Advanced Chemistry Sample Lab Report

The Hydrolysis of Sucrose

Author Name

Abstract:

"Carbohydrates are one of the principal sources of food energy" (Wile, Exploring Creation, 146). Even though carbohydrates are one of the most important chemicals in the human body, they are too large
a molecule to be utilized in their "raw" form. Thus, the body uses the process of hydrolysis to break them
into smaller pieces (Wile, Exploring Creation, 146). For this reason, hydrolysis plays a critical role in the
survival of human beings. This experiment explores a current theory regarding hydrolysis by performing
one such reaction and testing its results using Fehling's solution.

Introduction:

In order to equip the reader to better understand this experiment, several terms must be defined.
The first of these is hydrolysis. Dr. Wile, the author of a wide variety of textbooks, gives its definition as a reaction which "[breaks] down a molecule by the chemical addition of water" (Wile, Advanced Chemistry 409). So, hydrolysis simply refers to deconstructing a molecule by adding water to it. For example, this experiment involves hydrolyzing a chemical called sucrose (which will be further discussed later). Another topic important to this experiment is that of carbohydrates. Carbohydrates are molecules made exclusively of hydrogen, oxygen, and carbon atoms (Wile, Advanced Chemistry 407). They benefit the human body in several ways, including acting as an energy source and forming other molecules like DNA (Royal Society of Chemistry 2004). Thus, as Chemistry Professor Robert Neuman, Jr. stated, they have "enormous biological importance" (Neuman, accessed 2015). Carbohydrates can be further classified into three categories: monosaccharides, disaccharides, and polysaccharides. Monosaccharides are the simplest of carbohydrates and contain only between three and ten carbons. Disaccharides and polysaccharides are built of these "building blocks." Disaccharides are made of two monosaccharides; any carbohydrate with more than two is considered a polysaccharide (Wile, Advanced Chemistry 408).

Two especially important monosaccharides are glucose and fructose. Glucose acts as "the most
important carbohydrate fuel in human cells" (Royal Society of Chemistry 2004). Glucose and fructose, as
two "building blocks," can combine to form another significant carbohydrate, which will be explored next.

"[S]ucrose is a carbohydrate that occurs naturally in every fruit and vegetable," according to Dr. Charles Ophardt, a Professor of Chemistry at Elmhurst College (Ophardt, accessed 2015). More specifically, it is a disaccharide composed of glucose and fructose (Wile, Advanced Chemistry 411). Commonly known as table sugar (Plopper 19), it is the compound which was hydrolyzed in this experiment.

This experiment utilizes Fehling's solution. In the presence of monosaccharides, this solution turns brown in color, but does nothing to react with disaccharides. To discover if the sugar had truly been hydrolyzed in this experiment, a sample of the hydrolyzed sugar solution was mixed with Fehling's. If the solution were to turn brown, it would indicate the presence of monosaccharides. This in turn would mean the hydrolysis reaction proceeded according to the hypothesis. If, however, the brown color did not appear, it would point to a flaw either in the hypothesis or the setup. What actually occurred will be disclosed in the results section of this report.

The last term to be defined is "catalyst." Dr. Wile defines a catalyst as a, "substance that alters the rate of a chemical reaction without changing concentration throughout the course of the reaction" (Advanced Chemistry 472). Simply put, a catalyst either speeds or slows a reaction. Though it affects the rate of the reaction, the actual amount of catalyst does not change. Thus, they are used quite frequently in science to quicken or slow a reaction to make an experiment more convenient. For this one in particular, the experimenter used catalysts to speed up the otherwise intolerably slow hydrolysis of sugar.

Since this experiment aims to hydrolyze sucrose into glucose and fructose, the topics of hydrolysis, carbohydrates, glucose, fructose, sucrose, Fehling's solution, and catalyst are all important topics to understand. The general purpose of this experiment is to confirm the current theory regarding hydrolysis. More specifically, it aims to prove hydrolysis reactions decompose disaccharides into monosaccharides. If the hydrolysis reaction breaks the disaccharides in a sucrose solution into monosaccharides, the Fehling's indicator will 1) turn brown in the solution's presence, but 2) remain unchanged in the presence of sugar water.

