mg
40396	UDP-Galactose UDP-Gal; Uridine 5'-diphospho- $\alpha$ -D-galactose disodium salt BioChemika, $\geq 90\%$ (HPLC)	100 mg
63536	Manganese(II) chloride tetrahydrate puriss. p.a., ACS, $\geq 99.0\%$ (KT)	500 mg
93371	Trizma® hydrochloride <sup>2)</sup> BioChemika, pH 7.4	1 g
61289	$\alpha$ -Lactalbumin from bovine milk BioChemika, calcium depleted, $\geq 90\%$ (HPCE)	25 mg
79385	Phosphatase alkaline from bovine intestinal mucosa BioChemika, solution (clear), $>10000$ U/ $\mu\text{l}^3$ , E.C. 3.1.3.1	200 ml

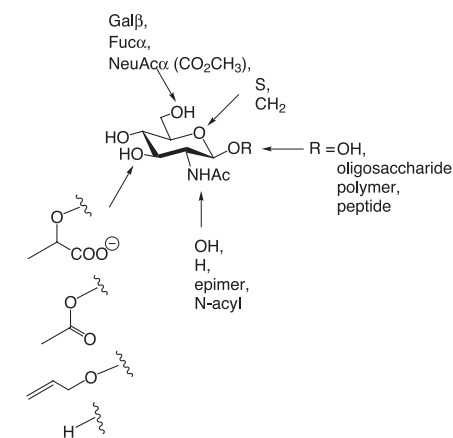
- 1) 1 U corresponds to the amount of enzyme, which transfers 1  $\mu\text{mol}$  of galactose from UDP-galactose to D-glucose per minute at pH 8.4 and 30°C in the presence of  $\alpha$ -lactalbumin.
- 2) Trizma® is a registered trademark of Sigma-Aldrich Biotechnology, L.P.
- 3) 1 U corresponds to the amount of enzyme, which hydrolyzes 1  $\mu\text{mol}$  4-nitrophenyl phosphate per minute at pH 9.8 and 37 °C.

$\beta(1\rightarrow 4)$  Galactosyltransferase from bovine milk (GalT, EC 2.4.1.22) is one of the most extensively studied mammalian glycosyltransferases with regard to synthesis and substrate specificity.<sup>[2-6,45-51]</sup>  $\beta(1\rightarrow 4)$  GalT catalyses the transfer of galactose from UDP-galactose (UDP-Gal) to the OH at the 4-position of N-acetyl glucosamine (GlcNAc) and also  $\beta$ -linked GlcNAc subunits to yield  $\beta$ -lactosamine ( $\beta$ -LacNAc) and  $\beta$ -Gal(1 $\rightarrow 4$ )- $\beta$ -GlcNAc structures.<sup>[52]</sup> When the enzyme forms a complex with  $\alpha$ -lactalbumin, the specificity is altered and D-glucose becomes the preferred acceptor. Thus, addition of  $\alpha$ -lactalbumin promotes the formation of lactose ( $\beta$ -Gal(1 $\rightarrow 4$ )-Glc). Both  $\alpha$ - and  $\beta$ -glycosides of glucose were utilized as acceptors in enzymatic galactosidation as well. The  $\alpha$ -glucosides required the presence of  $\alpha$ -lactalbumin.<sup>[5]</sup> Numerous other acceptor substrates for  $\beta(1\rightarrow 4)$ GalT catalyzed transfer of galactose have been described in the literature (see **Table 1**), e.g. 2-deoxyglucose, D-xylose, 5-thioglucose, N-acetylmuramic acid, and myoinositol. Moreover, 6-O-fucosylated and sialylated modifications served as acceptors<sup>[53]</sup> as well as 3-O-methyl-GlcNAc,<sup>[38,54]</sup> 3-deoxy-GlcNAc, 3-O-allyl-GlcNAc $\beta$ OBu and 3-oxo-GlcNAc.<sup>[55]</sup> Several modifications of GlcNAc that were employed as acceptor substrates are illustrated in Scheme 3.<sup>[2]</sup>

$\beta(1\rightarrow 4)$ GalT has been employed in solid-phase oligosaccharide synthesis on polymer supports like polyacrylamide or water-soluble poly(vinyl alcohol). The resulting galactosylated oligosaccharides are cleaved from the polymers photochemically or by using chymotrypsin.<sup>[56,57]</sup>

N-Acetylglucosaminyl amino acids and peptides were successfully galactosylated to afford glycopeptides with a disaccharide moiety.<sup>[58-60]</sup> Further extension of the carbohydrate chain was accomplished afterwards by employing  $\alpha(2\rightarrow 6)$ Sialyltransferase.<sup>[58-60]</sup>

The preparation of an asparagine-bound trisaccharide was accomplished by combined chemo-enzymatic synthesis.<sup>[58]</sup> Galactosidation of a N-acetylglucosaminyl oligopeptide followed



**Scheme 3. Modifications of GlcNAc employed as acceptors in  $\beta(1\rightarrow 4)$ GalT catalyzed transfer of galactose.**

by sialylation with  $\alpha(2\rightarrow 3)$ Sialyltransferase and fucosylation with  $\alpha(2\rightarrow 3)$ Fucosyltransferase yielded a glycopeptide containing a tetrasaccharide moiety.<sup>[61]</sup>

As different glycosides of N-acetylglucosamine and glucose can be used as acceptors in  $\beta(1\rightarrow 4)$ GalT catalyzed galactosidations, this enzymatic method was recently exploited in the modification of pharmacologically interesting glycosides.<sup>[15,16,62,63]</sup> Several currently published syntheses of new drug-sugar conjugates derived from the broad range of naturally occurring glycosides have accentuated the high potential of glycosylations in drug delivery, for example by increasing the solubility and bioavailability of large hydrophobic molecules under mild conditions.  $\beta(1\rightarrow 4)$ GalT catalyzed galactosidations of glycosides was successfully accomplished for elymoclavine-17-O- $\beta$ -D-glucopyranoside,<sup>[15]</sup> stevioside and steviolbioside,<sup>[64]</sup> colchicoside,<sup>[65]</sup> coumarinic glycoside fraxin,<sup>[65]</sup> and different ginsenosides.<sup>[66,67]</sup>

## 1.2. $\beta(1\rightarrow4)$ GALACTOSYLTRANSFERASE<sup>CONTINUED</sup>

Galactosylation of glycosides bearing a hydrophobic aglycone may suffer from poor solubility of the acceptor substrate. Recent systematic investigations of the stability of  $\beta(1\rightarrow4)$ GalT in different aqueous reaction mixtures and the effect of organic cosolvents are very instructive for choosing an appropriate solvent mixture.<sup>[65]</sup> Solvents like dimethyl sulfoxide, acetone, dioxane and ethanol seemed to be beneficial, increasing the stability of this enzyme, while other solvents such as N,N-dimethylformamide, acetonitrile and tetrahydrofuran enhanced the inactivation process.

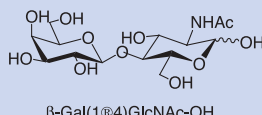
Transfer of galactose onto cyclodextrin was performed, because the recognition of the Gal-cyclodextrin conjugates by galectins was expected to enhance the drug delivery capabilities of the system.<sup>[68]</sup>

Employing C-glycoside analogues of the naturally occurring glycopeptide linkages (N-acetylglucosamine  $\beta$ -linked to either asparagine or serine) the corresponding C-lactosides were isolated in excellent yields.<sup>[69]</sup>

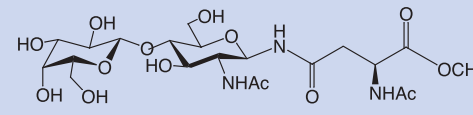
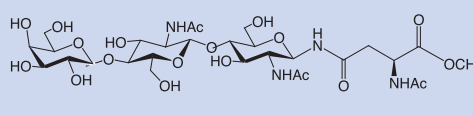
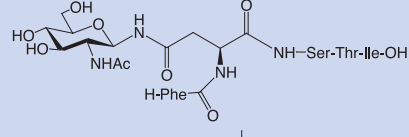
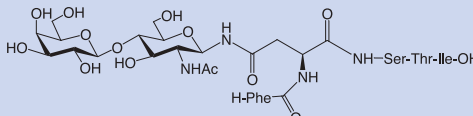
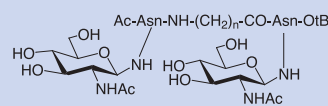
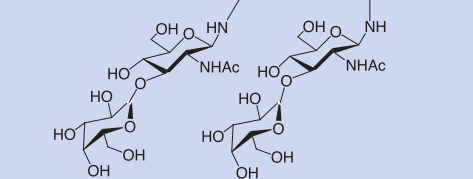
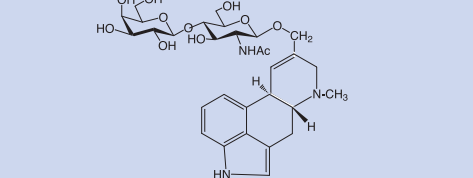
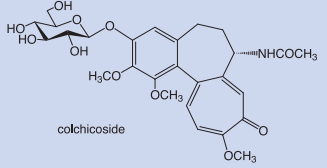
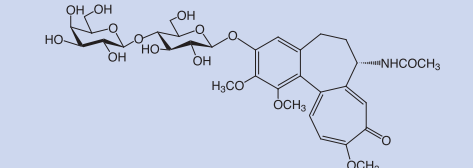
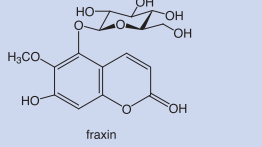
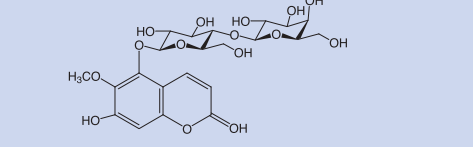
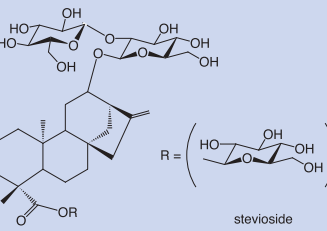
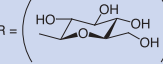
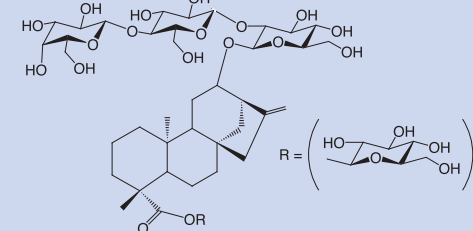
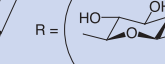
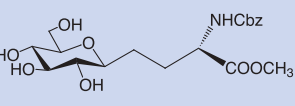
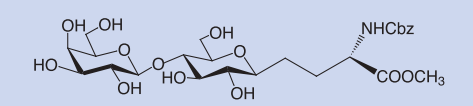
Neither D-mannose, D-allose, D-galactose, nor D-ribose are substrates.<sup>[4,5]</sup> Monosaccharides displaying a negative charge, such as glucuronic acid and  $\alpha$ -glucose-1-phosphate are also not accepted as substrates. Azasugars and glucals are considered to be very weak acceptors.<sup>[54]</sup>

With regard to the nucleotide sugar donors, several modified substrates were utilized, but the rate of enzyme-catalyzed transfer turned out to be rather slow.<sup>[4,5]</sup>

**Table 1. Acceptors and products of  $\beta(1\rightarrow4)$ GalT catalyzed transfer of galactose.**

Acceptor Substrate	→	Product	Ref.
GlcNAc-OH	→	 $\beta$ -Gal(1 $\rightarrow$ 4)GlcNAc-OH	[46,47]
Glc-OH	→	$\beta$ -Gal(1 $\rightarrow$ 4)-Glc-OH	[46,47]
$\beta$ -GlcNAc-hexanolamine	→	$\beta$ -Gal(1 $\rightarrow$ 4)- $\beta$ -GlcNAc-hexanolamine	[47]
$\beta$ -GlcNAc-hexanolamine-agarose	→	$\beta$ -Gal(1 $\rightarrow$ 4)- $\beta$ -GlcNAc-hexanolamine-agarose	[47]
$\beta$ -GlcNAc(1 $\rightarrow$ 4)-Gal-OH	→	$\beta$ -Gal(1 $\rightarrow$ 4)- $\beta$ -GlcNAc(1 $\rightarrow$ 4)-Gal-OH	[46]
$\beta$ -GlcNAc(1 $\rightarrow$ 4)-GlcNAc-OH	→	$\beta$ -Gal(1 $\rightarrow$ 4)- $\beta$ -GlcNAc(1 $\rightarrow$ 4)-GlcNAc-OH	[47,58]
$\beta$ -GlcNAc(1 $\rightarrow$ 6)-Gal-OH	→	$\beta$ -Gal(1 $\rightarrow$ 4)- $\beta$ -GlcNAc(1 $\rightarrow$ 6)-Gal-OH	[38,54]
$\beta$ -GlcNAc(1 $\rightarrow$ 3)-Gal-OH	→	$\beta$ -Gal(1 $\rightarrow$ 4)- $\beta$ -GlcNAc(1 $\rightarrow$ 3)-Gal-OH	[38,54]
$\beta$ -Glc-OCH <sub>2</sub> C <sub>6</sub> H <sub>4</sub> (NO <sub>2</sub> )-CONH-polymer	→	$\beta$ -Gal(1 $\rightarrow$ 4)- $\beta$ -Glc-OCH <sub>2</sub> C <sub>6</sub> H <sub>4</sub> (NO <sub>2</sub> )-CONH-polymer	[56,57]
$\beta$ -Glc(1 $\rightarrow$ 4)- $\beta$ -Glc-OCH <sub>2</sub> C <sub>6</sub> H <sub>4</sub> (NO <sub>2</sub> )-CONH-polymer	→	$\beta$ -Gal(1 $\rightarrow$ 4)- $\beta$ -Glc(1 $\rightarrow$ 4)- $\beta$ -Glc-OCH <sub>2</sub> C <sub>6</sub> H <sub>4</sub> (NO <sub>2</sub> )-CONH-polymer	[56,57]
$\beta$ -Glc(1 $\rightarrow$ 4)- $\beta$ -Glc-OCH <sub>2</sub> NH-L-Phe-CO-polymer	→	$\beta$ -Gal(1 $\rightarrow$ 4)- $\beta$ -Glc(1 $\rightarrow$ 4)- $\beta$ -Glc-OCH <sub>2</sub> NH-L-Phe-CO-polymer	[56,57]
$\beta$ -GlcNAc-(1 $\rightarrow$ 3) $\beta$ -Gal(1 $\rightarrow$ 4)- $\beta$ -GlcOCH <sub>3</sub> $\beta$ -GlcNAc-(1 $\rightarrow$ 6)	→	$\beta$ -Gal(1 $\rightarrow$ 4)- $\beta$ -GlcNAc-(1 $\rightarrow$ 3) $\beta$ -Gal(1 $\rightarrow$ 4)- $\beta$ -GlcOCH <sub>3</sub> $\beta$ -Gal(1 $\rightarrow$ 4)- $\beta$ -GlcNAc-(1 $\rightarrow$ 6)	[54,60]
$\beta$ -GlcNAc-(1 $\rightarrow$ 3) $\beta$ -Gal(1 $\rightarrow$ 4)- $\beta$ -GlcOCH <sub>3</sub> $\beta$ -GlcNAc-(1 $\rightarrow$ 6)	→	$\beta$ -GlcNAc-(1 $\rightarrow$ 3) $\beta$ -Gal(1 $\rightarrow$ 4)- $\beta$ -GlcOCH <sub>3</sub> $\beta$ -Gal(1 $\rightarrow$ 4)- $\beta$ -GlcNAc-(1 $\rightarrow$ 6)	[54,60]
$\alpha$ -L-Fuc-(1 $\rightarrow$ 6)- $\beta$ -GlcNAc-O(CH <sub>2</sub> ) <sub>8</sub> CO <sub>2</sub> CH <sub>3</sub>	→	$\alpha$ -L-Fuc-(1 $\rightarrow$ 6) $\beta$ -GlcNAc-O(CH <sub>2</sub> ) <sub>8</sub> CO <sub>2</sub> CH <sub>3</sub> $\beta$ -Gal(1 $\rightarrow$ 4)	[53]

## 1.2. $\beta(1\rightarrow4)$ GALACTOSYLTRANSFERASE<sup>CONTINUED</sup>

$\beta$ -GlcNAc-R ; R = Ac-Asn-OMe	→	 [58]
$\beta$ -GlcNAc(1 $\rightarrow$ 4)- $\beta$ -GlcNAc-R ; R = Ac-Asn-OMe	→	 [58]
 $\beta$ -GlcNAc-NHR (R = H-Phe-Asn-Ser-Thr-Ile-OH)	→	 [59]
$\beta$ -GlcNAc-R ; R = Gly-Gly-Asn-Gly-Gly	→	$\beta$ -Gal(1 $\rightarrow$ 4)- $\beta$ -GlcNAc-R ; R = Gly-Gly-Asn-Gly-Gly [59]
	→	 [61]
elymoclavine 17-O-(2-acetamido-2-deoxy- $\beta$ -D-glucopyranoside)	→	 [15]
 cackhioside	→	 [65]
 fraxin	→	 [65]
 R =  stevioside	→	 R =  [64]
	→	 [69]

### 1.3. $\alpha(1\rightarrow3)$ GALACTOSYLTRANSFERASE

#### 74188 $\alpha(1\rightarrow3)$ -Galactosyltransferase Kit **NEW!**

Cat. No.	Name	Amount
77038	$\alpha(1\rightarrow3)$ -Galactosyl Transferase, murine, recombinant from E. coli ~ 0.5 U/ml <sup>1)</sup> , E.C. 2.4.1.151	5 x 0.6 ml
40396	UDP-Galactose UDP-Gal; Uridine 5'-diphospho- $\alpha$ -D-galactose disodium salt BioChemika, $\geq 90\%$ (HPLC)	70 mg
63536	Manganese(II) chloride tetrahydrate puriss. p.a., ACS, $\geq 99.0\%$ (KT)	500 mg
93368	Trizma <sup>®</sup> hydrochloride <sup>2)</sup> BioChemika, pH 7	1 g
05470	Albumine from bovine serum BioChemika, lyophilized, crystallized, $\geq 98\%$ (HPCE)	25 mg
79385	Phosphatase alkaline from bovine intestinal mucosa BioChemika, solution (clear), $>10000$ U/ml <sup>3)</sup> , E.C. 3.1.3.1	150 ml

1) 1 U corresponds to the amount of enzyme, which transfers 1  $\mu$ mol of galactose from UDP-galactose to D-glucose per minute at pH 8.4 and 30°C in the presence of  $\alpha$ -lactalbumin.

2) Trizma<sup>®</sup> is a registered trademark of Sigma-Aldrich Biotechnology, L.P.

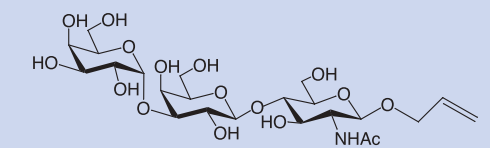
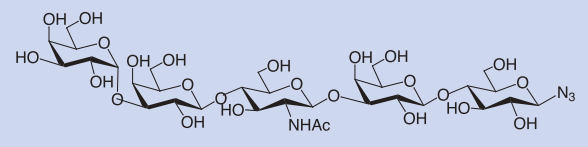
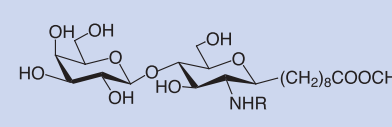
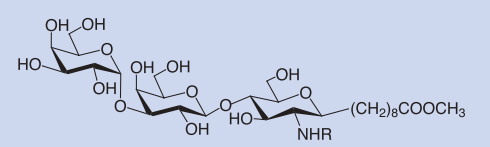
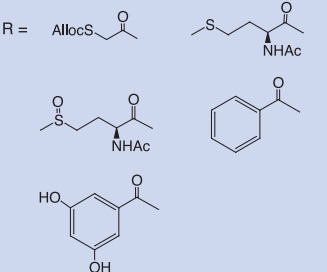
3) 1 U corresponds to the amount of enzyme, which hydrolyzes 1  $\mu$ mol 4-nitrophenyl phosphate per minute at pH 9.8 and 37 °C.

