Relationship Behind pH of a Liquid and Volume of Gas Produced by Sodium Bicarbonate

By Nicholas S. Weatherley

Writing for Engineering

Instructor: Thomas Barber

The City College of New York

Fall 2018

Abstract

Sodium Bicarbonate, hereafter called BiCarb, is used everyday and plays many different roles[1][2]. It can be used as an abrasive or as a laundry detergent[1]. Many of the uses require the BiCarb to be present and not react with its environment and thus require a basic to neutral enviroment. To find this optimal environment, different pH liquids are tested with BiCarb and the resultant gas is measured along with the remaining BiCarb tested for reactivity.

Introduction

From industrial to residential BiCarb is essential for many industries and products[1]. I can be used as a fungicide or for simply baking[1]. Some of the key reasons for its widespread use is that it is an amphoteric yet slightly basic with a pH of 8.31][3]. PH is the measure of ones basic, neutral, or acidic level[4]. It can range from 0, highly acidic and readily active to take OH- ions, to 14, highly basic and readily available to take H+ ions[4]. An amphoteric substance can either act as an acid, stealing OH- ions, or basic, stealing H+ ions[5].

This experiment aims to delve deeper into the relationship between pH levels and the amphoteric BiCarb. The data found during these tests can be used to increase cost efficiency everywhere by reducing the amount of BiCarb wasted on environmental factors. It will attempt to find the optimal pH environment where BiCarb can exists with limited reactions. This area should hopefully range from slightly acidic pH ~6.0 to slightly basic pH ~ 8.0.

Objective

This report will measure a liquids efficiency to breakdown BiCarb by measuring the volume of gas produced and remaining reactive bicarbonate. Once measured, the remaining reactive BiCarb along with the volume of gas will be compared to determine the most efficient pH catalyst in the BiCarb reaction.

Materials

- 15 Reseal-able One Quart Size Zip-lock Style bags
- 6 Tbsp. 5% Acetic Acid White Vinegar pH 2.4 [6]
- 6 Tbsp. 3% Hydrogen Peroxide pH 6.2 [7]
- 6 Tbsp.100% Pure Lemon Juice pH 2.6 [8]
- 6 Tbsp. Flat Sparkling Lemon Water pH 5.8 [9]
- 6 Tbsp. Target Brand Acetone Nail Polish Remover pH 7.0 [REMRef]
- 15 Tbsp.100% BiCarb Powder pH 8.3 [1]
- 1 Stopwatch
- 1 Imperial and Metric Ruler

Figure 1 – Materials used for lab

Procedure

1. Ensure that all materials are sterile.

   a. Clean and towel dry measuring spoon and inspect each bag for defects

b. Allow all liquids to reach ambient temperature by resting for no less than 30 minutes in testing environment

2. Fill each ziplock bag with exactly one tablespoon of BiCarb.

    a. Ensure that all BiCarb is in the lower left corner of each bag.

3. Measure and fill five bags with one tablespoon of their designated liquid.

    a. Fold the bag in half isolating the BiCarb from the other half of the bag.

    b. Close the ziplock bag on inch.

    b. Add one tablespoon of liquid to bag on the opposite side of the BiCarb

4. Close the bag and mix the BiCarb with the liquid.

    a. Tightly seal the the ziplock bag ensuring the liquid and BiCarb do not touch.

    b. Shake the now sealed bag for 30 seconds.

    c. Let sit for no less than two minutes

5. Visually measure the volume of gas produced and test for remaining BiCarb.

    a. Place the sealed bag on a flat level surface.

    b. Measure the center of the bag's height from the table with the ruler.

    c. Unseal and add one tablespoon of distilled white vinegar to bag

6. Repeat steps 3 – 5 for 12 remaining bags

    a. Take note to increase the volume of liquid by one tablespoon on each rotation.

Results

Below is the data pulled from the above procedure. Note that column five is measured from one to three. One being slightly to none reactive. Three being highly reactive.

