BIOL 342 Term Project Paper: The Effects of Borax in Slime

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Abstract

One of the most common recipes used to create slime only requires three ingredients: Water, liquid glue, and borax. In order for slime to become squishy and malleable enough to play with, polymers that exist in glue are linked together by borate ions, which are created when water and borax is mixed together. This process gives glue a bit more shape and structure to go from a liquid that spreads out to a slime substance that is more rigid yet flexible. Therefore, it is assumed that by changing the amount of borax used, we can change the consistency/stretchiness of the glue polymers. To determine exactly how the amount of borax can affect the stretchiness of slime, six different slime solutions were created with different amounts of borax added: 0 tsp, ¼ tsp, ½ tsp, ¾ tsp, 1tsp, and 1 ¼ tsp. Each slime was then stretched and measured to the point where the width at the skinniest part was 1cm or at the point of breaking. This experiment was replicated three times for each concentration. It was predicted that having more borax present in the slime should increase the stretchiness, meaning the solution with 0 tsp should not stretch and the solution with 1 ¼ tsp should stretch the most. However, our results found that there was no statistically significant difference in how much each recipe's slime stretched and cannot conclude the amount of borax had an effect on a slime's stretchiness.

Introduction

Making slime is a relatively easy do-it-yourself project that is enjoyed by many. Though there are multiple recipes one could follow to make different types of slime, a common recipe only requires three ingredients: Water, liquid glue, and borax. Among these materials, borax is something that one may not expect to be an ingredient as it is commonly used in cleaning products. However, in order for slime to become squishy and malleable enough to play with, molecules called polymers that are present in the liquid glue must form chains together, and creating this big net of linked polymers is essentially what gives slime its specific shape and structure. Borax is the key element in this process: by adding borax to water, borate ions are formed which help link these glue polymers together. Because of the role borax plays in slime

shape and formation, changing the amount of borax added to a slime solution should affect the stretchiness of the polymers present. In order to test this, six different slimes were created with varying amounts of borax added to each. One slime was made with 0 tsp of borax as a control, and the other five slimes were made with ¼ tsp, ½ tsp, ¾ tsp, 1tsp, and 1 ¼ tsp of borax added. This experiment was replicated three times for each concentration. It was predicted that if the concentration of borax water is increased, then the resulting polymer will become more stretchy because there are more borate ions in the solution which can bind with the glue to create a more stretchy polymer. Therefore, we should observe that the slime solution with 0 tsp of borax should not be able to stretch at all, whereas the solution with 1 ¾ tsp of borax should be able to stretch the most. Additionally, because there exists health concerns regarding skin contact with borax, we will also be determining the lowest amount of borax needed to create a good enough consistency of slime to minimize contact with borax through our experiment.

Methods

Six different types of slime solutions were created with varying amounts of borax powder added to each based on a DIY Slime recipe (Little Bins Little Hands). First, six plastic cups were filled with ½ cup of warm water and were each labelled with the following concentrations of borax: 0 tsp, ¼ tsp, ½ tsp, ¾ tsp, 1 tsp, and 1 ¼ tsp. The borax powder was added to each cup corresponding to the concentration written on it. In a separate mixing bowl, 3 cups of water and 3 cups of clear Elmer's glue were mixed together. Then, 1 cup of the glue/water mixture was added and mixed into each of the labelled cups. With gloves (to minimize direct contact with borax), each mixture was kneaded for 4 minutes. Lastly, each slime solution was stretched

horizontally to the point where the width at the skinniest part was 1cm or at the point of breaking, and the length of the slime was recorded with a ruler in cm.

Figure 1. Left: Slime made with 1 ¼ tsp borax breaking with no stretch. Right: Slime made with 1tsp being stretched. Gloves were removed to stretch the slime since the slime kept sticking to the gloves, making it difficult to manipulate properly.

Results

Each of the three trials was conducted by each member based on the predetermined guidelines set above. In order to analyze the results from this experiment, a simple linear regression model was used. This is because the hypothesis suggests the higher the concentration of borax water, the higher the stretch factor of the slime, up till to the point where the limiting agent of the reaction is the glue water. Hence we are expecting a linear result. The p-value was found to be 0.7332, and hence is not significant (Figure 2).