Materials and Methods:

The first task for this experiment was to prepare each of the three components of Fehling's solution. Since the solution itself is unstable (Wile, Advanced Chemistry 410), each ingredient was prepared separately and combined when needed. The first of these was a copper sulfate solution, concocted by mixing a few measures of copper sulfate with tap water in a depression (depression one) in a small plastic paint tray (which was substituted for the depression plate). The second ingredient was a solution saturated with cream of tartar. Water and cream of tartar were mixed in a simple test tube. The third and last component of Fehling's was a sodium hydroxide solution. To prepare this, lime water (calcium hydroxide) and sodium carbonate were combined in a test tube. The test tube was then placed in a cup of hot tap water to soak for twenty minutes. Combining a little of each ingredient resulted in Fehling's solution, which, as discussed previously, determines the presence of monosaccharides. After the hydrolysis reaction occurred, a sample of the solution was added to Fehling's to discover if the disaccharides in table sugar had broken into monosaccharides.

The next step was to hydrolyze sucrose. A teaspoon each of table sugar and vinegar were mixed with hot tap water and stirred. The vinegar and heat from the water acted as catalysts.

Next the experimenter prepared a simple solution of water and sugar in another depression of the paint tray (depression two). A sample this sugar water was mixed with Fehling's in another depression (depression three). This action allowed the experimenter to test the validity of the Fehling's solution. If the sugar water/Fehling's solution remained the same color, all would be well. Since sugar is composed of disaccharides, this would mean the Fehling's solution is working as it should. What actually occurred will be revealed in the results section.

The last step was to combine a sample of the hydrolyzed sugar solution with

Fehling's in a fourth
depression. The resulting color change to brown (if any) would indicate the hydrolysis reaction had indeed worked as expected. Again, the actual results will be discussed later.

After this process, the experimenter repeated everything, this time using much hotter water (near
boiling, in fact). All equipment was rinsed, every step repeated, and each solution remixed, except those of lime water (which came pre-prepared) and cream of tartar (since it did not require very hot water to be
prepared properly). However, the cream of tartar solution was stirred thoroughly before being used again.
In addition, the hydrolysis reaction was reconfigured in a larger cup than previously.

Several terms have yet to be identified. The occurrence of the hydrolysis reaction acted as the
dependent variable, while the independent variable was the presence (or absence) of monosaccharides. The experimenter conducted the experiment twice. If the results aligned with the hypothesis both times, it would validate the hypothesis even more so than simply completing the experiment once. The last item to mention is the control. This was the depression filled with pure sugar and water.

Results:
Several observations were made before performing the experiment. The basement in which the
experiment occurred was slightly cooler than room temperature, around sixty-five degrees Fahrenheit.
Classical music was playing in the background. The paint tray's depressions were two to three times larger than the those of the depression plate included in the chemical kit, and the paint tray itself was made of a thicker, more durable plastic than the original depression plate.

Other observations were noted while preparing the solutions. Tiny dark objects similar to dust balls
in appearance were drifting in the lime water, and a dark brown/black plaque covered much of the bottle's
rim and cap interior. As soon as the lime water was mixed with the copper sulfate solution, the resulting
liquid became cloudy, then cleared somewhat. To obtain hot water, the tap was allowed to run until the
stream of water became steamy and cloudy with tiny bubbles. Even so, the water did not feel as hot as it
looked. The cream of tartar was reminiscent of baking soda, white and almost

packable in texture. It crunched like powdery snow when pressed with the measuring scoop. While adding the ninth measure of cream of tartar to the test tube, a minute amount was lost from the measuring scoop. To compensate, the experimenter added a particularly large tenth measure. Regardless of stirring, the cream of tartar did not completely dissolve into the water. Instead, it settled on the bottom of the tube. The copper sulfate was a vibrant blue in color, and was textured like fine sugar. When combined with water in depression one, leftover grains remained. A minuscule piece of black fuzz was noticed in depression two after the sugar water was prepared. No attempt was made to remove it for fear of contaminating or losing a significant amount of the solution. In all, the sodium hydroxide solution soaked twenty minutes in the warm water bath.

