Studying the Effect of Hydrogen Peroxide Substrate Concentration on Catalase Induced Reaction

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1.0 Aim

In this experiment I have tried to study how the concentration level of the substrate Hydrogen Peroxide affects the reaction speed of the Catalase enzyme.

2.0 Background Research

2.1 Enzymes and Cell Metabolism

Biochemical reactions take place within a cell so that its regular operations can be performed. The pace of reactions can be sped up or slowed down according to the immediate needs and requirements of the body. The joining or separation of the cellular components can is facilitated in a coordinated and organized fashion by bringing them together in the enzyme-powered pathways to achieve this goal. Enzymes act as catalysts made up of protein that can facilitate this cellular arrangement by attaching or detaching the chemical groups with the substrates so that they can be converted into product, completing one biochemical reaction cycle. Enzymes achieve this through their shape changing and binding ability when they come in contact with the substrate molecules (Nature Education, 2010). The roles performed by the enzymes in aiding metabolism are as follows.

2.1.1 Accelerating Bio-Chemical Reactions

The chemical bond that exists in the molecules require a lot of energy to break down and to form. This energy cannot be generated by the body on its own to assist in all the chemical reactions happening at once. Enzymes help in catalyzing the reaction and reducing the amount of energy (called the activation energy) required by binding themselves to their specific substrates. The enzymes assume the complimentary position on the active site and the active site itself has the chemical properties that weaken the bond between the substrates. This causes the electron configuration of the bond to change thereby making it weaker and easier to break. Hence enzymes play their role to reduce the required activation energy by sourcing alternate reaction pathways so that the biochemical reaction can proceed faster without any corresponding increase in the temperature.

2.1.2 Lowering Activation Energy

Activation energy can only be reached by the substrates but only if supporting heat is provided. This is not possible as the heat would damage the living molecules and tissues. Moreover, heat

denatures proteins and organisms cannot survive at high temperatures. Therefore enzymes re there to reduce the amount of activation energy required by providing pathways to bring the specific molecules together instead of leaving everything to chances of coming in contact through random collision.

2.1.3 Substrate Specific Actions

Enzymes can aid reaction of their specific substrates only. Enzymes recognize their substrates by their respective chemical properties and active site. They can identify the reciprocally shaped active sites. The reaction itself does not have any effect on the chemical structure of enyme so it can be reused subsequently by the body.

2.2 Chemical Composition of Enzymes

Following are some of the characteristics as determined by the chemical composition of Enzymes (Tsai, 2006).

2.2.1 Catalytic Proteins

Enzymes are catalytic proteins that are made up of large chains of amino acids that can fold into different shapes. They have molecular weights ranging from 1.5×10^4 to 10^8 Da.

2.2.2 Cofactor Requirements

Some enzymes require cofactors substances for effective functioning. These cofactors are a non-protein group substance that can facilitate the formation of active sites. These are termed as holoenzymes. The non-protein part of the holoenzyme determine the reaction type and the protein part determine the substrate specifity.

2.2.3 Catalytic Efficiency

Enzymes are highly efficient catalytic reactors. They can increase the rate of reaction by upto 10^8 to 10^{15} times those of uncatalytic reactions without affecting the chemical equilibrium of reactions (Radzicka and Wolfenden, 1995).

2.3 Factors Affecting Enzymes

Following are major factors affecting the operation of enzymes.

2.3.1 Temperature

The rate of a reaction catalyzed by enzymes increases with the increase in temperature. This is because the increased temperature raises the kinetic energy of molecules so they travel faster and faster, increasing the chances of their collision with themselves and their interaction with the enzyme-powered pathways. Enzymes in human body are expected to work best at the normal body temperature of about 37c. They are expected to stop working at 60c as the excessive heat breaks down the hydrogen bond in enzymes.

2.3.2 Hydrogen Ion Concentration Level (pH)

Enzymes usually are found to work within a narrow range of pH concentration. Within this range there is one optimum pH level at which their activity is greatest. Besides it depends on the pH level of the environment in which enzymes operate, e.g., enzymes in the digestive system are expected to work best in the acidic conditions (Tsai, 2006).

2.3.3 Substrate Concentration

The rate of enzyme-catalyzed reactions are expected to have a direct correlation with the concentration of the substrate until all the enzymes are filled. As a result increasing the concentration further would not have any effect on the rate of reaction after a certain point (Tsai, 2006). I have selected this factor as an independent variable to test the effect of concentration of Hydrogen Peroxide on the catalytic reaction of Catalase (Kent, 2000).

3.0 Predictions

It is expected that the concentration of Hydrogen peroxide will increase proportionately the rate of reaction of Catalase-induced reaction up to a certain point after which it will become constant as every enzyme gets actively involved in operation and cannot work any faster even with the addition of more substrates. The Catalase is expected to decompose the hydrogen peroxide leaving water and oxygen gas behind which can be recorded to compare the volume of gas released within the same time.

