***Calcium Supplement  
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*My signature indicates that this document represents my own work. Excluding shared data, the information, thoughts, and ideas are my own, except as indicated in the references.*

*\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_***Abstract**

Osteoporosis is a disease widely spread around the globe, it is a disease known for the increase risk of bone fractures and the reduction of bone mineral density (BMD); ultimately weakening the skeleton in the Human Body1. In order to avoid such a disease doctors recommend Calcium Supplements as the human body starts to age or the human gets closer to the age of 50, which leads to this particular lab. This lab has the objective of designing and creating an alternative Calcium supplement that originates from a cheap source, Calcium Carbonate (also commonly known as chalk). Calcium Carbonate is combined with Acetic acid in order to create a clear and soluble substance that is safe (safe pH and isn’t toxic to the human body).

**Introduction**  
 Osteoporosis is a disease widely spread around the globe, it is a disease known for the increase risk of bone fractures and the reduction of bone mineral density (BMD); ultimately weakening the skeleton in the Human Body1. The reduction of the BMD causes the deterioration of the microarchitecture of the human bone and major alteration of the proteins in it. Since the risk of fractures increase, the spine/forearm/and the hip are the most common, 80%, fractures after the bone becomes weak. Within a years’ time, 20% of the hip fractures are lethal to the patients. It is also referred to as the “silent epidemic” because in many affected people, bone loss is common and doesn’t show symptoms until the disease has advanced. In addition, the risk of acquiring such a disease increases as the human body ages2.

In the United States, 44 million people suffer from either Osteoporosis or bone loss. 55% of these affected are patients over the age of 50. In women worldwide, the bone loss can occur as early as the age of 25; a female has a 30-40% risk of acquiring an osteoporotic fracture while a male has a 13% risk of acquiring it during his/her lifetime2.  
 Calcium is essential to the human body’s bone strength, which all in all, is the strength of the human body. Doctors often recommend elderly people or as the human body ages to consume a calcium supplement daily as a precaution for not acquiring Osteoporosis. There are numerous brands of Calcium Supplements including antacids such as Tums, and liquid supplements such as Mylanta. However, patients describe the feeling of digesting such supplements to be quiet “chalky” like; which leads to the fact that the cheapest source of Calcium is Calcium Carbonate (more commonly known as blackboard chalks) 3.

The principal objective of this particular experiment is to design a Calcium Supplement solution, which isn’t difficult, unpleasant to swallow, or “chalky” like, with Calcium Carbonate (CaCO3(s)) as a principal source. However there are some restrictions in order for it to be consumable; it has to be a clear solution, its pH level has to be between 4 and 10, it doesn’t contain any toxic materials (any amount below 500mg/kg is considered to be toxic), and a known concentration of the solution3.   
 Calcium Carbonate has a state of matter as a solid, which in order to create a solution must be clear and soluble. The mixture of an acid with CaCO3(s) is a very effective way; if acid is added, the system would try to decrease the concentration of the acid by favoring the forward reaction. Thus, more amounts of CaCO3(s) would be dissolving in the solution. Taking that into consideration, mixing CaCO3(s) with Acetic Acid (CH3COOH(aq)) would allow the CaCO3(s) to be soluble according to the following reaction:

Calcium Acetate is a result of the mixing of Calcium Carbonate and Acetic Acid, which has a Median Lethal Dose (LD50) of 4.

Calcium Acetate can be produced with the cheapest source of Ca2+, CaCO3(s), for a large-scale production as a safe Calcium Supplement.

**Results**

The whole experiment revolved around the following reaction:

A series of 3 trials were conducted in order to express the validity of the experiment. *Figure 1.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Trials** | Amount of CaCO3(s) added (±0.0001g) | Amount of Acetic Acid added (±0.01ml) | Final Temperature of the solution (°C/K) | pH of the final solution |
| ***Trial #1*** | *0.1008g* | *5.00ml* | *20*°C/293.15K | *6.10* |
| ***Trial #2*** | *0.1002g* | *5.00ml* | *21*°C/294.15K | *5.90* |
| ***Trial #3*** | *0.1000g* | *5.00ml* | *22*°C/295.15K | *5.92* |

* The data relation between the trials and the pH can also be seen through the following graph: *Figure 2*
* The data relationship between the temperature and trials can be seen by the following graph: *Figure 3*.

