Experiment of calcium carbonate composition of eggshells

INTRODUCTION

Calcium carbonate, $CaCO_3$, is found in nature giving hardness and strength to things such as seashells, rocks, and eggshells. As hard as this substance is, it will react readily with hydrochloric acid to yield carbon dioxide gas (and two other products). In this experiment students will design an experiment by reacting eggshells with 2 M HCl to compare the calcium carbonate composition of white (chicken) eggshells to brown eggshells.

A good quality eggshell will contain, on average, 2. 2 grams of calcium in the form of calcium carbonate. Approximately 94% of a dry eggshell is calcium carbonate and has a typical mass of 5. 5 grams, 1 although these values can differ depending on sources. Amounts as low as 78% have been published. The remaining mass is composed largely of phosphorus and magnesium, and trace amounts of sodium, potassium, zinc, manganese, iron, and copper. In the case of brown versus white eggs, a definitive difference in calcium carbonate amounts may be hard to uncover. However, consider this. The color of the eggs is nothing more than a result of a different breed. The quality, nutritional value, and taste are identical between white and brown eggs, though two notable differences are size and price. Brown eggs are usually larger and slightly more expensive. The reason for the price increase is because brown eggs come from larger hens, which need to be fed more food daily. With a larger intake of calcium each day, one might expect the produced egg to have a higher calcium carbonate content. However, since the eggs are larger, it must be kept in mind that the calcium is spread over a larger surface area during egg formation. A brown eggshell's increased tendency to break, when compared to white, is often attributed to this " thinning out" of calcium during deposition.

To avoid the breakage of eggs before reaching market, the eggshells needs to be as strong as possible. The strength of eggshells is mainly determined by the percentage of calcium carbonate in it. In order to monitor the quality of eggshells, the following experiment has to be done to determine the percentage of calcium carbonate in eggshells.

In this experiment, back titration is used. First, excess acid is reacted with the calcium carbonate in eggshells.

$2HCl(aq)+CaCO_3(s) \rightarrow CaCl_2(aq)+H_2O(l)+CO_2(g)$

Later, if we can find out the number of mole of unreacted acid, number of mole of calcium carbonate can then be found out. The number of mole of unreacted acid can be found by titration with the following reaction.

$HCl(aq)+NaOH(aq) \rightarrow H_2O(l)+NaCl(aq)$

Percentage by mass of calcium carbonate in eggshell can then be calculated by the following formula:

4. 2AIMS AND OBJECTIVES

The purpose of this experiment is to determine the percentage by mass of calcium carbonate in eggshells.

design an experiment that quantifies the amount of calcium carbonate present in a natural

substance.

- relate the amount of a reactant or product of a chemical reaction to another reactant or product.
- work collaboratively with their peers to solve a given problem in the laboratory in a way that models the scientific method.
- apply a common acid reaction between hydrochloric acid and the carbonate ion.

Chapter 2

THEORY & METHOLOGY

PRINCIPLE OF THE EXPERIMENT

During this experiment, the percentage of $CaCO_3$ in an eggshell is determined by reacting the eggshell with hydrochloric acid. The equation for this reaction is:

$$2HCl\ (aq) + CaCO_3(s) \rightarrow Ca^{2+}\ (aq) + CO_2\ (g) + H_2O\ (l) + 2Cl^-\ (aq)$$

This reaction cannot be used directly titrate with the $CaCO_3$. Instead, an excess of hydrochloric acid is added to dissolve the eggshell, and the remaining acid is titrated with NaOH solution to determine the amount of acid that did not react with the eggshell. The equation used to determine the amount of leftover acid is:

$$HCl\ (aq) + NaOH\ (aq) \rightarrow H_2O\ (l) + Na^+\ (aq) + Cl^-\ (aq)$$

APPARATUS AND EQUIPMENTS

- Beaker Pipette Filler
- Electronicbalance
- Volumetric flask
- BuretteWash bottle

- Mortar and pestle Conical flasks
- White tile
- Filter funnel
- Filtter paper 25. 00 cm
- 3 pipette