4.0 Source of Enzyme and Substrate Concentration

Similar source of single potato is cut out to provide enzymes as catalase is present in abundance therein. The substrate concentration in my experiment would be varied by keeping five different concentrations of the Hydrogen Peroxide with the intervals of 20%. Since temperature and pH

level has an effect on the rate of reaction, these factors must be kept constant for optimum results.

5.0 Apparatus Required

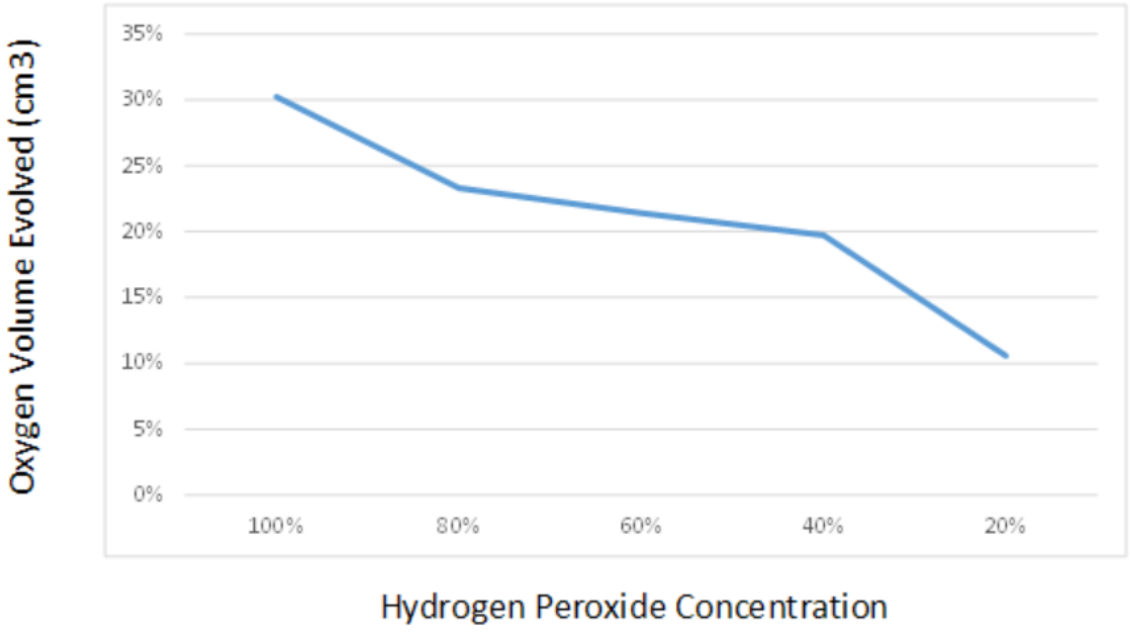
6 250 cm^3 beakers, 100 cm^3 burette, conical flask, electrical balance, stopwatch, 10 cm^3 syringes, white tile, hydrogen peroxide and potato as a source of enzyme.

6.0 Results, Patterns and Trends Observes

The trend found in the prediction was observed in the first 3 readings (and average thereof) showing the highest volumes of oxygen gas was evolved when the concentration level was highest at 100% and lower when diluted to 80%, and lowest when further diluted to 60% concentration as recorded in the readings taken at intervals of 120 seconds, shown in following table.

Concentration Level	First Reading (cm^3)	Second Reading (cm^3)	Third Reading (cm^3)	Average Reading (cm^3)
100%	34.1%	32.2%	24.4%	30.23
80%	25.7%	21.4%	23.0%	23.3%
60%	21.9%	20.7%	21.6%	21.4%
40%	16.8%	15.4%	27.0%	19.73%
20%	10.3%	9.3%	12.1%	10.57%

Average between the readings is taken to avoid any error due to fluctuations as observed above. This is demonstrated in the graph below. The oxygen gas released rapidly when the concentration level was highest. However, the volume of gas gradually decreased as concentration reduced. This is because at reduced concentration level of substrate, there are fewer Hydrogen peroxide molecules that can combine with the active sites in catalase. Hence the rate of reaction decreased and the oxygen produced is decreased.



7.0 Conclusion

The decreasing trend in the volume of oxygen gas produced in the reaction as a result of decomposition of hydrogen peroxide into water and oxygen gas as the concentration of hydrogen peroxide was decreased shows that the rate of reaction is directly proportional to the substrate concentration. The pace of reaction was fastest when the concentration of hydrogen was 100%, it reduced as the substrate solution was diluted. The rate of reaction levelled off and became constant after reaching a certain point as predicted. The findings are therefore in line with the background research.

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