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Crystal Investigation

Year 9-10

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Crystallography Report

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Aim: To see if the rate of growth depending on the size of the Seed Crystal.

Hypothesis: If the seed crystal begins with a lower mass, then the net mass growth of the crystal in comparison to the start will be increased.

Background information:

Crystallography is a fascinating and multidisciplinary field of science that focuses on the study of crystal structures. Crystals are highly ordered and repeating arrangements of atoms or molecules that can take many different shapes and forms, from the beautiful facets of a diamond to the intricate structures of biological macromolecules such as proteins and nucleic acids. (American Crystallographic Association)

The study of crystallography has a long history that dates back to the ancient Greeks, who recognized the geometric regularity of crystals and developed basic crystallographic principles. However, it wasn't until the early 20th century that significant progress was made in the field, thanks in part to the ground-breaking work of William Henry Bragg and his son, William Lawrence Bragg. (Nobel Prize Organisation)

The Braggs' discovery in 1912 of X-ray diffraction and its use in determining crystal structures revolutionized the field of crystallography and opened new avenues of research. Their work established the field of X-ray crystallography, which has since become a powerful tool for analysing the three-dimensional structures of crystals and molecules. (Science Direct)

Since then, crystallography has evolved into a diverse and interdisciplinary field that has applications in many areas of science, from materials science and geology to chemistry, biology, and medicine. It encompasses a wide range of techniques and methods, including X-ray, neutron, and electron diffraction, as well as computational modelling and simulation.

In recent years, crystallography has played a crucial role in advancing our understanding of complex biological systems, such as the structures of proteins and other biomolecules. It has also led to the discovery of new materials with unique properties and applications, such as semiconductors and superconductors.
Nature. (n.d.).

Variables:

Independent variable: The independent variable is the size of the original seed crystal. It is chosen by the researchers to investigate its effect on the size of the resulting crystal. The size of the original seed crystal is controlled by selecting seeds of different sizes, and this variable is manipulated by using seeds of different sizes in the experiments.

Dependent variable: The dependent variable is the size of the final crystal minus the size of the original seed crystal, or the change in size of the crystal from the start of the experiment to the end. This variable is dependent on the independent variable, as the size of the original seed crystal is expected to affect the size of the resulting crystal. The size of the dependent variable is measured by comparing the size of the crystal before and after the experiment using a ruler or other measuring device.

Controlled variables: The controlled variables are the factors that are kept constant throughout the experiment to ensure that they do not affect the results. In this experiment, the controlled variables may include the temperature and pressure of the environment, the type and concentration of the chemical solution used, the amount of time the crystals are allowed to grow, and the method used to create the supersaturated solution. These variables are kept constant so that any changes in the size of the resulting crystals can be attributed to the independent variable, the size of the original seed crystal.

Materials:

List of materials:
Boiling water (50 ml)
Potash Alum (Aluminium potassium sulphate)Filter paper
Beaker
Evaporation dish
Fume hood
String
Toothpick
Distilled water (for rinsing)Clean, dry cloth or paper towel (for drying)Storage container (for storing the crystals)

Methodology:

1. Add 50 ml of boiling water to a beaker.
2. Add and dissolve Potash Alum (Aluminium potassium sulphate) until the mixture is saturated (cannot dissolve anymore). This creates a supersaturated solution of alum.
3. Using filter paper, filter the solution to remove any impurities that may interfere with crystal growth. It is important to use a clean filter paper to ensure that no impurities from the filter paper itself get into the solution.
4. Place 15 ml of the filtered solution into an evaporation dish. The evaporation dish should be clean and dry to prevent any impurities from getting into the solution.
5. Leave the evaporation dish in a fume hood overnight to allow the solution to evaporate slowly. This allows the solution to cool down and reach equilibrium and allows for the formation of seed crystals.
6. Once the solution has evaporated, seed crystals should have formed. These seed crystals act as nuclei for further crystal growth.
7. To grow a larger crystal, select a seed crystal of desired size and tie it to a string using a toothpick at the top of the beaker. The string should be long enough so that the seed crystal can be suspended in the alum solution without touching the sides or bottom of the beaker. The toothpick is used to prevent the string from sliding down into the solution.
8. Suspend the seed crystal in a saturated solution of alum and water. The solution should be prepared as described in step 2, but with additional water added to create a larger volume of solution.
9. Leave the beaker undisturbed in a location where it will not be disturbed or jostled. It is important to keep the beaker away from any sources of vibration or movement, as this can disrupt crystal growth.

10. Over time, the seed crystal will start to grow into a larger crystal as it absorbs more alum from the solution. This process can take several days or even weeks, depending on the desired size of the crystal.
11. Repeat steps 7-8 whenever periodically as to keep the solution saturated for longer periods of time.
12. If you want to grow multiple crystals, repeat the process with different sized seed crystals to obtain crystals of varying sizes. It is important to use a new string and toothpick for each crystal to prevent any contamination between crystals.
13. Once the crystals have grown to the desired size, remove them from the solution and rinse them with distilled water to remove any remaining alum solution. The crystals can then be dried and stored for display or measured for research.

