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Crystal Investigation

Year 9-10

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Crystallography report

Temperature experiment

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Background:
Aluminium crystals, often referred to as potash alum or simply alum crystals, are chemical compounds with a formula KAl (SO_4). Alum crystals or stones are generally safe (non-toxic) and are easy to grow (ACS, N/A). The way these crystals bond together were formulated through the discovery of the reliable analytical method called crystallography. This has been employed in a number of disciplines, including the biological sciences, geology, and materials science. The structure of viruses, proteins, nucleic acids, gemstones, and other key components utilised in industry have all been revealed using this technique (John P. Rafferty, 2009).

Crystallography is one important technique for helping scientists understand the world around them. This is due to the fact that the advanced branches of technology widespread through the speciality gives scientists opportunities to view the molecular structure of almost any substance (IOP, 2022). This is used to receive knowledge to understand why things behave the way they do. A physical embodiment of the definition is X-ray crystallography, which is a form of crystallography that involves an X-ray with microscopic image representation that provides a 2-dimensional interactive view that gives an indication of 3-dimensional structure of material, enabling identification of the atomic and molecular structure configuration of bonds with-in a crystal (science museum, 2019).

Crystallography has come about since the discovery of X-ray diffraction by William and Lawrence Bragg in 1912. This discovery has enlarged the field of research and enabled scientists to further understand molecular structures of atoms and crystals. The invention was so advanced and helpful that the Braggs' became the first Nobel prize laureates to be biologically related (Nobel prize, 2023).

Since then, the Braggs' discovery advanced science further in multiple fields of not only medicine, but other scientific fields such as geology, mineralogy, and meteorology. This discovery is arguably the most significant in the field of crystallography, and one of the most important in all of science in general (Nobel prize, 2023).

Crystallography has also been used to advance modern-day technology in ways that many people may not even realise. For example, cell phones nowadays are very small and compact due to crystallography (Esther Y. Chen, Sanjay, 2018). This was accomplished when looking at the atomic structure of lithium and its electron structure in batteries. Through this knowledge scientists were able to understand the concept, in turn creating a more powerful, efficient yet more compact battery. The integrated battery on a phone was recently modulated due to the understanding of crystallography. This is one of many ways of how crystallography is used to benefit our lives without us even knowing it (Esther Y. Chen, Sanjay, 2018).

Aim:
The objective of this experiment is to determine how the temperature will affect the growth of the crystal.

Variables:

Independent – The independent variable was temperature in which a beaker is stored in.

Dependent – The dependent variable was the growth of the crystal.

Controlled – The controlled variables were concentration of the solution in each beaker, amount of solution in each beaker (as differentiation can alter concentration), airflow (as more/less can increase/decrease rate of evaporation, making the experiment inaccurate).

Hypothesis:
If a beaker with the concentrated solution is heated and kept at high temperature, it will react faster and pose larger crystal growth.

Apparatus:

- 3 100ml beakers
- 250ml beaker
- Measuring cylinder
- Funnel
- Spatula
- Stirring rod (glass)
- Alum salt
- Conical flask
- Filter paper
- Refrigerator
- incubator
- Paddle pop stick
- Fishing line

Methodology:

Step 1: Prepare a saturated solution of Alum potash, as described in experiment 1.

Step 2: Pour 50ml of saturated solution into three beakers.

Step 3: pick three similar sized seeding crystals to initiate the growth.

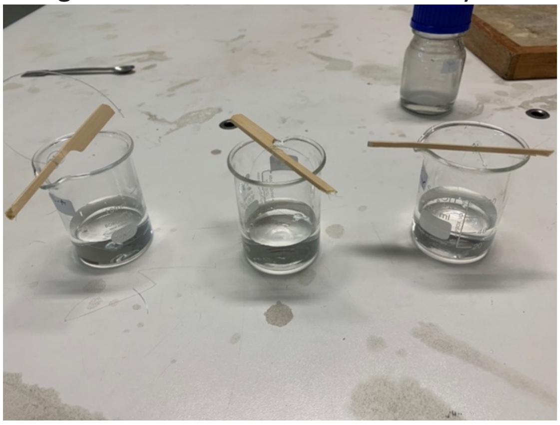
Step 4: tie fishing line around each crystal and attach it to the paddle pop stick.