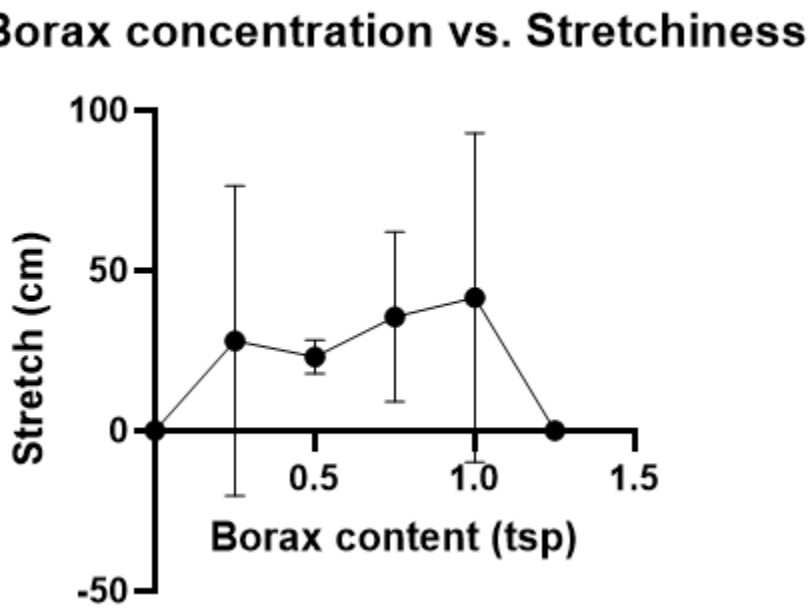

Figure 2. The stretch level of slime in cm as compared to borax amount in tsp. P value = 0.7332. Error bars represent SD between replicates.

Discussion

As our result was found to be non-significant based on a p-value of 0.7332 which is greater than 0.05, we failed to observe an effect of the amount of borax on the stretchiness of slime. In other words, we fail to reject the null hypothesis which states the amount of borax added to a slime recipe would not affect how much the resulting slime stretches. This differs from our initial expected outcome of borax concentrations impacting stretchiness and having the highest concentration of borax making the stretchiest slime.

Our initial predictions stemmed from the fact that borax, once added in water, forms borate ions and cross links with polymers already present in liquid glue, known as polyvinyl alcohol (PVA), to form a net of connected polymers.

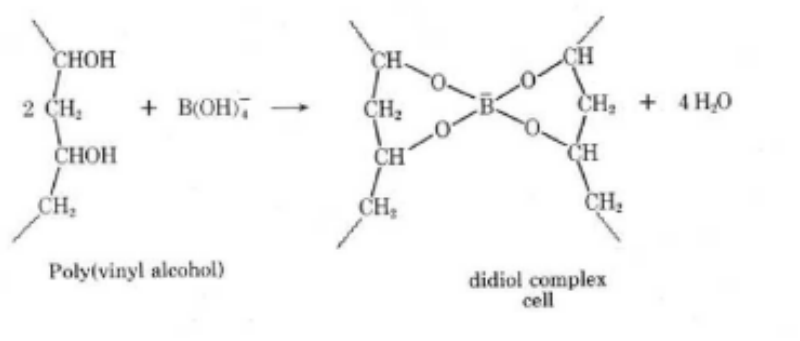

Figure 3. Reaction of PVA and borate ions resulting in borate ion crosslinking PVA molecules (Casassa et al. 58)

These cross linked molecules are rather dynamic because the cross links themselves are not covalent bonds, but hydrogen bonds as more closely shown in Figure 4 below. (Casassa et al. 59)

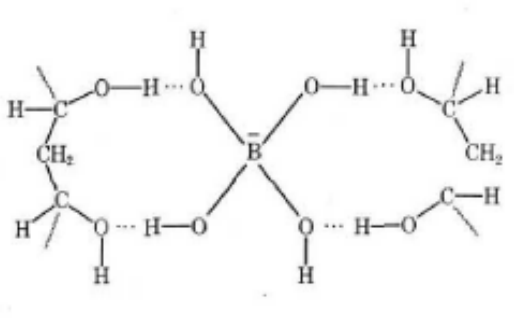

Figure 4. A more accurate visual description of the borate ion - PVA cross link with dotted lines representing hydrogen bonds. (Casassa et al. 59)

Hydrogen bonds are more easily broken and reformed than comparably permanent covalent bonds. This impermanence of hydrogen bonds help account for the above complex forming a gel-like structure than an insoluble and solid precipitate (Casassa et al. 59). However, it is a double-edged sword and the impermanent hydrogen bonds being the only component holding this complex together makes it so that the reaction is reversible (Casassa et al. 59). Increasing water, or decreasing the concentration of cross links, leads to compromising the slime's ability to hold itself together in a gel (Dixit et al. 272).