CHEMICALS USED

- 2 M HCl Phenolphthalein
- 2 M NaOH

PROCEDURE

- White and Red colour eggshells have taken and the protein membrane was removed on the inside of the eggshells.
- The eggshell was washed with distilled water
- Dried in an oven for few minutes.
- The eggshell was then grounded into fine powder by mortar and pestle.
- 2g of eggshell powder is weighted accurately by using an electronic balance and it was transferred to a conical flask.
- 25. 00 cm3 of HCl was pipetted to dissolve the eggshell powder.
- Distilled water was added to the flask until it reached about 100cm3. The flask was swirled gently.
- Put the solution into cubed for two days.
- Faltered the solution using filter papers.
- Pippet out 25. 00 cm3 from each solutions to titration flasks.
- The solution was then titrated with standardized NaOH.
- Repeat another two samples from each solution.
- Collect the correct burette readings at the end point.

Chapter 3

EXPERIMENTAL RESULTS

THE COLOR CHANGE OF THE SOLUTION

- White egg Brown egg
- Colourless pink Colourless pink

THE TITRATION RESULT OF BROWN EGG

	1	2	3
Volume of eggshells solution/cm3	25. 00	25. 00	25. 00
Volume of NaOH used/cm3	20. 10	19. 90	20. 10

- Average volume of NaOH used: (20. 10+19. 90+20. 10) = 20. 03cm33

THE TITRATION RESULT OF WHITE EGG

	1	2	3
Volume of eggshells solution/cm3	25. 00	25. 00	25. 00
Volume of NaOH used/cm3	20. 40	20. 35	20. 00

*Average volume of NaOH used: (20. 40+20. 35+20. 00) = 20. 25cm33

Chapter 4

CALCULATIONS

CALCULATIONS

- 2HCl (aq) + CaCO3(s)→Ca2+ (aq) + CO2 (g) + H2O (l) + 2Cl- (aq)

- HCl (aq) + NaOH (aq) → H_2O (l) + Na^+ (aq) + Cl^- (aq)

FOR BROWN EGG

Number of moles of NaOH used to react with HCl

= 20. 03cm3 /1000) X2M = 40. 06X 10-3 mol

Since number of moles of NaOH = number of moles of HCl in 25cm3

= 40. 06 X 10-3 mol

HCl mols in 100cm3 = 40. 06 X 10-3 X 4 mol

The initial no of moles of HCl: volume X molarity

= 100/1000 X2M = 200X10-3 mol

Number of moles of HCl used to react with CaCO3 =

(200X10-3 – 160. 24X 10-3) mol = 39. 76X10-3 mol

According to the equation, one mole of HCI required to react with 2 moles of CaCO3,

Number of moles of CaCO3 reacted = 39. 76X10- 3 /2

= 19. 88X10-3 mol

The weight of CaCO3 = 19. 88X10-3g X100g

The % of CaCO3 in eggshell (brown) = (1. 988/2) X100%

= 99. 4%

FOR WHITE EGG

Number of moles of NaOH used to react with HCl:

(20. 25cm3/1000)X2 = 40. 50X10-3mol

Since number of moles of NaOH= number of moles of HCl in 25cm3

= 4. 50X10-3mol

HCl Volume in 100cm3 = 40. 50 X10-3 X4 mol

The initial moles of HCl: volume X molarity

= 100/1000 X2M = 200X10-3 mol

Number of moles of HCl used to react with CaCO3 :

(200X10-3 – 162X10-3) mol = 38X10-3 mol

Number of moles of CaCO3 reacted = 38X10-3/2

= 19X10-3 mol

The weight of CaCO3 = 19X10-3g X100

The % of CaCO3 in eggshell (white) = (1. 9/2) X100%

= 95. 0%

Chapter 5

DISCUSSION AND CONCLUTION

CONCLUSION

- Percentage of CaCO3 in red eggshells= 99. 4%

- Percentage of $CaCO_3$ in white eggshells= 95. 0%

Therefore red eggshells has the higher percentage of $CaCO_3$.

DISCUSSION

Source of errors

- The eggshell powder did not dissolve completely
- Variation in visual judgment at the end point
- Instrumental errors of the electronic balance
- The eggshell was not fully dried
- Some droplets of solution may still adhere on the beaker and the glass rod which lead to the reduction in number of moles of excess HCl

In this Experiment we can also do the EDTA titration.

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