Step 5: do this for the other two crystals. Submerge each of the crystals into the beakers of potash solution at the same time.

Step 6: Place one beaker in a refrigerator at 4°C, one at room temperature and one in an incubator set at 50°C. Ensuring they receive the same amount of airflow (the room temperature beaker is recommended to be placed in a cupboard)

Step 7: observe results over the course of at least 3 weeks.

Figure 1: The beakers with the crystals



Safety issues:

Burns: Since boiling water is used to assist saturating solutions, individuals are prone to severely burning themselves. Hence, to prevent this, equipment are handled with care.

Inhalation: inhaling alum powder can irritate the nose, throat, and lungs. To avoid inhalation, safe distances were constantly maintained.

Eye injury: Potash alum can cause eye irritation and can cause severe ocular injury. This is prevented by wearing safety goggles.

Contamination: If consumed, potash alum could cause severe internal complications that at times can be fatal. To prevent this, it is recommended that individuals again handle equipment with care, conduct experiment under a fume hood and most importantly, keep away from body opening passages.

Results:

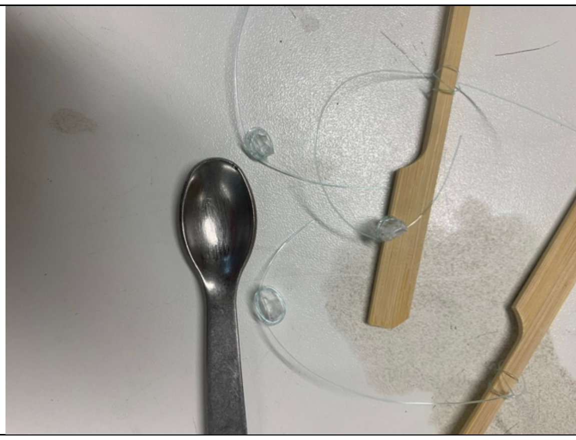
The results of this experiment did not support the hypothesis that the crystal in the beaker kept in the highest temperature will grow the fastest and largest. Note that the weight of the crystals were documented weekly, and the results are recorded in the table below.

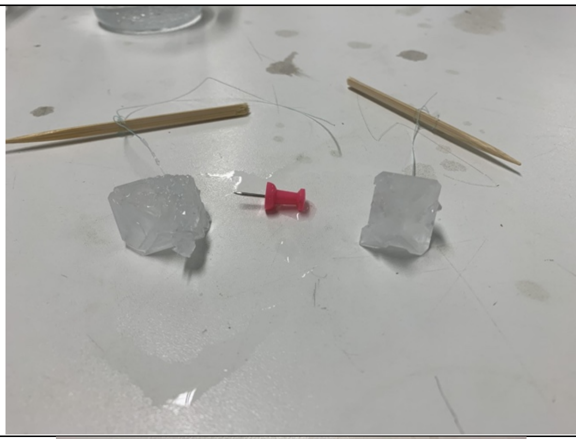
Table 1. The growth of the crystals over the course of 5 weeks under different temperature conditions.

Weight in Grams (g)	Cold conditions	Room temperature conditions	Hot conditions
Week 0 (beginning)	7.2g	7.0g	7.4g
Week 1	12.4g	14.7g	2.3g
Week 2	24.3g	25.5g	-
Week 3	33.0g	31.8g	-
Week 4	39.6g	37.4g	-
Week 5	46.2g	41.9g	-

Evident through the table, both the cold and room temperature conditions resulted in significant growth, with the crystal kept in cold temperatures (4°C) weighing the most at the end of the experiment. The crystal kept in the hottest temperature (50°C) completely melted by the second week. These results are displayed in the graph below for a visual representation of the growth rates.