$\alpha(1\rightarrow3)$  Galactosyltransferase (EC 2.4.1.151) has attracted much attention in recent years as a unique enzyme responsible for the formation of  $\alpha$ -galactosyl epitopes bearing  $\alpha$ -Gal(1 $\rightarrow$ 3)- $\beta$ -Gal-OR termini. The interaction of such  $\alpha$ -Gal epitopes (Galili antigens) on the surface of animal cells (e.g. porcine endothelial cells) with anti-galactosyl antibodies present in human serum is believed to be the main cause in antibody-mediated hyperacute rejection following xenotransplantation.<sup>[70-75]</sup> Experimental attempts to overcome hyperacute rejection revealed the need for substantial amounts of  $\alpha$ -Gal oligosaccharides as well as synthetic  $\alpha$ -Gal analogues and mimetics with high affinity for anti-Gal antibodies. Earlier chemical syntheses of  $\alpha$ -Gal trisaccharides were rather tedious,<sup>[76-79]</sup> while glycosidase-catalyzed transglycosylation reactions to form the desired  $\alpha$ -Gal(1 $\rightarrow$ 3)- $\beta$ -Gal-OR linkage resulted in poor yields and regioselectivities.<sup>[80-83]</sup>

Using recombinant  $\alpha(1\rightarrow3)$  Galactosyltransferase,  $\alpha$ -Gal epitopes and several derivatives were synthesized on preparative

scale.<sup>[84,85]</sup> This approach provides an easy access to a wide variety of antigens for studies on xenotransplantation and also for other pharmaceutical research.<sup>[86]</sup> The  $\alpha(1\rightarrow3)$  Galactosyltransferase transfers a galactose unit from UDP-galactose (UDP-Gal) onto the 3-OH group of a terminal  $\beta$ -linked galactose forming an  $\alpha$ -linkage. Several studies of  $\alpha(1\rightarrow3)$  Galactosyltransferase substrate specificity have been carried out, which showed a high acceptor promiscuity of the enzyme in vitro.<sup>[84,85,87-89]</sup> Acceptors that were successfully used include lactose,  $\beta$ -lactosyl azide,  $\beta$ -thiophenyl lactoside, N-acetyllactosamine derivatives and lactosamine.<sup>[85]</sup> A wide range of N-acyl derivatives of type II disaccharides are galactosylated by the enzyme. Carbamate, different protected amino acid residues and lipophilic, as well as hydrophilic bulky aromatic residues can replace the natural N-acetyl group.<sup>[84]</sup>  $\alpha(1\rightarrow3)$  Galactosyltransferase is reported to be capable of galactosyl transfer to an unnatural hindered tertiary hydroxyl of the acceptor sugar.<sup>[90]</sup>

### 1.3. $\alpha(1\rightarrow3)$ GALACTOSYLTRANSFERASE CONTINUED

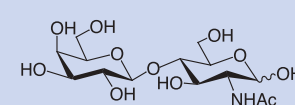
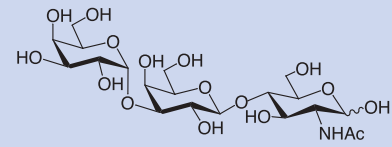
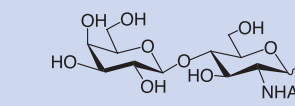
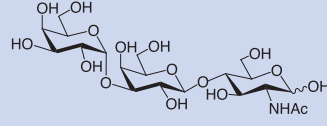
$\beta$ -Gal(1 $\rightarrow$ 4)- $\beta$ -GlcNAc-OAll	$\rightarrow$		[85]
$\beta$ -Gal(1 $\rightarrow$ 4)- $\beta$ -GlcN-OH	$\rightarrow$	$\alpha$ -Gal(1 $\rightarrow$ 3)- $\beta$ -Gal(1 $\rightarrow$ 4)- $\beta$ -GlcN-OH	[85]
$\beta$ -Gal(1 $\rightarrow$ 4)- $\beta$ -GlcNAc(1 $\rightarrow$ 3)- $\beta$ -Gal(1 $\rightarrow$ 4)- $\beta$ -Glc-N <sub>3</sub>	$\rightarrow$		[85]
$\beta$ -Gal(1 $\rightarrow$ 4)- $\beta$ -GlcNAc O(CH <sub>2</sub> ) <sub>8</sub> COOCH <sub>3</sub>	$\rightarrow$	$\alpha$ -Gal(1 $\rightarrow$ 3)- $\beta$ -Gal(1 $\rightarrow$ 4)- $\beta$ -GlcNAc O(CH <sub>2</sub> ) <sub>8</sub> COOCH <sub>3</sub>	[84]
	$\rightarrow$		[84]
		R = 	

### 1.4. References:

[1] E. J. Toone, *et al.*, *Tetrahedron*, **1989**, *45*, 5365. [2] D. G. Drueckhammer, *et al.*, *Synthesis*, **1991**, 499. [3] C.-H. Wong, *et al.*, *Angew. Chem.*, **1995**, *107*, 569. [4] C.-H. Wong, in *Enzyme Catalysis in Organic Synthesis*, K. Drauz., H. Waldmann [eds], VCH, Weinheim, **1995**, 279. [5] C. H. Wong, G. M. Whitesides, in *Enzymes in Synthetic Organic Chemistry, Tetrahedron Organic Chemistry Series, Vol. 12*, Elsevier Science Ltd, Oxford, **1994**, 252. [6] K. M. Koeller, C.H. Wong, *Chem.Rev.*, **2000**, *100*, 4465. [7] P. G. Wang, *et al.*, *Curr. Opin. in Drug Discovery & Development*, **2000**, *3*[6], 756. [8] for a collection of papers on glycoconjugates please see: *Carbohydr. Res.*, **1987**, *164*. [9] A. Varki, *Glycobiology*, **1993**, *3*, 97. [10] R. A. Dwek, *Chem.Rev.*, **1996**, *96*, 683. [11] P. Sears, C.-H. Wong, *Cell. Mol. Life Sci.*, **1998**, *54*, 223. [12] J. C. Paulson, in *The Receptors*, P. M. Cohn [ed.], Academic Press, New York, **1985**, Vol. 2, 131. [13] M. R. Sairam, in *The Receptors*, P.M. Cohn [ed.], Academic Press, New York, **1985**, Vol. 2, 307. [14] S. Hakomori, *Cancer Res.*, **1985**, *45*, 2405. [15] V. Kren, *et al.*, *J. Chem.Soc. Perkin Trans I*, **1994**, 2481. [16] S. Riva, *J. of Molecular Catalysis B: Enzymatic* **19-20**, **2002**, 43. [17] G. Ashwell, J. Harford, *J. Ann. Rev. Biochem.*, **1982**, *51*, 531. [18] E. G. Berger, *et al.*, *FEBS Lett.*, **1986**, *203*, 64. [19] W. B. Jacoby [ed.]: *Enzymatic Bases of Detoxification*, Academic Press, New York, **1980**, Vol. 2. [20] H. Schachter, *Biochem. Cell Biol.*, **1985**, *64*, 163. [21] Jenkins, R. A., *et al.*, *Nat. Biotechnol.*, **1996**, *14*, 975. [22] H. Paulsen, *Angew. Chem. Int. Ed. Engl.*, **1982**, *21*, 155. [23] H. Paulsen, *Chem. Soc. Rev.*, **1984**, *13*, 15. [24] H. Kunz, *Angew. Chem. Int. Ed. Engl.*, **1987**, *26*, 294. [25] L. F. Leloir, *Science*, **1971**, *172*, 1299. [26] R. Kornfeld, S. Kornfeld, *Ann. Rev. Biochem.*, **1985**, *54*, 631. [27] W. M. Watkins, *Carbohydr. Res.*, **1986**, *149*, 1. [28] A. T. Beyer, *et al.*, *Adv. Enzymol.*, **1981**, *52*, 24. [29] J. E. Sadler, *et al.*, *Method. Enzymol.*, **1982**, *83*, 458. [30] M. J. Morin, *et al.*, *J. Biochem. Pharm.*, **1983**, *32*, 553. [31] W. McDowell, *et al.*, *Biochem. J.*, **1987**, *248*, 523. [32] V.N. Shibaev, *Pure Appl. Chem.*, **1978**, *50*, 1421. [33] H. H. Higa, J. C. Paulson, *J. Biol. Chem.*, **1985**, *260*, 8838. [34] H. S. Conrad, *et al.*, *FEBS Lett.*, **1984**, *170*, 295. [35] H. J. Gross, *et al.*, *Eur. J. Biochem.*, **1987**, *168*, 595. [36] C. Augé, C. Gautheron, *Tetrahedron Lett.*, **1988**, *29*, 789. [37] C. Unverzagt, *et al.*, *J. Am. Chem. Soc.*, **1990**, *112*, 9308. [38] C. Augé, *et al.*, *Tetrahedron Lett.*, **1984**, *25*, 1467. [39] M. Ichikawa, *et al.*, *Methods Enzymol.*, **1994**, *247*, 107. [40] M. Ichikawa, *et al.*, *Tetrahedron Lett.*, **1995**, *36*, 8731. [41] S. Koizumi, *et al.*, *Nature Biotechnol.*, **1998**, *16*, 847. [42] T. Endo, *et al.*, *Carbohydr. Res.*, **1999**, *316*, 179. [43] K. Tabata, *et al.*, *Biotechnol. Lett.*, **2000**, *22*, 479. [44] T. Endo, *et al.*, *Appl. Microbiol. Biotechnol.*, **2000**, *53*, 257. [45] F. L. Schanbacher, K. E. Ebner, *J. Biol. Chem.*, **1970**, *245*, 5057. [46] L. Berliner, *et al.*, *Mol. Cell. Biochem.*, **1984**, *62*, 37. [47] H. A. Nunez, R. Barker, *Biochemistry*, **1980**, *19*, 489. [48] I. P. Trayler, R.L. Hill, *J. Biol. Chem.*, **1970**, *245*, 5057. [49] P. Andrews, *FEBS Lett.*, **1970**, *9*, 297. [50] R. Barker, *et al.*, *J. Biol. Chem.*, **1972**, *247*, 7135. [51] A. K. Rao, *et al.*, *Biochemistry*, **1976**, *15*, 5001. [52] G. Baisch, *et al.*, *Bioorg. Med. Chem. Lett.*, **1996**, *6*, 749. [53] M. M. Palcic, *et al.*, *Carbohydr. Res.*, **1987**, *159*, 315. [54] S. David, C. Augé, *Pure Appl. Chem.*, **1987**, *59*, 1501. [55] C. H. Wong, *et al.*, *J. Am. Chem. Soc.*, **1991**, *113*, 8137. [56] U. Zehavi, M. Herchman, *Carbohydr. Res.*, **1984**, *133*, 339. [57] U. Zehavi, *et al.*, *Carbohydr. Res.*, **1983**, *124*, 23. [58] J. Thiem, T. Wiemann, *Angew. Chem.*, **1990**, *102*, 78. [59] C. Unverzagt, *et al.*, *J. Am. Chem. Soc.*, **1990**, *112*, 9308. [60] C. Augé, *et al.*, *Carbohydr. Res.*, **1989**, *193*, 288. [61] G. Baisch, R. Ohrlein, *Angew. Chem.*, **1996**, *108*, 1949. [62] S. Riva, *et al.*, *Ann. N.Y. Acad. Sci.*, **1998**, *864*, 70. [63] L.Panza, *et al.*, *J.Chem. Soc. Perkin Trans. I*, **1997**, 1255. [64] B. Danieli, *et al.*, *Helv. Chim. Acta*, **1997**, *80*, 1153. [65] S. Riva, *et al.*, *Carbohydrate Research*, **1998**, *305*, 525. [66] B. Danieli, *et al.*, *J. Org. Chem.*, **2001**, *66*, 262. [67] S. Gebhard, *et al.*, *Helv. Chim. Acta*, **2002**, *85*, 1. [68] E. Leray, *et al.*, *J.Chem. Soc. Chem Commun.*, **1995**, 1019. [69] L. Tarantini, *et al.*, *J. of Molecular Catalysis B: Enzymatic* **11**, **2001**, 343. [70] U. Galili, *Immunol. Today*, **1993**, *14*, 480. [71] U. Galili, in: *Evolution and Pathophysiology of the Human Natural Anti- $\alpha$ -Galactosyl IgG Antibody*, Springer Semin. Immunopathol., **1993**, *15*, 155. [72] K. Gustafsson, *et al.*, *Immunol. Rev.*, **1994**, *141*, 59. [73] M. S. Sandrin, *et al.*, *Transplant. Rev.*, **1994**, *8*, 134. [74] M. S. Sandrin, I. F. C. McKenzie, *Immunol. Rev.*, **1994**, *141*, 169. [75] K. D. C. Cooper, *et al.*, *Immunol. Rev.*, **1994**, *141*, 31. [76] J.-C. Jacquinet, *et al.*, *J.Chem.Soc. Perkin Trans I*, **1981**, 326. [77] K. Koike, *et al.*, *Carbohydr. Res.*, **1987**, *163*, 189. [78] Y. Matsuzaki, *et al.*, *Tetrahedron Lett.*, **1993**, *34*, 1061. [79] G. V. Reddy, *et al.*, *Carbohydr. Res.*, **1994**, *263*, 67. [80] K. G. I. Nilsson, *Tetrahedron Lett.*, **1997**, *38*, 133. [81] G. Vic, *et al.*, *J.Chem.Soc. Chem Commun.*, **1996**, 1473. [82] G. Vic, *et al.*, *J.Chem.Soc. Chem Commun.*, **1997**, 1169. [83] I. Mstuo, *et al.*, *Bioorg. Med. Chem. Lett.*, **1997**, *7*, 255. [84] G. Baisch, *et al.*, *Bioorg. Med. Chem. Lett.*, **1998**, *8*, 1575. [85] J. Fang, *et al.*, *J. Am. Chem. Soc.*, **1998**, *120*, 6635. [86] C. H. Hokke, *et al.*, *Glycoconjugate J.*, **1996**, *13*, 687. [87] D. H. Joiasse, *et al.*, *Eur. J. Biochem.*, **1990**, *191*, 75. [88] K. Sujino, *et al.*, *Carbohydr. Res.*, **1998**, *305*, 483. [89] C. L. M. Stults, *et al.*, *Glycobiology.*, **1999**, *9*, 661. [90] X. Qian, *et al.*, *J. Am. Chem. Soc.*, **1999**, *121*, 12063.

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Table 2. Acceptors and products of  $\alpha(1\rightarrow3)$ GalT catalyzed transfer of galactose.

Acceptor Substrate	$\rightarrow$	Product	Ref.
	$\rightarrow$		[85]
$\beta$ -Gal(1 $\rightarrow$ 4)- $\beta$ -Glc-N <sub>3</sub>	$\rightarrow$	$\alpha$ -Gal(1 $\rightarrow$ 3)- $\beta$ -Gal(1 $\rightarrow$ 4)- $\beta$ -Glc-N <sub>3</sub>	[85]
$\beta$ -Gal(1 $\rightarrow$ 4)- $\beta$ -Glc-S-C <sub>6</sub> H <sub>5</sub>	$\rightarrow$	$\alpha$ -Gal(1 $\rightarrow$ 3)- $\beta$ -Gal(1 $\rightarrow$ 4)- $\beta$ -Glc-S-C <sub>6</sub> H <sub>5</sub>	[85]
	$\rightarrow$		[85]

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## 2. ENZYMES FOR ORGANIC SYNTHESIS

Our enzymes are listed according to their E.C. numbers in the following classes:

- 2.1. Oxidoreductases      → 2.3. Hydrolases  
→ 2.2. Transferases          → 2.4. Lyases

### WHAT'S COMING UP NEXT?

- **Recombinant  $\alpha(2\rightarrow6)$  Sialyltransferase and  $\alpha(1\rightarrow3)$  Fucosyltransferase VI!**  
→ **Corresponding Kits under development!**

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**NEW! 61374**  $\alpha(2\rightarrow6)$ -Sialyltransferase Kit  
**NEW! 81106**  $\alpha(1\rightarrow3)$ -Fucosyltransferase VI, human, recombinant from *Pichia pastoris*  
**NEW! 61843**  $\alpha(1\rightarrow3)$ -Fucosyltransferase VI Kit

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## 2.1. OXIDOREDUCTASES

#### Aldehyde Dehydrogenase from baker's yeast (*S. cerevisiae*)

E.C. 1.2.1.5  
[9028-88-0]

1 U corresponds to the amount of enzyme which oxidizes 1  $\mu$ mol acetaldehyde (00070) to acetic acid per minute at pH 8.0 and 25 °C

Component of NADH and NADPH cofactor recycling systems  
**82884** 25 mg, 100 mg  
BioChemika, lyophilisate, white,  $\geq 1$  U/mg  
Storage: -20 °C

**88307** 50 ml  
BioChemika, solution, slightly yellow, contains 50 mM potassium phosphate and 50% glycerol,  $\sim 1$  U/ml  
Storage: -20 °C

#### Alcohol Dehydrogenase from *Candida boidinii*

E.C. 1.1.1.1

1 U corresponds to the amount of enzyme which catalyzes the oxidation of 1  $\mu$ mol 2-propanol per minute at pH 7.5 and 30 °C

**91031** 250 mg  
BioChemika, powder, light brown,  $\geq 0.4$  U/mg  
Storage: -20 °C

#### Alcohol Dehydrogenase from *Candida parapsilosis*

E.C. 1.1.1.1

1 U corresponds to the amount of enzyme which liberates 1  $\mu$ mol ethyl 4-acetylbutyrate per minute at pH 8.0 and 37 °C

**81083** 10 ml  
BioChemika, solution, slightly red, contains 50% glycerol,  $\geq 4$  U/ml  
Storage: -20 °C

#### Alcohol Dehydrogenase from *Rhodococcus erythropolis*

E.C. 1.1.1.1

1 U corresponds to the amount of enzyme which reduces 1  $\mu$ mol ethyl (S)-3-hydroxybutyrate per minute at pH 9.5 and 30 °C

**68482** 1 ml  
BioChemika, solution, light yellow,  $>20$  U/ml  
Storage: -20 °C

#### Alcohol Dehydrogenase from *Saccharomyces cerevisiae*

Alcohol Dehydrogenase from yeast  
Alcohol:NAD<sup>+</sup> oxidoreductase  
ADH

E.C. 1.1.1.1  
[9031-72-5]

1 U corresponds to the amount of enzyme which oxidizes 1  $\mu$ mol ethanol per minute at pH 8.8 and 25 °C

Component of NADH cofactor recycling systems, biotransformations in organic solvents.<sup>[1,2]</sup>

[1] J.S. Deetz, J.D. Rozzell, *Ann. N.Y. Acad. Sci.*, 1988, 542, 230; [2] F. Yang, A.J. Russell, *Biotechnol. Prog.*, 1993, 9, 234.

**05640** 100 mg, 25 mg, 1 g  
BioChemika, lyophilized, powder, stab. with  $\sim 35\%$  sucrose,  $\sim 300$  U/mg  
Storage: -20 °C

**05635** 25 mg, 100 mg  
BioChemika, powder, off-white,  $\geq 250$  U/mg  
Storage: -20 °C

#### Alcohol Dehydrogenase from *Lactobacillus kefir*

Alcohol:NADP<sup>+</sup> oxidoreductase  
E.C. 1.1.1.2  
[9028-12-0]

1 U corresponds to the amount of enzyme which reduces 1  $\mu$ mol acetophenone per minute at pH 7.0 and 25 °C to phenylethanol (acetophenone, 00790), as substrate

Component of NADPH cofactor recycling systems; Application in biocatalysis.

C.W. Bradshaw et al., *J. Org. Chem.*, 1992, 57, 1532.

**05643** 50 mg, 250 mg  
BioChemika, powder, beige,  $\sim 0.4$  U/mg  
Storage: -20 °C

## 2.1. OXIDOREDUCTASES CONTINUED

#### Alcohol Dehydrogenase from *Thermoanaerobium brockii*

Alcohol:NADP<sup>+</sup> oxidoreductase  
TBADH

E.C. 1.1.1.2  
[9028-12-0]

1 U corresponds to the amount of enzyme which oxidizes 1  $\mu$ mol of 2-butyl alcohol per minute at pH 7.8 and 40 °C

Synthesis of chiral furan derivatives;<sup>[1]</sup> preparation of bifunctional chirons;<sup>[2]</sup> conversion of secondary alcohols to corresponding lactones;<sup>[3]</sup> synthesis of 8-methyldec-2-yl propanoate.<sup>[4]</sup>

[1] D.G. Drueckhammer, et al., *J. Org. Chem.*, 1988, 53, 1607; [2] E. Keinan, et al., *Biocatalysis*, 1990, 3, 57; [3] A.J. Willetts, et al., *J. Chem. Soc., Perkin Trans. I*, 1991, 1608; [4] E. Keinan, et al., *J. Org. Chem.*, 1992, 57, 3631.

