

We are IntechOpen, the world's leading publisher of Open Access books Built by scientists, for scientists

6,900

Open access books available

186,000

International authors and editors

200M

Downloads

Our authors are among the

154

Countries delivered to

TOP 1%

most cited scientists

12.2%

Contributors from top 500 universities



WEB OF SCIENCE™

Selection of our books indexed in the Book Citation Index
in Web of Science™ Core Collection (BKCI)

Interested in publishing with us?
Contact book.department@intechopen.com

Numbers displayed above are based on latest data collected.
For more information visit www.intechopen.com



Oxidoreductases: Significance for Humans and Microorganism

Hussein Mahdi Kareem

Abstract

Oxidoreductases consist of a large class of enzymes catalyzing the transfer of electrons from an electron donor (reductant) to an electron acceptor (oxidant) molecule. Since so many chemical and biochemical transformations comprise oxidation/reduction processes, it has long been an important goal in biotechnology to develop practical biocatalytic applications of oxidoreductases. During the past few years, significant breakthrough has been made in the development of oxidoreductase-based diagnostic tests and improved biosensors, and the design of innovative systems for the regeneration of essential coenzymes. Research on the construction of bioreactors for pollutants biodegradation and biomass processing, and the development of oxidoreductase-based approaches for synthesis of polymers and functionalized organic substrates have made great progress. Proper names of oxidoreductases are in a form of “donor:acceptor oxidoreductase”; while in most cases “donor dehydrogenase” is much more common. Common names also sometimes appeared as “acceptor reductase”, such as NAD⁺ reductase. “Donor oxidase” is a special case when O₂ serves as the acceptor. In biochemical reactions, the redox reactions are sometimes more difficult to observe, such as this reaction from glycolysis: $\text{Pi} + \text{glyceraldehyde-3-phosphate} + \text{NAD}^+ \rightarrow \text{NADH} + \text{H}^+ + 1,3\text{-bisphosphoglycerate}$, where NAD⁺ is the oxidant (electron acceptor), and glyceraldehyde-3-phosphate functions as reductant (electron donor).

Keywords: oxidoreductases, important of enzyme, application medical of this enzyme

1. Introduction

1.1 Enzymes

Are biotic chemical agents that rise the amount of biochemical reaction by depressing of activate energy. The particles convoluted in the enzyme intermediated responses is identified as substrate and the outcome of the reactions or produce are termed products. In general, the chemical structure of greatest for more enzymes is protein and hardly ever of other type e.g., Ribonucleic acid (RNA). The enzyme is too special on the way to their substrates of whom they re-join and thereby the reaction will also be so specific. At times the enzymes requests the turnout of a un protein part called coenzyme, if was a vitamin derivative Organic

complex or cofactor, if was a metal- ion for obtain the reactions. And for this, entire enzymes might be named a **holoenzyme**, the portion of protein by means of apoenzyme and the nonprotein basic a prosthetical collection.

2. Enzymes oxido-reductases

Oxido-reductases are a great collection of enzyme is existing of differential area in natural lifecycle such as microorganisms, plant and animals. The enzymes commission EC numbers taxonomy of enzymes. They are categorized by way of EC 1. It is include approximately one third of the enzyme actions that are recorded in BR aunschweig Enzyme List (Selles vidal *et al*, 2018). This enzyme stimulate (give-and-take) of electron among the (donor and acceptor) molecule, reaction comprising electrons transferal, protons, Hydrogen extractive, Hydride transfer, Oxygen insert, also extra significant stages [1, 2]. Generally, two in half reaction such as some oxidative and one reduction occurring and at smallest two substrate such as one reduces and one oxidize is activate and convert [3]. Oxidoreductases comprise of a great categorize of enzyme catalyze the transmission of electron from an electrons donor (reduction) to an electron acceptor (oxidation) molecules, general take NADP nicotinamide- adenine- dinucleotide phosphate or NAD nicotinamide –adenine- dinucleotide as cofactor (**Figure 1**) [4]. Then so various biochemical conversions include oxidant –reluctant methods, it has more been a significant aim in biotechnological to progress applied bio- catalytic uses of oxido-reductases. Through the past little years, significantly discovery has been through in the improvement of oxido-reductase-based diagnosis checks than developed bio-sensors and the plan of new system into the renewal of necessary co-enzymes. Study on the structure of bioreactor for contaminants biodegrade and Biomass treating, and the improvement of oxido-reductase-Based styles into production of polymer and functional Organic substrate have prepared grates progresses. Correct name of oxido-reductases is of donor-acceptor oxido-reductase. However in greatest case donor- dehydrogenase is much more public. Public name also at times appeared as (acceptors –reductase) for example NAD + reductase (donor –oxidative) is a specific example when O₂ render as acceptors. He catalyzed reaction are like to the reaction in **Figure 1**- A the reduction and B is oxidative. In active bio-chemical reaction, the reduction reaction are at times extra difficult to detect, example reactions glycolysis (Pi + glycer aldehyde⁻³ phosphate + NAD → NADH + H + 1,3-Bisphospho glycerate. NAD⁺ is the oxidant (electron - acceptor), and glyceraldehyde-3-phosphate function as reduction t (electrons -donors).