Image table:

Week 0	

Week 3	
Week 5	

Discussion:

The outcome of this experiment is nothing less of surprising and interesting, and proved that keeping the solution in a colder temperature, will increase the crystal volume in a long-term experiment.
After analysing the graph above, there are some visible trends. At first, the beaker kept at room temperature was growing at the fastest rate, however, it gradually became increasing at a decreasing rate, whereas the cold kept beaker started very slow but then increased significantly and mostly maintained this rate constant the majority of the experiment duration.

An estimation as to why this trend is present is because the solution in the room-temperature-kept beaker most likely evaporated faster, and overtime, the amount started decreasing and affected the growth rate negatively as there isn't enough water volume to support consistent growth. This is thought to be true because the cold-kept beaker most likely maintained the volume of water well as it won't evaporate as fast due to the low temperature. This means that the water volume is constant and maintained, explaining the consistent line (Mol Pathol, 2000).

Visible in the same graph, the cold beaker started the first week sluggishly as previously mentioned. This is most likely due to the fact that when the experiment first took place (the first week), the crystal in the cold beaker was not tied tight enough and was touching the bottom of the beaker. This most likely stunted the growth as it decreased the surface area of the crystal. Decreasing the surface area reduces the exposed particles available for precipitate to form on the seeding crystal. This error is shown in the image below and was taken in week 1 (the cold beaker is labelled; YS-A, and it is clear that it was not tied properly. Note that YS-C [room temperature] was being measured, and YS-B [Hot temperature] was not tied yet as it had just been measured):

Figure 2: display of the growth of the crystals

After tying fishing line tightly, moving the crystal in the middle of the solution, it grew significantly as visually shown in the graph.

The crystal in the hot temperature beaker is also visible in the image above in the beaker labelled YS-B. However, it is difficult to see because it was very clear and transparent as a result of the high temperature. This photograph was taken on a Friday, a week after the experiment was initiated. This was the last time the crystal in the high temperature kept beaker was seen as on Monday it was completely melted. The reason why this melted is because the salt in the solution couldn't settle on the seeding crystal because they were constantly moving (too much kinetic energy). This eventually broke the bonds of the crystal, dissolving it completely.

The hypothesis was formulated leaning towards the hot temperature kept beaker because it was assumed that due to the higher temperature, the particles would move faster and would form precipitate on the seeding crystal faster, resulting with a larger crystal by the end of the time period. As depicted through the results, 50°C is far too high for a crystal to grow.

Evaluation:

Random errors (human errors) – A human error would be the height of the crystal in the solution in beaker YS-A (cold). Not tying the fishing line tight enough is a human error because as previously mentioned the surface area decreases, in turn decreasing the growth rate. This is again showed in another image of the error.

Another human error could be potentially not fully saturating a certain solution. Despite this being unlikely, it is a possibility that could definitely alter the results.

Systematic errors – The reading of the scale may be inaccurate.

If the experiment was to be reconducted, it would be a good idea to use to different scales and find the average between the two for more accurate measurements. Another great idea would be decreasing the hot temperature kept beaker to a temperature that is still higher than the rest, but not enough to melt the crystal (such as 35°C for example). Furthermore, increasing the volume of the saturated solution in each beaker could also pose interesting results (such as 100ml instead of 50ml for example).

Conclusion:

All in all, this exceptional experiment showed that keeping the crystals in a well-ventilated and cool area will decrease the evaporation rate, thus maintaining solution level higher, providing the seeding crystal more space to grow. This will result with a larger crystal by the same time frame.

Unexpectedly, the findings of this experiment did not support the hypothesis which stated that keeping the beaker in a higher temperature area will increase the size of the crystal the most by the end of a certain time frame because the particles move with more kinetic energy, supposedly causing a higher chance of potash alum precipitating on the seeding crystal.

In addition to the findings, an interesting observation was that the cold kept crystal grew to be the most attractive with its flat, smooth and evenly angled sized. This is due to the fact that the colder temperature causes the particles to move slower, ultimately making the precipitates forming on the seeding crystal in an admirable and desired way.

The discoveries instigated through the experiment can assist scientists using X-ray crystallography to note that the crystals they examine could not only reach a larger size in a given time frame, but also grow out to be the most attractive. It could also help scientists decide where to store their crystals, as it was proven with this experiment these crystals prefer to be in a cooler temperature.

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