**05655** 1 mg, 5 mg  
BioChemika, powder, white,  $\sim 35$  U/mg  
Storage: -20 °C

#### Glycerol dehydrogenase from *Cellulomonas sp.*

E.C. 1.1.1.6  
[9028-14-2]

1 U corresponds to the amount of enzyme which oxidizes 1  $\mu$ mol of glycerol (49769) per minute at pH 10.5 and 25 °C

Component of NADH cofactor recycling systems.

**04356 NEW!** 1 mg, 5 mg  
BioChemika, powder, faintly yellow  $\geq 50$  U/mg  
Storage: -20 °C

#### Glycerol Dehydrogenase from *Geotrichum candidum*

E.C. 1.1.1.6  
[9028-14-2]

1 U corresponds to the amount of enzyme which oxidizes 1  $\mu$ mol of glycerol per minute at pH 8.0 and 25 °C

Asymmetric reduction of ketones.<sup>[1,2]</sup>

[1] K. Nakamura, et al., *Tetrahedron Lett.*, 1988, 29, 2453; [2] A. Liese, et al., *Biotechnol. Bioeng.*, 1996, 51, 544.

**49860** 10 mg, 50 mg  
BioChemika,  $\sim 30$  U/g  
Storage: -20 °C

#### Sorbitol Dehydrogenase from sheep liver

L-Iditol Dehydrogenase  
L-Iditol: NAD<sup>+</sup> 5-oxidoreductase

SDH  
Polyol Dehydrogenase

E.C. 1.1.1.14  
[9028-21-1]

1 U corresponds to the amount of enzyme which converts 1  $\mu$ mol D-fructose to D-sorbitol per minute at pH 7.6 and 25 °C  
Reduction of L-Iditol to L-sorbose. Reduction of ketones to polyoles.

**85535** 10 mg  
BioChemika, lyophilized, powder, white,  $\sim 6$  U/mg  
Storage: -20 °C

#### L-Lactate Dehydrogenase from bovine heart

(S)-Lactate: NAD<sup>+</sup> oxidoreductase  
L-LDH

E.C. 1.1.1.27  
[9001-60-9]

1 U corresponds to the amount of enzyme which reduces 1  $\mu$ mol pyruvate per minute at pH 7.0 and 25 °C  
Reduction of  $\alpha$ -ketoacids to  $\alpha$ -hydroxycarboxylic acids.

**61310** 100 mg  
BioChemika, off-white,  $\sim 250$  U/mg protein ( $\sim 10$  mg/ml)  
Storage: 2-8 °C

#### L-Lactate Dehydrogenase from rabbit muscle

L-LDH

E.C. 1.1.1.27  
[9001-60-9]

1 U corresponds to the amount of enzyme which reduces 1  $\mu$ mol pyruvate per minute at pH 7.0 and 25 °C

Substrate specificity and use as a catalyst in the synthesis of homochiral 2-hydroxycarboxylic acids; <sup>[1]</sup> inversion of chirality using an electroenzymatic reactor. <sup>[2]</sup>

[1] M.J. Kim, G.M. Whitesides, *J. Am. Chem. Soc.*, 1988, 110, 2959; [2] J.M. Laval, et al., *Ann. N.Y. Acad. Sci.*, 1992, 672, 213.

**61311** 25 mg, 100 mg  
BioChemika, suspension in 2.1 M ammonium sulfate solution, pH  $\sim 6.0$ , white,  $\sim 500$  U/mg protein ( $\sim 10$  mg/ml)  
Storage: 2-8 °C

**61309** 25 mg, 100 mg  
BioChemika, lyophilized, powder, off-white,  $\sim 140$  U/mg  
Storage: 2-8 °C

#### D-Lactate Dehydrogenase *Lactobacillus leichmanii*

(R)-Lactate: NAD<sup>+</sup> oxidoreductase  
D-LDH

E.C. 1.1.1.28  
[9028-36-8]

1 U corresponds to the amount of enzyme which will reduce 1  $\mu$ mol of pyruvate to D-lactate per minute at pH 7.0 and 25 °C

**61306** 1 ml, 5 ml  
BioChemika, suspension in 3.2 M ammonium sulfate solution, pH  $\sim 6.0$ , white,  $\sim 1000$  U/ml  
Storage: 2-8 °C

**49971 NEW!** 1 ml, 5 ml  
BioChemika, suspension, yellow, protein only partially soluble in water or buffer,  $\sim 1000$  U/ml  
Storage: 2-8 °C

#### D-Lactate Dehydrogenase from *Lactobacillus sp.*

D-LDH

E.C. 1.1.1.28  
[9028-36-8]

1 U corresponds to the amount of enzyme which reduces 1  $\mu$ mol pyruvate to D-lactate per minute at pH 7.0 and 25 °C

**59023** 10 mg, 50 mg  
BioChemika, powder, white,  $\geq 400$  U/mg  
Storage: -20 °C

#### D-Lactate Dehydrogenase from *Staphylococci*

D-LDH

E.C. 1.1.1.28

1 U corresponds to the amount of enzyme which reduces 1  $\mu$ mol pyruvate per minute at pH 7.0 and 25 °C

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## 2.1. OXIDOREDUCTASES CONTINUED

**17847** 25 mg, 100 mg  
BioChemika, lyophilisate, white, ~120 U/mg  
Storage: -20 °C

**3-Hydroxybutyrate Dehydrogenase from *Rhodospseudomonas spheroides***  
(R)-3-Hydroxybutanoate: NAD<sup>+</sup> oxidoreductase  
3-HBDH  
E.C. 1.1.1.30  
[9028-38-0]

1 U corresponds to the amount of enzyme which catalyzes the oxidation of 1 μmol D-3-hydroxybutyrate to acetoacetate per minute at pH 8.0 and 25°C  
**54975** 5 mg, 25 mg  
BioChemika, suspension in 3.2 M ammonium sulfate solution, pH ~6.0, white, 4-10 U/mg protein (~5 mg protein/ml)  
Storage: 2-8°C

**Glucose Dehydrogenase from *Pseudomonas sp.***  
E.C. 1.1.1.47  
[9028-53-9]

1 U corresponds to the amount of enzyme which oxidizes 1 μmol β-D-glucose to D-glucono-δ-lactone per minute at pH 8.0 and 37 °C  
NADH regenerating enzyme.  
**19359** 10 mg  
BioChemika, powder, white, ≥250 U/mg  
Storage: -20°C

**Glucose-6-phosphate Dehydrogenase from *Leuconostoc mesenteroides***  
G-6-P-DH  
E.C. 1.1.1.49  
[9001-40-5]

1 U corresponds to the amount of enzyme which oxidizes 1 μmol of glucose-6-phosphate per minute at pH 7.8 and 30°C (NAD as coenzyme)  
Catalyses the conversion of D-glucose-6-phosphate to D-glucono-γ-lactone-6-phosphate. Used for the determination of glucose, fructose and/or ATP.  
Component of a cofactor recycling system for NADH or NADPH. Under optimum conditions, the activity found with NAD is ~1.8x higher than with NADP. At pH 7.8 and 30°C the activity is 1.7x higher than at pH 7.4 and 25 °C.

**49275** 5 mg, 25 mg  
BioChemika, lyophilized, powder, slightly beige, ~170 U/mg  
Storage: -20 °C

**Glucose-6-phosphate Dehydrogenase from baker's yeast (*S. cerevisiae*)**  
G-6-P-DH  
E.C. 1.1.1.49  
[9001-40-5]

1 U corresponds to the amount of enzyme which oxidizes 1 μmol glucose-6-phosphate per minute at pH 7.6 and 25°C  
Component of a cofactor recycling system for NADH or NADPH.  
**49271** 1 mg, 5 mg, 10 mg  
BioChemika, crystalline, suspension in 3.2 M ammonium sulfate solution, pH ~6, ~240 U/ mg protein (~1 mg protein/ml)  
Storage: 2-8 °C

**49272** 1 mg, 5 mg, 25 mg  
BioChemika, lyophilized, powder, white, essentially sulfate free, ~210 U/mg  
Storage: -20°C

**Glucose-6-phosphate Dehydrogenase from yeast**  
G-6-P-DH  
E.C. 1.1.1.49  
[9001-40-5]

1 U corresponds to the amount of enzyme which oxidizes 1 μmol glucose-6-phosphate per minute at pH 7.6 and 25°C  
Component of a cofactor recycling system for NADH or NADPH.  
**49270** 1 mg, 5 mg, 25 mg  
BioChemika, standardized with bovine serum albumin, crystalline suspension in 3.2 M ammonium sulfate solution, pH ~6, ~120 U/mg protein (~5 mg protein/ml)  
Storage: 2-8°C

**49273** 1 mg, 5 mg  
BioChemika, lyophilized, powder, off-white, ~160 U/mg  
Storage: 2-8°C

**Glucose-6-phosphate Dehydrogenase from torula yeast**  
G-6-P-DH  
E.C. 1.1.1.49  
[9001-40-5]

1 U corresponds to the amount of enzyme which oxidizes 1 μmol glucose-6-phosphate per minute at pH 7.6 and 25°C  
Component of a cofactor recycling system for NADH or NADPH.  
**49279** 1 mg, 5 mg  
BioChemika, suspension, contains 3.2 M ammonium sulfate, ~15% sodium citrate, pH ~7.5, white, ~180 U/mg protein (~1 mg protein/ml)  
Storage: 2-8°C

**Glucose Oxidase from *Aspergillus niger***  
β-D-Glucose: oxygen 1-oxidoreductase  
GOD  
E.C. 1.1.3.4  
[9001-37-0]

1 U corresponds to the amount of enzyme which oxidizes 1 μmol glucose per minute at pH 7.0 and 25°C  
Oxidation of free and terminal bound glucose. Biotransformations in a bioelectrochemical cell.  
C. Laane, et al., *Enzyme Microb. Technol.*, 1984, 6, 165.  
**49177** 10 ml, 50 ml  
BioChemika, clear solution in 0.1 M sodium acetate buffer, pH 4.0, yellow, ~1000 U/ml  
Storage: 2-8°C

**49180** 250 mg, 1 g  
BioChemika, lyophilized, powder, ~200 U/mg  
Storage: -20°C

**49182** 250 mg, 1 g, 5 g  
BioChemika, powder, yellow, ~150 U/mg  
Storage: -20°C

**49181** 250 mg, 1 g, 5 g  
BioChemika, powder, yellow, ~130 U/mg  
Storage: -20°C

## 2.1. OXIDOREDUCTASES CONTINUED

**49178** 1 g, 5 g  
BioChemika, lyophilized, powder, ~25 U/mg  
Storage: -20°C

**Alcohol Oxidase from *Pichia pastoris***  
Alcohol:oxygen oxidoreductase  
E.C. 1.1.3.13  
[9073-63-3]

1 U corresponds to the amount of enzyme which oxidizes 1 μmol methanol to formaldehyde per minute at pH 7.5 and 25°C  
**92705** 1 ml  
BioChemika, solution, contains 0.1M potassium phosphate, 30% saccharose, pH ~8.0, red to deep red, ≥400 U/ml  
Storage: -20°C

**Formate Dehydrogenase from *Candida boidinii***  
Formate: NAD<sup>+</sup> oxidoreductase  
FDH  
E.C. 1.2.1.2  
[9028-85-7]

1 U corresponds to the amount of enzyme which oxidizes 1 μmol sodium formate (71539) per minute at pH 7.6 and 25°C

Preferred enzyme for regeneration of NADH from NAD.<sup>[1]</sup> Stereoselective lactone preparation.<sup>[2]</sup>  
[1] K. Drauz, H. Waldmann, *Enzyme Catalysis in Organic Synthesis*, VCH, Weinheim, 1995, 597.  
[2] G. Grogan, et al., *Biotechnol. Lett.*, 1992, 14, 1125.

**47753** 1 ml, 5 ml  
BioChemika, clear liquid clear, brown, ~50 U/ml  
Storage: 2-8°C

**47709** 50 mg, 250 mg  
BioChemika, powder, 0.3-0.6 U/mg  
Storage: -20°C

**Formate Dehydrogenase, *Pseudomonas spec.*, recombinant from *E. coli***  
E.C. 1.2.1.2  
[9028-85-7]

1 U corresponds to the amount of enzyme which oxidizes 1 μmol formiate per minute at pH 7.0 and 30°C (NAD as cofactor)  
The wildtype enzyme (Fluka 79900) has a K<sub>M</sub> of 100 mM for NAPD and a K<sub>M</sub> of 0.08 mM for NAD  
**79900** 1 ml, 10 ml  
BioChemika, solution, contains ammonium sulfate (5 % of the saturation), 15 % glycerol, 15 mM EDTA, light yellow, ~100 U/ml  
Storage: 2-8°C

**Formate Dehydrogenase, *Pseudomonas spec.*, recombinant mutante to 79900 from *E. coli***  
E.C. 1.2.1.2  
[9028-85-7]

1 U corresponds to the amount of enzyme which oxidizes 1 μmol formiate per minute at pH 7.0 and 30°C (NAD as cofactor)  
The introduced mutations have the effect that the enzyme has a higher affinity to NAD (K<sub>M</sub> of 0.04) than the wildtype enzyme (Fluka 79900). Furthermore, the mutant enzyme has a higher thermal stability. Increased stability of a mutant of a bacterial formate dehydrogenase with replaced Cys-255,

hydrophobisation of α-helices.<sup>[1,2]</sup>

[1] V.I. Tishkov, et al., *Biochem. Biophys. Res. Comm.*, 1993, 192, 976 ; [2] A.M. Rojkova, et al., *FEBS Lett.*, 1999, 445, 183.

**75274** 1 ml, 5 ml  
BioChemika, solution, contains ammonium sulfate (7 % of the saturation), 15 % glycerol, 15 mM EDTA, light yellow, >150 U/ml  
Storage: 2-8°C

**Formate Dehydrogenase, *Pseudomonas spec.*, NADP-dependant recombinant mutant to 79900 from *E. coli***  
E.C. 1.2.1.2  
[9028-85-7]

1 U corresponds to the amount of enzyme which oxidizes 1 μmol formiate per minute at pH 7.0 and 30°C (NADP as cofactor)

The introduced mutation has the effect that the enzyme has a higher affinity to NADP (K<sub>M</sub> of 0.3 mM) than to NAD (K<sub>M</sub> of 1 mM). Enzyme employed in a new efficient procedure to regenerate NADPH.  
K. Seelbach, et al., *Tetrahedron Lett.*, 1996, 37, 1377.

**79331** 1 ml, 5 ml  
BioChemika, solution, contains ammonium sulfate (10 % of the saturation), 20 % glycerol, 15 mM EDTA, light yellow, ~50 U/ml  
Storage: 2-8°C

**L-Alanine Dehydrogenase from *Bacillus subtilis***  
L-Alanine: NAD<sup>+</sup> oxidoreductase (deaminating)  
E.C. 1.4.1.1  
[9029-06-5]

1 U corresponds to the amount of enzyme which converts 1 μmol L-alanine to pyruvate and NH<sub>3</sub> per minute at pH 10.0 and 25°C  
Characterization,<sup>[1,2]</sup> Production of L-alanine with coenzyme regeneration.<sup>[3]</sup>  
[1] Y. Nitta, et al., *J. Bacteriol.*, 1974, 117, 588; [2] A. Yoshida, E. Freese, *Biochim. Biophys. Acta*, 1965, 96, 248 ;[3] T. Fujii, et al., *Biotechnol. Bioeng.*, 1991, 38, 1166.

**05192** 1 mg, 5 mg  
BioChemika, suspension in 2.4 M ammonium sulfate solution, pH 7.0, white, ≥30 U/mg protein (~10 mg protein/ml)  
Storage: 2-8°C

**Glutamate Dehydrogenase from bovine liver**  
L-Glutamate: NAD[P]<sup>+</sup> oxidoreductase (deaminating)  
L-GLDH  
E.C. 1.4.1.3  
[9029-12-3]

1 U corresponds to the amount of enzyme which reduces 1 μmol 2-oxoglutarate (75893) per minute at pH 7.9 and 25°C  
Determination of urea, L-glutamate, 2-ketoglutarate.<sup>[1,2]</sup>  
[1] M.G. Gore, *Int. J. Biochem.*, 1981, 13, 879; [2] H.F. Fischer, *Meth. Enzymol.*, 1985, 113, 16.

**49392** 100 mg, 1 g  
BioChemika, lyophilized, powder, >30 U/mg  
Storage: -20°C

**49390** 1 ml, 5 ml  
BioChemika, solution in 50% sodium phosphate buffer pH 7.3; 50% glycerol, viscous, amber, ~1600 U/ml  
Storage: 2-8°C

## 2.1. OXIDOREDUCTASES CONTINUED

**L-Leucine Dehydrogenase from *Bacillus cereus***  
 α-L-α-Leucine: NAD<sup>+</sup> oxidoreductase (deaminating)  
 E.C. 1.4.1.9  
 [9082-71-7]  
 1 U corresponds to the amount of enzyme which catalyzes the oxidation of 1 μmol L-leucine per minute at pH 10.7 and 30°C to 4-methyl-2-oxopentanoate and ammonia (NAD<sup>+</sup> as cofactor)  
**40453** 1 ml  
 BioChemika, solution, slightly brown, ~ 50 U/ml  
 Storage: -20°C

**L-Phenylalanine Dehydrogenase from *Rhodococcus sp. M4***  
 E.C. 1.4.1.20  
 [69403-12-9]  
 1 U corresponds to the amount of enzyme which catalyzes the oxidation of 1 μmol L-phenyl-alanine per minute at pH 10.7 and 30°C to phenyl-pyruvate and ammonia (NAD<sup>+</sup> as cofactor)  
**55001** 1 ml  
 BioChemika, solution clear, light yellow, ~150 U/ml  
 Storage: -20°C

**Laccase from *Agaricus bisporus***  
 E.C. 1.10.3.2  
 1 U corresponds to the amount of enzyme which converts 1 μmol catechol per minute at pH 6.0 and 25°C  
**40452** 1 g, 5 g  
 BioChemika, powder, deep brown, ≥4 U/mg  
 Storage: -20°C

**Laccase from *Trametes versicolor***  
 former Laccase *Coriolus versicolor*  
 E.C. 1.10.3.2  
 (53739) 1 U corresponds to the amount of enzyme which converts 1 μmol catechol per minute at pH 4.5 and 25°C  
 (38429) 1 U corresponds to the amount of enzyme which converts 1 μmol catechol per minute at pH 6.0 and 25°C  
**53739 NEW!** 100 mg, 1 g  
 BioChemika, powder, slightly beige, >20 U/mg  
 Storage: -20°C

**38429** 1 g, 10 g  
 BioChemika, powder, light brown, ≥0.8 U/mg  
 Storage: 2-8°C

**Chloroperoxidase from *Caldariomyces fumago***  
 Chloride peroxidase: hydrogen peroxide oxidoreductase  
 Chloride peroxidase  
 E.C. 1.11.1.10  
 [9055-20-3]

1 U corresponds to the amount of enzyme which converts 1 μmol of monochlorodimedone to dichlorodimedone per minute at pH 2.75 and 25°C in the presence of KCl and H<sub>2</sub>O<sub>2</sub>. Chloroperoxidase in synthesis,<sup>[1]</sup> oxidation of aminopyrine,<sup>[2]</sup> chloroperoxidase-catalyzed asymmetric transformations.<sup>[3,4]</sup>  
 [1] M.A. Pickard, et al., *J. Ind. Microbiol.*, 1991, 7, 235; [2] H. Sayo, et al., *Chem. Pharm. Bull.*, 1989, 37, 3347; [3] H. Fu, et al., *J. Org. Chem.*, 1992, 57, 7265; [4] S. Colonna, et al., *NATO ASI Ser., Ser. C*, 1992, 381, 323.

