Immobilized Lipases: An Old-Fashioned Twist for a New Generation of Industrial Biocatalysts

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Introduction

Lipase catalysed reactions are bio-inspired processes, serving the requirements to integrate environmental welfare with economical demands of modern industry [1]. Microbial lipases are especially prominent industrial biocatalysts with wide array of applications, owing to cost-effective production, pronounced chemo-, regio- and stereoselectivity, high catalytic efficiency in reaction systems with different water content (aqueous solutions to nearly anhydrous systems) and the possibility of tailoring them according to one’s need [2-5]. However, their application is often hampered by the lack of long-term stability and difficulties with biocatalyst recovery and recycling.

Elaboration of the right stabilization protocol for lipases is a true work of art, because myriad of opportunities available. Nonetheless, carefully executed immobilization still represents an indispensable tool to improve almost all lipase properties, required for industrial practice [6]. Due to the phenomenon of interfacial activation, lipases are traditionally immobilized on hydrophobic supports, leading to enzyme hyperactivation [7]. Recently, by simple physical adsorption of Candida rugosa lipase (CRL) on hydroxypatite, a biocompatible biocatalyst with improved thermal stability and excellent stability in methanol was designed, for innovative biosynthesis of short-chain methyl-alkyl-ester salts [8]. Two-step covalent immobilization of lipase B from Candida antarctica (CALB) on epoxy-activated Purolite A109 has yielded an immobilized preparation with higher thermal stability compared even with commercial immobilized CALB – Novozyme435 [9]. Such strategy was implemented for covalent attachment of CRL on Eupergit C, via lipase carbohydrate moiety. As a result, half-life of immobilized CRL at 75°C was 18 times higher, compared to free enzyme [10]. By immobilizing CRL, CALB and Rhizopus oryzae lipase in polymer networks, different membrane reactors for hydrolysis of olive oil, synthesis of butyl-butyrate and esterification of lauric acid were obtained [11-13]. Extremophilic lipase from Pseudomonas aeruginosa san-ai strain, used in detergents, leather manufacturing and for production of fine chemicals, was immobilized on alginate-type exo-polysaccharide, co-produced and co-secreted with the enzyme [14]. This cost-effective, time-saving approach for simultaneous production, purification and immobilization of lipase, showed a great potential of improving reusability of this enzyme.

Nanoparticles have also emerged as efficient immobilization supports, because of high specifc area, effective enzyme loading and resistance to mass transfer effects [15]. Upon immobilization on magnetic cellulose nanocrystals, significant improvements of Pseudomonas cepacia lipase pH, temperature, organic solvent and storage stability were observed. Moreover, the same immobilized enzyme preparation was used for high-yield asymmetric ketoprofen-ethyl ester hydrolysis [16]. Also, it was revealed that immobilization of CRL on chemically modified silica nanoparticles results with novel biocatalyst with increased thermal stability, operational stability and esterification activity [17,18].

Carrier-free immobilized preparations are relatively new self-assembled systems, based on covalent crosslinking of enzyme molecules in different forms (crystals, aggregates or spray-dried). This proved to be very convenient method for CRL immobilization, giving rise to improved thermal stability and enantioselectivity of immobilized biocatalyst [19].

Constant development in the field of industrial catalysis has given rise to novel applications of lipases as important group of industrial enzymes. Even though it is considered as an old-school technique, immobilization still remains an inexhaustible source of opportunities for making lipases suitable for industrial transformations of a new generation.

References


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