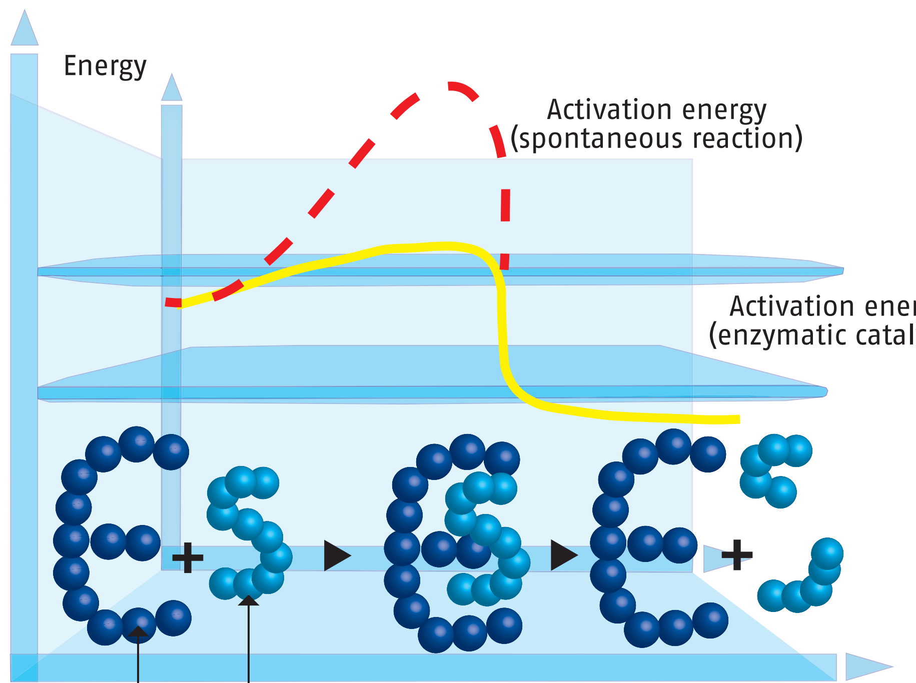
What are enzymes?

Mühlenchemie
Understanding Flour

Enzymes are biocatalysts. They accelerate biochemical reactions by lowering the activation energy, which has to be overcome to allow metabolism. They are no living organisms, but relatively small, water-soluble proteins.

Structure example: Simplified protein structure of a fungal α-amylase

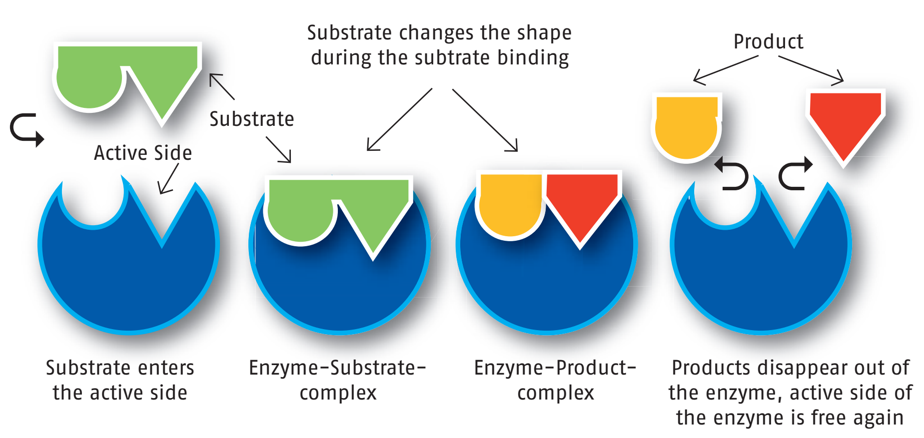
Enzymes are ubiquitous and occur in every cell of microbial, animal or plant life.



Theoretically, an enzymatic reaction is reversible, i.e. the products can be reconverted into the original substances. However, the reaction equilibria do often not match in practice. E.g. a hydrolysis, hence the degradation of a molecule under water adsorption, cannot be reversed in an aqueous environment, since the water released during the reverse reaction is confronted to a certain extent to the resistance of the ambient water and is pushed back into the substrate.

