Toothpickase Activity

Exploration Activity

Adapted by George Morse from an activity created by Peggy O'Neill Skinner, The Bush School
and modified by Barbara Grosz, Pine Crest School

Introduction

You have recently observed a demonstration involving the decomposition of hydrogen peroxide (H_2O_2) using manganese dioxide (MnO_2) as a catalyst for the reaction. Hydrogen peroxide is decomposed into water and oxygen gas. The glowing splint test that was performed helped to identify one of the products as oxygen.

Did you notice that the glowing splint test was negative for the hydrogen peroxide by itself? This shows that hydrogen peroxide did not *spontaneously* decompose.[1] This is because there was not enough energy for the reaction to get started. Manganese dioxide lowered the activation energy[2] needed for the reaction.

Biologists are very interested in *enzymes* – organic catalysts that control many of the reactions that occur in living organisms.

Toothpickase Procedure

You are going to simulate the action of an enzyme by breaking toothpicks during this activity. Hold a toothpick between your thumbs and fingers and break it. Your index fingers and thumbs represent the enzyme and the toothpick represents the *substrate*, the substance that the enzyme works on. The place where the toothpick fits between your fingers represents the *active site* of the enzyme. The active site is where the enzyme and substrate "fit together."

Count out 40 toothpicks and drop them in a pile in front of you. Pick up ***one*** toothpick and break it. Repeat this process as fast as you can for ten seconds. Drop the two broken pieces back onto the pile after you break the toothpick. Record the number of "reactions" that occur during the ten seconds. Record your data in Table 1.

Repeat this procedure for twenty more seconds. One group member counts the number of reactions and records them at ten second intervals. It is important to record the reactions at regular intervals so that they can be easily graphed.

Repeat the procedure for thirty more seconds. Again, one group member records the data at ten-second intervals.

Repeat the procedure for 60 more seconds and record the data.

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[1] Some spontaneous decomposition does occur but the rate of decomposition is very slow. There is not enough oxygen gas being produced to make the glowing split burst into flames. If you leave a bottle of hydrogen peroxide open long enough it will "go flat."

[2] Activation energy is the energy needed to start a chemical reaction.

Table 1: This is a data table for recording the number of reactions in 10-second intervals.

Time (seconds)	Number of Reactions	Time (seconds)	Number of Reactions	Time (seconds)	Number of Reactions
10		50		90	
20		60		100	
30		70		110	
40		80		120	

Figure 1:

Analysis

1. Write an appropriate title in the space next to "Figure 1." Plot a graph of the number of reactions verses time. Draw the curve that best conforms to the data. Label each axis of the graph.

2. Summarize Figure 1. What inferences can you make about enzyme reaction rate?

3. What do you think would happen to the reaction rate if the toothpicks were spread out so that the "enzyme" has to reach for them?

4. What do you think would happen to the reaction rate if the number of toothpicks were doubled? Use a colored pencil to draw a second curve on Figure 1 to describe your prediction.

5. What do you think would happen to the reaction rate if two students break toothpicks instead of one?