3. Classification of oxido-reductases

Oxidoreductases may be categorized accord to the arrangement or structure of three dimensions building, that is extremely instructive aimed at the identify of structure functions correlation, enzymes development, function genomic, and

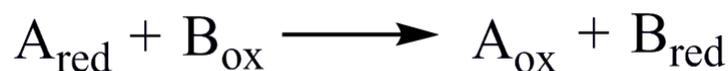


Figure 1.
Oxidation-reduction.

silicon new enzyme detection, for use, Oxido-reductases also may be categorized accord to their name stimulation and or co-enzyme-dependence.

Hydroxylases, oxygenases, peroxidases and reductases (Figure 2) [4, 5]. The molecule Oxygen actions as receptor of Hydrogen or electron. Their enzymes called **oxidases** is convoluted. But this enzyme was dehydrogenase, the outcome of which is confirmed by a hydrogen transmission of an acceptor r molecule that contains either/or nicotinamide adenines-adenine-dinucleotide phosphate NAD⁺/NADP⁺ or a flavic co-enzyme [6].

Peroxydases catalyze the reduction of the addition of hydroxyl to substrates. Oxygenases integrate oxygen into the organic substrates of molecular oxygen.

Reductases stimulate reduce reaction, and in more cases they action similar oxidases. Oxidoreductases accomplish essential role in together Aerobic metabolism and Anaerobic mechanism. They have an extensive variety of substrates, together Organic (alcohol, amine and ketone) and inorganics (some anions like sulfite and some types metal like (Mercury)). This enzymes has many reductive -active centers for performance many physiologically functions [7]. This centers safe via the poly peptide backbone of Oxido-reductases as they are very variable in environment. Polypeptides basis are of the enzymes as well supports in Selectivity, reactivity, redox potential, Stability and inhibit resistance. This Public reductive centers comprise amino acid excesses such as (tyrosine-cysteine), metals ions or complex Examples of these are the co-enzymes (c., mo, fe-s), pterion, and pyro-loquinolin (Pquq), for example (cu, mo, fe, fe-s group), and flavin mononucleotide (FMN) (Figure 2).

