

these catalyses the isomerization type reactions such as racemization or converting R to S or D to d & vice versa.

⑥ ligases -> these undergo joining of two molecules with covalent bond or in joining of DNA base pairs

Industrial Application of Biocatalysts.

Biocatalysts are highly advantageous in controlling pollution and are highly helpful at industrial level. The following are the applications of biocatalyst at industrial level.

1) It helps in the synthesis of ethanol, monosodium glutamate, citric acid and L-aspartate.

a) ethanol

- > used as solvent in manufacture of varnishes and perfumes.
- > used in preparation of essences and flavorings.
- > used as disinfectant.

b) monosodium glutamate

- > used as flavor enhancer
- > found in glucon-D, ORS, maggi.

c) citric Acid

- used in Kurkure (as sour powder)
- added to jams, jellies, candy and canned foods.

d) d-aspartate

- used as artificial sweetener.
- used as dietary supplement.

2) Lipases that are obtained from coat grains are used for hydrolysis and trans-esterification of oils and fats.

trans cinnamic acid when treated in presence of NH_3 lyase produces d-phenyl amine.

Driving forces for biocatalyst development

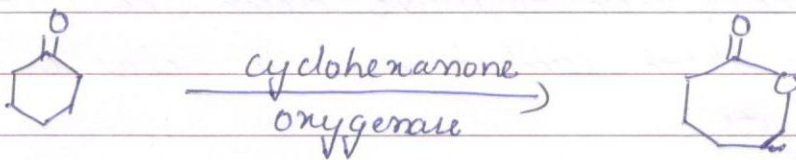
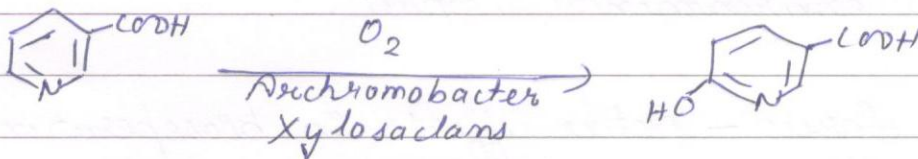
Four major forces drive biocatalyst technology in 'chemical-based' industries.

- 1) **Societal forces** - Society is constantly demanding new technologies, new products & new ways of living. Examples include health products such as biosensors, tissue plasminogen activator (TPA) & Epopen, and commodity items such as stain-removing detergents, preworn-looking blue jeans, and reduced-calorie food products. Society also demands that technology development includes minimal environmental impact.
- 2) **Business forces** - Active efforts in bioseparation systems are being undertaken to drive down the cost of biocatalysts to make them competitive with classic inorganic/organic catalysts.
- 3) **Government - , regulatory & "cause"-driven forces** - Concerns about "greenhouse gases", especially CO_2 , will drive new "closed carbon cycle" methods, e.g., fine organic chemicals produced by metabolic engineering of crops.
- 4) **Basic research pressure** - Significant industrial and

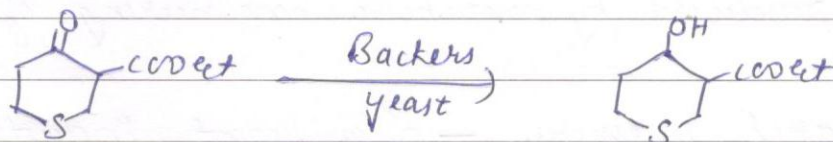
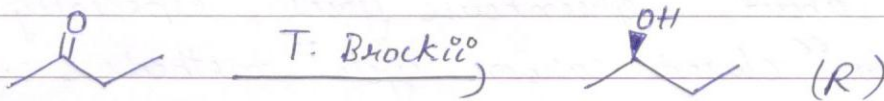
practical technologies result from the search of basic science for truth & discovery. Examples include DNA sequencing was designed to help researchers decode ~~gen~~ genetic information, but with improved methods, the sequencing of human genome & other improved important crops & species could lead to new health therapies & or improved crop production.

