

REDUCING THE CARBON FOOTPRINT

PURPOSE

This experiment will test three chemicals (activated carbon, calcium hydroxide, and potassium hydroxide) to compare their effectiveness in absorbing carbon dioxide.

INTRODUCTION

The increasing human population has created a greater energy demand. Fossil fuels have been used to support the energy demand but are considered nonrenewable and have led to greater pollution of the environment. According to the U.S. Energy Information Administration, 80% of the energy used in the United States comes from oil, coal, and natural gas. The burning of fossil fuels emits many air pollutants including a group of chemicals known as greenhouse gases.

Greenhouse gases are found in the atmosphere and trap the sun's heat when it is reflected off the Earth's surface causing the Greenhouse Effect. Carbon dioxide is one of the major greenhouse gas that is emitted from the burning of fossil fuels and atmospheric concentrations of carbon dioxide have increased by about 40% since the Industrial Revolution.

Although the Greenhouse Effect is necessary to warm the Earth for human survival, an increase in greenhouse gases in the atmosphere leads to global climate change. Global climate change is responsible for the increased average temperatures on Earth, melting of glacier ice, the rising of sea level, and the changes in precipitation and weather patterns, including El Nino. Due to the increases of carbon dioxide in the atmosphere from burning fossil fuels, scientists now estimate how much carbon dioxide an individual or a population puts into the environment. This measure of this estimate is referred to as a carbon footprint.

According to scientists, the best way to reduce one's carbon footprint is to reduce the carbon emissions from the burning of fuels. In industry, many companies are required to use scrubber systems that reduce the amount of atmospheric emissions. Although this helps to reduce the carbon footprint, over 11 million households in the United States burn wood or wood products as a primary or secondary source of heating their homes. The burning of wood products release carbon dioxide into the atmosphere most commonly through a chimney system. Most chimney systems do not have a scrubber system to capture the carbon emissions.

HYPOTHESIS

The hypothesis of this experiment is if activated carbon, calcium hydroxide, and potassium hydroxide are all used to absorb carbon dioxide, then potassium hydroxide will be most efficient at absorbing carbon dioxide. This hypothesis is based on hydroxides being used by industry to absorb carbon dioxide. Additionally, potassium hydroxide is used in both high school and college cellular respiration laboratories as an absorbent of carbon dioxide.

