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Research on Biocatalysts: A Review

Sunil Jayant Kulkarni[1*]

[1*]Chemical Engineering Department, Datta Meghe College of Engineering, Airoli, Navi Mumbai, Maharashtra, India.

*E-mail: suniljayantkulkarni@gmail.com

Abstract:

Reducing the cost of a process and improving product yield and selectivity are important aspects in process intensification. Many reactions are chemically catalyzed for increasing the rate. Many times the chemically catalyzed reactions have low selectivity. The formation of byproduct is also undesired. The use of biocatalysts is being explored for many reactions in pharmaceutical and fine chemical industries. Immobilization techniques can improve the biocatalyst reactions by providing chemical and physical stability to enzymes. The present review summarizes research carried out for application of biocatalysts in chemical and pharmaceutical product synthesis.

Keywords:

Enzymes; selectivity; biocatalysts; fine chemicals; pharmaceutical industries

Introduction

The processes used in chemical industries are ever evolving. The reduction in cost and space are always important factors in process intensification[1,2]. Nano particles are being used for intensifying many chemical reaction and processes[3,4]. Various process intensification methods used in chemical industries include reactive adsorption, reactive chromatography, extractive and reactive distillation[5,6,7,8]. Hydrotropism is also effective tool for intensifying processes [9,10]. Biotechnology and biochemical engineering has provided new dimension to process intensification and optimization. Conventional catalyzed reactions are many time less specific and produce undesired products. This aspect is more important in pharmaceutical and fine chemicals production. Replacing conventional reactions by enzyme catalyzed reactions is effective alternative in synthesis of many products. These enzymes are typically derived from plants, or animal tissue, micro-organisms like yeast, bacteria or fungi. High selectivity is a major advantage of enzyme catalyzed reactions. The present review provides summery of research on application of biocatalyst for various products in chemical, pharmaceutical and allied industries.

Research on Biocatalysts

Safarikova et.al. used ferrofluid modified Saccharomyces cerevisiae cells as biocatalyst[11] .They used it to catalyze hydrogen peroxide decomposition. They prepared yeast cells from bakers yeast and modified them magnetically. They found, for the ferrofluid formation with citric acid , the prepared magnetically responsive biocomposite was very fine and its complete magnetic separation took a long time (ca. 30 min). Also it was observed that tetramethylammonium hydroxide stabilized ferrofluid provided significantly better results for tested intracellular enzymes activities compared to ferrofluid stabilized with perchloric acid. They concluded that