**25810** 1 ml  
 BioChemika, suspension in 0.1 M sodium phosphate, pH 4.0, suspension, brown, >10000 U/ml  
 Storage: 2-8°C

**Catalase from *Aspergillus niger***  
 E.C. 1.11.1.6  
 [9001-05-2]

1 U corresponds to the amount of enzyme which decomposes 1 μmol H<sub>2</sub>O<sub>2</sub> per minute at pH 7.0 and 25°C  
 Removal of hydrogen peroxide; properties;<sup>[1]</sup> stability.<sup>[2]</sup>

[1] K. Kikuchi-Torii, et al., *J. Biochem.*, 1982, 92, 1449; [2] B.P. Wasserman, H.O. Hultin, *Arch. Biochem. Biophys.*, 1981, 212, 385.

**60631** 100 mg, 500 mg  
 BioChemika, ~170 U/mg  
 Storage: -20°C

**60628** 1 ml, 5 ml  
 BioChemika, suspension in 3.2 M ammonium sulfate solution, pH 6, suspension, dark green-brown, ~70000 U/ml  
 Storage: 2-8°C

**Catalase from bovine liver**  
 E.C. 1.11.1.6  
 [9001-05-2]

1 U corresponds to the amount of enzyme which decomposes 1 μmol H<sub>2</sub>O<sub>2</sub> per minute at pH 7.0 and 25°C  
 Removal of hydrogen peroxide; properties,<sup>[1,2]</sup> biocatalytic production of glyoxylic acid,<sup>[3]</sup> removal of oxidation products during production of gluconic acid in a disk reactor with immobilized glucose oxidase.<sup>[4]</sup>

[1] M.E. Percy, *Can. J. Biochem. Cell Biochem.*, 1984, 62, 100; [2] L. Goth, *Enzyme*, 1989, 41, 191; [3] J.E. Seip, et al., *J. Org. Chem.*, 1993, 58, 2253; [4] H.N. Chang, et al., *Biotechnol. Lett.*, 1984, 6, 487.

**60640** 25 ml, 100 ml, 500 ml  
 BioChemika, for technical purposes, in 30% glycerol, ≥200000 U/ml  
 Storage: 2-8°C

**60630** 50 mg, 250 mg  
 BioChemika, crystalline, suspension in water, pH ~6, ~65000 U/mg protein (~20 mg protein/ml)  
 Storage: 2-8°C

**60635** 5 g, 25 g, 100 g  
 BioChemika, lyophilized, powder, brown, ~ 2500 U/mg  
 Storage: -20°C

**60632** 5 g, 25 g, 100 g  
 BioChemika, powder, dark-brown, ~1300 U/mg  
 Storage: -20°C

**Catalase from *Corynebacterium glutamicum***  
 E.C. 1.11.1.6  
 [9001-05-2]

1 U corresponds to the amount of enzyme which decomposes 1 μmol H<sub>2</sub>O<sub>2</sub> per minute at pH 7.0 and 25°C  
**02071 NEW!** 1 ml, 5 ml  
 BioChemika, solution, contains ~30% glycerol, 10% ethanol, deep brown, ≥500000 U/ml  
 Storage: 2-8°C

## 2.1. OXIDOREDUCTASES CONTINUED

**Catalase from *Micrococcus lysodeikticus***  
 E.C. 1.11.1.6  
 [9001-05-2]

1 U corresponds to the amount of enzyme which decomposes 1 μmol H<sub>2</sub>O<sub>2</sub> per minute at pH 7.0 and 25°C  
**60634** 100 ml, 500 ml

BioChemika, solution, dark brown, ~170000 U/ml  
 Storage: 2-8°C

**Catalase from microorganisms**  
 E.C. 1.11.1.6  
 [9001-05-2]

1 U corresponds to the amount of enzyme which decomposes 1 μmol H<sub>2</sub>O<sub>2</sub> per minute at pH 7.0 and 25°C  
**60633** 25 mg, 100 mg

BioChemika, lyophilized, powder, brown, ~1700 U/mg  
 Storage: 2-8°C

**Peroxidase from *Arthromyces ramosus***  
 donor:hydrogen peroxide oxidoreductase  
 E.C. 1.11.1.7  
 [9003-99-0]

1 U corresponds to the amount of enzyme which oxidizes 1 μmol ABTS (11557) per minute at pH 6.0 and 25°C  
**41366** 10 mg, 50 mg

BioChemika, powder, light brown, >400 U/mg  
 Storage: -20°C

**Peroxidase from horse radish**  
 donor:hydrogen peroxide oxidoreductase  
 E.C. 1.11.1.7  
 [9003-99-0]

1 U corresponds to the amount of enzyme which oxidizes 1 μmol ABTS (11557) per minute at pH 6.0 and 25°C  
 Enantioselective sulfoxidations catalysed by chloroperoxidase and horseradish peroxidase,<sup>[1]</sup> use of chemically modified peroxidase in benzene,<sup>[2]</sup> cross-linking of proteins,<sup>[3]</sup> enzyme-catalyzed polymerisation and precipitation of aromatic compounds from waste water,<sup>[4]</sup> oxidation of N-substituted aromatic amines.<sup>[5]</sup>

[1] S. Colonna, et al., *NATO ASI Ser., Ser. C*, 1992, 381, 323; [2] K. Takahashi, et al., *Biochem. Biophys. Res. Comm.*, 1984, 121,216; [3] G. Matheis, J.R. Whitaker, *J. Prot. Chem.*, 1984, 3, 35; [4] J.A. Nicell, et al., *Water Sci. Technol.*, 1992, 25, 157; [5] J. Van der Zee, et al., *J. Biol. Chem.*, 1989, 264, 19828.

**77334** 10 mg, 50 mg, 250 mg  
 BioChemika, lyophilized, powder, red-brown, ~850 U/mg  
 Storage: -20°C

**77333** 100 mg, 500 mg  
 BioChemika, lyophilized, powder, red-brown, ~700 U/mg  
 Storage: -20°C

**77335** 100 mg, 500 mg  
 BioChemika, powder, red-brown, ~550 U/mg  
 Storage: -20°C

**77332** 100 mg, 500 mg  
 BioChemika, lyophilized, powder, beige, ~150 U/mg  
 Storage: -20°C

**Lactoperoxidase from bovine milk**  
 donor: hydrogen peroxide oxidoreductase  
 E.C. 1.11.1.7  
 [9003-99-0]

1 U corresponds to the amount of enzyme which oxidizes 1 μmol ABTS per minute at pH 6.0 and 25°C  
 Properties<sup>[1,2]</sup>, lactoperoxidase-catalyzed iodination as a tool for investigation of proteins,<sup>[3,4]</sup> enzymatic method of incorporation of <sup>125</sup>I into DNA.<sup>[5]</sup> Lactoperoxidase-catalyzed oxidation of thiocyanate and halides.<sup>[6]</sup>

[1] B. Reiter, *Immunol. Ser.*, 1985, 27, 123; [2] P.I. Ohlsson, et al., *Protides Biol. Fluids*, 1984, 32, 125; [3] G.S. David, R.A. Reisfeld, *Biochemistry*, 1974, 13, 1014; [4] M. Morrison, *Meth. Enzymology*, 1980, 70, 214; [5] A. Gladek, M. Modarski, *Arch. Immunol. Ther. Exp.*, 1983, 31, 541; [6] E.L. Thomas, *Immunol. Ser.*, 1985, 27, 31.

**61328** 1 mg, 10 mg  
 BioChemika, lyophilized, powder, light brown, ~250 U/mg  
 Storage: -20°C

**61331** 5 mg, 25 mg  
 BioChemika, lyophilized, powder, yellow-brown, ~150 U/mg  
 Storage: -20°C

**2-Tridecanone Monooxygenase from *Pseudomonas cepacia***  
 E.C. 1.14.13.x

1 U corresponds to the amount of enzyme which catalyzes the 2-tridecanone-stimulated oxidation of 1 μmol NADPH per minute at pH 7.8 and 30°C  
 L.N. Britton, A.J. Markovetz, *J. Biol. Chem.*, 1977, 252, 8561.

**91530** 5 mg, 25 mg  
 BioChemika, ~0.5 U/g  
 Storage: -20°C

**Cyclopentanone Monooxygenase from *Pseudomonas sp.***  
 E.C. 1.14.13.16

1 U corresponds to the amount of enzyme which catalyzes the cyclopentanone-stimulated oxidation of 1 μmol of NADPH per minute at pH 7.7 and 30°C  
 Catalyses the first two steps in the cleavage of the carbocyclic ring of cyclopentanone and related compounds.<sup>[1,2]</sup>

[1] P.W. Trudgill, *Meth. Enzymol.*, 1990, 188, 77; [2] B. Adger, et al., *Chem. Comm.*, 1995, 1563.

**29800** 25 mg, 100 mg  
 BioChemika, powder, off-white, ~ 10 U/g  
 Storage: -20°C

**Cyclohexanone Monooxygenase from *Acinetobacter sp.***  
 E.C. 1.14.13.22

1 U corresponds to the amount of enzyme which catalyzes the cyclohexanone-stimulated oxidation of 1 μmol of NADPH per minute at pH 9.0 and 30°C  
 Catalyst for the enantioselective synthesis of lactones from achiral cyclohexanones and bicyclo[3.2.0]heptan-ones introducing enantioselectivity to the classical Baeyer-Villiger oxidation<sup>[1-4]</sup>

[1] N. Donoghue, et al., *Eur. J. Biochem.*, 1976, 63, 175; [2] M.J. Taschner, D.J. Black, *J. Amer. Chem. Soc.*, 1988, 110, 6892; [3] M.J. Taschner, L. Peddada, *Chem. Comm.*, 1992, 1384; [4] D.R. Kelly, et al., *J. Chem. Soc., Perkin Trans. I*, 1995, 2057.

**29170** 25 mg, 100 mg  
 BioChemika, powder, off-white, ~5 U/g  
 Storage: -20°C

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## 2.1. OXIDOREDUCTASES CONTINUED 2.2 TRANSFERASES

### Cyclohexanone Monooxygenase from *Nocardia globberula*

E.C. 1.14.13.22

1 U corresponds to the amount of enzyme which catalyzes the cyclohexanone-stimulated oxidation of 1 μmol NADPH per minute at pH 7.1 and 30°C  
Catalyst for enantioselective Baeyer-Villiger oxidation<sup>[1,2]</sup>

[1] N. Donoghue, et al., *Eur. J. Biochem.*, 1976, 63, 175; [2] M.J. Taschner, et al., *NATO ASI Ser., Ser. C*, 1992, 381, 347.

29172 25 mg, 100 mg

BioChemika, powder, grey, ~4 U/g  
Storage: -20°C

### Cyclohexanone Monooxygenase from *Xanthobacter sp.*

E.C. 1.14.13.22

1 U corresponds to the amount of enzyme which catalyzes the cyclohexanone-stimulated oxidation of 1 μmol NADH per minute at pH 7.5 and 30°C

M.K. Trower, et al., *Eur. J. Biochem.*, 1989, 181, 199.

29174 25 mg, 100 mg

BioChemika, powder, off-white, ~6 U/g  
Storage: -20°C

### 2-Hydroxybiphenyl 3-Monooxygenase recombinant

E.C. 1.14.13.44

1 U corresponds to the amount of enzyme which catalyzes the 2-hydroxybiphenyl activated oxidation of 1 μmol NADH per minute at pH 7.2 and 30°C

93043 5 mg

BioChemika, solution, slightly yellow, ~2 U/ml  
Storage: -20°C

### (+)-Camphor Monooxygenase from *Pseudomonas putida*

E.C. 1.14.15.x

9030824

1 U corresponds to the amount of enzyme which catalyzes the conversion of 1 μmol (+)-camphor (21300) per minute at pH 7.1 and 30°C Stereoselective lactone formation in vitro applying coupled enzyme systems<sup>[1,2]</sup>

[1] G. Grogan, et al., *Biotechnol. Lett.*, 1992, 14, 1125; [2] R. Gagnon, et al., *J. Chem. Soc., Perkin Trans I*, 1994, 2539.

21332 5 mg, 25 mg, 100 mg

BioChemika, ~0.3 U/g  
Storage: -20°C

### Tyrosinase from mushrooms

Catechol Oxidase

Polyphenol Oxidase

Monophenol, dihydroxyphenylalanine: oxygen oxidoreductase

Monophenol Monooxygenase

E.C. 1.14.18.1

[9002-10-2]

1 U corresponds to the amount of enzyme which increases the absorbance at 305 nm by 0.001 per minute at pH 6.5 and 25°C (L-tyrosine as substrate, 3.0 ml reaction mix); 30 absorbance-U as described above are equivalent to ~1 U (when 1 U is the amount of enzyme which oxidizes 1 μmol 4-methylcatechol per minute at pH 6.5 and 25°C).

93898 10 mg, 50 mg, 250 mg

BioChemika, lyophilized, powder, brown, ≥2000 U/mg  
Storage: -20°C

### Progesterone Monooxygenase from *Cylindrocapsa radicola*

E.C. 1.14.99.4

1 U corresponds to the amount of enzyme which catalyzes the progesterone-stimulated oxidation of 1 μmol NADPH per minute at pH 7.4 and 30°C

E. Itagaki, *J. Biochem.*, 1986, 99, 815.

81703 25 mg, 100 mg

BioChemika, powder, beige, ~0.6 U/g  
Storage: -20°C

## 2.2 TRANSFERASES

### Catechol-O-methyl Transferase from porcine liver

Pyrocatechol-O-methyl Transferase COMT

S-Adenosyl-L-methionine: catechol O-methyltransferase

E.C. 2.1.1.6

[9012-25-3]

1 U corresponds to the amount of enzyme which forms 1 nmol 3-O-methylepinephrine from epinephrine and S-adenosylmethionine per minute at pH 7.9 and 37°C

28059 5 ml, 25 ml

BioChemika, suspension, brown-green, protein partially soluble in water or buffer, >10 U/ml

Storage: -20°C

### Transketolase from *E. coli*

Glycolaldehyde Transferase

E.C. 2.2.1.1

[9014-48-6]

1 U corresponds to the amount of enzyme which will produce 1 μmol of glyceraldehyde-3-phosphate from xylulose-5-phosphate per minute at pH 7.7 and 25°C, in the presence of ribose-5-phosphate, thiamine pyrophosphate and Mg<sup>2+</sup>

Catalyst for stereoselective aldol reactions<sup>[1,2]</sup>

[1] K.G. Morris, et al., *Tetrahedron: Asymmetry*, 1996, 7, 2185; [2] R.P. Chauhan, et al., *Biotechnol. Bioeng.*, 1997, 56, 345.

88804 5 mg, 25 mg

BioChemika, powder, white, ~0.5 U/mg  
Storage: -20°C

### Transketolase from baker's yeast (*S. cerevisiae*)

Glycolaldehyde Transferase

D-Sedoheptulose-7-phosphate:D-glyceraldehyde-3-phosphate glycoaldehydetransferase

E.C. 2.2.1.1

[9014-48-6]

1 U corresponds to the amount of enzyme which will produce 1 μmol of glyceraldehyde-3-phosphate from xylulose-5-phosphate per minute at pH 7.7 and 25°C, in the presence of ribose-5-phosphate, thiamine pyrophosphate and Mg<sup>2+</sup>

Catalyst for carbohydrate syntheses<sup>[1-4]</sup>

[1] J. Bolte, et al., *Tetrahedron. Lett.*, 1987, 28, 5525; [2] C. Demuynek, et al., *Tetrahedron. Lett.*, 1991, 32, 5085; [3] Y. Kobori, et al., *J. Org. Chem.*, 1992, 57, 5899; [4] F. Effenberger, et al., *Tetrahedron Lett.*, 1992, 33, 5157.

90197 1 mg, 5 mg

BioChemika, powder, white, ~5 U/mg  
Storage: -20°C

## 2.2 TRANSFERASES CONTINUED 2.3 HYDROLASES

### Transaldolase from *Candida utilis*

Dihydroxyacetone Transferase

E.C. 2.2.1.2

[9014-46-4]

1 U corresponds to the amount of enzyme, which converts 1 μmol D-fructose 6-phosphate and D-erythrose 4-phosphate to glyceraldehyde-3-phosphate and sedoheptulose-7-phosphate per minute at pH 7.6 and 25°C  
Catalyst for stereoselective aldol reactions<sup>[1,2]</sup>

[1] B.L. Horecker, O. Tsolas, *Meth. Enzymol.*, 1990, 182, 788; [2] A. Moradian, S. Benner, *J. Amer. Chem. Soc.*, 1992, 114, 6980.

89605 10 mg, 50 mg

BioChemika, powder, slightly brown, ~0.9 U/mg  
Storage: -20°C

### Levansucrase from *Pseudomonas aurantiaca*

Sucrose-6-fructosyl-Transferase

E.C. 2.4.1.10

[9030-17-5]

1 U corresponds to the amount of enzyme which liberates 1 μmol glucose per minute at pH 6.0 and 37°C from sucrose  
Optimum temperature for levan formation: 0-20°C, the enzyme stable below 42°C; Optimum pH: 4.8-5.5

53723 NEW! 25 mg, 100 mg, 500 mg

BioChemika, powder lyophilized, light brown, ≥5 U/mg  
Storage: 2-8°C

### β(1→4)-Galactosyltransferase from bovine milk

Lactose Synthase

E.C. 2.4.1.22

[9030-11-9]

1 U correspond to the amount of enzyme which transfers 1 μmol galactose from UDP-galactose to D-glucose per minute at pH 8.4 and 30°C in the presence of alpha-lactalbumin

Catalyst for enzymatic oligosaccharide synthesis

48279 1 mg, 5 mg

BioChemika, lyophilized, powder, off-white, ~1 U/mg  
Storage: -20°C

48281 100 mg, 500 mg

BioChemika, lyophilized, powder, ~8 U/g  
Storage: -20°C

### β(1→4)-Galactosyltransferase I human, recombinant from *Saccharomyces cerevisiae*

UDP-galactose-N-acetylglucosamine-β(1→4)

galactosyltransferase

N-Acetylglucosamine Synthase

E.C. 2.4.1.90

[9054-94-8]

1 U correspond to the amount of enzyme which transfers 1 μmol galactose from UDP-galactose to D-glucose per minute at pH 8.4 and 30°C in the presence of α-lactalbumin

Catalyst for enzymatic oligosaccharide synthesis<sup>[1-4]</sup>

[1] Y. Nishida, et al., *J. Amer. Chem. Soc.*, 1993, 115, 2636; [2] G.F. Herrmann, et al., *J. Org. Chem.*, 1994, 59, 6356; [3] T. Wiemann, et al., *J. Org. Chem.*, 1994, 59, 6744; [4] Y. Kanie, et al., *Anal. Biochem.*, 1998, 263, 240.

90261 100 mg, 500 mg

BioChemika, powder, contains Tris buffer salts and BSA, slightly yellow, ≥5 U/g  
Storage: -20°C

### α(1→3)-Galactosyltransferase murine recombinant from *E. coli*

E.C. 2.4.1.151

1 U corresponds to the amount of enzyme which catalyzes the transfer of 1 μmol galactose from UDP-galactose to N-acetylglucosamine per minute at pH 7.0 and 37°C

Catalyst for enzymatic oligosaccharide synthesis

77038 1 ml

BioChemika, clear solution, contains 50% glycerol, 25 mM TRIS pH 8.0, 0.5 mM DTT, colorless, ~0.5 U/ml

Storage: -20°C

### Glutamic-Oxalacetic Transaminase from porcine heart

L-Aspartate: 2-oxoglutarate aminotransferase

Aspartate Aminotransferase

GOT

E.C. 2.6.1.1

[9000-97-9]

1 U corresponds to the amount of enzyme which converts 1 μmol 2-oxoglutarate to L-glutamate per minute at pH 7.5 and 37°C in the presence of L-aspartic acid

49396 1 ml, 5 ml

BioChemika, suspension suspension in 3 M (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub>, 0.05 M malate, 2.5 mM 2-oxoglutarate solution, pH 6.0, yellow, ~1400 U/ml

Storage: 2-8°C

### Glutamic-Pyruvic Transaminase from porcine heart

L-Alanine: 2-oxoglutarate aminotransferase

Alanine Aminotransferase

GPT

E.C. 2.6.1.2

[9000-86-6]

1 U corresponds to the amount of enzyme which converts 1 μmol alpha-ketoglutarate to L-glutamate per minute at pH 7.6 and 37°C in the presence of L-alanine

49400 5 mg, 10 mg

BioChemika, suspension in 1.8 M ammonium sulfate aqueous solution, pH ~6.0, greenish-yellow, ≥100 U/mg protein (4-20 mg protein/ml)

Storage: 2-8°C

## 2.3 HYDROLASES

### Esterase basic Kit

Composition:

01022 Acetylcholin Esterase from *Electrophorus electricus* 1 mg46062 Esterase from *Bacillus sp.* 10 mg46051 Esterase from *Bacillus stearothermophilus* 10 mg46054 Esterase from *Bacillus thermoglucosidasius* 10 mg46056 Esterase from *Candida lipolytica* 50 mg46059 Esterase from *Mucor miehei* 50 mg

46069 Esterase from horse liver 50 mg

46071 Esterase from *Saccharomyces cerevisiae* 25 mg

46058 Esterase from porcine liver 10 mg

46061 Esterase from *Thermoanaerobium Brockii* 50 mg

46041 1 kit

BioChemika,

Storage: -20°C

## 2.3 HYDROLASES CONTINUED

**Esterase from *Bacillus sp.***

E.C. 3.1.1.1

[9016-18-6]

1 U corresponds to the amount of enzyme which will hydrolyze 1 μmol ethyl valerate (30784) per minute at pH 8.0 and 25°C

**46062** 25 mg  
BioChemika, ~0.1 U/mg  
Storage: 2-8°C

**Esterase from *Bacillus stearothermophilus***

E.C. 3.1.1.1

[9016-18-6]

1 U corresponds to the amount of enzyme which releases 1 μmol 4-nitrophenol per minute at pH 7.0 and 65°C (4-nitrophenyl-*n*-caproate as substrate)  
Esterase stable at elevated temperatures

D.A. Cowan, *Enzyme Microb. Technol.*, 1990, 12, 374.