Mechanism

The starting materials (educts and/or substrates) of an enzyme reaction are bound in the so-called active side of the enzyme, forming an enzyme-substrate complex. By a reduction of the binding energy in the substrate molecule, the enzyme enables the conversion into the reaction products, which the complex subsequently releases.

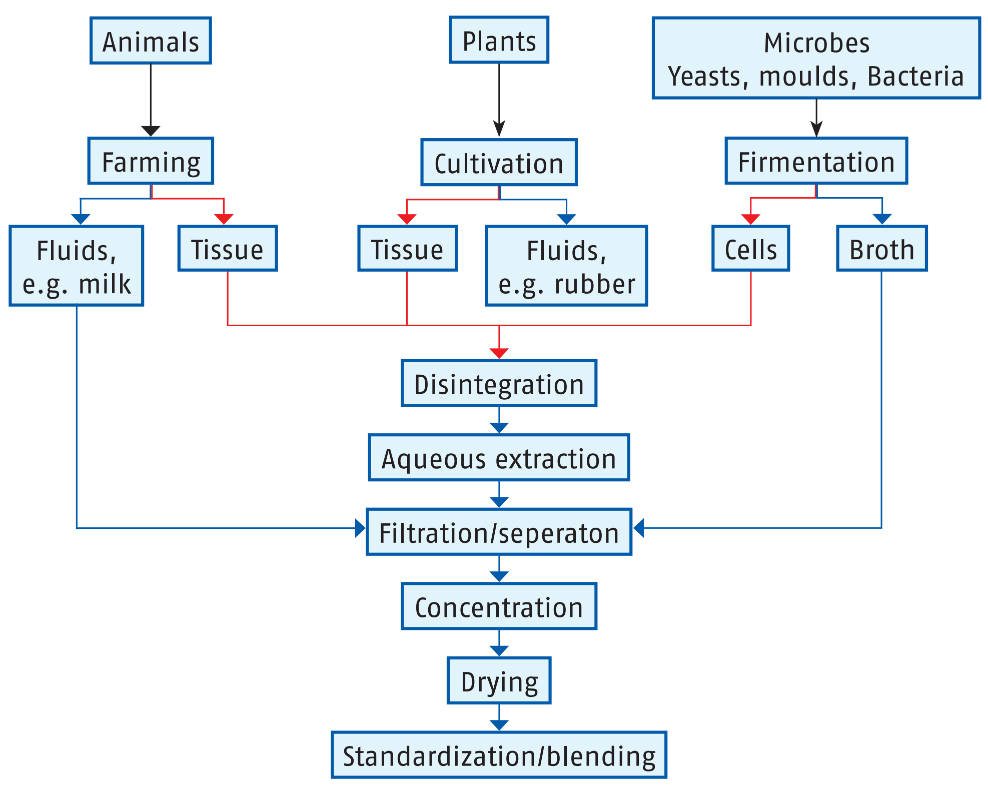


Enzymes are specific; they may oxidize and/or reduce, transfer, hydrolyze, separate, transform or generate. Enzymes are characterized by high substrate and reaction specificity, i.e. under numerous substances they select only the suitable substrates and catalyze exactly one of many conceivable reactions.

Due to specificity, the general term "key lock principle" is used, i.e. a substrate fits an enzyme and/or an enzyme fits a substrate. Like all catalysts, the enzyme is again present in the starting form after the reaction.

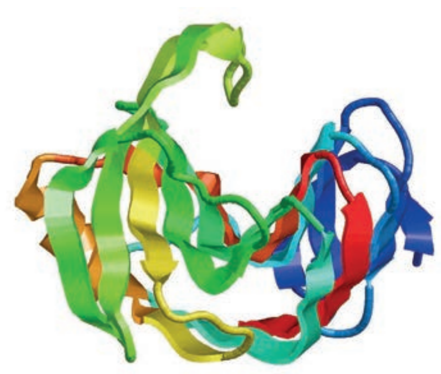
Origin

Enzymes are always of natural origin, namely animal, plant and, in most of the cases, microbial origin. Plant enzymes are mostly added as ingredients and/or extract to the food, e.g. the enzyme-active malt flour. They are obtained by germination and drying or extraction. Enzymes of microorganisms are won by fermentation or by cultivation on surfaces, and subsequent extraction. More rarely used are enzymes from animal sources, an example is lysozyme from egg as preservative in hard cheese, or lab enzyme in cheese production.



