The Science of Surface Tension and Elephant Toothpaste

By Student 803

Introduction!!!!!!

What causes elephant toothpaste to have a chain reaction?

I have noticed that elephant toothpaste expands more when soap is added.

Does the type of soap affect the chain reaction? Or do the other ingredients affect the reaction?

What if I add different types of soaps? Will different types of soap produce different amounts of elephant toothpaste?

I want to test if changing the type of soap will affect the amount of elephant toothpaste produced.

My Investigation:

What types of soap changes surface tension and produces the greatest volume of elephant toothpaste?

Controls and Variables:

Controls

- Same amount of yeast
- Same amount of hydrogen peroxide
- Same amount of food coloring

Variables

- Types of soap (surfactant) added

Research

- Elephant toothpaste is a reaction between hydrogen peroxide and yeast.
- Hydrogen peroxide is made of hydrogen atoms and oxygen atoms, its chemical formula is H_2O_2.
  - When hydrogen peroxide breaks down it turns into water and oxygen.
- Hydrogen peroxide is unstable when exposed to light which is why it is stored in a dark brown bottle.
- Yeast acts as a catalyst by speeding up the chemical reaction that turns hydrogen peroxide into water and oxygen.
  - The catalyst lowers the amount of energy needed for the reaction to occur.
- Heat is produced when yeast is add to hydrogen peroxide.
  - This is called an exothermic reaction.
- Adding soap (surfactant) to hydrogen peroxide can increase its surface tension, causing the molecules to stretch like a rubber band.
  - The soap traps the oxygen gas producing bubbles.

My Hypothesis/Prediction

If I add different types of soap to the the hydrogen peroxide and yeast mixture,

Then the volume of oxygen gas produced will be different depending on the type of soap,

Because the different types of soap will affect the surface tension.

My Experiment- Materials

- 750 mL of 3% hydrogen peroxide
- 90 mL of active dry yeast
- 275 mL of warm water (79.4□C / 175□F)
- 15 mL of TRESemmé shampoo
- 15 mL of Dr. Bubbello's bubble bath
- 15 mL of Germ X hand sanitizer
- 15 mL of Dawn platinum dish soap
- 15 mL of Ajax dish soap
- 3 large mason jars (1892 mL / 2 quarts)
- 500 mL measuring cup
- 250 mL measuring cup
- 15 mL measuring spoon
- Baking tray
- Blue tape
- Black sharpie
- Food coloring
- Paper towels
- Metric ruler
- Goggles

Experiment - Procedure

1. Put on goggles.
2. Place baking tray on table.
3. Place three mason jars on baking tray.
4. Label mason jars using blue tape and black sharpie.
5. Measure 125 mL of hydrogen peroxide into a 250 mL measuring cup and pour into mason jar; repeat two times.
6. Put in ONE DROP of food coloring into mason jar and swirl gently to mix; repeat two times.
7. Measure 15 mL of soap using a 15 mL measuring spoon and put into mason jar. Swirl mixture gently.
    a. Skip this step for the control that measures the reaction without soap.
8. Measure 45 mL of warm water, using a 15 mL measuring spoon, and measure 15 mL of active dry yeast, using a 15 mL measuring spoon, into 500 mL measuring cup. Mix together and wait 1 minute for bubbling to happen. Repeat step two times.
9. Pour yeast solution into mason jar with hydrogen peroxide. Repeat step two times.
10. Measure volume of bubbles produced using graduated markings on mason jar and metric ruler.
11. Washout mason jars and repeat steps 3 through 10 for each type of soap.

Observations

Image 1 (upper left): Control with no soap produced large bubbles with a very quick reaction. Jars are hot to touch.

Image 2 (lower right): TRESemmé shampoo made dense, small bubbles. Reaction was slow, taking over 11 minutes to complete. Jars are slightly warm to touch.

Observations

Image 3 (upper left): Dr. Bubbello's bubble bath (BB) created a quick reaction. Jar 2 had large bubbles that went over the rim. Jars 1 and 3 had smaller bubbles. All three jars were slightly warm to touch.

Image 4 (lower right): Germ X hand sanitizer (HS) produced large bubbles that did not rise very high. It had a similar reaction to the control with no soap. Jars are hot to the touch.

