Enzymes in lipid modification: From classical biocatalysis with commercial enzymes to advanced protein engineering tools

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Biocatalysis plays an important role in lipid modification due to the high chemo-, regio- and stereoselectivity, the mild reaction conditions and the commercial availability of many enzymes [1-3]. Lipases are the predominant enzymes, as they can be used to synthesize a broad range of products from natural fats or oils, they show very high stability/activity and consequently a range of processes have been commercialized by industry.

Application of lipases include structured triglycerides [4,5], enrichment and incorporation of polyunsaturated fatty acids (such as EPA or DHA from fish oil) [6], the synthesis of sugar esters [7], cosmetic ingredients or fatty acid methylesters used as Biodiesel [8]. Most of these are based on a few commercial immobilized lipases. However, modern methods of protein engineering [9-11] allow to tailor-design the properties of enzymes for a given process. We used this tool to create and identify a lipase with improved stability in the transesterification of lipids [12]. More recently, we could substantially alter the selectivity of lipase A from Candida antarctica (CAL-A). The best lipase variants show distinct selectivity for trans- and saturated fatty acids, which is a very useful feature to remove trans fatty acids from partionally hydrogenated plant oil [13]. Furthermore, we created mutants of CAL-A, which now can only hydrolyze short to medium chain fatty acids making these variants interesting for the selective enrichment of these fatty acids and for the synthesis of specific triglycerides [14]. Beside lipases, we have also investigated various phospholipases: phospholipase D was used for head group exchange [15] and phospholipase C for degumming of natural oils [16,17]. In order to remove the contaminant 3-mono-chloro-1,2-propanediol (3-MCPD) we developed an enzymatic method based on the combined use of a dehalogenase and an epoxide hydrolase

resulting in the efficient detoxification of plant oils by converting 3-MCPD into glycerol [18].

This lecture will hence give an overview about the different applications of enzymes in lipid modification developed in the past two decades. In addition, a prospective view on novel concepts such as synthetic biology and metabolic engineering for the production of lipids and related products as well as current challenges for biocatalysis in lipid modification will be addressed.

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