Cleaning time using the power of enzymes

Keywords: substrate, washing powder

Meta Description

Are you a messy eater? Then I am sure that you stain your clothes a lot. But how do these tough stains get removed? Let`s find out!

Learning Objectives

This experiment will show you how biological washing powders work to remove all those nasty stains. The experiment will also guide you to understand how differences in temperature affect stain removal, so that next time you make a mess on your clothes, you can clean it yourself.

Key Terms

Enzyme
Biological catalysts.

Catalyst

Increase reaction rate by providing an alternative route having lower activation energy.

Denature

Change in structure.

Substrate

The molecule acted upon by the enzyme.

Hydrolosis

Hydro means water while lysis means to break. Therefore hydrolysis refers to the breaking of a chemical bond by introducing a water molecule.

Tertiary structure

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The 3D shape of a polypeptide.

Active site

The part of the enzyme to which the substrate attaches and undergoes a chemical change.

Polypeptide
Amino acid chain.

Method

Step 1
Dissolve around 0.6 g of the biological powder in around 600 mL of water. If it does not dissolve, heat the water gently until the powder dissolves.

Step 2

Stain a piece of cloth with 10 drops of orange juice. The drops should be placed in the same spot, using a pipette.

Step 3

Place the cloth in a beaker containing 100 mL of the dissolved biological powder.

Step 4

Repeat this for the chocolate sauce and cooking oil.

Step 5

Repeat steps 2-4 but this time heating the beakers containing the stained cloths at around 37 degrees on a hot plate or bunsen burner for 30 minutes (using the thermometer to check).

Step 6

Leave the cloths in the beakers for around 24 hours.

Step 7

Remove the cloths and observe the differences in stain removal between room temperature and an increased temperature.

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Alternative Method

If you want to carry out the experiment at home and you do not have access to a bunsen burner or hot plate, you can prepare a water bath instead. This can be done by pouring water in a pan and then placing the beaker inside the pan. Add hot water in between the pan and the beaker until the temperature inside the beaker is around 37 degrees. Add hot/cold water as necessary to the pan.

Instead of using the suggested staining materials, you might want to utilise other staining agents such as soil (which can produce quite a mess) or other fruit juices.

In science, you have to make do with what you have available. Hence, if you do not have beakers, practice this concept, and utilise other items instead such as baby food jars, jam jars, mugs.

Precautions

Biological washing powder may cause serious eye irritation therefore it is important to wash your hands after the experiment. You might also want to reduce any risks and wear gloves.
http://www.bunzlchs.com/medias/sys_master/root/h23/h22/8815643951134/032065.pdf

Since the staining materials can be rather messy, it would be of good practice to wear a lab coat during the experiment.

In case of any allergies to the staining, materials suggested, you can always use other food items instead such as soya sauce or ketchup.

Narrative

Imagine you are a football player and following an important match your gear is a total mess. You have grass stains on the shirts, on the shirts and on the socks. You have another game in two days so you need to clean your gear ASAP so you immediately place it in the washing machine. And that is what we are going to practice in this experiment. The science of how your gear gets clean every time you place it in a washing machine using biological washing powder.

Questions

What is biological washing powder?
A washing powder that contains enzymes.

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What are enzymes?
Biological catalysts.

What will happen to the stain once the temperature is increased?
The rate of reaction increases resulting in greater stain removal.

What happens if you increase the temperature too much?

Enzymes denature, no longer functional in removing stains.

What is the difference between biological washing powders and non-biological washing powders?

Biological washing powders contain enzymes.

Brief Explanation

Biological washing powders use enzymes to remove stains. Enzymes are molecules that help speed up reactions. They do so by finding an alternative reaction route which has a lower minimum energy required for a reaction to occur.

Stains are made of a variety of different molecules and since enzymes are specific, a range of enzymes are needed in order to remove the stains. Specificity means that the enzyme can only act on a specific type of substance. This is very important so that enzymes only work on specific chemical reactions and not other reactions which they were not meant to work on.
http://www.ducksters.com/science/biology/enzymes.php

To break up those greasy stains, lipase enzymes are required. These enzymes break down the fats to simpler compounds. To break up stains that are made of proteins for example blood and gravy, protease enzymes are used. These enzymes break up the proteins into peptides (2 or more peptides stick to each other to form a protein), or amino acids (the building blocks of peptides) which are even smaller than peptides. The products produced after the substrate were acted upon by the enzymes are soluble and hence can easily be washed out with water, thus removing the stain.
https://www.sciencelearn.org.nz/resources/1947-enzymes-in-washing-powders
http://www.bbc.co.uk/schools/gcsebitesize/science/triple_ocr_gateway/beyond_the_microscope/enzymes_in

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The stains on the cloth which were exposed to a temperature of 37 degrees, faded the most. This is as when the temperature rises, the molecules making up the stains (referred to as substrates)and the enzymes present in the biological washing liquid have more energy. The increase in energy increases the chances for the substrate and enzymes to meet and react. This in turn increases the rate of reaction between the substrate and the enzymes leading to a fainter stain.
http://www.rsc.org/Education/Teachers/Resources/cfb/enzymes.htm

A high temperature would cause the enzyme to lose its shape. On doing so, the enzyme would no longer fit to the substrate and hence loses its functionality. Therefore, it would no longer function in removing the stain.

Those stains which were not acted upon by the enzymes, and thus remain unchanged, could be due to the fact that there was no enzyme specific to that substrate making up the stain.

