Paula Caras and Lena Hildebrand

Honors Biology

Date Performed: 10/01/13

Date Due: 10/07/13

Determining the Effects of the Age of a Ketchup Stain on Stain Removal by Enzymatic

Detergent

Introduction

This experiment focused on how the age of a stain affects the ability of the enzymes in
laundry detergent to break down staining molecules. A common belief about stain removal is that
the quicker a stain is removed, the better it will come out. For this experiment, ketchup has been
chosen as a staining agent because in past experience its red pigment has been known to cause
stains. The lab will test whether or not the age of a ketchup stain influences the ease of its
removal. The hypothesis was that if a stain remains on a piece of fabric for a long period of time,
then it will be harder to remove. In addition to past experience and popular opinion, a
comprehensive Cornell study on stain removal also found newer stains easier to remove. (1)
Therefore, for this experiment it is expected that the most recent ketchup stain will come out the
best.

In order to effectively remove stains, enzymes are required to aid in the digestion of
macromolecules. Enzymes are protein molecules that act as catalysts in chemical reactions. In
this way, they speed up reactions and lower the reaction’s required activation energy. (2) It is
shown in the results from a previous study that laundry detergents contain enzymes in order to digest the macromolecules found in stains. (3) Because stains are made up of different types of these molecules, various enzymes are needed to break them down. Some examples are proteases to break down proteins, amylases to break down carbohydrates, and lipases to break down fats. Different detergents contain varied amounts of these enzymes, if any at all, which accounts for certain detergents working better in the removal of stains than others. (3)

The removal of ketchup stains requires successful digestion of the red coloring it contains. The red pigment that gives ketchup its color comes from the lycopene in tomatoes, and is the protein that colors the stain. The enzymes that digest these proteins are called proteases. (4) The type of detergent used in this lab is Tide, because results from a previous study indicate that Tide performs better than many common laundry detergents. (3) These results also suggest that Tide laundry detergent contains proteases, because the detergent digested the milk agar, which contains protein. (3) Since the building blocks of proteins are amino acids, it was expected that the proteases in the Tide detergent would break down the lycopene in ketchup into amino acids, which would then be dissolved in the water.

The results of this lab are important because they can be useful in one’s daily life. Stains are a nuisance, often permanently ruining clothing and furniture. These stains can be defined as chemical reactions between substances and the material they stain. (1) If a stain is found on a piece of material, the knowledge obtained from this experiment may urge the owner to wash it out immediately before it dries, which could improve stain removal efforts in everyday life.
Methods

In order to determine whether or not the age of a stain affects how it is removed, four white pieces of 4 inch by 4 inch T-shirt material were stained with ketchup. This process began three days prior to the experiment. On each of these three days, a 0.5 mL, disposable pipette was used to place three drops of ketchup on a piece of fabric, resulting in a stain measuring roughly 15 millimeters in diameter. These three pieces of fabric were labeled ‘1’, ‘2’, and ‘3’ respectively, and were brought to class along with the fourth, unstained piece of fabric, which was labeled ‘4’.

At the start of the experiment, the final scrap of fabric was stained with ketchup. This provided a control, and allowed the varying ages of the stains to be compared with an immediate cleaning. In order to attempt to remove the stains from the material, four identical 500 mL bottles were filled with 500 milliliters each of cold tap water. A 2 mL pipette pump with a long, 1 mL serological tip was then used to put 0.74 milliliters of Tide laundry detergent into each bottle. These bottles were labeled with the numbers 1 through 4, corresponding to the pieces of material. These pieces of material were then placed into their individual bottles. The caps were placed on these bottles and they were then shaken and rolled across the lab bench for 30 seconds each. In order to ensure maximum stain removal, the serological tip was then used to stir the contents of the bottles for 30 seconds each. The bottles were then washed out and the pieces of fabric removed and rinsed. They were left to dry on a paper towel in order to better examine the results of the cleaning. The final results were observed two days later to look for the results of the cleaning on dried pieces of material.
Discussion

The findings of this lab suggest that a more recent stain can be removed with more ease than an older stain, which supports the hypothesis. This seems to be because immediate removal of a stain gives the stain less time to set into a piece of material. (1) The results suggest that a dry stain is difficult to remove regardless of the age of the stain, because the first three pieces of stained material looked the same even though they were each stained a day apart. Though the results agree with the hypothesis, the expectation was that the older the stain the more difficult the removal, but this does not seem to be the case. The fourth piece of material, however, was much cleaner, which illustrates the effects of immediate removal. A dry stain is harder to digest and therefore to remove, because it has time to sink down into the fibers of the material. The stain is also dehydrated because of the lack of water, therefore harder to digest because of hydrolysis. (1)

The results also illustrate the power of enzymes, specifically proteases, in their ability to break down macromolecules, in this case proteins, to clean stains in laundry. Tide detergent was originally chosen as a cleaning agent because of its proven effectiveness in past studies. (3) The Tide detergent was very effective at removing the ketchup coloring, however this may have been a disadvantage in this experiment. Because of its ability to remove the ketchup stains, differences in stain removal were slight. This made the results difficult to evaluate. If performed again, it may be a good idea to use a detergent with less effective stain removal abilities. This may provide results which would be more varied and easier to observe.
Another useful alteration that could be made to the experiment would be to use stains of more widely varying ages. Because of time constraints, it was practical to begin staining only three days before the experiment, yet this may have affected the results. It is true that after one, two, and three days of staining the results were very similar, yet this does not necessarily indicate that the age of a stain does not have an increasing effect on its ease of removal. If further research were to be done, this hypothesis could be tested further with stains which are weeks or months old, to compare to stains which are only days old. This may yield different results.

An additional question could be answered with a second experiment using warm water, which is thought to be a better way to remove stains. During the initial experiment time constraints made the use of cold water easier. This also allowed for better temperature consistency, because heated water may have had differences in temperature that would affect the results. An additional experiment with equally heated water would allow for comparisons between the two results, and may also suggest that heated water could counteract the effects of an old stain because heat is known to speed up reaction rates. (1) The second hypothesis would be that if the age of a stain makes it difficult to remove, then hot water could counteract this effect. This would be a logical next step in experimentation.
References