Table 1 – Results for BiCarb Reaction

Liquid	pH	Liquid Volume (Tbsp)	Volume of Gas (Inches)	BiCarb Remaining Reactivity
Acetone Nail Polish Remover	7	1 2 3	0.1 0.1 0.2	3 3 3
Flat Sparkling lemon Water	5.8	1 2 3	0.6 1.1 1.2	3 3 3
Lemon Juice (100%)	2.6	1 2 3	0.9 1.5 2.1	3 2 1
White Vinegar (5%)	2.4	1 2 3	1.1 1.9 2.3	3 2 1
Hydrogen Peroxide (3%)	6.2	1 2 3	0.1 0.1 0.2	3 3 3

Analysis

The experiment shows that the optimal environment is that of a slightly acidic, pH of ~6.2, that of neutral, pH of 7. A slightly acidic liquid of pH of 6.2 produced relatively similar gas levels to that of a neutral liquid pH of 7. This shows that a maximum potential lifespan could be achieved by keeping BiCarb in these optimal environments thus reducing costs and potential shutdown times for companies. Though my findings may be skewed by user error.

One of the greatest potential losses would be during step three of the procedure. It was noticed that residual BiCarb was prematurely reacting with the added liquid. One way to resolve this would be to keep the liquid and the BiCarb completely isolated in a sealed container until one is ready for the experiment. Another potential error prone step is during step two. Using a tablespoon rather than using a precise scale may result in nonuniform amounts. Future testing can resolve these issues along with testing with a wider range of pH liquids.

Reference List

[1] Pubchem.ncbi.nlm.nih.gov. (2018). *Sodium bicarbonate*. [online] Available at: https://pubchem.ncbi.nlm.nih.gov/compound/sodium_bicarbonate [Accessed 13 Nov. 2018].

[2] "Sodium Bicarbonate Uses", *ScienceStruck*, 2018. [Online]. Available: https://sciencestruck.com/sodium-bicarbonate-uses. [Accessed: 13- Nov- 2018].

[3] Airhuff, "Can sodium bicarbonate be considered an acid?", *Chemistry Stack Exchange*, 2018. [Online]. Available: https://chemistry.stackexchange.com/questions/72775/can-sodium-bicarbonate-be-considered-an-acid. [Accessed: 13- Nov- 2018].

[4] C. Ophardt, "pH Scale", *Chemistry.elmhurst.edu*, 2018. [Online]. Available: http://chemistry.elmhurst.edu/vchembook/184ph.html. [Accessed: 13- Nov- 2018].

[5] A. Helmenstine Ph. D., "What Does Amphoteric Mean in Chemistry?", *ThoughtCo*, 2018. [Online]. Available: https://www.thoughtco.com/definition-of-amphoteric-and-examples-604776. [Accessed: 13- Nov- 2018].

[6] Danijoo, "What's the pH of vinegar containg 5% acetic acid?", *Chemistry Stack Exchange*, 2018. [Online]. Available: https://chemistry.stackexchange.com/questions/24917/whats-the-ph-of-vinegar-containg-5-acetic-acid. [Accessed: 13- Nov- 2018].

[7] "What is the pH of H2O2 solutions? | USP Technologies", *H2o2.com*, 2018. [Online]. Available: http://www.h2o2.com/faqs/FaqDetail.aspx?fId=26. [Accessed: 13- Nov- 2018].

[8] J. Staughton, "What is the pH of Lemon Juice | Organic Facts", *Organic Facts*, 2018. [Online]. Available: https://www.organicfacts.net/ph-lemon-juice.html. [Accessed: 13- Nov- 2018].

[9] "Analyzing & Comparing Brands of Bottled Water", *Alkalinewaterplus.com*, 2018. [Online]. Available: https://www.alkalinewaterplus.com/analyzing-comparing-brands-of-bottled-water. [Accessed: 13- Nov- 2018].