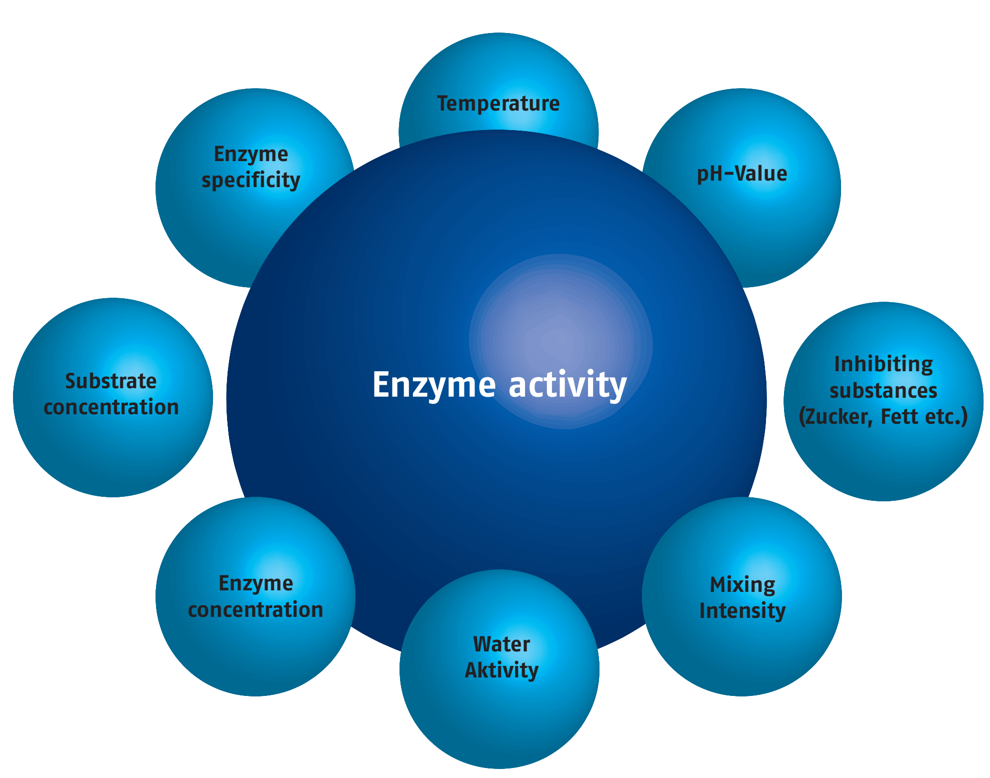
In some cases, the origin of an enzyme has a strong influence on the characteristic. Thus, e.g. alpha-amylase from a bacterium is different from alpha-amylase from fungi (see diagrams on pH and temperature dependence of the activity).