Safety Issues:

- Burns: Handling boiling water poses a risk of burns. Care should be taken while handling hot materials, and appropriate protective equipment such as gloves should be worn.

- Inhalation: Inhalation of alum powder can irritate the nose, throat, and lungs. It is essential to work in a well-ventilated area or under a fume hood.

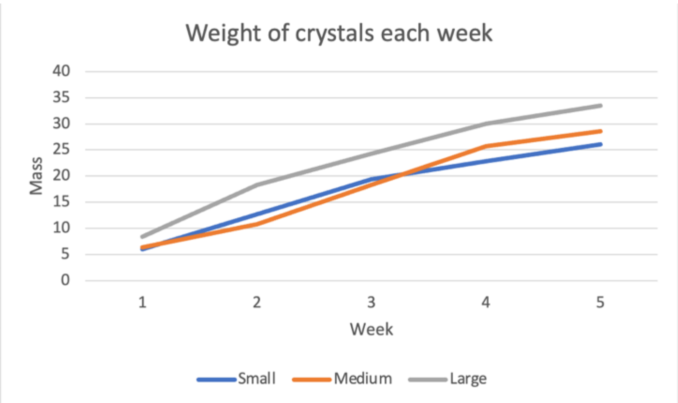
- Eye injury: Alum powder can cause eye irritation and injury. Eye protection such as goggles should be worn while handling the powder.

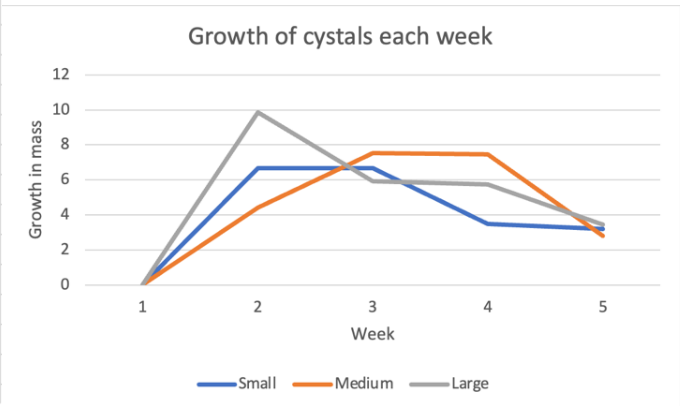
- Chemical exposure: Potash alum is a chemical compound and should be handled with care. It is important to read the Material Safety Data Sheet (MSDS) for the compound and follow appropriate safety measures.

- Contamination: Contamination can occur if the equipment and materials are not clean. It is essential to use clean filter paper, a clean evaporation dish, and clean string and toothpicks.

- Inhalation of fumes: Potash alum can release irritating or toxic fumes when heated or exposed to acid. Therefore, it is important to work in a well-ventilated area or fume hood to avoid inhaling these fumes.

Results:





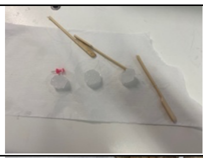
		Size		
		Small	Medium	Large
Week	1	6.02	6.36	8.43
	2	12.68	10.78	18.3
	3	19.36	18.3	24.23
	4	22.85	25.75	29.98
	5	26.04	28.56	33.42

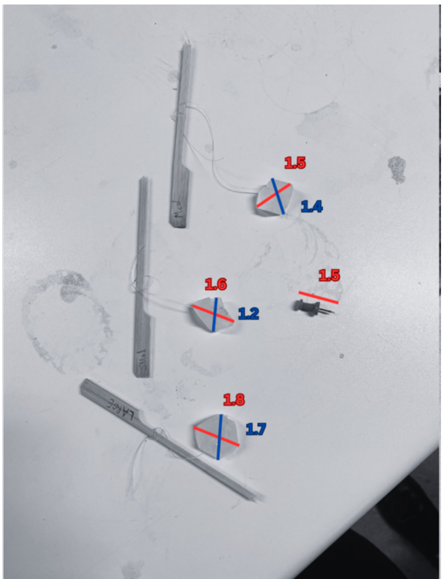
		Size		
		Small	Medium	Large
Week	1	0	0	0
	2	6.66	4.42	9.87
	3	6.68	7.52	5.93
	4	3.49	7.45	5.75
	5	3.19	2.81	3.44

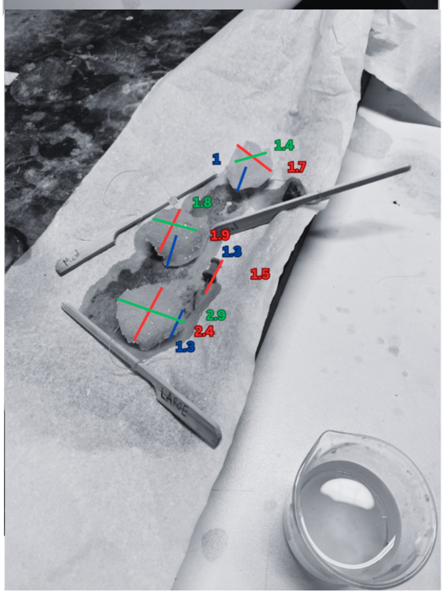
Small	Medium	Large
3.3255814	3.49056604	2.96441281

Small	Medium	Large
20.02	22.2	24.99

Table of Photos





Discussion:

The experimental data showed that the crystals grew at varying rates over the course of the investigation. Moreover, on average, the growth rate of the crystals slowed down as the investigation progressed. This finding suggests that the growth of the crystals is influenced by various factors, such as their initial size and the surface area.

