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Overview of biocatalysis

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PERSPECTIVE

Biocatalysis is the use of live (biological) systems or components of living (biological) systems to accelerate (catalyse) chemical processes. Natural catalysts, such as enzymes, execute chemical changes on organic substances in biocatalytic processes. For this purpose, enzymes that have been more or less isolated as well as enzymes that are still present inside living cells are used. The manufacture of modified or non-natural enzymes is now possible thanks to modern biotechnology, especially controlled evolution. This has facilitated the development of enzymes capable of catalysing new small molecule transformations that would otherwise be difficult or impossible to achieve using traditional synthetic organic chemistry.

The biocatalyst is stated as the use of enzymes that occupy the inside of the living cells to initiate the conversions of organic compounds by chemical reactions.

The examples of biocatalyst include hormones or enzymes, which increase the rate of biochemical reactions. Eg: digestive enzymes such as trypsin, pepsin etc.

Advantages of chemoenzymatic synthesis

- Enzymes are ecologically friendly, as they disintegrate entirely in the environment. Most enzymes operate at mild or biological conditions, which reduces the risk of unwanted side reactions including decomposition, isomerization, racemization, and rearrangement that afflict older methods.
- For chemoenzymatic synthesis, enzymes can be immobilised on a solid substrate. These immobilised enzymes have excellent stability and reusability and may be utilised to run continuous reactions in microreactors.
- Enzymes may be changed to enable non-natural reactivity through the advent of protein engineering, specifically site-directed mutagenesis and directed evolution. Modifications may also make it possible to use a wider range of substrates, improve reaction rate, or increase catalyst turnover.

Enzymes are quite selective when it comes to their substrates. In most cases, enzymes have three distinct forms of selectivity:

Chemoselectivity: Because an enzyme's job is to operate on a specific type of functional group, other sensitive functionalities that would typically react to a degree during chemical catalysis are preserved. As a result, biocatalytic processes are "cleaner" and arduous product purification from contaminants introduced by side reactions may be largely avoided.

Diastereoselectivity and regioselectivity: Enzymes can discriminate between functional groups that are chemically located in various areas of the substrate molecule due to their complicated three-dimensional structure.

Enantioselectivity: Enzymes are chiral because they are virtually entirely comprised of L-amino acids. As a result, any chirality present in the substrate molecule is "identified" when the enzyme-substrate combination is formed. As a result, aprochiral substrate can be converted into an optically active product, and a racemic substrate's two enantiomers can react at different speeds.

These are the primary reasons why synthetic chemists are interested in biocatalysis, particularly the latter. The necessity to produce enantiopure molecules as chiral building blocks for pharmaceutical medicines and agrochemicals has sparked this interest.

Asymmetric biocatalysis

Biocatalysis may be classified into two types of approaches for obtaining enantiopure compounds:

1. A racemic mixture's kinetic resolution
2. Asymmetric synthesis catalysed by biocatalysis

The presence of a chiral item (the enzyme) in kinetic resolution of a racemic mixture turns one of the stereoisomers of the reactant into its product at a faster pace than the other stereoisomer of the reactant. The stereochemical combination has now been turned into a mixture of two distinct chemicals, allowing them to be separated using conventional methods.

In the purification of racemic mixtures of synthetic amino acids, biocatalyzed kinetic resolution is widely used. Many common amino acid synthesis methods, such as the Strecker Synthesis, produce a mix of R and S enantiomers. By acylating the amine with an anhydride and then selectively deacylating just the L enantiomer using hog kidney acylase, this combination may be purified. These enzymes are usually exceedingly selective for one enantiomer, resulting in very substantial rate differences, allowing selective deacylation. Finally, traditional methods such as chromatography can now separate the two compounds.

In such kinetic resolutions, the maximum yield is 50%, because a yield of more than 50% indicates that part of the incorrect isomer has also reacted, resulting in a lower enantiomeric excess. As a result, such processes must be stopped before reaching equilibrium. If such resolutions can be achieved while the two substrate-enantiomers are racemizing continually, then all substrate might theoretically be transformed into enantiopure product. This is referred to as "dynamic resolution."

A non-chiral unit becomes chiral in biocatalyzed asymmetric synthesis in such a way that the different potential stereoisomers are produced in varied amounts. The chirality is introduced into the substrate by influence of enzyme, which is chiral. Yeast is a biocatalyst for the enantioselective reduction of ketones. The chirality is introduced into the substrate by the impact of a chiral enzyme. Yeast is a biocatalyst for reducing ketones in an enantioselective manner.