As such, our hypothesis was founded on the expectation that with decreasing concentrations of crosslinks (through decreasing concentrations of borax), stretchiness would decrease; contrarily, increasing concentrations of cross links (through increasing concentrations of borax) would increase stretchiness. Our control confirmed this as using 0 tsp of borax clearly induced no cross linking and the glue-water mixture was of the same consistency or less viscous than packaged liquid glue.

However, as our resulting p-value indicates above, we failed to ultimately conclude that the amount of borax used in making slime had an effect on the stretchiness of slime. There are three main points for discussion as to why this result was observed. First possible area of variability

was the use of off-brand glue in mixture with Elmer's glue. To keep our source of PVA consistent between group members, it was predetermined to use glue from a specific manufacturer named Elmer's in our slime, however, one of our group members could not purchase the sufficient amount of Elmer's glue due to the store's limited stock and had to mix in off-brand glue as well. This could have resulted in a slightly different ratio of PVA in the off-brand glue, ultimately altering the borax to PVA ratio in the slime, which could have in turn affected the amount of cross linking that gelitinates slime.

A second point of discussion is the small amount of data collected. As a group of three members, each member made one slime for each of the six different concentrations of borax which added up to a sample group of 18, three measurements per treatment. Using such a small sample per treatment could have led to results being skewed or not being properly representative of the true measurement of the stretch in each treatment group. Being fully aware that having more trials may have led to more accurate and reliable outcomes, our group still chose to limit our experiment due to the large amount of glue required in the slime recipe, as well as minimizing our contact time with borax.

Firstly, each batch of making slime for six treatments requires three cups, or 710mL, of liquid glue. Across three members making a batch each, that totalled up to 9 cups, or 2130mL of liquid glue that would be used and discarded. Our group determined that was a significant amount of waste created at the end of our experiment and limited ourselves in consideration of the environment. Secondly, borax has been shown to be linked to allergic contact dermatitis and be an irritant to skin when handled (Brazen et al.) which was a concern for our group members. As

such, in the best interest of our group and of the environment, our sample group was limited which could have made an impact on our statistical findings.

The last point of discussion is that gelatinization of PVA and borax changes with temperature (Li et al. 998) which was not held constant in our experiment. Although all group members performed their experiment indoors in roughly room temperature surroundings, there was no set temperature our slime mixture was aimed to be at and this could have been a variability that affected the experimental outcome. If this experiment was to be repeated, it would be wise to set a specific temperature for the water used. The same cannot be said for heating or cooling the slime itself to adjust temperature as it may not be a safe procedure in regular homes and household kitchens.

To address the potential health concern of the use of borax as mentioned above, our hope for our experiment was to also determine the minimum amount of borax used to still achieve stretchiness and entertainment for young kids. Even though we did not conclude on finding the effect of the amount of borax on the stretchiness, through visual and qualitative observations, using ¼ tsp was enough for one of our group members to achieve stretch. This is the same amount as recommended in our referred recipe (Little Bins Little Hands).

Conclusion

Changing the amount of borax in slime recipe had no significant effect on the stretchiness of the slime contrary to our hypothesis where we expected increasing amounts of borax used would increase stretchiness of the produced slime. Some variability in our data collection methods that may have influenced the outcome includes variability of brand of glue, variability of temperature, and a small sample size attributed to health and environment concerns.

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Appendix

Table 1: Raw Data from each of the three replicates			
Borax amount (tsp)	Trial 1 stretch (cm)	Trial 2 stretch (cm)	Trial 3 stretch (cm)
0	0	0	0
0.25	0	0	84
0.5	25	27.1	17
0.75	51.5	50.2	5
1	99	25.5	0
1.25	0	0	0