Averages:

* Temperature:
  + 21°C
  + 294.15K
* pH
  + 5.97

Observations:

* In each trial, as soon as Acetic Acid was added to Calcium Carbonate, the Calcium Carbonate started to jump around almost as if it was boiling (because of the release of CO2(g) as well as acetic acid being a weak acid). At first it wasn’t a clear solution, although it cleared out over a matter of 2 minutes into a clear solution.

**Discussion**

As stated earlier, Osteoporosis is a disease widely spread around the globe, it is a disease known for the increase risk of bone fractures and the reduction of bone mineral density (BMD); ultimately weakening the skeleton in the Human Body1. Since 55% of the patients are elderly over the age of 50, doctors have recommended the consumption of Calcium supplements that are essential to the human bones regarding their strength. However, most of the Calcium supplements are described to be unpleasant and “chalky” like at the point of swallowing, leading to the objective of this particular experiment: designing a Calcium Supplement with a pH between 4-10, a clear solution, and a safe substance for digestion in the human body.

According to the results, an approximate of 0.1000g of CaCO3(g) was used with 5ml of Acetic Acid in each trial, this was calculated by the following method:

* As the reaction above is a balanced equation, there is a 1:1 molar ratio between CaCO3(s) and CH3COOH(aq), this means that CaCO3(s) contains the same amount of moles as CH3COOH(aq). Thus the following calculations were conducted in order to acquire the amount of moles of Acetic Acid (1.000M of CH3COOH(aq)):
  + By using the formula:
  + Thus in order to find the moles, the known values are plugged into the equation and solved for the unknown value (in this case, the amount of moles of 1.000M of Acetic Acid)

**=**

=*0.005 mol of Acetic Acid*

* + Since it’s a 1:1 molar ratio, there are 0.005 moles of Calcium Carbonate.
  + In order to figure out the amount of Calcium Carbonate needed (as it’s the Limiting Reagent), the following formula would be used:
  + Thus in order to find the amount of Calcium Carbonate needed in grams for the reaction, the known values were plugged in (0.005 moles of CaCO3(s) and 100.09 g/mol as a Molar Mass of the substance) and solve for the unknown value:

=

= 0.500 grams needed of Calcium Carbonate.

* + 0.500 grams are need of Calcium Carbonate in a reaction of 5 ml of Acetic Acid. Since it’s a limiting reagent, any amount below 0.5g should still react, thus the amount set of Calcium Carbonate used was to be approximate of 0.100 g for the reaction.
  + Also the moles of Calcium carbonate with only .1 g used is:
  + The Concentration of Ca2+ is:

A recommended dose for 19-30 year olds to be 1g per day, which is the same for 51-70 year old males; however, 51-70 year old females are recommended to take 1.2g per day of calcium5. Thus the amount needed of this particular solution is:

Since the recommended dose for a male between the ages 51-70 needs 1 grams per day, then they need 49.96ml/day of this solution.

After all the calculations, it theoretically proves that it should be soluble, although, it should be tested, thus a very quick trial was conducted. It showed that the Calcium Carbonate is soluble in Acetic acid; it is a clear solution with a ph of an approximate of 6.00. However, the reaction was slow due to Acetic Acid being a weak acid, thus the help of a hot plate was used in order to heat up the solution, which allows the increase of Kinetic Energy between the molecules and thus speeding up the reaction in order to acquire a clear solution in less amounts of time. Although, after heating up the reaction, the solution had to be cooled down to the room temperature of approx. 21C in order for the validity of the experiment and hypothesis. In the end all the results can be seen below in the table: *Figure 4.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Trials** | Amount of CaCO3(s) added (±0.0001g) | Amount of Acetic Acid added (±0.01ml) | Final Temperature of the solution (°C/K) | Clear Solution? (Yes or No) |
| ***Trial #1*** | *0.1008g* | *5.00ml* | *20*°C/293.15K | Yes |
| ***Trial #2*** | *0.1002g* | *5.00ml* | *21*°C/294.15K | Yes |
| ***Trial #3*** | *0.1000g* | *5.00ml* | *22*°C/295.15K | Yes |

By using the hot plate, the CaCO3(s), while in the process of dissolving, was bouncing around in the 50 ml glass beaker and had a increased speed of reaction due to the heating of the molecules in the solution.

