Hong Kong Student Science Project Competition 2022

Template of Extended Abstract (Investigation Design)
(Word Limit: 1,000 words, Pages: 2 pages only)

Team Number: JBBC130

Project Title: Carbon capture using sodium carbonate

Project Type: Investigation Design Proposal

To our best knowledge and after thorough literature research, as at 1/5/2022 , there are similar works. If there are, the reference links are as below:

https://pubs.acs.org/doi/10.1021/ie50281a014# Publication Date:May 1, 1933 C. R. Harte Jr. E. M. Baker and H. H. Purcell
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwi-o4botb33AhXGNOwKHTueCs0QFnoECAQQAw&url=https%3A%2F%2Fwww.mdpi.com%2F1996-1944%2F11%2F2%2F183%2Fpdf&usg=AOvVaw23SZ3sTQ2Y9SkFdwmNd3sZ(pdf) date of publication: 2018 Yuanhao Cai Weilin Wang, Liang Li, Zhaofeng Wang, Suying Wang, Hao Ding, Zhengguo Zhang , Luyi Sun and Weixing Wang
https://www.eeer.org/upload/eer-21-3-297.pdf (pdf) Publication Date: May 10, 2016, Jae-Goo Shim†, Dong Woog Lee, Ji Hyun Lee, No-Sang Kwak

The enhancement our project has made for the existing related products or research is summarized as below:

We will be changing the temperature of the sodium carbonate solution to see if it changes the reaction rate.

***Please delete if not applicable. HKSSPC values the originality of works. Students must conduct literature research thoroughly to ensure that their works are unique, and to list relevant reference materials to complement the research or invention.**

I. Background

Amid the intense, worldwide discussion concerning global warming and climate change, carbon dioxide (CO_2), as a greenhouse gas in the atmosphere, has been identified as the primary contributor. Carbon emission has drastically increased throughout the centuries since the industrial revolution. In this project, we aim to remove CO_2 in the atmosphere through a process known as carbon capture, mitigating global warming.
In this experiment, we will utilise the key reaction of:

$$Na_2CO_3\,(s) + CO_2\,(g) + H_2O(l) \rightarrow 2NaHCO_3\,(s)$$

A previous research paper published by Yuanhao Cai [1] conducted experiments on the effective capture of carbon dioxide focusing on the dispersion of Na_2CO_3 powders on solid supports, utilising hydrated sodium carbonate powder to test the sorption of carbon dioxide. Another research by C. R. Harte [2] explores the rate at which carbon dioxide tends to be absorbed from gas by aqueous sodium carbonate.
However, in our experiment, we aim to discover the efficiency of absorption of carbon dioxide by changing the temperature of the $NaHCO_3$. We will use calcium carbonate ($CaCO_3$) to react with HCl to create CO_2, this will then react with Na_2CO_3 solution to form bicarbonate ($NaHCO_3$). The limewater will then turn chalky if there is carbon dioxide, and will turn chalky quicker if more carbon dioxide is present, and less carbon dioxide is absorbed.

II. Objective(s)

Our investigation is to find out the relationship between the absorption efficiency of carbon dioxide of Na_2CO_3 solution and the temperature of Na_2CO_3 solution.

III. Hypothesis

We believe that as temperature increases, the time taken for limewater to turn chalky would increase as an increase of temperature leads to an increase in kinetic energy in the sodium carbonate, making it more likely to collide with the carbon dioxide flowing in, and bonding with it. We can use a system, where we produce 0.015 mol of carbon dioxide using calcium carbonate and hydrochloric acid, and put a tube connecting it to a test tube containing sodium carbonate. We can put the test tube in a water bath to increase the temperature of sodium carbonate solution.Using this set up, we can test the hypothesis.

IV. Methodology

Materials:
Limewater, 1 mol/dm^3 sodium carbonate solution (Na_2CO_3), calcium carbonate ($CaCO_3$), 0.5 mol/dm^3 hydrochloric acid (HCl), 100cm^3 measuring cylinder, stopwatch, digital water bath, stopper with tubes attached, lab jack, retort stand, baking paper, test tube rack, gas delivery tube
Methodology:
Add calcium carbonate to hydrochloric acid to produce carbon dioxide, then put a test tube with sodium carbonate in the water bath until it reaches a 30^{0}C. Put a test tube of limewater on the end of the set up. When the calcium carbonate is added, start the stopwatch, and stop the stopwatch when white precipitate is seen and record the time. Repeat the experiment three times and increase the temperature by 10^{0}C repeat all steps until all temperatures are recorded.
For the control set up we replaced sodium carbonate with water and redid the experiment thrice at 30^{0}C.
In theory, the hydrated sodium carbonate is supposed to react with carbon dioxide. This reduces the amount of carbon dioxide in the air through this reaction, as the carbon dioxide reacts with the sodium carbonate solution to form a new product, sodium bicarbonate. This can be shown in the equation below:

$$Na_2CO_3\,(s) + CO_2\,(g) + H_2O(l) \rightarrow 2NaHCO_3$$

Furthermore, we use limewater in order to record the time taken for it to turn chalky in order to compare how the temperature of sodium carbonate can affect the amount of carbon dioxide absorbed. As limewater turns chalky in the presence of carbon dioxide.
The analysis of the experiment would include finding the average of the three experiments we did for each temperature point and draw plot points on a graph using the average of the three experiments, then draw a line of best fit to show the trend between the temperature and the time taken for limewater to turn chalky.

V. Results

	Temperature (^{0}C)						
	control	30	40	50	60	70	
Measured in min and seconds	Avg of the 3 tests (not including outliers)	(AVG.) 47.3sec	(AVG.) 98.0 sec	(AVG.) 97.3 sec	(AVG) 81.7 sec	(AVG.) 68.7 sec	(AVG.) 55 sec

We repeated the experiment as many times as it took for us to achieve 3 sets of data that are close enough that it can be counted into the data set without it being an outlier (15 seconds away from any of the other points). We then took the three times for the experiments and found the average for them.
The results show a trend which shows that as the temperature increases, the amount of carbon dioxide absorbed decreases, meaning that at lower temperatures, sodium carbonate absorbs more carbon dioxide.
This can impact which countries in the world it is most effective in (countries with cooler temperatures). This also leads to an increase in the efficiency of sodium carbonate and how it can help reduce the amount of carbon in the air, leading to less global warming in addition to a lesser impact that climate change has on the planet.

VI. Conclusion

Our investigation has reached the objective of finding out if temperature affects how quickly sodium carbonate absorbs carbon dioxide. Based on the results obtained, we can easily conclude that the rate of carbon dioxide in washing soda (sodium carbonate) will decrease as the temperature increases. However, this research can move forward by having day to day usages and used in real life situations and put in place in different places in order to help our world against climate change.