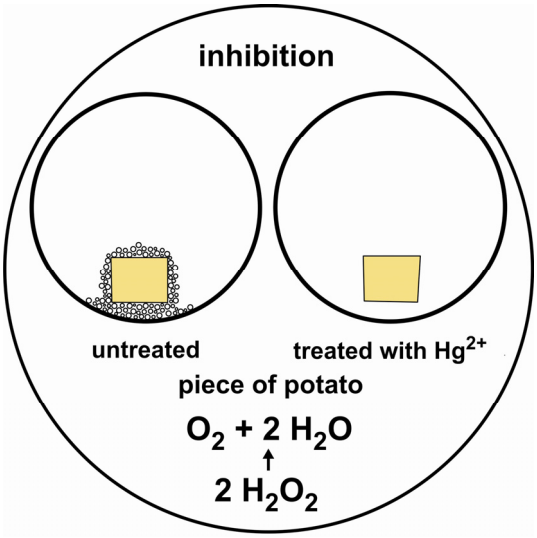
Inhibition of the Enzyme Catalase by Hg^{2+} Ions



Equipment:

2 small beakers
2 Petri dishes
tweezers

Chemicals:

peeled raw potato
hydrogen peroxide solution (6 % w/w)
mercury(II) chloride (0.1 % w/w)
deionized water

Safety:

hydrogen peroxide solution (H_2O_2):

H302, H318
P102, P280, P305 + P351 + P338, P301 + P312, P501

mercury(II) chloride ($HgCl_2$):

H341, H361f, H300, H372, H314, H410
P281, P280, P273, P301 + P330 + P331, P305 + P351 + P338

Mercury(II) chloride is highly toxic! It can be absorbed even through intact skin. In principle, the substance causes eye irritation.
It is necessary to wear a lab coat, safety goggles and protective gloves, because every contact with eyes or skin should be avoided. An adequate ventilation has to be provided.
The experiment can also be performed with other salts of heavy metals (e.g. $Pb(NO_3)_2$ or $CuCl_2$) but the inhibition effect is less pronounced; the enzymatic activity is only reduced. Precisely because mercury compounds are highly toxic they are very efficient as inhibitors.

Procedure:

Preparation: Two pieces of approximately equal size are cut out of the potato. 20 mL of mercury(II) chloride solution are filled in the first and 20 mL of deionized water in the second beaker. Subsequently, one potato piece is put in each of the beakers for approx. 1 min. The two Petri dishes are filled with hydrogen peroxide solution.
Procedure: The potato pieces are taken with tweezers out of the beakers and added to the hydrogen peroxide solution in the Petri dishes.

Observation:

An intense formation of foam caused by the escape of a gas can be observed immediately around the untreated potato piece. Around the potato piece treated with $HgCl_2$ solution, however, nearly no formation of gas takes place.

Explanation:

The disproportionation of hydrogen peroxide in aqueous solution to oxygen and water according to

$$2\ H_2O_2|w \rightarrow 2\ H_2O|l + O_2|g$$

is highly accelerated by the reaction-specific enzyme catalase present for example in potatos.
The tertiary and quaternary structure of proteins and therefore also of enzymes is often stabilized by disulfide bridges between cystine chains. Heavy metal ions, especially highly poisonous Hg^{2+} ions, exhibit a high affinity for (anionic) sulfur. Therefore, such ions may disrupt the disulfide bonds and modify the structure of the protein. This modification has an influence on the “active site;” the enzyme loses its catalytic properties irreversibly (“enzyme poisoning”).

Disposal:

The solution containing mercury has to be disposed of as especially hazardous heavy metal waste.