Observations

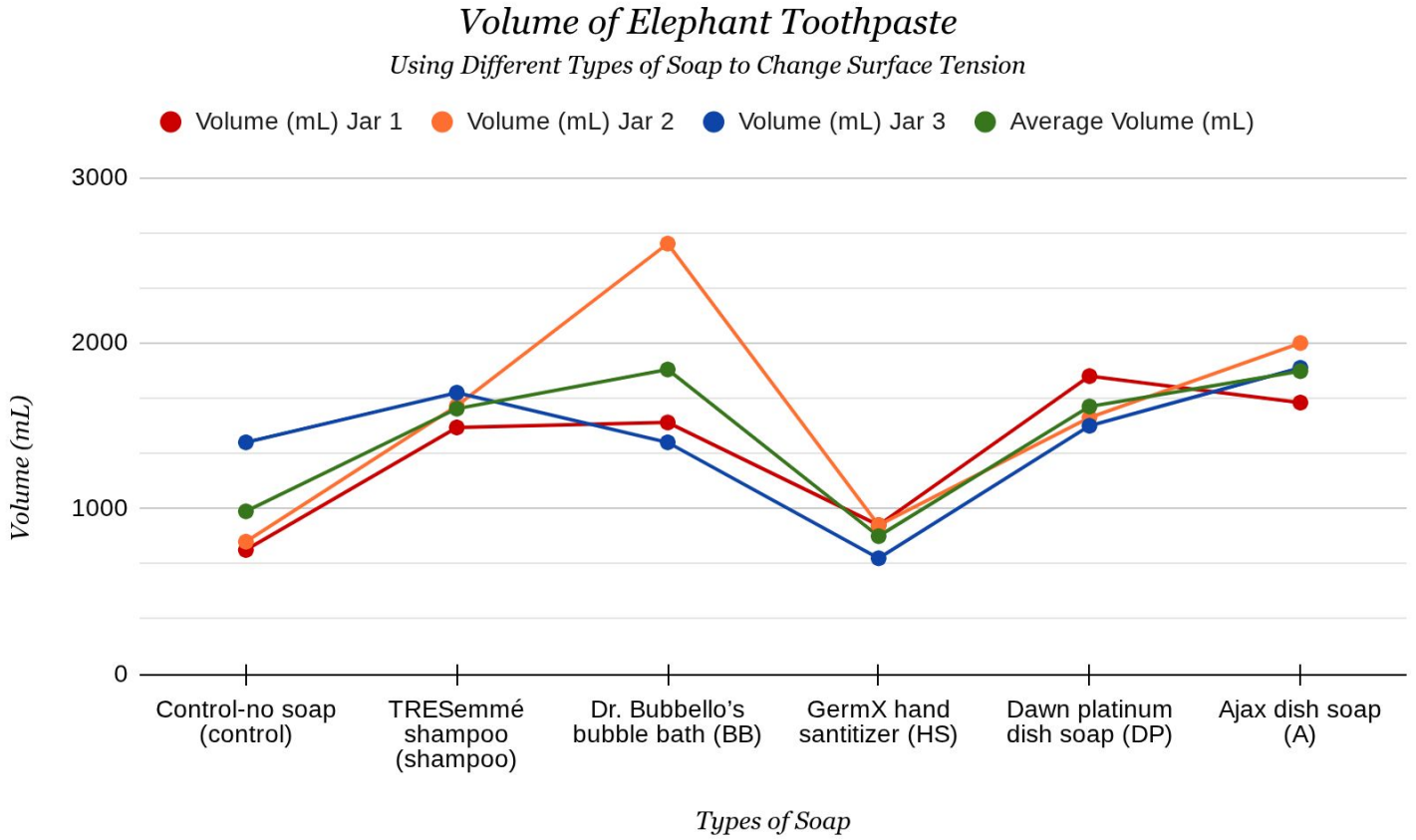
Image 5 (upper left): Dawn platinum dish soap (DP) made dense bubbles. It had a quicker reaction time than shampoo and the jars are slightly warm to touch.

Image 6 (lower right): Ajax dish soap (A) also produced dense bubbles. However, its volume was more than the Dawn dish soap. The jars are also only slightly warm to touch.

Results

Data for Elephant Toothpaste Volumes				
Type of Soap	**Volume (mL) Jar 1**	**Volume (mL) Jar 2**	**Volume (mL) Jar 3**	**Average Volume (mL)**
Control-no soap (control)	750	800	1400	983.3
TRESemmé shampoo (shampoo)	1490	1620	1700	1603.3
Dr. Bubbello's bubble bath (BB)	1520	2600	1400	1840
Germ X hand sanitizer (HS)	900	900	700	833.3
Dawn platinum dish soap (DP)	1800	1550	1500	1616.7
Ajax dish soap (A)	1640	2000	1850	1830

Results


Volume of Elephant Toothpaste
Using Different Types of Soap to Change Surface Tension
Volume (mL) Jar 1
Volume (mL) Jar 2
Volume (mL) Jar 3
Average Volume (mL)
3000
2000
1000
0
Volume (mL)
Control-no soap (control)
TRESemmé shampoo (shampoo)
Dr. Bubbello's bubble bath (BB)
GermX hand santitizer (HS)
Dawn platinum dish soap (DP)
Ajax dish soap (A)
Types of Soap

Conclusion!

Claim:
Is the volume of elephant toothpaste affected by different types of soap (surfactant)? Yes, during my investigation, I found the largest volume of elephant toothpaste (ET) was a result of adding Dr. Bubbello's bubble bath and Ajax dish soap. The only reaction that produced a smaller volume of ET compared to the control was Germ X Hand Sanitizer.

Evidence:
Following the experiment the the reactions with soap added produced 57.1% more ET. Dawn, Ajax, Dr. Bubbello's, and TRESemmé soaps all produced significantly higher volumes of elephant toothpaste (75.2%) in comparison to the control. The only soap that produced less ET than the control was Germ X Hand Sanitizer.

Reasoning:
After conducting my experiment and research I learned that adding the different types of soap (surfactant) increased the surface tension of the reaction in comparison to the control. I also learned that Hand Sanitizer works differently than soap, and is designed to kill bacteria which would explain why it produced 15.3% less volume of ET likely because it is killing the yeast.

Findings and Further Investigations

Elephant toothpaste is affected by the type of soap you use to create it. Each type of soap affected the surface tension differently. When the active dry yeast was added to the hydrogen peroxide, the oxygen from the chemical reaction was captured differently depending on if the surface tension was lower or higher.

Now I have more questions like:

- Is there something unique to bubble bath that causes it to produce the most volume? Do different bubble baths produce different amounts of bubbles?
- What is in Ajax that causes it to produce more volume than Dawn, even though they are both dish soaps?
- Is the speed of the reaction affected by soap? Does it reach different temperatures?
- I thought that the ethyl alcohol found in GermX hand sanitizer would increase the surface tension producing a larger volume of elephant toothpaste than it did. I think that this can explained by the yeast being killed by the alcohol in the hand sanitizer. I could test this with different alcohols such as isopropyl alcohol or research other things that kill yeast such as bleach or vinegar.
- I’d like to understand if the outliers in the experiment were due to procedure error or if they have a wide range of outcomes.

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