The hypotheses tested in this experiment was that smaller crystals would grow more compared to their starting size. This hypothesis was supported by the data obtained from the experiment. Specifically, tables 3 and 4 displayed the number of times the crystals grew between week 1 and week 5. The results showed that the largest crystal grew the least, with only a 2.9-fold increase from the starting size in week 1. In contrast, the smaller crystals grew more, with the small and medium crystals growing 3.3x and 3.4x, respectively. This finding suggests that smaller seeding crystals tend to grow at a faster rate, relative to their size.

Table 4 further revealed the overall growth of the crystals from week 1 to 5. The results showed that the larger crystals had a slower growth rate compared to the smaller crystals. This finding supports the hypothesis that the growth rate of crystals is influenced by their initial size and surface area. Overall, these findings suggest that the size and surface area of the seeding crystals play a crucial role in determining the growth rate of crystals.

The images on the right showcase the crystal growth process and highlight the significant changes that occurred during the experiment. The "before" images show relatively smooth and less imperfect crystals, whereas the "after" images display more rough and textured surfaces. The annotations on the images are drawn to scale and indicate the growth of the crystals over time.

Limitations:

- The experiment only tested the growth rate of one type of crystal, potash alum. Other types of crystals may have different growth rates and behaviours, so the results may not be applicable to other crystals.

- The experiment only tested the effect of the size of the seed crystal on growth rate. Other factors, such as temperature, humidity, and impurities in the solution, could also affect crystal growth and were not accounted for in the experiment.

The experiment relied on visual observation to measure the size of the crystals. This method may not be accurate and could introduce subjective biases.

- The experiment was conducted over a relatively short period of time (5 weeks). Longer-term observations may be necessary to fully understand the growth patterns of crystals and to identify any potential trends or fluctuations in growth rates over time.

Improvements for the method:

- To reduce variability in room temperature and humidity levels, the experiment could be conducted in a controlled environment with stable conditions.
- More precise equipment and techniques could be used to measure the mass and size of the crystals, reducing measurement errors.
- To ensure consistency in the concentration and quality of the chemical solution used, a single batch could be prepared and used for all trials.
- To reduce the potential for human error, automated equipment could be used for the preparation of the chemical solution and for monitoring the crystal growth process.
- To reduce the potential for systematic errors related to seed crystal size, multiple seeds for each of the sizes could be tested in the experiment and their effects could be analysed.
- To ensure consistency in the growth period, a predetermined duration could be used for all trials.
- To reduce the potential for systematic errors related to equipment and apparatus, the same materials should be used in all trials.
- To reduce measurement errors, equipment should be calibrated before each trial and careful attention should be paid to the measurement process.

Errors:
Random errors:
- Inconsistent temperature
- Contamination
- Human error
- Equipment error

- Evaporation
- Light exposure

Systematic errors:

- Solution pH
- Solution concentration

Random errors refer to unpredictable variations or mistakes that can occur during an experiment, leading to inconsistent or erroneous results. These errors can arise from external factors or human actions and are typically difficult to control or eliminate completely. Examples of random errors in the given context include inconsistent temperature, contamination, human error, equipment error, evaporation, and light exposure. These factors can introduce variability in the experiment and affect the growth rate, size, or shape of the crystals.

On the other hand, systematic errors are consistent and predictable inaccuracies that occur throughout an experiment. They are often associated with specific sources or factors that consistently affect the measurements or observations. In the given context, the systematic errors include the solution pH and solution concentration. If these factors are not consistent throughout the experiment, they can introduce a bias in the results and affect the growth rate and size of the crystals in a systematic manner.

Conclusion:

In conclusion, this report aimed to investigate the rate of growth of a crystal depending on the size of the seed crystal. The hypothesis suggested that if the seed crystal began with a lower mass, then the net mass growth of the crystal in comparison to the start would be increased. The independent variable was the size of the original seed crystal, while the dependent variable was the change in size of the crystal from the start of the experiment to the end. The controlled variables were the factors that were kept constant throughout the experiment to ensure that they did not affect the results. The methodology involved creating a supersaturated solution of Potash Alum, filtering the solution to remove any impurities, allowing the solution to evaporate slowly, suspending the seed crystal in the saturated solution, and leaving the beaker undisturbed for several days or even weeks. The data provides valuable insights into the fascinating field of crystallography and the techniques involved in growing crystals of varying sizes and how sizes affect the growth rate of crystals.

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