Detailed Explanation

Biological washing powders use enzymes to help remove stains. Enzymes are globular proteins that act as biological catalysts. They help speed up reactions by providing an alternative reaction route which has lower activation energy. Due to a specific tertiary structure, enzymes are specific, that can only work against one type of substrate molecule. This is achieved through a specific active site. The substrates are exactly complementary to the active site, hence any change in the active site would not allow the substrates to fit into this site, and would thus not be acted upon.
http://www.chemguide.co.uk/organicprops/aminoacids/enzymes.html

The process occurring can be summarized as follows:

Enzyme+Substrate ? Enzyme-Substrate complex ? Enzyme + Product.

The enzymes present in biological washing powders include proteases that cleave proteins (present for example in bloodstains) through a hydrolysis reaction (addition of a water molecule in the peptide bond) into smaller polypeptide chains. https://www.ncbi.nlm.nih.gov/books/NBK22526/
Lipases are also present. These enzymes breakdown fatty molecules such as those found in grease stains into fatty acids and glycerol molecules.
http://www.bbc.co.uk/schools/gcsebitesize/science/triple_ocr_gateway/beyond_the_microscope/enzymes_in

In this experiment, the enzyme activity at different temperatures was tested. It was noted, that an increase in temperature caused the formation of a fainter stain. This is as upon increasing the temperature, the substrates (which make up the stains), and the enzymes have an increase in energy. Hence, an increase in temperature results in a greater chance for the substrates and enzymes to collide with an energy equal (or greater than) the activation energy required for the reaction to occur. http://www.chemguide.co.uk/organicprops/aminoacids/enzymes2.html#top

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Apart from this, an increase in temperature results in a greater chance for a successful collision between the substrates and the enzymes. This is as an increase in energy leads to an increase in motion for both the substrate and enzymes and hence has a greater chance of colliding.
http://www.chemguide.co.uk/organicprops/aminoacids/enzymes2.html#top

An increase in reaction rate with an increase in temperature occurs until the enzyme becomes denatured at which point the substrate is no longer exactly complementary to the enzyme due to a change in the enzyme's tertiary structure. This makes the enzyme no longer functional.

Those stains which were not acted upon by the enzymes, and thus remain unchanged, could be due to the fact that there was no enzyme specific to that substrate making up the stain.

Applications and Research

Applications

The biological washing powders are used to enhance the breakdown of fats and proteins present on our dirty clothes. Since they can function in relatively low temperatures, they can also save us energy!
http://www.rsc.org/images/TM0313%20Trade%20secrets%20-%20bio%20or%20non-bio%20washing%20powder_tcm18-230874.pdf

Applications

Apart from acting as washing powders, enzymes have a variety of other applications including for medicinal purposes. Common enzymes used in the medical field include asparaginase which is a therapeutic enzyme used against leukaemia, collagenase used against skin ulcers and urokinase used to treat blood clots.
http://www1.lsbu.ac.uk/water/enztech/medical.html

Research

Research conducted in Italy in the year 2016 proposed a set up of a business plan for the development and selling of products including enzyme formulations for biosensing and decontamination/detoxification. These would be used on surfaces such as air, water, and skin.
http://cordis.europa.eu/project/rcn/198535_en.html

Research

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In the same year, an article published by the Cold Spring Harbor Laboratory Press showed key insights in the role of TET enzymes in DNA methylation, development and cancer. Abnormalities in DNA methylation are often observed in diseases. The TET enzymes in turn show a locus-specific reversal of DNA methylation and this article highlights the recent advances in understanding the role of these TET enzymes.
http://genesdev.cshlp.org/content/30/7/733.short

Investigation

A change in pH is known to cause a change in enzymatic activity. Show this by adding another variable to the experiment which is pH. This can be done by adding lemon juice to the biological washing powder to increase acidity. The observed results are compared with biological washing liquid in basic environment which can be done by adding household ammonia to the biological washing liquid.

Enzymes can be denatured. Show at what temperatures the enzymes experience this phenomenon by testing the experiment in a wide range of temperatures and observe at which temperatures the stain remains the same even though it was carried out an elevated temperature.

Test what enzymes are present by using different stains. This can be done by using protein stains to show if protease enzymes are present, fatty stains to show if lipases are present and starch stains to show if amylase enzymes are present.

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Subjects

Biology
Chemistry

Education

Secondary
Post Secondary

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Time Required

1 day or more
Preparation: 20mins
Conducting: 1 day
Clean Up: 15 mins

Cost

10 – 25 €

Recommended Age

10 – 12
13 – 16

Number of People

4 participants

Supervision

Required

Location

Indoors
Laboratory

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Materials

Biological washing powder
Fabrics
6 Beaker
Thermometers
Water
Cooking oil
Orange juice
Chocolate sauce
Bunsen burner (or hot plate)

Contributors

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Sources

Chemistry for Biologists

Biology for KidsEnzymes

The Difference Between Bio and Non-Bio Detergent

The use of enzymes in detergents

Using enzymes

Biological Detergents | Organic Chemistry | Chemistry | FuseSchool

Enzymes (Updated)

Enzymes

Enzymes

How Enzymes Denature | Cells | Biology | FuseSchool

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Additional Content

What are enzymes? (Beginner)

The Difference Between Bio and Non-Bio Detergent (Intermediate)

Enzymes for Cancer
Low Enzymes Levels Found With Cancer (Advanced)

Cite this Experiment

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