Biocatalysis - INTRODUCTION

Biocatalysis, also referred to as enzymatic catalysis or biotransformation, is the use of enzymes or other biological catalysts to catalyse chemical reactions. In most cases, a group of proteins called enzymes will be carrying out the catalysis.

Enzymes are involved in life processes, including digestion and getting energy from digested food. Therefore, a lot of chemical reactions catalyzed by enzymes have a biologically-related function. Possibly the oldest example of biocatalysis is brewing, where microorganisms are used to convert sugars into alcohol.

Major Classes:

1. **Oxido-Reductases:** They catalyze oxidation-reduction reactions. Transfer of electron take place from one molecule to another.

2. **Transferases:** They catalyze the transfer of functional groups from one substrate to another.

3. **Hydrolases:** They catalyze hydrolytic reactions, in which a substrate is hydrolysed into two simpler products.

4. **Lyases:** They catalyze the reactions involving removal of a group leaving a double bond or the addition of a group to a double bond.

5. **Isomerase:** They control the conversion of one ~~of~~ isomer of a compound into another isomer of the same compound.

6. **Ligases:** This group of enzymes catalyze reactions in which new chemical bonds are formed. ATP provides the energy to make the new chemical bonds.

Advantages Over Traditional Catalysts

The use of enzymes, isolated enzymes or whole cells, as catalysts offer several advantages over traditional metal catalysts.

1. Enzymes are highly efficient, providing faster reaction rates than chemically catalysed reactions, and at lower concentrations.

2. Enzymes function under mild temperature and pH conditions, as well as in aqueous environments, enabling a tendency towards green large-scale processes.

3. Enzymes offer high specificity, being chemo-, regio-, diastereo-, and enantiospecific, targeting specific functional groups.

4. Enzymes lower the cost of chemical synthesis, and can be mass produced.

Applications :

The pharmaceutical, chemical, petroleum, agricultural, polymer and electronic industries have reported applications of enzyme catalysed syntheses. Industrial scale organic biotransformation includes hydrolysis, oxidation, reduction, addition-elimination, halogenation and dehalogenation, and transesterification reactions.

INDUSTRIAL APPLICATIONS OF ENZYME CATALYSIS

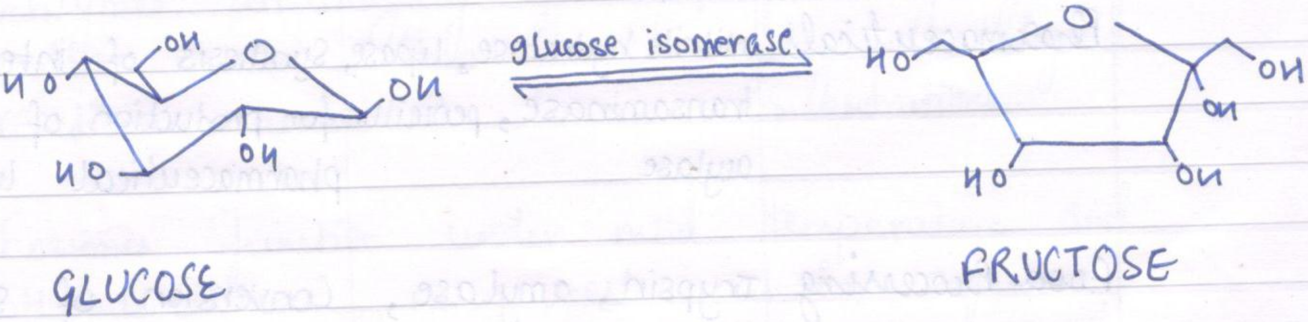
SECTOR	ENZYME	APPLICATIONS
Pharmaceuticals	Nitrile hydratase, Lipase, transaminase, penicillin acylase	Synthesis of intermediates for production of active pharmaceutical ingredients.
Food Processing	Trypsin, amylase, glucose isomerase, papain, pectinase	Conversion of starch to glucose, production of high fructose corn syrup, production of prebiotics, debittering of fruit juice.