RESULTS

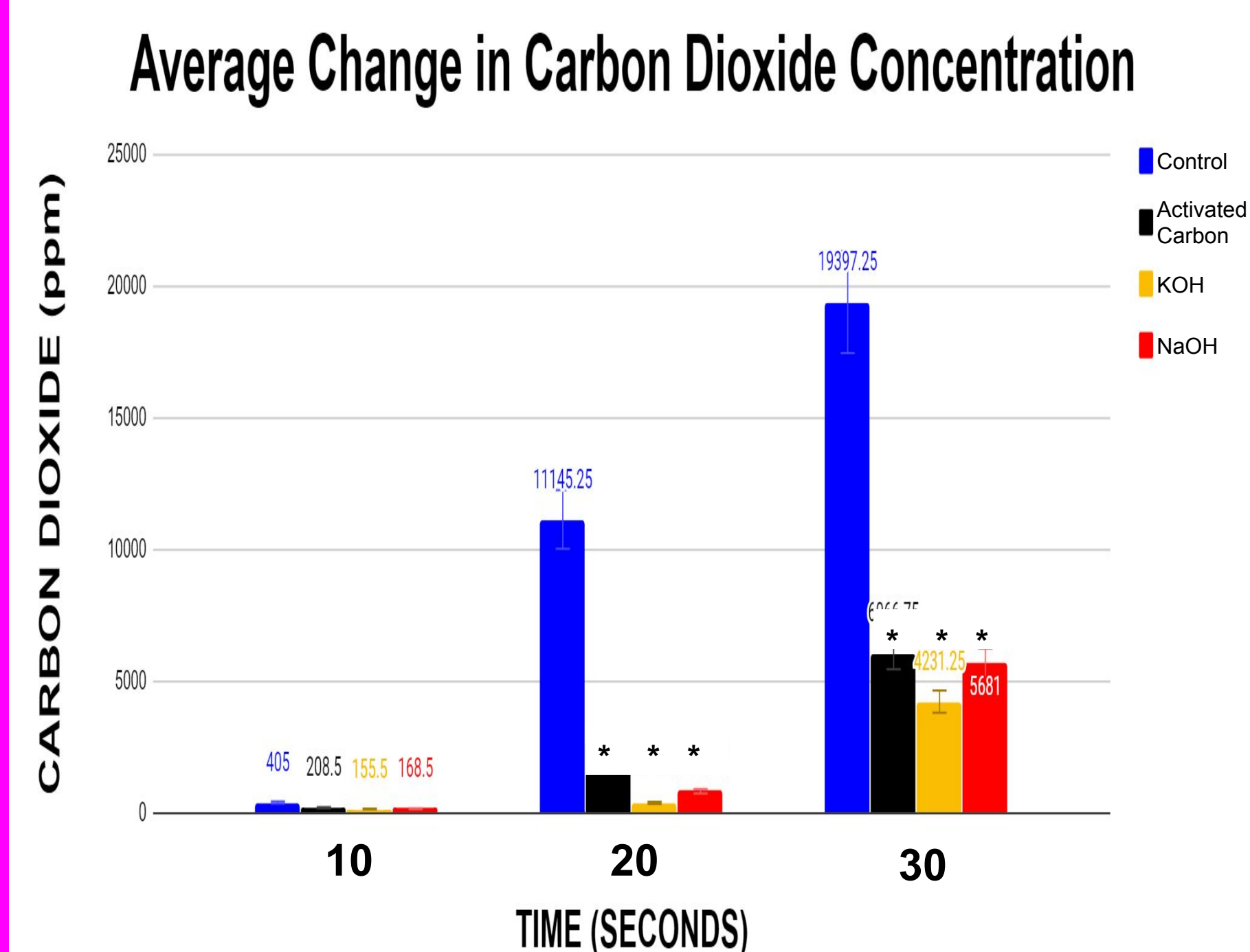


Figure 1. The average change in carbon dioxide concentration at 10, 20, and 30 second intervals (mean \pm standard error). * represents significant difference at $\geq 95\%$ confidence versus the control.

TRIAL	0 seconds	10 seconds	20 seconds	30 seconds
1	960 ppm	1241 ppm	10617 ppm	21241 ppm
2	1034 ppm	1873 ppm	14284 ppm	25280 ppm
3	760 ppm	954 ppm	11282 ppm	22682 ppm
4	890 ppm	1096 ppm	12323 ppm	21687 ppm

Table 1. Carbon dioxide concentrations measured in the control for each of the four trials.

TRIAL	0 seconds	10 seconds	20 seconds	30 seconds
1	877 ppm	1134 ppm	2068 ppm	7845 ppm
2	934 ppm	1058 ppm	3608 ppm	9206 ppm
3	775 ppm	930 ppm	3760 ppm	9330 ppm
4	971 ppm	1269 ppm	6151 ppm	13473 ppm

Table 2. Carbon dioxide concentrations measured in the presence of activated carbon for each of the four trials.

TRIAL	0 seconds	10 seconds	20 seconds	30 seconds
1	690 ppm	971 ppm	1525 ppm	6930 ppm
2	690 ppm	780 ppm	1219 ppm	6071 ppm
3	877 ppm	940 ppm	1125 ppm	5169 ppm
4	602 ppm	790 ppm	1177 ppm	3801 ppm

Table 3. Carbon dioxide concentrations measured in the presence of potassium hydroxide for each of the four trials.

TRIAL	0 seconds	10 seconds	20 seconds	30 seconds
1	971 ppm	1134 ppm	1438 ppm	5543 ppm
2	877 ppm	971 ppm	2836 ppm	8430 ppm
3	877 ppm	1064 ppm	1842 ppm	8902 ppm
4	967 ppm	1198 ppm	1578 ppm	7543 ppm

Table 4. Carbon dioxide concentrations measured in the presence of sodium hydroxide for each of the four trials.