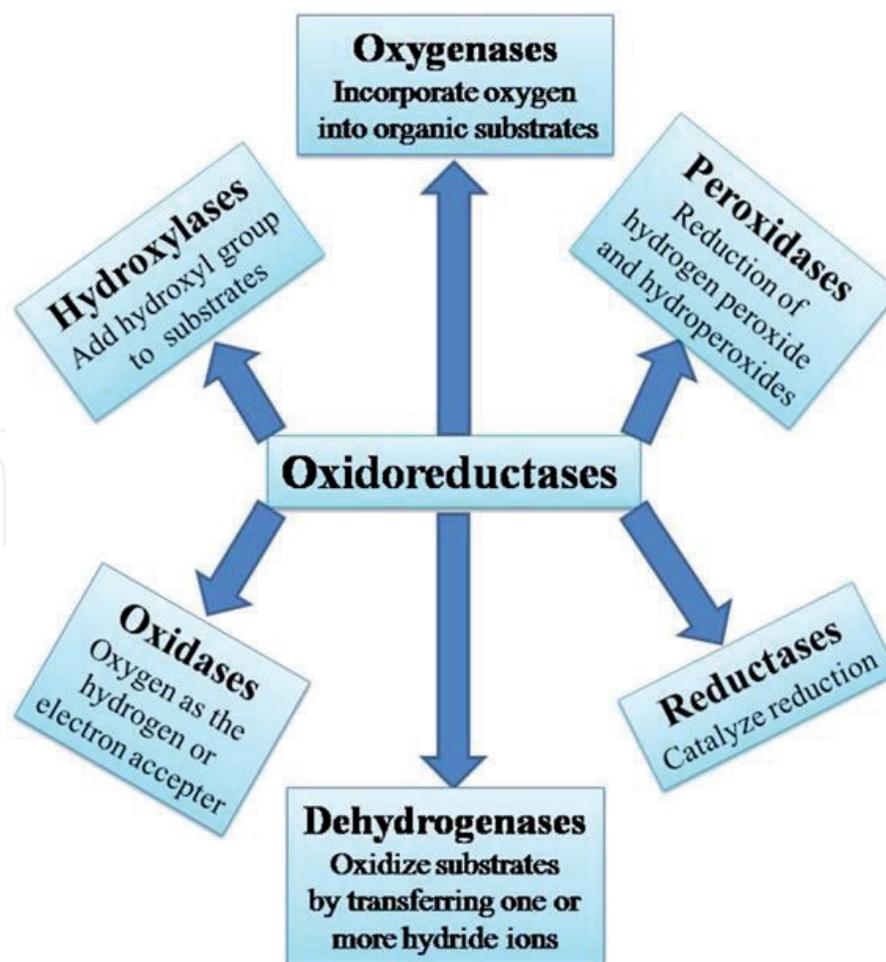


Figure 2.
Classification of oxidoreductases.

4. Applications of oxidoreductases

Since several chemical and biochemical conversions include methods for oxidation reduction, it was attractive, albeit somewhat elusive, to develop developed bio-catalytic uses of oxidation enzymes since the early years of biomedical technologies [8]. Application envision for these enzymes have involved a symmetric oxy functionalization of steroid and other pharmaceutical, production and alteration of polymer, oxidation degrade of contaminants, oxy functionalization of hydrocarbons, and the structure of biosensors for a diversity of analytical and clinical application. Oxidoreductase created catalysis turns well by way of the improvement in greatly effective, maintainable, and medium-friendly industry then they are recyclable, exact in natural surroundings, and energy save. This enzymatic system can include diverse co-factors like Simetric steroid and other pharmaceutical oxygen functions, polymer synthesis and modification, oxidative degradation of pollutants, hydrocarbon Oxyfunction, and a biosensor structure were included in the application of those enzymes for a range of analytical and clinical applications [9].

4.1 Carbohydrates application

Particle carbohydrates can be employed as a renewable resources and cheap rare material, forerunner, building block, or addition for numerous industrial produces. Once, beneficial Organic acid like lactic acid takes been produce from sugar by complete cellular fermentation methods [10]. By the Oxidoreductases uses enzymes, Particle sugar use in everyday our life like particles (glucose, sucrose) can be altered into new beneficial products. Also Particle D-glucose was modified by enzyme glucose Oxidase to Type-glucosone [11]. The cheese processing industry has produced lactose by way of by-products, which has been renewed to lactobionic acid by enzyme lactose oxidase) [12]. Also the lactobionic acid is employed as a worthy diet addition, chelators, acid, and a polymers forerunner [13].

4.2 Conversion of biomass

Conservative dealignment of the pulp is based on a single chlorine or chemical oxidant based on oxygen. While very active, these agents can cause serious problems in the disposal of products or damage to cellulose fiber. Enzymatic delignifying devices are appealing alternatives [14]. Laccase- peroxidase- and other oxidoreductases share in the natural delignification by lignolytic white-rot fungi. Numerous laccases have been shown capable of degrading together natural and artificial lignin (Balakshin *et al*, 2001). They oxidation by direct the phenolic elements of lignin's in the existence of a correct reduction reactions pander, indirect, the hetero geneous Phenolic and non-phenolic chiefly methoxy benzene component. The product, radical can be made in lignin's, which could leads to aliphatic or aromatic C-C connection split and de polymerization. Enzymes Lignins peroxidase is also a strong DE lignifying factor. Its high valent Oxo - Ferryl types can extract electron or proton from the non-phenolic part of structure lignins, therefore producing radical that split the Heterogeneous polymers. Similar enzymes lignin peroxidase, enzymes Mn peroxidase is also working by White Rot Fungus to destroy Lignins. Enzymes Mn peroxidase is of specific importance, for the reason that its oxidation agent. Enzyme Mn peroxidase [III] may stabilize by lesser chelator such as oxalate C_2O_4 (2-) and diffusion on the places in lignins normal impossible in enzyme [15].