**46051** 25 mg, 100 mg  
BioChemika, ~0.4 U/mg  
Storage: 2-8°C

**Esterase BS2 *Bacillus subtilis*, recombinant from *E. coli***

E.C. 3.1.1.1

[9016-18-6]

1 U corresponds to the amount of enzyme which hydrolyzes 1 μmol ethyl valerate (30784) per minute at pH 8.0 and 25°C

**54288** 5 mg, 25 mg  
BioChemika, powder, slightly beige, ≥ 10 U/mg  
Storage: 2-8°C

**Esterase from *Bacillus thermoglucosidarius***

E.C. 3.1.1.1

[9016-18-6]

1 U corresponds to the amount of enzyme which hydrolyzes 1 μmol ethyl valerate (30784) per minute at pH 8.0 and 25°C

**46054** 25 mg, 100 mg  
BioChemika, lyophilized, powder, beige, ~0.1 U/mg  
Storage: 2-8°C

**Esterase from *Candida lipolytica***

E.C. 3.1.1.1

[9016-18-6]

1 U corresponds to the amount of enzyme which hydrolyzes 1 μmol α-methyl-DL-phenylalanine-*O*-methyl ester per minute at pH 7.5 and 25°C

Resolution of tertiary α-substituted carboxylic acid esters

C. Yee, *et al.*, *J. Org. Chem.*, 1992, 57, 3525.

**46056** 100 mg, 500 mg  
BioChemika, ~0.1 U/mg  
Storage: 2-8°C

**Esterase from horse liver**

HLE

E.C. 3.1.1.1

[9016-18-6]

1 U corresponds to the amount of enzyme which hydrolyzes 1 μmol ethyl butyrate (19230) per minute at pH 8.0 and 25°C

Enantioselective hydrolysis of mono- and diesters; slightly higher ee's compared to PLE are reported<sup>[1-3]</sup>

[1] L. Blanco, *et al.*, *Tetrahedron Lett.*, 1988, 29, 1915; [2] J.E. Guibé, *et al.*, *Tetrahedron Lett.*, 1989, 30, 67; [3] E. Fouqué, G. Rousseau, *Synthesis*, 1989, 661.

**46069** 100 mg, 500 mg  
BioChemika, lyophilized, powder, brown, 0.5-1.0 U/mg  
Storage: -20°C

**Esterase from porcine liver**

Esterase hog liver

Pig liver Esterase

PLE

Carboxyl esterase

Carboxylic-ester hydrolase

E.C. 3.1.1.1

[9016-18-6]

(46058; 70351) 1 U corresponds to the amount of enzyme which hydrolyzes 1 μmol ethyl valerate (30784) per minute at pH 8.0 and 25°C  
(46063) 1 U corresponds to the amount of enzyme which hydrolyzes 1 μmol ethyl butyrate (19230) per minute at pH 8.0 and 25°C

Enantioselective hydrolysis of mono- and diesters<sup>[1,2]</sup>  
Substrate specificity and stereoselectivity.<sup>[3]</sup>

[1] M. Ohno, M. Otsuka, *Org. React.*, 1989, 37, 1; [2] L.-M. Zhu, M.C. Tedford, *Tetrahedron*, 1990, 46, 6587; [3] C. Tamm, *Pure Appl. Chem.*, 1992, 64, 1187.

**46058** 10 mg, 50 mg  
BioChemika, lyophilized, powder, contains 1,4-dithioerythritol, slightly beige, ≥130 U/mg  
Storage: -20°C

**46063** 1 ea  
BioChemika, suspension in 3.2 M ammonium sulfate solution, ~130 U/mg protein (~10 mg protein/ml)  
Storage: 2-8°C

**70351 NEW!** 500 mg  
BioChemika, powder, light beige, protein only partially soluble in water or buffer 3 U/mg  
Storage: -20°C

**Esterase Isoenzyme 1 hog liver**

E.C. 3.1.1.1

[9016-18-6]

1 U corresponds to the amount of enzyme which hydrolyzes 1 μmol ethyl valerate (30784) per minute at pH 8.0 and 25°C

**46048** 1 ml, 5 ml  
BioChemika, suspension in 3.2 M ammonium sulfate solution, ~200 U/mg protein (~15 mg protein/ml)  
Storage: 2-8°C

**Esterase, immobilized on Eupergit® C, from hog liver**

1 U corresponds to the amount of enzyme which hydrolyzes 1 μmol ethyl valerate (30784) per minute at pH 8.0 and 25°C

Immobilized enzyme for the convenient synthesis of several chiral building blocks. Immobilized on copolymer of methacrylamide, allyl-glycidyl ether and methylene-bisacrylamide,

K. Laumen, *et al.*, *Tetrahedron Lett.*, 1985, 26, 407.

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## 2.3 HYDROLASES CONTINUED

**46064** 1 g, 5 g  
BioChemika, moist pearls (dried material ~35%, particle diameter ~150 μm); ~500 U/g  
Storage: 2-8°C

**Esterase from *Mucor miehei***

E.C. 3.1.1.1

[9016-18-6]

1 U corresponds to the amount of enzyme which hydrolyzes 1 μmol ethyl valerate (30784) per minute at pH 8.0 and 25°C  
Used in esterifications in nonaqueous solvents.

I.L. Gatfield, *Ann. N.Y. Acad. Sci.*, 1984, 434, 569.

**46059** 100 mg, 500 mg  
BioChemika, powder, slightly brown, ~1 U/mg  
Storage: 2-8°C

**Esterase *Rhizomucor miehei*, recombinant from *Aspergillus oryzae***

E.C. 3.1.1.1

[9016-18-6]

1 U corresponds to the amount of enzyme which liberates 1 μmol oleic acid per minute at pH 7.0 and 37°C (triolein, 62314 as substrate)

**75900** 10 ml, 50 ml  
BioChemika, solution, very deep brown, ≥ 250 U/ml  
Storage: 2-8°C

**Esterase from *Rhizopus oryzae***

E.C. 3.1.1.1

[9016-18-6]

1 U corresponds to the amount of enzyme which liberates 1 μmol oleic acid per minute at pH 7.0 and 37°C (triolein, 62314 as substrate)

**79208** 5 g, 25 g  
BioChemika, powder, light-beige, ≥ 20 U/g  
Storage: 2-8°C

**Esterase from *Saccharomyces cerevisiae***

E.C. 3.1.1.1

[9016-18-6]

1 U corresponds to the amount of enzyme which hydrolyzes 1 μmol ethyl valerate per minute at pH 8.0 and 25°C  
Enzymatic resolution yielding enantiopure (S)-2-hydroxy heptanoate.

K. Ushio, *et al.*, *Biotechnol. Lett.*, 1991, 13, 495.

**46071** 50 mg, 250 mg  
BioChemika, lyophilized, powder, beige, ~2 U/g  
Storage: 2-8°C

**Esterase from *Streptomyces diastatochromogenes*, recombinant from *E. coli***

E.C. 3.1.1.1

[9016-18-6]

1 U corresponds to the amount of enzyme which hydrolyzes 1 μmol 4-nitrophenylacetate per minute at pH 7.5 and 25°C

**78042** 100 mg  
BioChemika, powder, slightly beige, ≥ 50 U/mg  
Storage: 2-8°C

**Esterase from *Thermoanaerobium brockii***

E.C. 3.1.1.1

[9016-18-6]

1 U corresponds to the amount of enzyme which hydrolyzes 1 μmol ethyl valerate (30784) per minute at pH 8.0 and 25°C

**46061** 100 mg, 500 mg  
BioChemika, powder, off-white, ~2 U/g  
Storage: 2-8°C

**Esterase from *Thermomyces lanuginosus*, recombinant from *Aspergillus oryzae***

E.C. 3.1.1.1

[9016-18-6]

1 U corresponds to the amount of enzyme which liberates 1 μmol oleic acid per minute at pH 7.0 and 37°C (triolein, 62314 as substrate)

**27637** 5 ml, 25 ml  
BioChemika, solution, light brown, >1200 U/ml  
Storage: 2-8°C

**Lipase basic Kit**

Composition:

<b>84205</b>	Lipase from <i>Aspergillus</i>	100 mg
<b>62299</b>	Lipase from <i>Candida Antarctica</i>	50 mg
<b>62316</b>	Lipase from <i>Candida cylindracea</i>	1000 mg
<b>62298</b>	Lipase from <i>Mucor miehei</i>	100 mg
<b>62309</b>	Lipase from <i>Pseudomonas cepacia</i>	100 mg
<b>95608</b>	Lipase from <i>Pseudomonas fluorescens</i>	50 mg
<b>62305</b>	Lipase from <i>Rhizopus arrhizus</i>	1000 mg
<b>62310</b>	Lipase from <i>Rhizopus niveus</i>	1000 mg
<b>62300</b>	Lipase from <i>hog pancreas</i>	1000 mg
<b>62327</b>		1 kit

BioChemika

Storage: 2-8°C

**Lipase extension Kit**

Composition:

<b>62285</b>	Lipase from <i>Aspergillus oryzae</i>	100 mg
<b>62303</b>	Lipase from <i>Candida lipolytica</i>	1000 mg
<b>62304</b>	Lipase from <i>Mucor javanicus</i>	500 mg
<b>62308</b>	Lipase from <i>Penicillium roquefortii</i>	500 mg
<b>28602</b>	Lipase from <i>Pseudomonas fluorescens</i>	50 mg
<b>62291</b>	Lipase <i>Rhizomucor miehei</i> , recombinant from <i>Aspergillus oryzae</i>	50 mg
<b>62306</b>	Lipase from <i>wheat germ</i>	500 mg
<b>62333</b>	Lipoprotein lipase from <i>Chromobacterium viscosum</i>	25 mg
<b>62335</b>	Lipoprotein lipase from <i>Pseudomonas sp.</i>	10 mg
<b>62336</b>	Lipoprotein lipase from <i>Pseudomonas sp.</i>	50 mg
<b>62323</b>		1 kit

BioChemika

Storage: 2-8°C

**Lipase from *Aspergillus sp.***

E.C. 3.1.1.3

[9001-62-1]

1 U corresponds to the amount of enzyme which hydrolyzes 1 μmol acetic acid per minute at pH 7.4 and 40°C (triacetin, 90240 as substrate)

**84205** 100 mg, 500 mg  
BioChemika, lyophilisate, slightly brown, ~0.5 U/mg  
Storage: 2-8°C

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**Lipase from *Aspergillus niger***Lipase AP6  
E.C. 3.1.1.3  
[9001-62-1]

1 U corresponds to the amount of enzyme which hydrolyzes 1 μmol acetic acid per minute at pH 7.4 and 40°C (triacetin, 90240 as substrate)  
50 U as described above are equivalent to ~1 U using triolein, 62314 as substrate, at pH

Selective acylation and deacylation of furanose and pyranose derivatives;<sup>[1]</sup> enantioselective hydrolysis of 2-methyl-3-acetoxy esters;<sup>[2]</sup> resolution of the diols of bicycloheptane and bicyclooctane;<sup>[3]</sup> glyceride synthesis.<sup>[4]</sup>

[1] W.J. Hennen, *et al.*, *J. Org. Chem.*, 1988, 53, 4939; [2] H. Akita, *et al.*, *Tetrahedron Lett.*, 1986, 27, 5241; [3] K. Naemura, *et al.*, *J. Chem. Soc., Perkin Trans. 1*, 1992, 2337; [4] M.K. Tahoun, *et al.*, *Microbios. Lett.*, 1985, 28, 133.

**62301** 1 g, 5 g  
BioChemika, powder fine, ~200 U/g  
Storage: 2-8°C

**Lipase, immobilized in Sol-Gel-AK from *Aspergillus niger***

1 U is the amount of immobilized enzyme which forms 1% octyl laurate (GC, area percent) from 0.5 mmol lauric acid and 1.0 mmol 1-octanol in 10 ml water-saturated isooctane in 1 hour at 20°C

M.T. Reetz, *et al.*, *Angew. Chem.*, 1995, 107, 373.

**62281** 1 g, 5 g  
BioChemika, ≥ 1U/g  
Storage: 2-8°C

**Lipase from *Aspergillus oryzae***E.C. 3.1.1.3  
[9001-62-1]

1 U corresponds to the amount of enzyme which liberates 1 μmol oleic acid per minute at pH 8.0 and 40°C (triolein, 62314 as substrate)

**62285** 100 mg, 500 mg  
BioChemika, lyophilized, powder, white, ~50 U/mg  
Storage: 2-8°C

**95184** 1 g, 5 g  
BioChemika, powder, almost white, ~2 U/mg  
Storage: 2-8°C

**Lipase from *Burkholderia sp.***E.C. 3.1.1.3  
[9001-62-1]

1 U corresponds to the amount of enzyme which liberates 1 μmol oleic acid per minute at pH 8.0 and 40°C (triolein, 62314 as substrate)

**75577** 100 mg, 500 mg  
BioChemika, lyophilisate, protein partially soluble in water or buffer, slightly beige, ~12 U/mg  
Storage: -20°C

**Lipase from *Candida antarctica***E.C. 3.1.1.3  
[9001-62-1]

1 U corresponds to the amount of enzyme which liberates 1 μmol oleic acid per minute at pH 8.0 and 40°C (triolein, 62314 as substrate)

H.P. Heldt-Hansen, *et al.*, *Biocatal. Agric. Biotechnol.*, ACS Symp. Ser., 1988, 389, 158.

**62299** 100 mg, 500 mg  
BioChemika, powder, light brown, ~ 3 U/mg  
Storage: 2-8°C

**02569** 100 mg, 500 mg  
BioChemika, lyophilized, powder, beige, ~0.5U/mg  
Storage: 2-8°C

**Lipase A from *Candida antarctica*, recombinant from *Aspergillus oryzae***E.C. 3.1.1.3  
[9001-62-1]

1 U corresponds to the amount of enzyme which liberates 1 μmol oleic acid per minute at pH 8.0 and 40°C (triolein, 62314, as substrate)

1 U as described above is equivalent to ~0.15 U using tributyrine, Fluka-No. 91010, as substrate, at pH 8.0.

S.A. Patkar, *et al.*, *Ind. J. Chem. 32B*, 1993, 76.

**62287** 50 mg, 250 mg  
BioChemika, powder, beige, ~2 U/mg  
Storage: 2-8°C

**Lipase B from *Candida antarctica*, recombinant from *Aspergillus oryzae***E.C. 3.1.1.3  
[9001-62-1]

1 U corresponds to the amount of enzyme which liberates 1 μmol butyric acid per minute at pH 8.0 and 50°C (tributyryn, 91010, as substrate)

**62288** 50 mg, 250 mg  
BioChemika, powder, beige, ~9 U/mg  
Storage: 2-8°C

**Lipase B, recombinant, cross-linked enzyme crystals, *Candida antarctica***

1 U corresponds to the amount of enzyme which hydrolyzes 1 μmol acetic acid per minute at pH 7.4 and 30°C (triacetin, 90240 as substrate)

Cross-linked enzyme crystals of *Candida antarctica* Lipase B.

A.M. Anderson, *et al.*, *Biocat. Biotransform.*, 1998, 16,

**86491 NEW!** 10 mg, 50 mg  
BioChemika, suspension in 50 mM Tris pH 7.0, strongly brown, ≥10 U/mg solid material (~150mg solid material/ml)  
Storage: 2-8°C

**Lipase, immobilized from *Candida antarctica* Novozym 435®**

AS 1 U corresponds to the amount of enzyme which liberates 1 μmol butyric acid per minute at pH 8.0 and 40°C (tributyryn, 91010, as substrate)

@Registered Trademark of Norvo Nordisk  
**73940** 1 g, 5 g  
BioChemika, beads, slightly brown, >2 U/mg  
Storage: 2-8°C

**Lipase, immobilized on Eupergit®, *Candida antarctica***

1 U corresponds to the amount of enzyme which liberates 1 μmol oleic acid per minute at pH 8.0 and 40°C (triolein, 62314 as substrate)

@Registered Trademark of Röhm Pharma GmbH  
**77926 NEW!** 1 g, 5 g  
BioChemika, >3 U/g  
Storage: 2-8°C

**Lipase, immobilized in Sol-Gel-AK from *Candida antarctica***

1 U is the amount of immobilized enzyme which forms 1% octyl laurate (GC, area percent) from 0.5 mmol lauric acid and 1.0 mmol 1-octanol in 10 ml water-saturated isooctane in 1 hour at 20°C

M.T. Reetz, *et al.*, *Angew. Chem.*, 1995, 107, 373.

**62277** 1 g, 5 g  
BioChemika, ≥ 1 U/g  
Storage: 2-8°C

**Lipase from *Candida cylindracea***

CCL

E.C. 3.1.1.3  
[9001-62-1]

1 U corresponds to the amount of enzyme which liberates 1 μmol oleic acid per minute at pH 8.0 and 40°C (triolein, 62314 as substrate)

Highly stereospecific catalyst employed in the preparative resolution of racemic acids and alcohols; <sup>[1]</sup> stereoselective ester synthesis <sup>[2]</sup>, benzyl-alkyl transesterification under mild neutral conditions.<sup>[3]</sup>

[1] B. Cambou, A.M. Klibanov, *Biotechnol. Bioeng.*, 1984, 26, 1449; [2] Y. Ikushima, *et al.*, *Chem. Lett.*, 1993, 109; [3] A. Gutman, *et al.*, *Tetrahedron*, 1992, 48, 8775.

**62302** 100 mg, 500 mg  
BioChemika, lyophilized, powder fine, 15-25 U/mg  
Storage: 2-8°C

**62316** 10 g, 50 g  
BioChemika, powder, yellow-brown, ~2 U/mg  
Storage: 2-8°C

**Lipase, immobilized in Sol-Gel-AK from *Candida cylindracea***

1 U is the amount of immobilized enzyme which forms 1% octyl laurate (GC, area percent) from 0.5 mmol lauric acid and 1.0 mmol 1-octanol in 10 ml water-saturated isooctane in 1 hour at 20°C

M.T. Reetz, *et al.*, *Angew. Chem.*, 1995, 107, 373.