When performing the hydrolysis reaction, the teaspoon was not rinsed between uses. The length of time required for the sugar to dissolve into the warm water was longer than expected.

After adding the Fehling's solution ingredients to depression four, the experimenter mistakenly waited about thirty seconds before adding a sample of the hydrolyzed sugar. The same dropper was used to add samples of both the pure sugar water (depression three) and hydrolyzed sugar (depression four) to Fehling's. It was used for the sugar water first. After about two and a half minutes, depression three's solution looked cloudier than previously, and slightly yellowed. Depression four did not appear significantly different, so the experimenter combined samples of Fehling's and hydrolyzed sugar in another depression (depression five). By this time, the copper sulfate solution in depression two had developed a slight yellow ring around the top of the solution. After preparing depression five, the experimenter left it undisturbed for twenty minutes. Still, depressions four and five did not look different from depression three.

After this, the entire experiment was repeated, this time using near boiling water. This time, the components of Fehling's fizzed when combined. The experimenter was also careful to add the samples of

sugar water and hydrolyzed sugar immediately after combining the ingredients to make Fehling's solution
in depressions three and four. When the hydrolyzed sugar was added to depression four, the liquid appeared a deep, clear blue (similar to windshield wiper solution). In addition, a minuscule piece of fuzz was observed in depression three. After a few minutes, a white crusty formation appeared in depression three, but depressions three and four did not appear different otherwise.

Discussion:
The end result of this experiment was a failure. The Fehling's solution did not change significantly
in color for either the control or hydrolyzed sugar. As a result, it cannot be determined if the hydrolysis
reaction worked according to the current scientific theory.

The reasons for this are numerous. A flaw in the experimenter's method is certainly a possibility.
Perhaps one of solutions was prepared incorrectly, due to misreading the labels on the chemical bottles or
something of that nature. Perhaps the experimenter miscounted the number of drops of each ingredients
required to make Fehling's solution. The opportunities for mistakes are endless. However, since the
experiment was repeated, performed even more carefully the second time, a flaw in either the materials or
environment is more likely. The paint tray may have been too thick to allow the heat of the water to catalyze the reactions. Also, the lime water had suspicious particles drifting in it. Maybe the solution had been contaminated with something that compromised its function. The rather cold temperature in the basement could also have hampered the results by cooling the hot water too quickly. Whatever the case, the experiment failed.

This experiment's failure has several implications. If the experiment's design was not flawed, the
results would point to a flaw in the hypothesis. If this experiment's hypothesis is skewed, the consequences would be drastic. The vast majority of scientists, doctors, students, and dietitians has believed hydrolysis reactions work as the hypothesis dictates. If such an assumption is proved false, just imagine the necessary changes in science and medicine!

Such an occurrence, however, is quite unlikely. Many other scientists, more

experienced than the
author, have performed more detailed, careful experiments and achieved results aligned with the hypothesis. Thus, the proper course of action would be for the experimenter to repeat the procedure taking measures to guard against the possible flaws described previously (acquiring new lime water and a proper depression plate, heating the room to room temperature, and so on). In all likelihood, the experiment would yield results corresponding to the hypothesis if given sufficient opportunity.

However, if retrying the experiment fails again, several other experiments must be performed to
explore the topic further. One option is to use Benedict's reagent instead of Fehling's solution to test for the presence of monosaccharides. Benedict's reagent is simply a laboratory-prepared solution which turns
orange in the presence of glucose (Whitson, accessed 2015). Perhaps this experiment's problem originated
with Fehling's solution. Another change may use maltose in place of table sugar. Maltose is a disaccharide composed of two glucose molecules, instead of fructose and glucose (Plopper 19). Using maltose instead of table sugar would result in more glucose in the hydrolyzed solution, perhaps increasing the chances of a positive reaction with the indicator. Either change has good chances of upholding the hypothesis.

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