

Toothpickase Activity

Adapted from an activity created by Peggy O'Neill Skinner

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 at a rate we can measure with a burning splint. This is because there was not enough energy for the reaction to get started. Manganese dioxide lowered the activation energy needed for the reaction.

Biologists are very interested in *enzymes* – organic (protein) catalysts that control the myriad reactions that occur in living organisms. Enzymes are used in all metabolic pathways to control the rate of reactions and decrease the amount of activation energy necessary for each reaction to take place. Enzyme molecules are specific for each reaction catalyzed, and are reusable. Enzymes have an area called the active site to which a specific substrate will bond temporarily while the reaction is taking place. In this activity, you will simulate the reaction of an enzyme with its substrate.

Materials:

1 box of uncolored toothpicks per team
30 colored toothpicks per group
clock/watch with a second hand
1 roll of masking tape per team
Pencil
data sheet

Procedure:

In this activity, the toothpicks represent a substrate and your thumbs and index fingers represent the enzyme, *toothpick-ase*. When you break a toothpick, the place where the toothpick fits between your fingers represents the active site of the enzyme.

1. Count out 100 toothpicks on your desk. Do not add unbroken toothpicks at any time during this trial.
2. Break as many toothpicks as you can in 10 seconds and record this on the data table. Broken toothpicks should be thrown into the pile of unbroken toothpicks because products & reactants mix in metabolic reactions. DO NOT BREAK TOOTHPICKS ALREADY BROKEN!
3. Do another 10 seconds of breaking and count and record the number of toothpicks broken in the 20 seconds slot.

4. Do 10 seconds more of breaking and count and record the number of toothpicks broken in the 30 seconds slot.
5. Continue breaking toothpicks for additional times and record the total number of toothpicks broken at time intervals of 60, 120, 180, and 360 seconds of total running time. REMEMBER TO ALWAYS THROW BROKEN TOOTHPICKS BACK IN THE PILE, BUT DON'T RE-BREAK THEM!
6. Graph the total number of toothpicks broken as a function of time (10, 20, 30, 60, 120, 180 & 360 seconds. Be sure to title your graph and to label the x and y-axes.
7. Repeat steps 1-6 after spreading 100 unbroken toothpicks out over a very large area ($>2\text{m}^2$) area. Do not sweep the toothpicks into a pile, and remember to leave the broken toothpicks in the mix.
8. Add 30 colored toothpicks to a new pile of 100 unbroken toothpicks and repeat steps 1-6.
9. Use masking tape to tape the thumbs of the toothpick breaker to the palms of his or her hands. (In other words, immobilize the toothpick breaker's thumbs.) Repeat steps 1-6.

Data Table:

Time (seconds)	Number of toothpicks broken	Number of toothpicks broken with low substrate concentration	Number of toothpicks broken with competitive inhibition	Number of toothpicks broken with allosteric inhibition
10				
20				
30				
60				
120				
180				
360				

Analysis & conclusions:

1. What happens to the reaction rate as the substrate (supply of toothpicks) runs out?
2. What happens to the reaction rate when the toothpicks were spread out (the initial substrate concentration was lowered) so that the "breaker" had to reach for them?
3. What would happen to the reaction rate if more substrate (toothpicks) were added?
4. What would happen to the reaction rate if there were a higher enzyme concentration (two "breakers")?
5. What happens if there is allosteric inhibition (the active site is blocked- the breaker's thumbs are taped) when picking up toothpicks?