**62278** 1 g, 5 g  
BioChemika, ≥10 U/g  
Storage: 2-8°C

**Lipase from *Candida lipolytica***E.C. 3.1.1.3  
[9001-62-1]

1 U corresponds to the amount of enzyme which liberates 1 μmol oleic acid per minute at pH 8.0 and 40°C (triolein, 62314 as substrate)

Enzyme for the modification of fats and oils

N. Bati, *et al.*, *J. Am. Oil Chem. Soc.*, 1984, 61, 1743.

**62303** 1 g, 5 g  
BioChemika, powder fine, ~1 U/g  
Storage: 2-8°C

**Lipase from *Candida rugosa***

Lipase AY 30 Amano

Triacylglycerol acylhydrolase

E.C. 3.1.1.3  
[9001-62-1]

1 U corresponds to the amount of enzyme which liberates 1 μmol oleic acid per minute at pH 8.0 and 40°C (triolein, 62314 as substrate)

Enzyme activity: the optimum temperature is 45°C, the optimum

pH is 7.0 (highly active from pH 6-8), the activity is inhibited by Ag<sup>+</sup> and Pb<sup>+</sup>

**90860** 5 g, 25 g  
BioChemika, powder, slightly beige, >2 U/mg  
Storage: 2-8°C

**Lipase from *Candida utilis***E.C. 3.1.1.3  
[9001-62-1]

1 U corresponds to the amount of enzyme which liberates 1 μmol of oleic acid per minute at pH 8.0 and 40°C (triolein, 62314, as substrate)

**62307** 50 mg, 250 mg  
BioChemika, powder, brown, ~0.1 U/mg  
Storage: 2-8°C

**Lipase from *Mucor javanicus***

Triacylglycerol lipase

Triacylglycerol acylhydrolase

E.C. 3.1.1.3  
[9001-62-1]

1 U corresponds to the amount of enzyme which liberates 1 μmol fatty acid from triglycerides per minute at pH 8.0 and 37°C (olive oil as substrate). 2000 U as described above (using olive oil) are equivalent to ~1 U using triolein, 62314, as substrate.

Purification and properties; <sup>[1]</sup> hydrolysis of the dibutyl ester of bishydroxymethyl-1,7-dioxaspiroundecane.<sup>[2]</sup>

[1] H. Ishihara, *Biochim. Biophys. Acta*, 1975, 388, 413; [2] J.-G. Gourcy, *et al.*, *Tetrahedron Asym.*, 1991, 2, 31.

**62304** 1 g, 5 g  
BioChemika, powder fine, ~10 U/mg  
Storage: 2-8°C

**Lipase from *Mucor miehei***

Triacylglycerol lipase

Triacylglycerol acylhydrolase

E.C. 3.1.1.3  
[9001-62-1]

1 U corresponds to the amount of enzyme which liberates 1 μmol oleic acid per minute at pH 8.0 and 40°C (triolein, 62314 as substrate)

Characterization; <sup>[1,2]</sup> biocatalytic esterifications; <sup>[3]</sup> synthesis of fatty hydroxamic acids.<sup>[4]</sup>

[1] B. Høge-Jensen, *et al.*, *Lipids*, 1987, 22, 559; [2] B. Høge-Jensen, *et al.*, *J. Am. Oil Chem. Soc.*, 1988, 65, 905; [3] F. Servat, *et al.*, *J. Am. Oil Chem. Soc.*, 1990, 67, 646; [4] P.A.S.S. Marques, *et al.*, *J. Chem. Tech. Biotechnol.*, 1992, 55, 25.

**62298** 100 mg, 500 mg  
BioChemika, powder, slightly brown, ~1 U/mg  
Storage: 2-8°C

**Lipase from *Mucor miehei*, recombinant from *Aspergillus oryzae***E.C. 3.1.1.3  
[9001-62-1]

1 U corresponds to the amount of enzyme which liberates 1 μmol of butyric acid per minute at pH 7.0 and 25°C (tributyryn as substrate) 20 U as described above are equivalent to ~1 U using triolein, 62314 as substrate, at pH 8.0 and 40°C

**62289** 100 mg, 500 mg  
BioChemika, lyophilized, powder, brown, ≥ 200U/mg  
Storage: 2-8°C

## 2.3 HYDROLASES CONTINUED

**73416** 1 g, 5 g  
BioChemika, powder, slightly brown, ~10 U/mg  
Storage: 2-8°C

**Lipozyme<sup>®</sup>, immobilized, from *Mucor miehei***

AS 1 U corresponds to the amount of enzyme which liberates 1 μmol oleic acid per minute at pH 8.0 and 40°C (triolein, 62314 as substrate)

® Registered Trademark of Norvo Nordisk  
Lipase, immobilized on a macroporous ion-exchange resin, 1,3-specific, for esterification and interesterification.<sup>[1,2]</sup>

[1] T.T. Hansen, P. Eigtved, *Proc.-World Conf. Emerging Technol. Fats Oils Ind. Ed. B.A. Richard*, 1985, 365; [2] G. Nicolosi, et al., *Tetrahedron Lett.*, 1995, 36, 6545.

**62350** 10 g, 50 g  
BioChemika, granulated material, brown, >30 U/g  
Storage: 2-8°C

**Lipase, immobilized in Sol-Gel-AK from *Mucor miehei***

1 U is the amount of immobilized enzyme which forms 1% octyl laurate (GC, area percent) from 0.5 mmol lauric acid and 1.0 mmol 1-octanol in 10 ml water-saturated isooctane in 1 hour at 20°C

M.T. Reetz, et al., *Angew. Chem.*, 1995, 107, 373.

**62282** 1 g, 5 g  
BioChemika, ≥2 U/g  
Storage: 2-8°C

**Lipase from *Penicillium camemberti***

Lipase G50 Amano  
E.C. 3.1.1.3  
[9001-62-1]

1 U corresponds to the amount of enzyme which liberates 1 μmol oleic acid per minute at pH 7.0 and 37°C (triolein, 62314 as substrate)

**96888** 5 g, 25 g  
BioChemika, powder, slightly beige, ≥ 5 U/g  
Storage: 2-8°C

**Lipase from *Penicillium roqueforti***

E.C. 3.1.1.3  
[9001-62-1]

1 U corresponds to the amount of enzyme which liberates 1 μmol fatty acid from triglycerides per minute at pH 8.0 and 37°C (olive oil as substrate);

200 U as described above (using olive oil) are equivalent to ~1 U using triolein, 62314, as substitute

Substrate specificity: preferentially hydrolyzes the 1- and 3-position (short fatty acids); optimum pH 6.0-8.0; optimum temperature 30-40°C

**62308** 1 g, 5 g  
BioChemika, powder fine, >0.4 U/mg  
Storage: 2-8°C

**Lipase from porcine pancreas**

PPL  
Triacylglycerol acylhydrolase  
E.C. 3.1.1.3  
[9001-62-1]

1 U corresponds to the amount of enzyme which liberates 1 μmol fatty acid from triglycerides per minute at pH 8.0 and 37°C (olive oil as substrate)

Selective acylation of primary alcohols in organic solvents;<sup>[1]</sup>

enantioselective transesterifications;<sup>[2]</sup> removal of lipid contaminants;<sup>[3]</sup> use in the continuous synthesis of glycerides.<sup>[4]</sup>

[1] S. Ramaswamy, et al., *Tetrahedron Lett.*, 1990, 31, 3405; [2] J. Shield Wallace, et al., *J. Org. Chem.*, 1990, 55, 3544; [3] S. Misra, et al., *Lipids*, 1984, 19, 302; [4] M.M. Hoq, et al., *J. Am. Oil Chem. Soc.*, 1984, 61, 776.

**62313** 5 mg, 25 mg  
BioChemika, lyophilized, powder, ≥100 U/mg  
Storage: -20°C

**62300** 25 g, 100 g, 500 g  
BioChemika, powder, 15-35 U/mg  
Storage: -20°C

**Lipase, immobilized in Sol-Gel-AK porcine pancreas**

1 U is the amount of immobilized enzyme which forms 1% octyl laurate (GC, area percent) from 0.5 mmol lauric acid and 1.0 mmol 1-octanol in 10 ml water-saturated isooctane in 1 hour at 20°C

M.T. Reetz, et al., *Angew. Chem.*, 1995, 107, 373.

**62324** 100 mg, 500 mg  
BioChemika, ≥40 U/g  
Storage: 2-8°C

**Lipase from *Pseudomonas cepacia***

PS Lipase  
Triacylglycerol acylhydrolase  
E.C. 3.1.1.3  
[9001-62-1]

1 U corresponds to the amount of enzyme which liberates 1 μmol oleic acid per minute at pH 8.0 and 40°C (triolein, 62314 as substrate)

Chemoenzymatic synthesis of (-)-carboxy-7-deazaoxetanocin.

X. Chen, et al., *Tetrahedron Lett.*, 1992, 33, 2249.

**62309** 100 mg, 500 mg  
BioChemika, powder, light beige, ~50 U/mg  
Storage: -20°C

**Lipase, immobilized in Sol-Gel-AK from *Pseudomonas cepacia***

1 U is the amount of immobilized enzyme which forms 1% octyl laurate (GC, area percent) from 0.5 mmol lauric acid and 1.0 mmol 1-octanol in 10 ml water-saturated isooctane in 1 hour at 20°C

M.T. Reetz, et al., *Angew. Chem.*, 1995, 107, 373.

**62279** 1 g, 5 g  
BioChemika, ≥40 U/g  
Storage: 2-8°C

**Lipase, immobilized in Sol-Gel-AK on sintered glass from, *Pseudomonas cepacia***

1 U is the amount of immobilized enzyme which forms 1% octyl laurate (GC, area percent) from 0.5 mmol lauric acid and 1.0 mmol 1-octanol in 10 ml water-saturated isooctane in 1 hour at 20°C

M.T. Reetz, et al., *Chem. Commun.*, 1996, 1397.

**62334** 5 g, 25 g  
BioChemika, ≥10 U/g  
Storage: 2-8°C

**Lipase, immobilized on Ceramic particles from *Pseudomonas cepacia***

1 U corresponds to the amount of enzyme which liberates 1 μmol oleic acid per minute at pH 8.0 and 40°C (triolein, 62314 as substrate)

## 2.3 HYDROLASES CONTINUED

**17261** 1 g, 25 g  
BioChemika, powder, light beige, ~15000U/g  
Storage: 2-8°C

**Lipase from *Pseudomonas fluorescens***

E.C. 3.1.1.3  
[9001-62-1]

1 U corresponds to the amount of enzyme which liberates 1 μmol oleic acid per minute at pH 8.0 and 40°C (triolein, 62314 as substrate)

**28602** 50 mg, 250 mg  
BioChemika, powder, slightly beige, ~300 U/mg  
Storage: -20°C

**95608** 100 mg, 500 mg  
BioChemika, powder, slightly beige, ~40 U/mg  
Storage: 2-8°C

**71548** 5 g, 25 g  
BioChemika, powder, almost white, ~2 U/mg  
Storage: 2-8°C

**Lipase, immobilized on Eupergit C, from *Pseudomonas fluorescens***

E.C. 3.1.1.3  
[9001-62-1]

1 U corresponds to the amount of enzyme which liberates 1 μmol of oleic acid per minute at pH 8.0 and 40°C (triolein, Fluka-No. 62314, as substrate)

**62319** 1 g  
BioChemika, granules, brown, ≥0.4 U/mg  
Storage: 2-8°C

**Lipase from *Pseudomonas stutzeri***

E.C. 3.1.1.3  
[9001-62-1]

1 U corresponds to the amount of enzyme which liberates 1 μmol fatty acid per minute from triglycerides at pH 7.7 and 37 °C (olive oil as substrate)

**66727** 100 mg, 1 g  
BioChemika, powder, light beige, ≥4 U/mg  
Storage: 2-8°C

**Lipase *Rhizomucor miehei*, recombinant from *Aspergillus oryzae***

E.C. 3.1.1.3  
[9001-62-1]

1 U corresponds to the amount of enzyme which liberates 1 μmol oleic acid per minute at pH 8.0 and 40°C (triolein, 62314 as substrate).

The stereoselectivity of this lipase was controlled via the surface pressure

E. Rogalska, et al., *J. Biol. Chem.*, 1993, 268, 792.

**62291** 100 mg, 500 mg  
BioChemika, powder, beige-brown, ~0.5 U/mg  
Storage: 2-8°C

**Lipase from *Rhizopus arrhizus***

Triacylglycerol lipase  
Triacylglycerol acylhydrolase  
E.C. 3.1.1.3  
[9001-62-1]

1 U corresponds to the amount of enzyme which liberates 1 μmol of butyric acid per minute at pH 8.0 and 40°C (tributylin, 91010 as substrate).

5000 U as described above are equivalent to ~1 U using triolein, 62314 as substrate, at pH 8.

Catalyst for the interesterification of oils and fats;<sup>[1]</sup> removal of interfering triglycerides in the electroimmunoassay of apolipoprotein B;<sup>[2]</sup> resolution of racemic epoxy esters through enantioselective ester hydrolysis.<sup>[3]</sup>

[1] T. Kim, K. Chung, *Enzyme Microb. Technol.*, 1989, 11, 528; [2] P. Laburre, et al., *Clin. Chem.*, 1985, 31, 787; [3] J.A. Laffitte, et al., *Indian J. Chem., Sect. B*, 1993, 32B, 94.

**62305** 1 g, 5 g  
BioChemika, powder fine, ~10 U/mg  
Storage: 2-8°C

**Lipase from *Rhizopus delemar***

E.C. 3.1.1.3  
[9001-62-1]

1 U corresponds to the amount of enzyme which liberates 1 μmol fatty acid from triglycerides per minute at pH 8.0 and 37°C (olive oil as substrate)

**62328** 50 mg  
BioChemika, ≥0.4 U/mg  
Storage: 2-8°C

**Lipase from *Rhizopus niveus***

Triacylglycerol lipase  
Triacylglycerol acylhydrolase  
E.C. 3.1.1.3  
[9001-62-1]

1 U corresponds to the amount of enzyme which liberates 1 μmol fatty acid from a triglyceride per minute at pH 7.7 and 40°C (olive oil as substrate).

300 U as described above are equivalent to ~1 U using triolein, 62314, at pH 8.0 and 40°C as substrate

P. Braun, et al., *Synlett.*, 1990, 105.

**62310** 1 g, 5 g  
BioChemika, powder, fine, ~1.5 U/mg  
Storage: 2-8°C

**Lipase from *Rhizopus oryzae***

Lipase F-AP 15  
E.C. 3.1.1.3  
[9001-62-1]

1 U corresponds to the amount of enzyme which releases 1 μmol fatty acid from triglycerides per minute at pH 7.2 and 37 °C (olive oil as substrate)

enzyme activity: the optimum temperature is 40°C, the optimum pH is 7.2 (highly active from pH 6.5-7.5)

**80612** 5 g, 25 g  
BioChemika, powder, light brown, ≥30 U/mg  
Storage: 2-8°C

**Lipase from *Thermus aquaticus***

E.C. 3.1.1.3  
[9001-62-1]

1 U corresponds to the amount of enzyme which liberates 1 μmol palmitic acid per minute at pH 8.0 and 65°C from p-nitrophenyl palmitate

**62293** 25 mg, 100 mg  
BioChemika, lyophilized, powder, ~3 U/g  
Storage: 2-8°C

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## 2.3 HYDROLASES CONTINUED

**Lipase from *Thermus flavus***

E.C. 3.1.1.3

[9001-62-1]

1 U corresponds to the amount of enzyme which liberates 1 μmol palmitic acid per minute at pH 8.0 and 65°C from *p*-nitrophenyl palmitate

**62295** 25 mg, 100 mg

BioChemika, powder, brown, ~0.7 U/g

Storage: 2-8°C

**Lipase from *Thermus thermophilus***

E.C. 3.1.1.3

[9001-62-1]

1 U corresponds to the amount of enzyme which liberates 1 μmol palmitic acid per minute at pH 8.0 and 65°C from *p*-nitrophenyl palmitate

**62296** 25 mg, 100 mg

BioChemika, powder, brown, ~0.6 U/g

Storage: 2-8°C

**Lipase from wheat germ**

Triacylglycerol lipase

Triacylglycerol acylhydrolase

E.C. 3.1.1.3

[9001-62-1]

1 U corresponds to the amount of enzyme which hydrolyzes 1 μmol acetic acid per minute at pH 7.4 and 40°C (triacetin, 90240 as substrate)

Hydrolysis of *N*-Boc-*cis*-2,6-(acetoxymethyl) piperidine.R. Chênevert, M. Dickman, *Tetrahedron: Asymmetry*, 1992, 3, 1021.**62306** 1 g, 5 g

BioChemika, ~ 0.1U/mg

Storage: 2-8°C

**Acetylcholine Esterase from*****Electrophorus electricus* (electric eel)**

Cholinesterase, AChE

Acetylcholine acetylhydrolase

E.C. 3.1.1.7

[9000-81-1]

1 U corresponds to the amount of enzyme which hydrolyzes 1 μmol acetylcholine per minute at pH 8.0 and 37°C  
Application in the selective hydrolysis or condensation of carboxylic ester bonds.<sup>[1-3]</sup>

[1] D.R. Deardorff, et al., *Tetrahedron Lett.*, 1986, 27,1255; [2] C.R. Johnson, Th.D. Penning, *J. Am. Chem. Soc.*, 1988, 110, 4726; [3] T.L. Rosenberg, et al., *Meth. Enzymol.*, 1982, 82, 325.

**01022** 1 mg, 5 mg

BioChemika, powder, slightly yellow, ~850 U/mg

Storage: -20°C

**01023** 5 mg, 25 mg

BioChemika, lyophilized, crystals, brown, 200-600 U/mg

Storage: -20°C

**Cholesterol Esterase from porcine pancreas**

Cholesterol Esterase hog pancreas

Sterol-ester acylhydrolase

E.C. 3.1.1.13

[9026-00-0]

1 U corresponds to the amount of enzyme which liberates 1 μmol cholesterol per minute at pH 7.0 and 37°C

(cholesterol acetate as substrate)

Application in the selective hydrolysis or condensation of carboxylic ester bonds.

R.J. Kazlauskas, *J. Am. Chem. Soc.*, 1989, 111, 4953.**26745** 10 mg, 100 mg

BioChemika, lyophilized, powder, white, ~35 U/mg

Storage: -20°C

**Lipoprotein Lipase from *Chromobacterium viscosum***

Diacylglycerol lipase

Diacylglycerol acylhydrolase

E.C. 3.1.1.34

[9004-02-8]

1 U corresponds to the amount of enzyme which liberates 1 μmol oleic acid per minute at pH 8.0 and 40°C (triolein, 62314 as substrate)

**62333** 25 mg, 100 mg

BioChemika, lyophilized, powder, ~2500 U/mg after

reconstitution

Storage: -20°C

**Lipoprotein Lipase from *Pseudomonas sp.***

Diacylglycerol lipase

Diacylglycerol acylhydrolase

E.C. 3.1.1.34

[9004-02-8]

1 U corresponds to the amount of enzyme which liberates 1 μmol oleic acid per minute at pH 8.0 and 40°C (triolein, 62314 as substrate)

**62335** 10 mg, 50 mg

BioChemika, lyophilized, powder, 1500-2500 U/mg

Storage: -20°C

**Epoxide Hydrolase, *Aspergillus niger sp.*, recombinant from *Aspergillus niger***

licensed from CNRS

E.C. 3.3.2.3

[9048-63-9]

1 U corresponds to the amount of enzymes which hydrolyzes 1 μmol (S)-NEPC ((2S,3S)-*trans*-3-Phenyl-2-oxiranylmethyl-4-nitrophenyl carbonate, 04088) per minute at pH 8.0 and 25°C

Catalyst for asymmetric hydrolysis of epoxides to optically active diols.

A. Archelas, R. Furstoss, *Curr. Opin. Chem. Biol.* 2001, 5(2), 112.**71832** 25 mg

BioChemika, powder, light-brown, ~35 U/g

Storage: 2-8°C

**Epoxide Hydrolase from *Rhodococcus rhodochrous***

E.C. 3.3.2.3

[9048-63-9]

1 U corresponds to the amount of enzymes which hydrolyzes 1 μmol (S)-NEPC ((2S,3S)-*trans*-3-phenyl-2-oxiranylmethyl-4-nitrophenyl carbonate, 04088) per minute at pH 8.0 and 25°C. Asymmetric hydrolysis of epoxides to optically active diols.<sup>[1,2]</sup>

[1] P. Hechtberger, et al., *Tetrahedron: Asymmetry*, 1993, 4, 1161; [2] M. Mischitz, et al., *Tetrahedron: Asymmetry*, 1996, 7, 2041.