Ferrofluid modified S. cerevisiae cells can thus be used as non-toxic and efficient magnetically responsive whole cell biocatalysts. Reduction of cyanobacteria as biocatalysts was used by Gorak et.al. for the reduction of diethyl 2-oxopropylphosphonate[12]. They, for the first time reported effective use of phototrophic microorganisms as a potential biocatalyst for the production of chiral 2-hydroxyalkylphosphonate esters. When Arthrospira maxima were applied, the degree of conversion of the substrate was 26.4%, for 7 days biotransformation process. Fechter and Griengl reviewed the state of the art regarding the application of hydroxynitrile lyases to obtain, (R)- and (S)-cyanohydrins of aldehydes and ketones[13]. They observed that the contributions by different research groups has enabled the enantioselective cyanohydrin reaction that is catalyzed by hydroxynitrile lyases to develop into a valuable tool for obtaining both (R)- and (S)-configured products in high enantiomeric purity.Rodak used Fungi as biocatalyst for the synthesis of optically pure phosphonates[14]. They emphasized that biocatalysis was an effective and in many cases preferable alternative to the standard, chemical synthesis of optically active forms of fine chemicals, including phosphonates. According to Rodrigues et.al. in the process intensification developments, applied biomagnetic processes can be very handy[15]. Their work addressed preparation of magnetic biocatalysts (whole cells). The work was aimed at unconventional production of biodiesel by magnetically assisted bioprocesses. They observed that the carrier mechanical resistance, stability and consequently their catalytic performance was affected by the magnetic content and the immobilization method. They used chitosan for microorganism immobilization by applying adsorption technique. For alginate, entrainment was used. They concluded that deeper study is necessary for detailed understanding of the effect of using magnetite in enzymatic activity of particles. Kaushik et.al. provided an insight into biocatalysis and biotransformation Processes[16]. In order to find economically viable, reliable and scalable processes with minimal waste generation, it very important to explore application of biocatalyst . The biocatalyst processes are widely accepted in the pharmaceutical and fine chemicals. High selectivity of biocatalyst offers unique advantage over conventional chemical catalyst for high yield of molecules with the functional groups at the desired locations. Miletic et.al. explored possibilities, advantages, and applications in immobilization of biocatalysts for enzymatic polymerization[17]. According to them biocatalytic pathways not only have enormous scientific and technological promise but also provide ecofriendly technology solutions. Bird et.al. described monitoring and controlling biocatalytic processes[18]. Biocatalysts are very important in process development. Since these biocatalysts are very sensitive, it is very important to have proper design and control strategy. They designed and tested a monitoring and control strategy that gave 30 percent product gain. According to them, the addition of reactant should be controlled and that an in-situ product removal process should be in place for effective and productive operation. Brady et.al. presented application of biocatalysis in synthetic chemistry[19]. According to them, biocatalysis helps in achieving, fewer Reaction Steps and Reduced material requirements. Also safety and environmental aspects are improved. Kinfe et.al. carried out investigation on application of stereoselective biocatalysts for the enantiomeric resolution of beta-hydroxynitriles[20]. According to them, stumbling blocks in the wide application of these enzymes biocatalytic methods for hydrolyzing nitriles using nitrilases and nitrile hydratase, include limited commercial availability, thermal instability, and limited range of substrates and poor stereoselectivity. They studied Asymmetric hydrolysis of 3-hydroxy-3-arylpropanenitriles and 3-hydroxy-4-aryloxybutanenitriles and obtained moderate to high selectivity. In their review, Bornscheuer and Pohl presented successful examples of the creation of suitable biocatalysts[21]. Their review was more focused on those published since 1999. According to the review, rational design and directed evolution are both applicable to creating desired mutant enzymes, although the positions of mutations often differ considerably. They also concluded that sequencing of variants from directed evolution followed by their structural analysis very often reveals that mutations were far away reaction site. The review on biocatalyst was also carried out by Robertson and Steer[22]. For implementation of enzyme technology in harsh industrial conditions, it is important to discover new enzymes and optimize the process. They also discussed enzyme discovery using novel genomic approaches. Enzymes are optimized by also direct mutagenesis. According to them, biocatalyst will be widely accepted when, enzymes are perceived to be robust, specific and inexpensive (i.e. process compatible). End and Schoning studied immobilized biocatalysts in industrial research and production[23]. They introduced the use of various immobilized biocatalysts in industrial research and production. Covalent bonding, entrapment and adsorption techniques were used in enzyme catalysis. Also the study revealed that the immobilization of catalyst provides higher stability with regard to temperature, pH and catalyst poisoning. Also higher shear resistance, repetitiveness, high activity, separation and rate of reaction are other advantages of immobilization. Cost and diffusional resistance are barriers in applying this technique for enzymes. It also important to develop proper immobilization technique. It was concluded that hydrolases was most widely used enzyme.

Conclusion

Enzyme catalyzed reactions are being widely used in chemical, biochemical and pharmaceutical industries. Various enzymes are being developed for replacing conventional catalysts. The immobilization provides physical and chemical stability to enzymes. They are also environmental friendly. It can be concluded that biological pathways like enzyme catalyzed reactions are very effective and environmental friendly alternative to chemically catalyzed reactions.

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About Author

Mr. Sunil Jayant Kulkarni has completed his Masters in Chemical Engineering from Tatyasaheb Kore Institute of Engineering and Technology, Warananagar. He is working as Assistant Professor in Chemical Engineering Department of Datta Meghe College of Engineering, Airoli, Navi Mumbai, India. He has published 45 international review and research papers and presented 13 research papers in international conferences. His area of research includes adsorption, distillation, environmental engineering. He is on the reviewer/editorial board of 16 international journals and reviewed many international papers.