4.3 Technologies for textiles

Potential for the use of oxidoreductase in textile manufacture consists of cotton fiber bleaching, dyeing and waste management. The enzyme whitening process of cotton is explained in a recent study [16]. Significant result of lacquer application to the bleaching of the cotton I observed in the peroxide mix. Potential benefits are chemical, energy and saving water Laccase-catalyzing textile dye bleaching is advantageous for the finish of the cotton fabric [17].

4.4 Technologies for food

The essential components of several diets and beverages include many oxidoreductase substrates, including carbohydrates, unsaturated fatty acids, phenolics, and thiol. The alteration of oxidoreductase may lead to new functionality, quality development, or cost reduction [18]. Often O_2 , because of excessive oxidative, is useful in the consistency or storage of food drinks. Oxidase can be used as O_2 -scavengers for enhanced food packaging [19]. The promotion of glucose oxidase for bread making uses. Addition of the enzymes to dough can lead to several chemical physical variations comprising cross-link of protein albumin protein, globulin, and to reduced amount, glutenins [20]. Therefore the paste demonstrations improved viscoelasticity - rheological properties, and the baked bread has better structure, greater volume, or extra features. The influence is like caused by molecule H_2O_2 made by the enzymes. But, the actions of these enzymes is not higher to that induce oxidation additive like Bromic acid anion, BrO^{-3} and azodicarbonamide. For bread making applications, glucose oxidase has been commercialized. Addition of the enzyme to dough can lead to various physicochemical changes including cross-linking of wheat albumin, globulin, and to some extent, glutenin chemical [21]. So, they are essential to detect or improve other enzyme Carbohydrate oxidases for this enforcement. The lipoxygenase enzymes are a favorable nominee for the bread application [22]. The effect of paste strengthening and bread whitening can be achieved with enzymes by modification and emulsifying properties of endogenous fatty acid saturated lipids and the formation of hydroperoxide. But adding enzymes to a certain food may cause the endogenous antioxidant to lack or deplete.

4.5 Bioconversion, biocontrol, and environmental use

Bioconversion of extensively used insecticides, herbicides and many agrochemicals is a significant importance in technological advance the social order, and peroxidase enzymes have great potential for like applications. Mention researcher [23] the ability of Phanerochaetaceae Onygenaceae, Basidiomycota genus Trametes, Tinea versicolor, Coriopsis gallica and family of fungi Pleurotaceae grow in a nitrogen- contain amount lower of mineral culture media which degradation PCBs was compared, then separate amount of PCBs extracted from these fungal culture media for period four weeks were 25, 50, 41, and 0 %, respectively. Enzymes examined established that both in elevation and comparatively firm activities of all enzymes following: Mn dependent peroxidase, Mn independent peroxidase, lignin peroxidase and lactase described efficacious degradation. In linked works, lactase from *Pityriasis versicolor* was presented to be qualified for in vitro oxidative of polycyclic arene hydrocarbons with construction of the congruous Quinone as oxidative products [24] Amazingly, adding of the pander 1-hydroxybenzotriazole for enzyme response solution helped the reactions to such an extent that polycyclic aromatic hydrocarbon (PAH), Fluorenes, solid polycyclic aromatic hydrocarbon, Benzopyrene $C_{20}H_{12}$, and perylene were almost completely removed from the solution.

