17.2D: Enzymes Used in Industry

Enzymes are biological molecules that catalyze (increase the rates of) chemical reactions.

Learning Objectives

- Describe the use of enzymes in industry

Key Points

- Since enzymes are selective for their substrates and speed up only a few reactions from among many possibilities, the set of enzymes made in a cell determines which metabolic pathways occur in that cell.
- Synthetic molecules called artificial enzymes also display enzyme-like catalysis.
- Enzymes are used in the chemical industry and other industrial applications when extremely specific catalysts are required.

Key Terms

- **chemical reactions**: Processes that lead to the transformation of one set of chemical substances to another.
- **rennin**: A proteolytic enzyme, obtained the gastric juice of the abomasum of calves, used to coagulate milk and make cheese.
- **enzymes**: Biological molecules that catalyze (i.e., increase the rates of) chemical reactions.
- **Synthetic**: The combination of two or more parts, whether by design or by natural processes. It may imply being prepared or made artificially, in contrast to naturally.
Enzymes are biological molecules that catalyze (increase the rates of) chemical reactions. In enzymatic reactions, the molecules at the beginning of the process, called substrates, are converted into different molecules, called products. Almost all chemical reactions in a biological cell need enzymes in order to occur at rates sufficient for life. Since enzymes are selective for their substrates and speed up only a few reactions from among many possibilities, the set of enzymes made in a cell determines which metabolic pathways occur in that cell.

![Figure: Enzymatic Catalysis](https://bio.libretexts.org/Bookshelves/Microbiology/Book%3A_Microbiology_(Boundless)/17%3A_Industrial_Microbiology/17.2…)

**Figure: Enzymatic Catalysis: Model of enzymatic catalysis**

Like all catalysts, enzymes work by lowering the activation energy for a reaction, thus dramatically increasing the rate of the reaction. As a result, products are formed faster and reactions reach their equilibrium state more rapidly. Most enzyme reaction rates are millions of times faster than those of comparable un-catalyzed reactions.

As with all catalysts, enzymes are not consumed by the reactions they catalyze, nor do they alter the equilibrium of these reactions. However, enzymes do differ from most other catalysts in that they are highly specific for their substrates. A few RNA molecules called ribozymes also catalyze reactions, with an important example being some parts of the ribosome. Synthetic molecules, called artificial enzymes, also display enzyme-like catalysis.

Enzyme activity can be affected by other molecules. Inhibitors can decrease enzyme activity; activators can increase activity. Many drugs and poisons are enzyme inhibitors. Activity is also affected by temperature, pressure, chemical environment (e.g., pH), and substrate concentration. Some enzymes are used commercially; for example, in the synthesis of antibiotics. In addition, some household products use enzymes to speed up biochemical reactions (e.g., enzymes in biological washing powders break down protein or fat stains on clothes; enzymes in meat tenderizers break down proteins into smaller molecules, making the meat easier to chew).

Enzymes are used in the chemical industry and other industrial applications when extremely specific catalysts are required. However, enzymes in general are limited in the number of reactions they have evolved to catalyze, and by their lack of stability in organic solvents and at high temperatures. As a consequence, protein engineering is an active area of research and involves attempts to create new enzymes with novel properties, either through rational design or in vitro evolution. These efforts have begun to be successful, and a few enzymes have now been designed “from scratch” to catalyze reactions that do not occur in nature.

In food processing, the enzymes used include amylases from fungi and plants. These enzymes are used in the production of sugars from starch, such as in making high-fructose corn syrup. In baking, they catalyze the breakdown of starch in the flour to sugar. Yeast fermentation of sugar produces the carbon dioxide that raises the dough. Proteases are used by biscuit manufacturers to lower the protein level of flour. Trypsin is used to predigest baby foods. For the processing of fruit juices, cellulases and pectinases are used to clarify fruit juices. Papain is used to tenderize meat for cooking.
In the dairy industry, rennin, derived from the stomachs of young ruminant animals (like calves and lambs) is used to manufacture of cheese, used to hydrolyze protein. Lipases are implemented during the production of Roquefort cheese to enhance the ripening of the blue-mold cheese. Lactases are used to break down lactose to glucose and galactose.

In the brewing industry, enzymes from barley are released during the mashing stage of beer production. They degrade starch and proteins to produce simple sugar, amino acids, and peptides that are used by yeast for fermentation. Industrially-produced barley enzymes are widely used in the brewing process to substitute for the natural enzymes found in barley. Amylase, glucanases, and proteases are used to split polysaccharides and proteins in the malt. Beta-glucanases and arabinoxylanases are used to improve the wort and beer filtration characteristics. Amyloglucosidase and pullulanases are used for low-calorie beer and adjustment of fermentability. Proteases are used to remove cloudiness produced during storage of beers.

In the starch industry, amylases, amylglucosideases, and glucoamylases convert starch into glucose and various syrups. Glucose isomerase converts glucose into fructose in production of high-fructose syrups from starchy materials.

In the paper industry, amylases, xylanases, cellulases, and ligninases are used to degrade starch to lower viscosity, aiding sizing and coating paper.

In the biofuel industry, cellulases used to break down cellulose into sugars that can be fermented (see cellulosic ethanol).

In the production of biological detergents, proteases, produced in an extracellular form from bacteria, are used in pre-soak conditions and direct liquid applications, helping with the removal of protein stains from clothes.

In molecular biology, restriction enzymes, DNA ligase, and polymerases are used to manipulate DNA in genetic engineering, important in pharmacology, agriculture and medicine, and are essential for restriction digestion and the polymerase chain reaction. Molecular biology is also important in forensic science.

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