Commercialized & bioprocesses

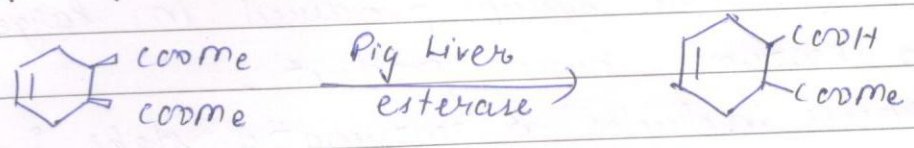
1) Oxidation



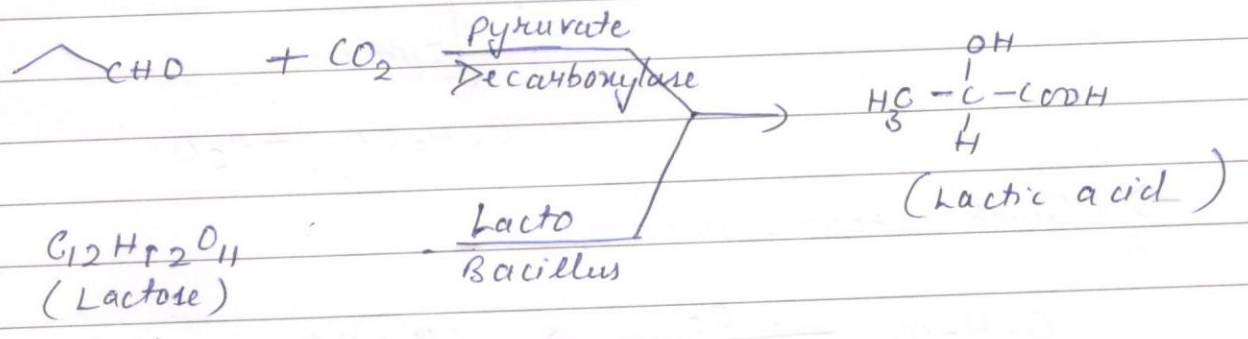
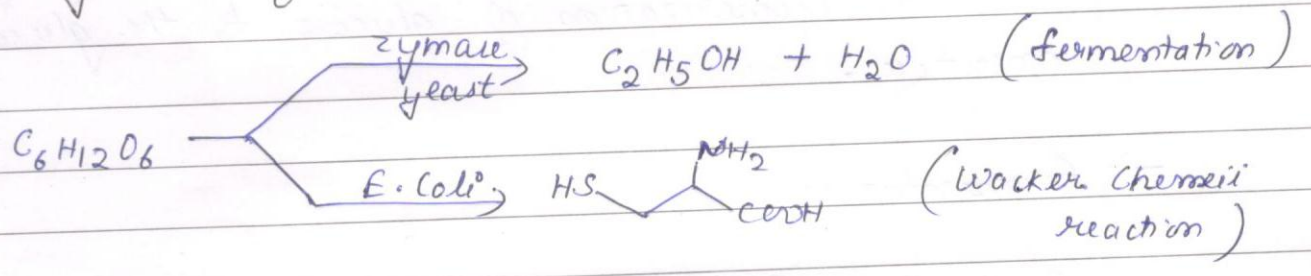
2) Reduction as well as stereoselective reduction.



3) Hydrolytic Process



4) Enzyme specific reactions



Other examples

-> The enzyme nitrile hydratase from *R. rhodococcus* strain has been developed for the hydrolysis of acrylonitrile to acrylamide for use in plastics.

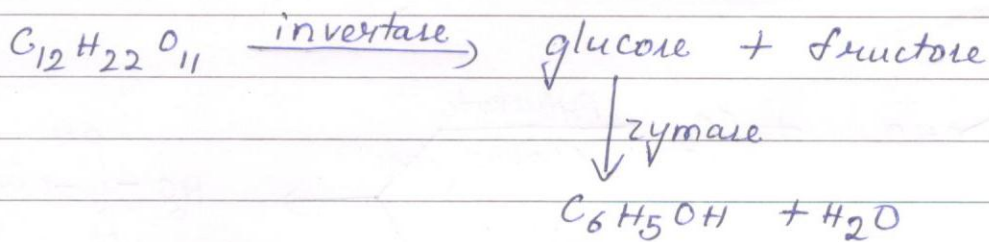
-> The DSM-Toyo Soda process uses the enzymatic protease thermolysin for manufacture of aspartame and is illustrative of two types of biocatalyst selectivity: chemical & stereoselectivity.

-> High fructose corn syrup produced in large quantities is an enzyme based product.

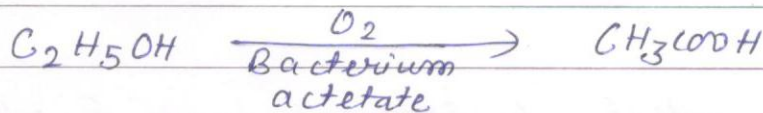
The process includes 3 enzymatic steps:

The α -amylase catalyzed liquefaction of corn syrup, further hydrolysis of sugar oligomers by glucoamylase & the isomerization of glucose to the glucose-fructose mixture.

-> fermentation



-> Quick vinegar process



Limitations of Biocatalysts

- 1) The reactions may be slow and not all organic substrates are soluble in aqueous medium.
- 2) The enzymes are highly expensive and difficult to recover and reuse.
- 3) The enzymes lose their activity too quickly especially at elevated temperature. The recovery of the product from dilute solution is highly complicated.
- 4) It is difficult to obtain pure enzymes free of contamination and it might degrade the substrate or produce by-product.
- 5) It may be difficult to shift the equilibrium in the reaction for 100% conversion.
- 6) In biology, the organisms may secrete products into the medium that can destroy the cells for recovery of product as the optimal growth of organism is difficult to work out.