4.6 Medicine and other synthetic enforcement

The enzyme oxidoreductases are essential in medical combination. For example enzyme Laccases can be employed to produce a great amount of compound medical mediators, like Triazolobenzodiazepine, Cycloalkyl Thiadiazoles, (Cephalosporin β -lactam antibiotics), vincalokoblastine, Penicillin X methyl ester [25, 26]. The enzymes benzenediol: oxygen oxidoreductases; EC 1.10.3.2 may be application to produce numerous practical Organic combinations include polymer of similar electric optical mechanical characteristics, flavor agent, texture dyes, structure cosmetic pigment, and pesticide [27]. By use of Oxidoreductases can leads for improvement of modern industry artificial techniques. Such as Baeyer-Villiger mono oxygenase can stimulate beneficial expansions of ring reactions by transformation a cyclic ketone to the congruent lactone [28]. Macrophomic acid production enzymes can stimulate Diels alder reactions [29]. At times after the Oxido-reductases performances on its substrates, it can induce a second response with parts of the substrates that lead to modern types of bio catalysis [30]. The use enzyme oxido-reductases we can stimulate reaction that are not simply favorable Such as chloroperoxidase and Cytochrome P450 enzyme can functionalizing indeclinable hydro carbons by hydroxylation [31]. Enzyme enone reductase can Hydrogenation unsaturated bond to change component ketone to hydrocarbons [32]. Old yellow enzyme gained from type of fungi that called Yeast that contain FMN enzyme, can stimulate the reduction by NADPH of the Olefinic ($>C^{1/4}C<$) not carbonyl $>C^{1/4}O$ the site of 2-Cyclohexen- [33]. Application oxidoreductases can leads to different industry produce methods. Such as Baeyer-Villiger mono oxygenase can stimulate A valuable ring-expanding reaction by altering a cyclic ketone to a corresponding lactone [28]. Sulfoxidation of alkyl aryl sulfides, nitroso- and-hydroxylamino-compounds N-oxidation, or styrene epoxidation can be done by horseradish peroxidase. Enone reductase can hydrogenate unsaturated bonds to convert ketones to hydrocarbons [32].

IntechOpen

Author details

Hussein Mahdi Kareem

Institute of Technical Diwanayah, Al-Furat Al-Awsat Technical University, Iraq

*Address all correspondence to: mahdihussein73@gmail.com; dw.hus10@atu.edu.iq

IntechOpen

© 2020 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/3.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. 

References

- [1] Husain Q (2017) High yield immobilization and stabilization of oxidoreductases using magnetic nanosupports and their potential applications: an update. *Current Catal* 6(3):168-187
- [2] Toone EJ (2010) *Advances in enzymology and related areas of molecular biology, Protein evolution*, vol 75. Wiley, Hoboken, NJ
- [3] Laskar AA, Alam MF, Younus H (2017) In vitro activity and stability of pure human salivary aldehyde dehydrogenase. *Int J Biol Macromol* 96:798-806
- [4] Nicholas C, Lewis S (1999) *Fundamentals of enzymology: the cell and molecular biology of catalytic proteins*. Oxford University Press, Oxford
- [5] Husain, M. F. Ullah (2019). *Biocatalysis Enzymatic Basics and Applications*, Springer Nature Switzerland <https://doi.org/10.1007/978-3-030-25023-2>
- [6] Alam MF, Laskar AA, Choudhary HH, Younus H (2016) Human salivary aldehyde dehydrogenase: purification, kinetic characterization and effect of ethanol, hydrogen peroxide and sodium dodecyl sulphate on the activity of the enzyme. *Cell Biochem Biophys* 74:307-315
- [7] Webb EC (1992) *Enzyme nomenclature 1992. Recommendations of the Nomenclature Committee of the International Union of Biochemistry and Molecular Biology on the nomenclature and classification of enzymes*. Academic, San Diego, CA
- [8] May SW. (1999). Applications of oxidoreductases. *Current Opinion in Biotechnology*, 10(4), 370-375
- [9] May SW, Padgett SR (1983) Oxidoreductase enzymes in biotechnology: current status and future potential. *Nat Biotech* 1:677-686
- [10] Ghaffar T, Irshad M, Anwar Z, Aqil T, Zulifqar Z, Tariq A, Kamran M, Ehsan N, Mehmood S (2014) Recent trends in lactic acid biotechnology: a brief review on production to purification. *J Radiat Res Appl Sci* 7:222-229
- [11] Karmali A, Coelho J (2011) Bioconversion of D-glucose into D-glucosone by glucose 2-oxidase from *Coriolus versicolor* at moderate pressures. *Appl Biochem Biotechnol* 163:906-917
- [12] Koka R, Mehnert D, Fritsch R, Steffan W, Habermeier P, Bradbury A, Wolfschoon-Pombo A, Rose M (2004) Process for manufacturing cheeses and other dairy products and products thereof. In: Google Patents
- [13] Gutiérrez LF, Hamoudi S, Belkacemi K (2012) Lactobionic acid: a high value-added lactose derivative for food and pharmaceutical applications. *Int Dairy J* 26:103-111
- [14] Call H. PCT patent WO2003061550-A2 (2003)
- [15] Hofrichter M. (2002). *Enzyme Microb Technol* 30, 454-46
- [16] Tzanov T, Basto C, Gübitz GM, and Cavaco-Paulo A. (2003). *Macromol Mater Eng.* 288, 807-810
- [17] Xu F. (1999). in *The Encyclopedia of Bioprocessing Technology: Fermentation, Biocatalysis, and Bioseparation*, eds. John Wiley & Sons, New York Flickinger MC, and Drew SW. 1545-1554
- [18] Minussi RC, Pastore GM, and Durán N. (2002)., *Trends Food Sci Technol* 13, 205-216