**45299** 250 mg, 1 g

BioChemika, lyophilisate, beige, ≥0.5 U/g

Storage: 2-8°C

## 2.3 HYDROLASES CONTINUED

**α-Glucosidase from *Saccharomyces cerevisiae***

α-D-Glucosidase

Maltase from yeast

α-D-Glucoside glucohydrolase

E.C. 3.2.1.20

[9001-42-7]

1 U corresponds to the amount of enzyme which hydrolyzes 1 μmol *p*-nitrophenyl-α-D-glucopyranoside per minute at pH 6.8 and 37°C (after 1-2 h preincubation in 20 mM borate, pH 9.1, 4°C)

Synthesis of various 1'-*O*-sucrose and 1-*O*-fructose esters.G. Carrea, et al., *J. Chem. Soc., Perkin Trans. I*, 1989, 1057.**63412** 5 mg, 25 mg

BioChemika, lyophilised powder, off-white, ~65 U/mg

Storage: 2-8°C

**70797** 1 g, 5 g

BioChemika, lyophilisate, beige, protein only partially

soluble in water or buffer, 4-8 U/mg

Storage: -20°C

**β-Glucosidase from almonds**

β-D-Glucoside glucohydrolase

E.C. 3.2.1.21

[9001-22-3]

1 U corresponds to the amount of enzyme which liberates 1 μmol glucose per minute at pH 5.0 and 35°C (salicin as substrate)

Enzymatic hydrolysis of cellulose<sup>[1-2]</sup>; Stereospecific attachment of carbohydrates to amino acid derivatives<sup>[3-4]</sup>; Enzyme-catalyzed synthesis of alkyl β-D-glucosides in organic media<sup>[5]</sup>

[1] J.G. Shewale, *Int. J. Biochem.*, 1982, 14, 435; [2] G.P. Philippidis, et al., *Biotechnol. Bioeng.*, 1993, 41, 846; [3] N.J. Turner, M.C. Webberley, *J. Chem. Soc., Chem. Commun.*, 1991, 19, 1349; [4] D. Cantacuzene, et al., *Biomed. Biochim. Acta*, 1991, 50, 231; [5] G. Vic, D. Thomas, *Tetrahedron Lett.*, 1992, 33, 4567.

**63412** 5 mg, 25 mg

BioChemika, lyophilised powder, &gt;6 U/mg

Storage: 2-8°C

**Acetaminocinnamate Acylase from *Brevibacterium sp.***

ACA-Acylase

E.C. 3.4.13

1 U corresponds to the amount of enzyme which hydrolyzes 1 μmol *N*-Acetyldehydrophenylalanine per minute at pH 8.5 and 30°C

**52987** 5 ml, 25 ml

BioChemika, solution contains 50 % glycerol, 0.25 M

NaCl, 0.3 M K-phosphate, pH ~6.5, yellow, ≥3 U/ml

Storage: -20°C

**Carboxypeptidase Y from baker's yeast (*S. cerevisiae*)**

Serine carboxypeptidase

Peptidyl-L-amino acid hydrolase

E.C. 3.4.16.1

[9046-67-7]

1 U corresponds to the amount of enzyme which hydrolyzes 1 μmol Z-L-phenylalanyl-L-alanine per minute at pH 6.75 and 25°C

Catalyst used in peptide coupling<sup>[1-4]</sup>

[1] W. Kullmann, *J. Prot. Chem.*, 1983, 2, 289; [2] P. Kuhl, et al., *Mh. Chem.*, 1973, 114, 343; [3] P. Kuhl, H.-D. Jakubke, *Pharmazie*, 1990, 45, 393; [4] Flörsheimer, M.-R. Kula, *Monatsh. Chem.*, 1988, 119, 1323.

**21945** 1 mg, 5 mg

BioChemika, lyophilised powder (~ 10 % protein),

~12 U/mg

Storage: -20°C

**92269** 1 mg, 5 mg

BioChemika, powder, white, &gt;60 U/mg

Storage: -20°C

**21943** 5 mg, 25 mg

BioChemika, powder (~20 % protein), light brown,

~20 U/mg

Storage: -20°C

**Carboxypeptidase Y, immobilized on Eupergit® C from baker's yeast**

1 U corresponds to the amount of enzyme which hydrolyzes 1 μmol Z-L-phenylalanyl-L-alanine per minute at pH 6.8 and 25°C

©Registered Trademark of Röhm Pharma GmbH

**21947 NEW!** 250 mg, 1 g

BioChemika, &gt; 1 U/g

Storage: 2-8°C

**α-Chymotrypsin from bovine pancreas**

E.C. 3.4.21.1

[9004-07-3]

1 U corresponds to the amount of enzyme, which hydrolyzes 1 μmol Suc-(Ala)<sub>2</sub>-Pro-Phe-4-NA per minute at pH 7.8 and 25°C

Application in the selective hydrolysis or condensation of carboxylic ester bonds;<sup>[1,2]</sup> catalyst used in peptide coupling;<sup>[3,4]</sup> enzymatic synthesis of oligosaccharides on a chymotrypsin-enzymic polymer support.<sup>[5]</sup>

[1] J. Porter, et al., *Int. J. Pep. Prot. Res.*, 1987, 30, 13; [2] E. Santaniello, et al., *J. Org. Chem.*, 1988, 53, 1567; [3] P. Kuhl, et al., *Monatsh. Chem.*, 1984, 115, 423; [4] K. Aso, *Agr. Biol. Chem.*, 1989, 53, 729; [5] M. Zehavi, et al., *Carbohydrate Res.*, 1984, 133, 339.

**27270** 100 mg, 1 g, 5 g

BioChemika, lyophilised, powder, ~70 U/mg

Storage: -20°C

**27272** 1 g, 5 g

BioChemika, powder, almost white, ~50 U/mg

Storage: -20°C

**α-Chymotrypsin, TLCK treated**

TLCK-Chymotrypsin

E.C. 3.4.21.1

[9004-07-3]

1 U corresponds to the amount of enzyme, which hydrolyzes 1 μmol Suc-(Ala)<sub>2</sub>-Pro-Phe-4-NA per minute at pH 7.8 and 25°C

Useful in protein hydrolysis where no foreign trypsin activity should be present.<sup>[1,2]</sup>

[1] Y. Okamoto, T. Sekine, *J. Biochem. (Tokyo)*, 1985, 98, 1143; [2] E. Santaniello, et al., *J. Org. Chem.*, 1988, 53, 1567.

**27280** 25 mg, 100 mg

BioChemika, lyophilised, powder, white, 60 U/mg

Storage: -20°C

**Trypsin from bovine pancreas**

E.C. 3.4.21.4

[9002-07-7]

1 U corresponds to the amount of enzyme which increases the absorbance at 253 nm by 0.001 per minute at pH 7.6

## 2.3 HYDROLASES CONTINUED

and 25°C (*N*-benzoyl-L-arginine ethyl ester, 12880, as substrate)

Application in the selective hydrolysis or condensation of carboxylic ester bonds;

T. Sakurai, *et al.*, *J. Am. Chem. Soc.*, 1988, 110, 7236.

**93610** 250 mg, 1 g  
BioChemika, essentially salt free, lyophilized, powder, slightly beige, ~9000 U/mg  
Storage: -20°C

**Trypsin, DPCC treated, from bovine pancreas**

DPCC-Trypsin

E.C. 3.4.21.4

[9002-07-7]

1 U corresponds to the amount of enzyme which increases the absorbance at 253 nm by 0.001 per minute at pH 7.6 and 25°C (*N*-benzoyl-L-arginine ethyl ester, 12880, as substrate)

Treatment with DPCC reduces any chymotrypsin present. Synthesis of peptide derivatives containing 3-thia-analogues of amino acids.

P. Hermann, *et al.*, *Amino Acids*, 1992, 3, 105.

**93611** 250 mg, 1 g, 5 g  
BioChemika, lyophilized, powder, off-white, 6000-12000 U/mg  
Storage: -20°C

**Trypsin, TPCK treated from bovine pancreas**

TPCK-Trypsin

E.C. 3.4.21.4

[9002-07-7]

1 U corresponds to the amount of enzyme which increases the absorbance at 253 nm by 0.001 per minute at pH 7.6 and 25°C (*N*-benzoyl-L-arginine ethyl ester, 12880, as substrate)

Treatment with TPCK irreversibly inhibits the chymotrypsin activity without affecting the trypsin activity. Application in the selective hydrolysis or condensation of amide bonds.

Flörsheimer, M.-R. Kula, *Monatsh. Chem.*, 1988, 119, 1323.

**93630** 25 mg  
BioChemika, powder crystalline, ~7500 U/mg  
Storage: -20°C

**Trypsin from porcine pancreas**

Trypsin hog pancreas

E.C. 3.4.21.4

[9002-07-7]

1 U corresponds to the amount of enzyme which increases the absorbance at 253 nm by 0.001 per minute at pH 7.6 and 25°C (*N*-benzoyl-L-arginine ethyl ester, 12880, as substrate)

**93614** 250 mg, 1 g  
BioChemika, ≥10000 U/mg  
Storage: -20°C

**93615** 1 g, 5 g, 25 g  
BioChemika, powder, white, ~1500 U/mg  
Storage: 2-8°C

**93613** 50 g, 250 g, 1 kg  
BioChemika, powder, ~90 U/mg  
Storage: 2-8°C

**Proteinase, bacterial**

Subtilisin Carlsberg, bacterial

Nagarse

E.C. 3.4.21.14

[9001-92-7]

1 U corresponds to the amount of enzyme which liberates 1 μmol folin-positive amino acids and peptides (calculated as tyrosine) per minute at pH 7.5 and 37°C (casein, 22078, as substrate)

**82518** 25 mg, 100 mg, 500 mg  
BioChemika, powder, off-white, ~10 U/mg  
Storage: -20°C

**Proteinase from *Bacillus subtilis* var. *biotecus* A**

Subtilisin Carlsberg *Bacillus subtilis* var. *biotecus* A

Subtilo peptidase A

E.C. 3.4.21.14

[9014-01-1]

1 U corresponds to the amount of enzyme which liberates 1 μmol folin-positive amino acids and peptides (calculated as tyrosine) per minute at pH 7.5 and 37°C (hemoglobin, 51290, as substrate)

Regioselective biocatalyst for peptide bond formation in anhydrous organic solvents;<sup>[1]</sup> resolution of β-hydroxy-α-amino acids via enzymatic hydrolysis of their *N*-acyl methyl esters;<sup>[2]</sup> synthesis of ester of deoxynojirimycin and castanospermine by enzymatic regioselective acylation in pyridine.<sup>[3]</sup>

[1] H. Kitaguchi, *et al.*, *Tetrahedron Lett.*, 1988, 29, 5487; [2] R. Chênevert, *et al.*, *Can. J. Chem.*, 1990, 68, 960; [3] D.L. Delinck, A.L. Margolin, *Tetrahedron Lett.*, 1990, 31, 3093.

**82490** 100 mg, 500 mg  
BioChemika, lyophilized, powder, ~20 U/mg  
Storage: 2-8°C

**Protease from *Bacillus globigii* (*Bacillus licheniformis*)**

Proteinase from *Bacillus licheniformis*

Subtilisin from *Bacillus licheniformis*

Alcalase

E.C. 3.4.21.14

[9014-01-1]

1 U corresponds to the amount of enzyme which liberates 1 μmol folin-positive amino acids and peptides (calculated as tyrosine) per minute at pH 7.5 and 37°C (casein, 22078, as substrate)

Enzyme activity: the optimum temperature is 50°C (the temperature is stable up to 55°C), the optimum pH range is from pH 6-10

Serine endoproteinase used in transesterification and transeptidation.<sup>[1-3]</sup>

[1] A. N. Glazer, *J. Biol. Chem.*, 1968, 241, 635; [2] A.O. Barel, A. N. Glazer, *J. Biol. Chem.*, 1968, 243, 1344; [3] R. Brieva, *et al.*, *J. Chem. Soc., Chem. Commun.*, 1990, 16686.

**85968** 25 mg, 100 mg  
BioChemika, fine white crystals, ≥12 U/mg  
Storage: 2-8°C

**85967** 100 mg, 500 mg  
BioChemika, powder, light brown, ~6 U/mg  
Storage: 2-8°C

**Papain from *Carica papaya***

E.C. 3.4.22.2

[9001-73-4]

1 U corresponds to the amount of enzyme which hydrolyzes 1 μmol *N*-benzoyl-L-arginine ethyl ester (BAEE,

## 2.3 HYDROLASES CONTINUED

12880) per minute at pH 6.2 and 25°C

Specificity;<sup>[1]</sup> release of synthetic colours from food for their determination;<sup>[2]</sup> catalyst for peptide bond formation.<sup>[3,4]</sup>

[1] A.N. Glaze, E.L. Smith, *The Enzymes*, P.D. Boyer ed., 3rd Ed., 1971, 3, 501; [2] N.P. Boley, *et al.*, *Analyst*, 1979, 104, 472; [3] J. Green, A.L. Margolin, *J. Prot. Chem.*, 1983, 2, 289; [4] M.Y. Gololobov, E.V. Kozlova, *Biotechnol. Bioeng.*, 1992, 40, 432.

**76218** 50 mg, 250 mg, 1 g  
BioChemika, powder, almost white, ~12 U/mg  
Storage: -20°C

**76220** 25 g, 100 g  
BioChemika, powder, ~3 U/mg  
Storage: 2-8°C

**76222** 100 g, 500 g  
BioChemika, powder, ~0.5 U/mg  
Storage: 2-8°C

**Papain, immobilized on Eupergit® C, from *Carica papaya***

1 U corresponds to the amount of enzyme which hydrolyzes 1 μmol of *N*-benzoyl-L-arginine ethyl ester (12880) per minute at pH 6.2 and 25°C. ®Registered Trademark of Röhm Pharma GmbH

**76221** 1 g, 5 g  
BioChemika, granulated material moist, light brown, ~60 U/g  
Storage: 2-8°C

**Clostripain from *Clostridium histolyticum***

Clostridiopeptidase B

Proteinase from *Clostridium histolyticum*

E.C. 3.4.22.8

[9028-00-6]

1 U corresponds to the amount of enzyme which hydrolyzes 1 μmol *N*-benzoyl-L-arginine ethyl ester (BAEE, 12880) per minute at pH 7.1 and 2°C

**27549** 1 ea  
BioChemika, lyophilized, protein ~80%, powder, white, >100 U/mg protein  
Storage: -20°C

**Bromelain pineapple stem**

E.C. 3.4.22.32

[37189-34-7]

1 U corresponds to the amount of enzyme which releases 1 μmol 4-nitrophenol per minute at pH 4.6 and 25°C (*N*-Z-L-lysine-4-nitrophenyl ester as substrate)

Cysteine protease;<sup>[1]</sup> resolution of β-hydroxy-α-amino acids via enzymatic hydrolysis of their *N*-acyl methyl esters.<sup>[2]</sup>

[1] A. Ritonja, *et al.*, *FEBS Lett.*, 1989, 247, 419; [2] R. Chênevert, *et al.*, *Can. J. Chem.*, 1990, 68, 960.

**16990** 25 g, 100 g  
BioChemika, powder, yellow-brown, 2-5 U/mg  
Storage: -20°C

**Pepsin porcine gastric mucosa**

Pepsin hog stomach

Pepsin A

E.C. 3.4.23.1

[9001-75-6]

1 U corresponds to the amount of enzyme which increases the absorbance at 280 nm by 0.001 per minute at pH 2.0 and 37°C (Hemoglobin, Fluka-No. 51290, as substrate). Employed in peptide synthesis.<sup>[1,2]</sup>

[1] C.A. Abdel Malak, *et al.*, *Int. J. Pep. Prot. Res.*, 1993, 41, 97; [2] J.S. Fruton, *Carlsberg Res. Commun.*, 1984, 49, 41.

**77151** 1 g, 5 g, 25 g  
BioChemika, powder, slightly beige, 1200-2400 U/mg  
Storage: 2-8°C

**77160** 25 g, 100 g  
BioChemika, powder, slightly beige, 600-1200 U/mg  
Storage: 2-8°C

**77163** 100 g, 500 g  
BioChemika, powder, light-beige, 200-600 U/mg  
Storage: 2-8°C

**Proteinase from *Bacillus subtilis***

Subtilo peptidase A

E.C. 3.4.24.4

[9001-92-7]

1 U corresponds to the amount of enzyme which liberates 1 μmol folin-positive amino acids and peptides (calculated as tyrosine) per minute at pH 7.5 and 37°C (casein, 22078, as substrate)

**96887** 5 g, 25 g  
BioChemika, powder, slightly beige, >2 U/mg  
Storage: 2-8°C

**Thermolysin from *Bacillus thermoproteolyticus* rokko**

Protease from *Bacillus thermoproteolyticus* rokko

Thermophilic-bacterial protease

E.C. 3.4.24.27

[9073-78-3]

1 U corresponds to the amount of enzyme which liberates under test conditions 1 μmol folin-positive amino acids and peptides (calculated as tyrosine) per minute at pH 7.2 and 37°C (casein as substrate)

Thermostable neutral protease;<sup>[1]</sup> employed in peptide synthesis.<sup>[2,3]</sup>

[1] J. Feder, *et al.*, *Dev. Ind. Microbiol.*, 1977, 18, 267; [2] J.S. Fruton, *Carlsberg Res. Commun.*, 1984, 49, 231; [3] M. Reslow, *et al.*, *Eur. J. Biochem.*, 1988, 177, 313.

**88303** 25 mg, 100 mg  
BioChemika, lyophilized, powder, ~40 U/mg  
Storage: -20°C

**Penicillin Amidase solution, from *E. coli***

Penicillin Acylase

Penicillin amidohydrolase

E.C. 3.5.1.11

[9014-06-6]

1 U corresponds to the amount of enzyme which hydrolyzes 1 μmol benzylpenicillin per minute at pH 7.6 and 37°C

Characterisation;<sup>[1]</sup> employed in chiral resolution;<sup>[2]</sup> synthesis of ampicillin and benzylpenicillin.<sup>[3]</sup>

[1] T.A. Savidge, M. Cole, *Meth. Enzymol.*, 1975, 43, 705; [2] A. Guy, *et al.*, *Bioorg. Med. Chem. Lett.*, 1993, 3, 1041; [3] V. Kasche, *et al.*, *Hoppe-Seyler's Z. Physiol. Chem.*, 1984, 365, 1435.

**76427** 250 mg, 1 g  
BioChemika, solution in 0.1 M phosphate buffer, pH 7.5, 20-40 U/mg protein (~70 mg protein/ml)  
Storage: -20°C

**Penicillin Amidase, immobilized on Eupergit® C, from *E. coli***

1 U corresponds to the amount of enzyme which hydrolyzes 1 μmol benzylpenicillin per minute at pH 7.6 and 37°C.

Used in the resolution of several secondary alcohols.  
®Registered Trademark of Röhm Pharma GmbH  
E. Baldaro et al., *Tetrahedron: Asymmetry*, 1993, 4, 1031.

**76429** 5 g, 25 g  
BioChemika, powder, beige, ~100 U/g  
Storage: 2-8°C

**Penicillin G Amidase, immobilized, from *E. coli***

1 U corresponds to the amount of enzyme which hydrolyzes 1 μmol of benzylpenicillin per minute at pH 7.6 and 37°C

Immobilized on a polyacrylamide copolymer

**76428** 1 g, 5 g  
BioChemika, powder, wet material, white, ~150 U/g  
Storage: 2-8°C

**Acylase I from *Aspergillus melleus***

Aminoacylase  
Acylase 'Amamo'  
E.C. 3.5.1.14  
[9012-37-7]

1 U corresponds to the amount of enzyme which hydrolyzes 1 μmol *N*-acetyl-L-methionine per minute at pH 8.0 and 37°C

Enzyme activity: the optimum temperature is 40-45°C, the optimum pH is 8.0 (stable form pH 6-10). The enzyme is activated by CoCl<sub>2</sub> in the range of 10<sup>-4</sup> to 10<sup>-3</sup> M.  
Resolution of *N*-acylated amino acids.

K. Uchida, M. Kainosho, *J. Labelled Compd. Radiopharm.*, 1991, 29, 867.

**17877** 250 mg, 1 g  
BioChemika, powder, light-brown, 2-5 U/mg  
Storage: -20°C

**01818** 5 g, 25 g  
BioChemika, powder, brown, >0.5 U/mg  
Storage: 2-8°C

**Acylase I, immobilized on Eupergit C from *Aspergillus***

Aminoacylase, immobilized, Plexazym® AC

1 U corresponds to the amount of enzyme which hydrolyzes 1 μmol *N*-acetyl-L-methionine per minute at pH 8.0 and 25°C

Standard procedure: a 10-20% substrate solution, pH 6-8, with an addition of CoCl<sub>2</sub> (10<sup>-4</sup> moles) at 33°C was used. Prior to use, the polymer was washed with water (50 times bed volumes); when used in a fixed bed reactor, a velocity of flow of 3 bed volumes/h leads to a hydrolysis degree of 80%.