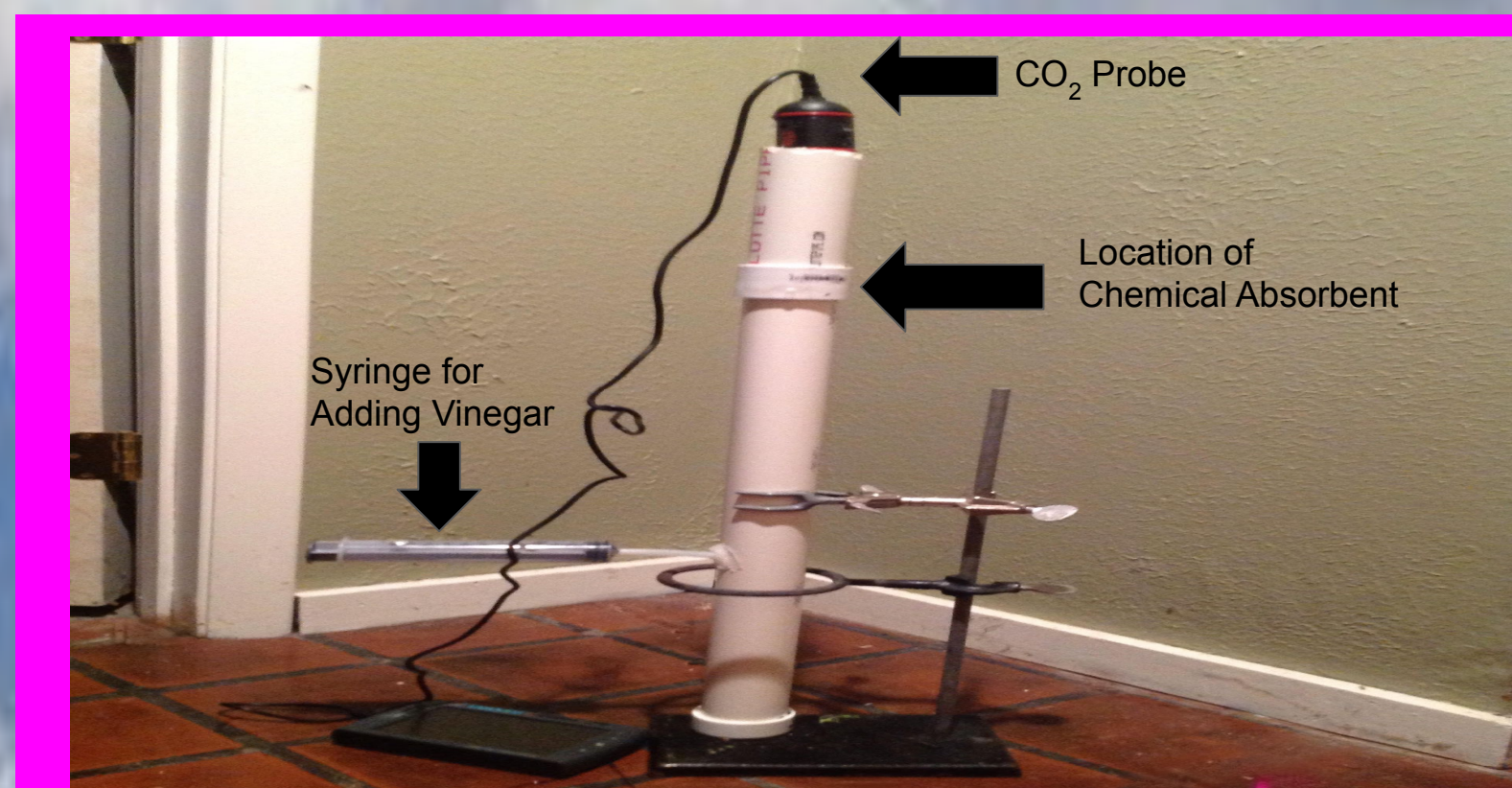


Figure 2. A picture of the testing apparatus used in the experiment to model a chimney.

PROCEDURE

- 1) Glue one PVC end cap onto one end of the 24 inch (60.96 cm) long PVC pipes using PVC pipe glue and allow glue to dry.
2. Drill a hole in each PVC pipe at a height of 15 cm and insert a 20 cm long tube
3. Cut a 24 inch (60.96 cm) PVC pipe into three equal length pieces
4. Cut two pieces of mesh to a 6 cm x 6 cm size
5. Add 25 grams of baking soda to the capped 24 inch (60.96 cm) PVC pipe.
6. Cover the 24 inch (60.96 cm) PVC pipe with the two pieces of mesh
7. Connect the small PVC pipe to the larger PVC pipe with a coupling
8. Connect a Vernier CO₂ probe to a Vernier Labquest 2
9. Add the CO₂ probe to the top of the small PVC pipe
10. Obtain 50 mL of vinegar by using a 50 mL syringe
11. Inject 50 mL of vinegar into the 20 cm long tube in the side of the long PVC pipe
12. Hit record on the Vernier Labquest 2 to record data for 30 seconds
13. Repeat steps 4-13 three more times to collect data for the control
14. Cut two pieces of mesh to a 6 cm x 6 cm size
15. Add 25 grams of baking soda to the capped 24 inch (60.96 cm) PVC pipe.
16. Cover the 24 inch (60.96 cm) PVC pipe with the two pieces of mesh
17. Connect the small PVC pipe to the larger PVC pipe with a coupling
18. Add 15 grams of activated carbon on top of the mesh
19. Connect a Vernier CO₂ probe to a Vernier Labquest 2
20. Add the CO₂ probe to the top of the small PVC pipe
21. Obtain 50 mL of vinegar by using a 50 mL syringe
22. Inject 50 mL of vinegar into the 20 cm long tube in the side of the long PVC pipe
23. Hit record on the Vernier Labquest 2 to record data for 30 seconds
24. Repeat steps 14-23 three more times to collect data for activated carbon
25. Repeat steps 14-23 replacing the activated carbon with potassium hydroxide for a total of four trials
26. Repeat steps 14-23 replacing the activated carbon with sodium hydroxide for a total of four trials

CONCLUSION

This experiment used three chemicals (activated carbon, potassium hydroxide, and sodium hydroxide) to absorb carbon dioxide. The hypothesis that potassium hydroxide would have the greatest absorption of carbon dioxide was not supported. All three chemicals did significantly absorb carbon dioxide but there were no significant differences between the amount of carbon dioxide absorbed. Thus, when constructing a device to collect carbon dioxide from chimneys, any of the three chemicals tested in the experiment could be used.

Pictures taken by Matlyn Haze Miller

Figures and Tables created by Matlyn Haze Miller