- [19] Andersson M, Andersson T, Adlercreutz P, Nielsen T, and Hörnsten EG. (2002). *Biotechnol Bioeng* 79, 37-42
- [20] Rasiah IA, Sutton KH, Low FL, Lin HM, Gerrard JA (2005) Crosslinking of wheat dough proteins by glucose oxidase and the resulting effects on bread and croissants. *Food Chem* 89:325-332
- [21] Kohajdová Z, Karovičová J, Schmidt Š (2009) Significance of emulsifiers and hydrocolloids in bakery industry. *Acta Chimica Slovaca* 2:46-61
- [22] Casey R, West SI, Hardy D, Robinson DS, Wu Z, Hughes RK (1999) New frontiers in food enzymology: recombinant lipoxygenases. *Trends Food Sci Technol* 10:297-302
- [23] Novotny C, Vyas BRM, Erbanova P, Kubatova A, Sasek V (1997). Removal of PCBs by various white rot fungi in liquid cultures. *Folia Microbial*, 42:136-140.
- [24] Majcherczyk A, Johannes C, Huettermann A (1998). Oxidation of polycyclic aromatic hydrocarbons (PAH) by lactase of *Trametes versicolor*. *Enzyme Microb Technol*, 22:335-341.
- [25] Mikolasch A, Niedermeyer THJ, Lalk M, Witt S, Seefeldt S, Hammer E, Schauer F, Gesell Salazar M, Hessel S, Jülich WD (2007) Novel cephalosporins synthesized by amination of 2, 5-dihydroxybenzoic acid derivatives using fungal laccases II. *Chem Pharma bulletin* 55:412-416
- [26] Sagui F, Chirivì C, Fontana G, Nicotra S, Passarella D, Riva S, Danieli B (2009) Laccase-catalyzed coupling of catharanthine and vindoline: an efficient approach to the bisindole alkaloid anhydrovinblastine. *Tetrahedron* 65:312-317
- [27] Ose T, Watanabe K, Mie T, Honma M, Watanabe H, Yao M, Oikawa H, Tanaka I (2003) Insight into a natural Diels-Alder reaction from the structure of macrophomate synthase. *Nature* 422:185-189
- [28] Alphanh V, Carrea G, Wohlgemuth R, Furstoss R, Woodley JM (2003) Towards large-scale synthetic applications of Baeyer-Villiger monooxygenases. *Trends Biotechnol* 21:318-323
- [29] Sedmera P, Halada P, Peterbauer C, Volc J (2004a) A new enzyme catalysis: 3,4-dioxidation of some aryl β -d-glycopyranosides by fungal pyranose dehydrogenase. *Tetrahedron Lett* 45:8677-8680
- [30] Kimoto N, Yamamoto H (2004). Novel enone reductases isolated from *Kluyveromyces lactis*, methods for producing same, and methods for selectively reducing a carbon-carbon double bond of an Alpha, Beta-unsaturated ketone using the reductases. In: Google Patents
- [31] Bell SG, Orton E, Boyd H, Stevenson JA, Riddle A, Campbell S, Wong LL (2003) Engineering cytochrome P450cam into an alkane hydroxylase. *Dalton Transac* 11:2133-2140
- [32] Colonna S, Pironti V, Carrea G, Pasta P, Zambianchi F (2004a) Oxidation of secondary amines by molecular oxygen and cyclohexanone monooxygenase. *Tetrahedron* 60:569-575
- [33] Massey V (2000) The chemical and biological versatility of riboflavin. *Biochem Soc Trans* 28:283-296