The immobilized acylase is used for the convenient resolution of amino acids via selective deacetylation of *N*-acetylamino acids in D,L-racemates.<sup>[1-4]</sup>

® Registered Trademark of Röhm Pharma GmbH

[1] D. Jaworek, et al., *Meth. Enzymol.*, 1976, 44, 195; [2] W. Kuhlmann, et al., *Chem. Ing. Tech.*, 1980, 52, 607; [3] J. Tramber, in *Solid Phase Biochemistry*, W.H. Scouten, Ed., New York, 1983, 393; [4] T. Sato, T. Tosa, *Bioprocess Technol.*, 1993, 16, 3.

**01824** 1 g, 5 g  
BioChemika, moist pearls (dried substance ~30%, pearl diameter 50-100 μm), covalent fixation of the acylase, ≥50 U/g  
Storage: 2-8°C

**50837** 5 g, 25 g  
BioChemika, moist pearls (dried substance ~30%, pearl diameter 50-100 μm), covalent fixation of the acylase, >15 U/g  
Storage: 2-8°C

**Acylase from *Penicillium sp.***

L-Aminoacylase  
E.C. 3.5.1.14  
[9012-37-7]

1 U corresponds to the amount of enzyme which hydrolyzes 1 μmol *N*-acetyl-L-methionine per minute at pH 8.0 and 37°C

**50606** 250 mg, 1 g  
BioChemika, powder, light brown, 1-2 U/mg  
Storage: 2-8°C

**Acylase I from porcine kidney**

Aminoacylase  
*N*-Acetylamino acid amidohydrolase  
E.C. 3.5.1.14  
[9012-37-7]

1 U corresponds to the amount of enzyme which hydrolyzes 1 μmol *N*-acetyl-L-methionine per minute at pH 7.0 and 25°C

Enantioselective hydrolysis of racemic *N*-acetylamino acids yielding L-amino acid enantiomers exclusively; <sup>[1,2]</sup> separation of L-leucine and L-isoleucine, <sup>[3]</sup> selective hydrolyses/condensations of amide bonds.<sup>[2,4-6]</sup>

[1] J.P. Greenstein, M. Winitz, *Chemistry of Amino Acids, Vol. 1*, New York, 1961, 1, 728; [2] G.M. Whitesides, et al., *J. Amer. Chem. Soc.*, 1989, 111, 6354; [3] J. Martens, H. Weigel, *Liebigs Ann. Chem.*, 1983, 2052; [4] C. Wandrey, in *Enzymes as Catalysts in Organic Chemistry*, M.P. Schneider, ed., Dordrecht, Holland, 1986, 263; [5] C. Sambale, M.R. Kula, *Biotechnol. Appl. Biochem.*, 1987, 9, 251; [6] H.K. Chenault, et al., *J. Amer. Chem. Soc.*, 1989, 111, 6354.

**01816** 100 mg, 500 mg  
BioChemika, powder, yellow-brown, ~30 U/mg  
Storage: -20°C

**01821** 250 mg, 1 g  
BioChemika, lyophilized, powder, ~15 U/mg  
Storage: -20°C

**Acylase from *Streptomyces griseocarneus***

L-Aminoacylase  
E.C. 3.5.1.14  
[9012-37-7]

1 U corresponds to the amount of enzyme which hydrolyzes 1 μmol *N*-acetyl-DL-methionine per minute at pH 8.0 and 37°C

**94810** 100 mg, 1 g  
BioChemika, lyophilisate, light brown, ~0.15 U/mg  
Storage: -20°C

**Acylase from *Streptomyces hachijoensis***

L-Aminoacylase  
E.C. 3.5.1.14  
[9012-37-7]

1 U corresponds to the amount of enzyme which hydrolyzes 1 μmol *N*-acetyl-DL-methionine per minute at pH 8.0 and 37°C

**82856** 100 mg, 1 g  
BioChemika, lyophilisate, light-brown, ≥ 30U/g  
Storage: -20°C

**Acylase from *Streptomyces chartreusis***

L-Aminoacylase  
E.C. 3.5.1.14  
[9012-37-7]

1 U corresponds to the amount of enzyme which hydrolyzes 1 μmol *N*-acetyl-DL-methionine per minute at pH 8.0 and 37°C

**90222** 100 mg, 1 g  
BioChemika, lyophilisate, light-brown, ≥0.1U/mg  
Storage: -20°C

**Acylase from *Streptomyces toyocaensis***

L-Aminoacylase  
E.C. 3.5.1.14  
[9012-37-7]

1 U corresponds to the amount of enzyme which hydrolyzes 1 μmol *N*-acetyl-DL-methionine per minute at pH 8.0 and 37°C

**94734** 100 mg, 1 g  
BioChemika, lyophilisate, light brown, ~40 U/g  
Storage: -20°C

**Acylase from *Streptomyces zaomyceticus***

L-Aminoacylase  
E.C. 3.5.1.14  
[9012-37-7]

1 U corresponds to the amount of enzyme which hydrolyzes 1 μmol *N*-acetyl-DL-methionine per minute at pH 8.0 and 37°C

**75288** 100 mg, 1 g  
BioChemika, lyophilisate, light-brown, ~0.25 U/mg  
Storage: -20°C

**D-Hydantoinase from *Vigna angularis* (adzuki bean)**

Dihydropyrimidinase  
D-Hydantoinase from Azuki beans  
E.C. 3.5.2.2  
[9030-74-4]

1 U corresponds to the amount of enzyme which hydrolyzes 1 μmol hydantoin (53760) per minute at pH 9.0 and 40°C

**53763** 250 mg, 1 g  
BioChemika, powder, brown, ~400 U/g  
Storage: 2-8°C

**Nitrilase from *Alcaligenes faecalis***

E.C. 3.5.5.1  
[9024-90-2]

1 U corresponds to the amount of enzyme which liberates 1 μmol ammonia per minute at pH 7.5 and 30°C with the conversion of 3-phenylpropionitrile to 3-phenylpropionic acid  
T. Nagasawa et al., *Eur. J. Biochem.*, 1990, 194, 765.

**82429** 10 mg, 50 mg  
BioChemika, powder, slightly red, ~15 U/g  
Storage: -20°C

**Nitrilase, *Arabidopsis thaliana*, recombinant from *E. coli***

E.C. 3.5.5.1

[9024-90-2]

1 U corresponds to the amount of enzyme which liberates 1 μmol ammonia per minute at pH 8.0 and 35°C with the conversion of 3-phenylpropionitrile to 3-phenylpropionic acid

Catalyst for the (E)-selective hydrolysis of (E,Z)-α,β-unsaturated nitriles to carboxylic acids;<sup>[1]</sup> selective hydrolysis of aliphatic dinitriles to monocarboxylic acids;<sup>[2]</sup> enantioselective hydrolysis of (±)-arylacetonitriles.<sup>[3]</sup>

[1] F. Effenberger, S. Osswald, *Tetrahedron: Asymmetry*, 2001, 12, 2581; [2] F. Effenberger, S. Osswald, *Synthesis*, 2001, 1866; [3] F. Effenberger, S. Osswald, *Tetrahedron: Asymmetry*, 2001, 12, 279.

**53841 NEW!** 10 mg, 50 mg  
BioChemika, powder, light beige, 0.3-1.0 U/mg  
Storage: -20°C

**Nitrilase from *Pseudomonas fluorescens***

E.C. 3.5.5.1  
[9024-90-2]

1 U corresponds to the amount of enzyme which liberates 1 μmol ammonia per minute at pH 7.5 and 30°C with the conversion of 2-thiopheneacetonitrile to 2-thiopheneacetic acid

Enantioselective hydrolysis of *O*-acetylmandelonitrile.

N. Layh, et al., *Arch. Microbiol.*, 1992, 158, 405.

**78424 NEW!** 10 mg, 50 mg  
BioChemika, powder, slightly yellow ≥ 10-15 U/g  
Storage: -20°C

**Nitrilase from *Rhodococcus rhodochrous***

E.C. 3.5.5.1  
[9024-90-2]

1 U corresponds to the amount of enzyme which liberates 1 μmol ammonia per minute at pH 8.0 and 30°C with the conversion of benzonitrile to benzoic acid

Enantioselective hydrolysis of nitriles.<sup>[1,2]</sup>

[1] T.C. Bhalla, et al., *Appl. Microbiol. Biotechnol.*, 1992, 37, 184; [2] M.L. Gradley, C.J. Knowles, *Biotechnol. Lett.*, 1994, 16, 41.

**76713 NEW!** 10 mg, 50 mg  
BioChemika, powder, slightly beige, ~10 U/g  
Storage: -20°C

**Nitrilase from *Rhodococcus sp.***

E.C. 3.5.5.1  
[9024-90-2]

1 U corresponds to the amount of enzyme which liberates 1 μmol ammonia per minute at pH 7.5 and 30°C with the conversion of benzonitrile to benzoic acid

**72295 NEW!** 10 mg, 50 mg  
BioChemika, powder, slightly red, >0.1 U/mg  
Storage: -20°C

## 2.4 LYASES

**2-Deoxyribose-5-phosphate Aldolase from *Lactobacillus plantarum***

DERA Aldolase from *Lactobacillus plantarum*  
E.C. 4.1.2.4  
[9026-97-5]

1 U corresponds to the amount of enzyme which converts

1 μmol 2-deoxy-D-ribose-5-phosphate to D-glyceraldehyde-3-phosphate and acetaldehyde per minute at pH 7.5 and 25°C

Enzyme for the stereoselective synthesis of carbohydrates by multi-substrate aldol reactions.<sup>[1,2]</sup>

[1] C.H. Wong, et al., *J. Am. Chem. Soc.*, 1995, 117, 3333; [2] H.J.M. Gijsen, et al., *J. Am. Chem. Soc.*, 1995, 117, 7585.

**41228** 10 mg

BioChemika, powder, slightly yellow, ~15 U/g

Storage: -20°C

#### L-Threonine Aldolase from *Candida humicola*

E.C. 4.1.2.5

1 U corresponds to the amount of enzyme which converts 1 μmol L-threonine to glycine and acetaldehyde per minute at pH 8.6 and 30°C

Catalyst for stereoselective aldol reactions.<sup>[1,2]</sup>

[1] V.P. Vassilev, et al., *Tetrahedron Lett.*, 1995, 36, 4081; [2] K. Shibata, et al., *Tetrahedron Lett.*, 1996, 37, 2791.

**53806** 250 mg

BioChemika, lyophilisate, slightly beige, ~10 U/g partially soluble in water or buffer

Storage: -20°C

#### L-Threonine Aldolase from *Pseudomonas putida*

E.C. 4.1.2.5

1 U corresponds to the amount of enzyme which converts 1 μmol L-threonine to glycine and acetaldehyde per minute at pH 8.6 and 30°C

Catalyst for stereoselective aldol reactions.<sup>[1-3]</sup>

[1] B.T. Lotz et al., *J. Chem.Soc., Chem. Commun.*, 1990, 1107; [2] R.B. Herbert, et al., *J. Chem.Soc., Chem. Commun.*, 1993, 205; [3] L.Q. Liu, et al., *Applied Microbiol., Biotechnol.*, 1998, 49, 70.

**96586** 10 mg, 50 mg

BioChemika, lyophilisate, slightly yellow, ~0.2 U/mg

Storage: -20°C

#### Fructose-1,6-bisphosphate Aldolase from *Bacillus subtilis*

D-Fructose-1,6-bisphosphate-D-glyceraldehyde-3-phosphate-lyase

FDP Aldolase

E.C. 4.1.2.13

[9024-52-6]

1 U corresponds to the amount of enzyme which converts 1 μmol dihydroxyacetone phosphate from fructose-1,6-diphosphate per minute at pH 7.6 and 37°C in a system coupled to triosephosphate isomerase.

Catalyst for stereoselective aldol reactions.<sup>[1,2]</sup>

[1] L.C. Packman, A. Berry, *Eur. J. Biochem.*, 1995, 227, 510; [2] I. Henderson, in *Enzyme Catalysis in Organic Synthesis*, Vol. 2, K.H. Drauz, H. Waldmann, Eds., VCH, Weinheim, 1995, 547.

**80753** 10 mg, 50 mg

BioChemika, lyophilisate, slightly beige, ~ 30 U/g partially soluble in water or buffer

Storage: 2-8°C

#### Fructose-1,6-bisphosphate Aldolase from *Staphylococcus aureus*

D-Fructose-1,6-bisphosphate-D-glyceraldehyde-3-phosphate-lyase

FDP-Aldolase

E.C. 4.1.2.13

[9024-52-6]

1 U corresponds to the amount of enzyme which converts 1 μmol dihydroxyacetone phosphate from fructose-1,6-

diphosphate per minute at pH 7.6 and 25°C in a system coupled to triosephosphate isomerase.

Characterization

F. Götz, et al., *Eur. J. Biochem.*, 1980, 108, 295.

**05522** 5 mg

BioChemika, powder, white, ≥10 U/mg

Storage: -20°C

#### Fructose-1,6-bisphosphate Aldolase from *Staphylococcus carnosus*

D-Fructose-1,6-bisphosphate-D-glyceraldehyde-3-phosphate-lyase

FDP-Aldolase

E.C. 4.1.2.13

[9024-52-6]

1 U corresponds to the amount of enzyme which converts 1 μmol dihydroxyacetone phosphate from fructose-1,6-diphosphate per minute at pH 7.6 and 25°C in a system coupled to triosephosphate isomerase.

Catalyst for stereoselective aldol reactions.<sup>[1,2]</sup>

[1] H.P. Brockamp, M.-R. Kula, *Tetrahedron Lett.*, 1990, 31, 7123; [2] M.T. Zannetti, et al., *Chem. Eur. J.*, 1999, 5, 1882.

**94864** 5 mg

BioChemika, lyophilisate, slightly beige, ~ 0.4 U/mg

Storage: -20°C

#### Fructose-1,6-bisphosphate Aldolase from *Thermus aquaticus*

D-Fructose-1,6-bisphosphate-D-glyceraldehyde-3-phosphate-lyase

FDP-Aldolase

E.C. 4.1.2.13

[9024-52-6]

1 U corresponds to the amount of enzyme which converts 1 μmol dihydroxyacetone phosphate from fructose-1,6-diphosphate per minute at pH 7.6 and 25°C in a system coupled to triosephosphate isomerase.

**05525** 100 mg, 500 mg

BioChemika, lyophilisate, yellow, ~ 5 U/g

Storage: 2-8°C

#### (S)-Oxynitrilase from *Manihot esculenta* (manioc)

Acetone-cyanohydrin Lyase

E.C. 4.1.2.37

[9024-43-5]

1 U corresponds to the amount of enzyme which cleaves 1 μmol mandelonitrile to cyanide and benzaldehyde per minute at pH 5.0 and 25°C

Catalyst for the synthesis of optically active cyanohydrins.<sup>[1-3]</sup>

[1] F. Effenberger, *Chimia*, 1999, 53, 3; [2] D.V. Johnson, et al., *Tetrahedron*, 2000, 56, 781; [3] S. Förster, et al., *Angew. Chem., Int. Ed. Engl.*, 1996, 35, 437.

**71811** 1 ml, 5 ml

BioChemika, turbid solution, contains 20 mM citrate/phosphate pH ~5.4, ≥3000 U/ml

Storage: 2-8°C

#### (R)-Oxynitrilase, *Linum usitatissimum* (flax), recombinant from *Pichia pastoris*

Acetone-cyanohydrin lyase

E.C. 4.1.2.37

[9024-43-5]

1 U corresponds to the amount of enzyme which cleaves

1 μmol acetone cyanohydrin to cyanide and acetone per minute at pH 4.2 and 30°C

Catalyst for the synthesis of optically active cyanohydrins.<sup>[1,2]</sup>

[1] F. Effenberger, *Chimia*, 1999, 53, 3; [2] H.Wajant, F. Effenberger, *Biol. Chem.*, 1996, 377, 611.

**77398** 5 ml

BioChemika, clear solution, contains ~20 mM sodium acetate, ~20 mM ZnCl<sub>2</sub>, ~1 M NaCl, pH ~5.7, slightly yellow, ≥50 U/ml

Storage: 2-8°C

#### (R)-Oxynitrilase from *Prunus amygdalus* (almonds)

Mandelonitrile lyase

E.C. 4.1.2.10

[9024-43-5]

1 U corresponds to the amount of enzyme which hydrolyzes 1 μmol DL-mandelonitrile per minute at pH 3.8 and 30°C. Catalyst for the synthesis of optically active cyanohydrins.

U. Kragl, et al., *Ann. N.Y. Acad. Sci.*, 1990, 613, 167.

**38942** 100 ml

BioChemika, solution hazy, yellow, ≥30 U/ml

Storage: 2-8°C

#### (R)-Oxynitrilase from bitter almonds

Acetone cyanohydrin lyase

Mandelonitrile lyase

E.C. 4.1.2.10

[9024-43-5]

1 U corresponds to the amount of enzyme which hydrolyzes 1 μmol DL-mandelonitrile per minute at pH 3.8 and 30°C

**08788** 10 mg

BioChemika, powder, only partially soluble in water or buffer, white, ~0.2 U/mg

Storage: -20°C

#### (S)-Oxynitrilase from Sorghum

Acetone cyanohydrin lyase

Mandelonitrile lyase

E.C. 4.1.2.10

[9024-43-5]

1 U corresponds to the amount of enzyme which hydrolyzes 1 μmol DL-p-hydroxymandelonitrile per minute at pH 3.8 and 30°C

**06989** 5 mg, 25 mg

BioChemika, powder, light brown, >50 U/mg

Storage: -20°C

#### (S)-Oxynitrilase from *Sorghum vulgare*

(S)-Acetone cyanohydrin lyase

(S)-Mandelonitrile lyase

E.C. 4.1.2.10

[9024-43-5]

1 U corresponds to the amount of enzyme which hydrolyzes 1 μmol DL-p-hydroxymandelonitrile per minute at pH 3.8 and 30°C

**91843** 250 mg

BioChemika, powder, slightly brown, ≥40 U/g

Storage: 2-8°C

#### 4-Hydroxy-2-oxoglutarate Aldolase from *E. coli*

KHG-Aldolase

2-Keto-4-hydroxyglutarate Aldolase

E.C. 4.1.3.16

[9030-81-3]

1 U corresponds to the amount of enzyme which decarboxylates 1 μmol oxalacetate to pyruvate and benzaldehyde per minute at pH 8.4 and 37°C

Catalyst for stereoselective aldol reactions.<sup>[1,2]</sup>

[1] N.C. Floyed, et al., *J. Chem. Soc., Perkin Trans I*, 1992, 1085; [2] I. Henderson in *Enzyme Catalysis in Organic Synthesis*, Vol. 2, K.H. Drauz, H. Waldmann, Eds., VCH, Weinheim, 1995, 567.

**59892** 10 mg

BioChemika, lyophilisate, white, ~0.1 U/mg

Storage: -20°C

#### Tryptophanase from microorganisms

E.C. 4.1.99.1

[9024-00-4]

1 U corresponds to the amount of enzyme which hydrolyzes 1 μmol tryptophan to indole, pyruvate and ammonia per minute at pH 7.0 and 37°C

**52384** 1 mg, 5 mg

BioChemika, solution, contains glycerol (20 %) and pyridoxal-5-phosphate (0.1 mM), yellow, ≥2.5 U/mg protein (~100 mg protein/ml)

Storage: -20°C

#### Phenylalanine Deaminase from *Rhodotorula glutinis*

Phenylalanine Ammonia-Lyase

E.C. 4.3.1.5

[9024-28-6]

1 U corresponds to the amount of enzyme which deaminates 1 μmol L-phenylalanine to *trans*-cinnamate per minute at pH 8.5 and 30°C

C.W. Abell, R.S. Shen, *Meth. Enzymol.*, 1987, 142, 242.

**78084** 5 mg, 25 mg

BioChemika, lyophilized, powder, ~0.2 U/mg

Storage: -20°C

**78085** 1 mg, 5 mg

BioChemika, clear, colorless solution in 60% glycerol, 3 mM TRIS HCl, pH 7.5 and 0.5 M ammonium sulfate, >0.4 U/mg protein (~8 mg protein/ml)

Storage: -20°C