CALIFORNIA STATE SCIENCE FAIR
2003 PROJECT SUMMARY

Name(s)
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Project Number
J0407

Project Title
Enzyme-Catalyzed Reactions: What Affects Their Rate?

Abstract

Objectives/Goals
I wanted to look at how we can control the rate of an enzyme-catalyzed reaction such as the breakdown of hydrogen peroxide into water and oxygen (2H2O2>>H2O + O2) which is catalyzed by the enzyme catalase. I hypothesized that an enzyme-catalyzed reaction can be speeded-up, slowed down, or even stopped, by changing enzyme or substrate concentration, temperature, pH, or exposed area (between source of enzyme to substrate).

Methods/Materials
For the reaction 2H2O2>>2H2O + O2, I observed oxygen output which is proportional to the reaction's rate, by dipping filter disks in catalase enzyme extract (prepared from ground potato filtered through cheesecloth), and placing them at the bottom of a beaker with hydrogen peroxide (H202). The oxygen bubbles produced by the reaction "lifted" the filter disks, and I recorded the 'time-to-rise' which is inversely proportional to the reaction rate. I performed over 150 trials including variations (3-5 trials per variation for accuracy) on dilutions of enzyme or substrate, temperature, and pH, as well as a number of control runs.

Results
The rate of the reaction (1) increased with stronger catalase enzyme concentrations and leveled off at enzyme concentrations >60%; (2) increased with increasing concentrations of substrate (H2O2) and leveled off at 1.5% H2O2; (3) had optimum temperature range around 30C with lower temperatures decreasing the rate and higher temperatures decreasing the rate and even stopping the reaction (at >65C) when the enzyme was denatured; and (4) showed an optimum pH of 7 with the rate decreasing for lower pH. Control trials with enzyme-free disks showed that O2 production is only observable in the presence of catalase enzyme. Separately, placing different shapes of potato in H2O2 showed that the rate of the reaction is proportional to the exposed area between source of enzyme (potato) and H2O2 substrate.

Conclusions/Discussion
All variables observed were important for optimum enzyme activity, emphasizing the importance of being able to manage them to best control reactions in life processes, food preservation, and other applications. I was able to determine the optimum ranges for catalase (that I extracted from potatoes) as a catalyst in the breakdown of hydrogen peroxide to water and oxygen. The method I used to compare rates was reliable and I was able to duplicate results when I repeated similar conditions on different days.

Summary Statement
This project showed how enzyme-catalyzed reactions can be speeded-up, slowed down, or even stopped by adjusting certain key variables, and determined optimum ranges for the enzyme catalase

Help Received
My mother helped me get supplies, paste the board and enter this form online, and supervised my experiments. Ron Kalman helped me take digital photos of my techniques and results.