In order to come to the conclusion that this is a suitable solution, a series of rules and concepts of chemistry. Solubility rules were taken in consideration, which allowed Calcium Carbonate to be soluble and a safe solution. Also, since acetic acid is a weak acid, acid is added, the system would try to decrease the concentration of the acid by favoring the forward reaction. Thus, more amounts of CaCO3(s) would be dissolving in the solution.

Calcium Acetate is a result of the mixing of Calcium Carbonate and Acetic Acid, which has a Median Lethal Dose (LD50) of 4.

Using a hot plate in order to speed up the reaction for the solution to be a clear solution. It would’ve been a more accurate experiment if time were given for the process of dissolving rather than speeding up the reaction by a hot plate, because it adds heat to it and speeds up the natural process of dissolving. In addition, since every instrument/glass ware used, had a particular uncertainty that could’ve made the values added to the reaction to be un-precise; even though in the experiment time was given for the solution to cool down to the room temperature (which was measured by a thermometer), it wasn’t quiet effective as time had to be given for it to cool down to the room temperature.

**Conclusion**

The main objective of this particular laboratory experiment was to create a Calcium supplement that was not too “chalky” or unpleasant at the point of digestion by a human body. The usage of 1.00M of Acetic Acid was a success according to the hypothesis at the beginning of the experiment as .1000g of Calcium carbonate was poured in 5ml of Acetic Acid in order for it to dissolve over a hot plate. During the reaction, the molecules in the solution started to heat up and increase their kinetic energy, resulting in the increase of the rate of reaction, which was observed by Calcium Carbonate constantly turning into light bubbles and bouncing around the edges of the 5ml glass beaker; also the feeling of a warm gas that is a result of CO2(g) as a product of the reaction between calcium carbonate and Acetic Acid. It also proved to be a safe substance as it was a clear solution, pH of 5.97, and a LD50 of 4280mg/kg (which isn’t considered to be toxic). The concentration of Calcium is calculated to be 0.2M. A recommended dose for 19-30 year olds to be 1g per day, which is the same for 51-70 year old males; however, 51-70 year old females are recommended to take 1.2g per day of calcium. For a male of an age between 51-70 requires 1 grams/day, then they require 49.96ml/day of this calcium supplement.

**Experimental**

Procedure:

1. Gather up one 50ml beaker, a watch glass, a pipette, cleaning cloth, soapy water, distilled water in a wash bottle, heating plate, glass thermometer, 25ml graduated cylinder, a weighing scale, 15ml of Acetic acid, pH probe and meter.
2. Rinse all the glassware with soapy water and distilled water. Clean them with the cleaning cloth.
3. Measure 15ml of acetic acid into the 25ml graduated cylinder.
4. Measure an approximate of .1grams of Calcium Carbonate in the weighing scale.
   1. If you exceed or are close to, then record that amount into your data collection.
5. Place Calcium carbonate into the 5ml glass beaker and measure 5ml of acetic acid and pour it into the 5ml glass beaker with Calcium carbonate in it.
6. Place the 5ml glass beaker onto a hot plate with medium heat till it is a clear solution
7. Measure the temperature with a thermometer.
8. Let it sit for a couple of minutes in order for it to cool down to room temperature. Record the temperature when its at room temperature (or near it) when you are going to measure the pH
9. Calibrate the pH probe.
10. Measure the pH and record the data.
11. Rinse the 5ml beaker and dry it with the cleaning cloth
12. Repeat steps 4-11 for the remaining two trials and record your data and observations

**References**

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