Detergent	Protease, lipase, amylase, cellulose	Stain removal, removal of fats & oils, color retention.
Biofuels	Lipase, cellulase, xylanase	Production of fatty acids methyl esters, decomposition of lingocellulotic material for bioethanol production
Paper & Pulp	Lipase, cellulase, xylanase	Removal of lignin for improved bleaching, improvement in fibre properties.

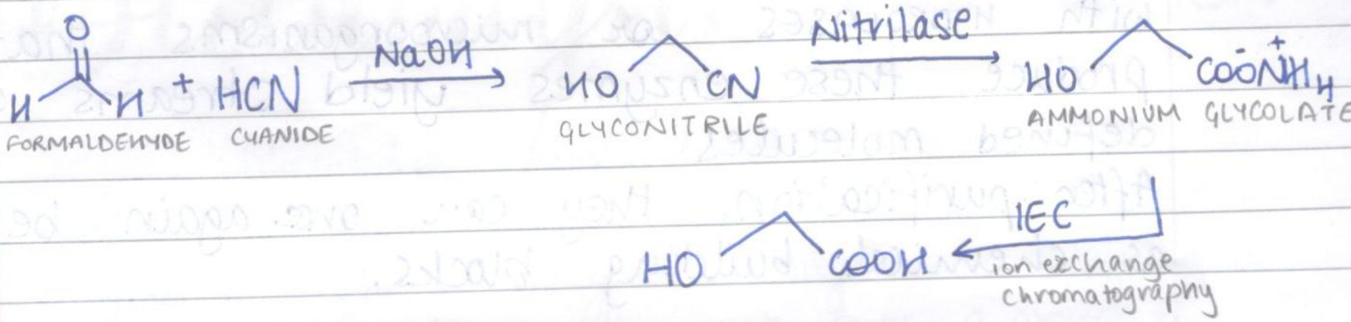
- Synthesis of fructose

There is a huge demand for sweeteners. A straightforward manner to increase the sweetness of glucose is its isomerisation to fructose.
The resulting high fructose corn syrup is used on bulk scale in our everyday food.

The enzyme used: Glucose isomerase.



- Chemoenzymatic synthesis of glycolic acid

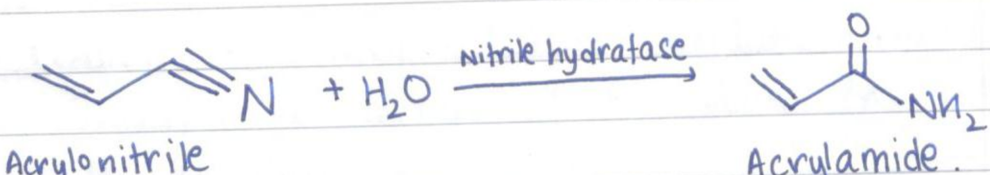


The enzyme used: Nitrilase

Nitrilases convert nitrile directly to the acid without amide intermediate.
The nitrilase is produced in E. Coli and is used in the immobilised whole cells of E. Coli

- Acrylamide production

The enzyme used: Nitrile hydratase
This enzyme selectively hydrolyse a nitrile to the amide but not any further.



- Plastic recycling

The biodegradation of plastics by microorganisms is a popular topic for research, as it represents a cheap & green technology for the degradation process of synthetic polymers.

The treatment of plastics that contain hydrolysable bonds in their backbones with HYDROLASES or microorganisms that produce these enzymes yield streams of defined molecules.
After purification, they can once again be used as chemical building blocks.

Polyester- and polyamide- based plastics have repeated units of one/two monomers which are kept together either by ester or amide bond. The selective hydrolysis of these bonds using enzymes releases the monomer

∴ enzymes allow recycling of polyester-based polymers like PET, PLA etc.

Enzymes used: cutinase, lipase, esterase, Alkaline protease, urethanase, aryl acylamidase.