Structure example: Simplified protein structure of a bacteria xylanase

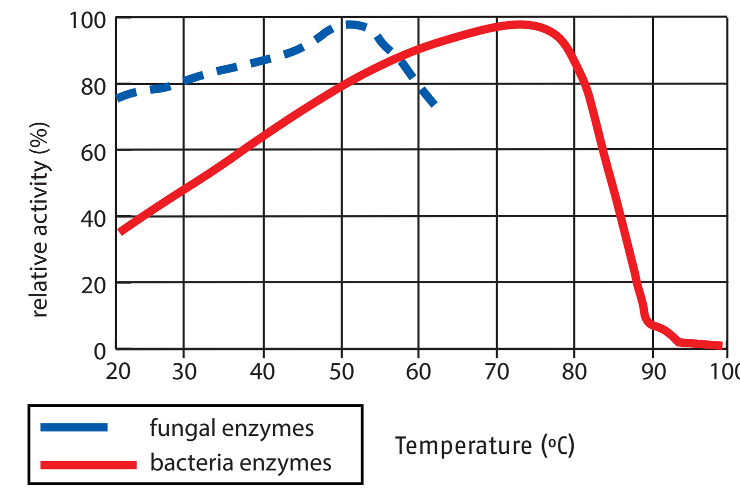


Factors of influence

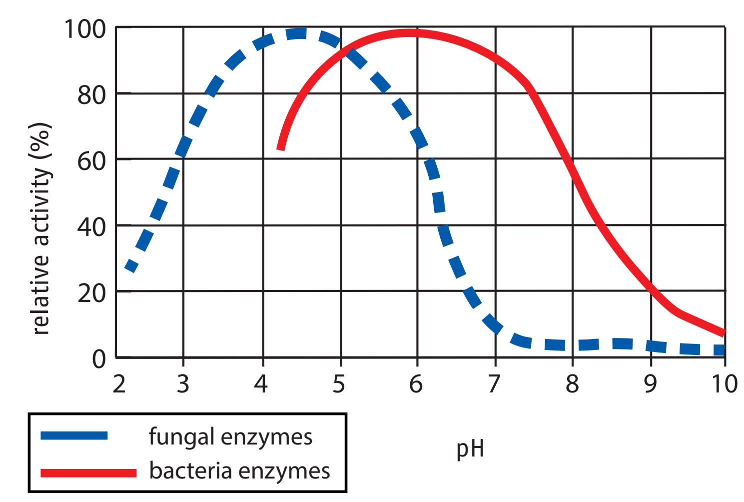
How fast an enzyme reaction runs off depends on many factors (see fig. Enzyme activity):It is important that all factors, which have an influence on the activity, reach an optimum. A sudden total loss of activity out of the optimal range is unusual.



Example temperature:



Example pH value:



Enzyme classes:

EC 1: Oxidoreductases
A- + B → A + B- [electrons] (e.g. metabolism)

EC 2: Transferases
A-X + B → A + B-X (e.g. transglutaminases)

EC 3: Hydrolases
A-B + H2O ↔ A-H + B-OH
(e.g. amylase, esterase, lactase, lipase etc.)

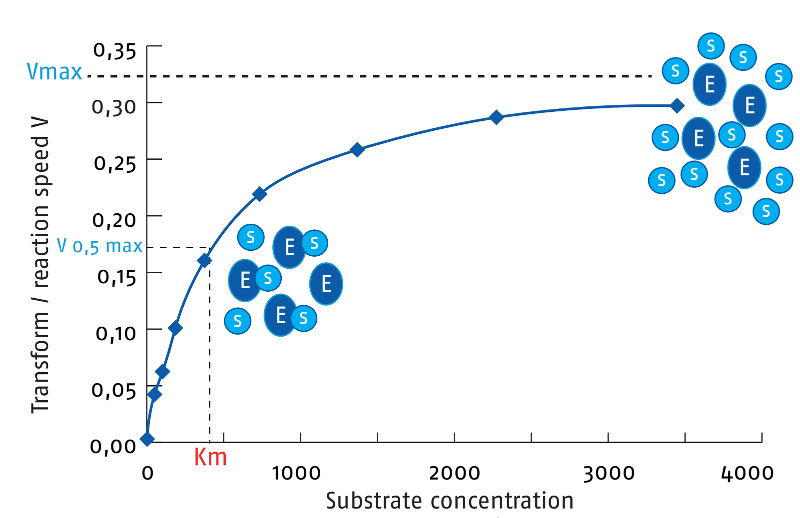
EC 4: Lyases
A-B → A+B (e.g. metabolism)

EC 5: Isomerases
A-B → B-A (often in medicine/DNA)

EC 6: Ligases
M1 + M2 + NTP → M1-M2 + NDP + P oder M1-M2 + NMP + 2P
(e.g. DNA)

Concentration and availability of the substrate

The concentration of the enzyme must as well be in the optimum range. If it is too low, the reaction rate is also low, as enzyme molecules are available only at few points of the system (e.g. a dough). If the concentration is too high, the enzyme molecules block and do not optimally reach the substrate.



If the substrate concentration is too high, it may come to an inhibition. Nevertheless, an inhibition can also be caused by other influences and/or other substances, e.g. by high salt concentrations.

Authors: Florian Paschen and Dr. Lutz Popper

Mühlenchemie GmbH & Co. KG | Kurt-Fischer Str. 55, D-22926 Ahrensburg | Tel.: + 49 (0) 41 02 / 202-001 | Fax: + 49 (0) 41 02 / 202-010 | info@muehlenchemie.com | www.muehlenchemie.com