Growth of Alum Crystals

Background Information:

Alum, also known as potassium aluminium sulfate (KAI (SO4)2-12H20), is a naturally occurring mineral compound. In its powdered form, alum is an odourless, white, fine powder. However, when grown into crystals, alum forms transparent, smooth, and solid structures. (Chemistry, 2018) (Helmenstine, 2022)

Alum has a wide range of household and industrial applications. It can be used as a chemical flocculant to purify drinking water by causing suspended particles to coagulate and settle out. This process of using alum for water purification is known as chemical flocculation. Alum also serves as an adjuvant in some vaccines, enhancing the immune response by stimulating the body's immune system. Additionally, alum is a pickling agent to preserve and preserve flavour for certain foods. (PubChem, 2019)

Beyond its uses in water treatment, pharmaceuticals, and food preservation, alum has other applications. In the textile industry, alum is used as a mordant, helping dyes bind to fabrics. Alum is also used in the production of certain types of paper, as well as in the manufacture of fire-resistant materials. (The Editors of Encyclopedia Britannica, 2014) (www.Crystals.eu, n.d.)

Hypothesis:

By controlling the concentration, temperature, environment, and seeding of an alum (KAl(SO4)2·12H2O) solution, it is possible to grow large, well-formed alum crystals over 10 weeks

Well-formed being;

- Crystal shows excellent regularity of edges, and symmetrical growth (Diamond shape)
- Faces are highly light-reflective and smooth (no growth lines evident)
- Excellent clarity of crystal, Highly transparent through the crystal. Crystal is clear (without imperfections) throughout Excellent overall aesthetic appeal.

Influences on growth and quality of alum crystals

1. Achieving the proper saturation level of the alum solution through the correct alum/water ratio.
2. Maintaining a consistent temperature around 24°C to enhance slow, steady crystal growth.
3. Providing a seed crystal to act as a seed to help assist in the formation of a single, large crystal rather than many smaller crystals
4. Minimizing disturbance and temperature errors during the crystal growth process.

By being through with the detailed procedure provided and monitoring the crystal growth per week throughout the 10 weeks. It is hypothesized that it will be possible to grow large, high-quality alum crystals meeting the success criteria.

Variables

Independent Variable: Alum concentration
The amount of alum ($KAl(SO_4)_2 \cdot 12H_2O$) dissolved in the water is the primary independent variable that is manipulatedin this experiment.

Dependent Variable: Alum crystal growth
The size, shape, and quality of the alum crystals that form over time are the dependent variables being measured and observed.

Controlled Variables:
1. Temperature
The temperature of the alum solution is maintained at a constant of 24°C during the crystal growth process.
2. Seed crystal
A single, well-formed alum crystal is used as a seed to guide the growth of the final crystal.
3. Solution volume and container
The volume of the alum solution and the size of the beaker/container are kept consistent.
4. Stirring and disturbance
The alum solution is not stirred or physically disturbed once the seed crystal is added.
5. Lighting/environment
The crystal growth takes place in a controlled environment, to help assist in minimizing potential external influences.
6. Time
The crystal growth is observed and measured over a consistent period, such as one week throughout the whole 10-week time period.
By controlling these key variables, the experiment can isolate the effect of the alum concentration (the independent variable) on the growth and characteristics of the resulting alum crystals (the dependent variable).

Materials utilized

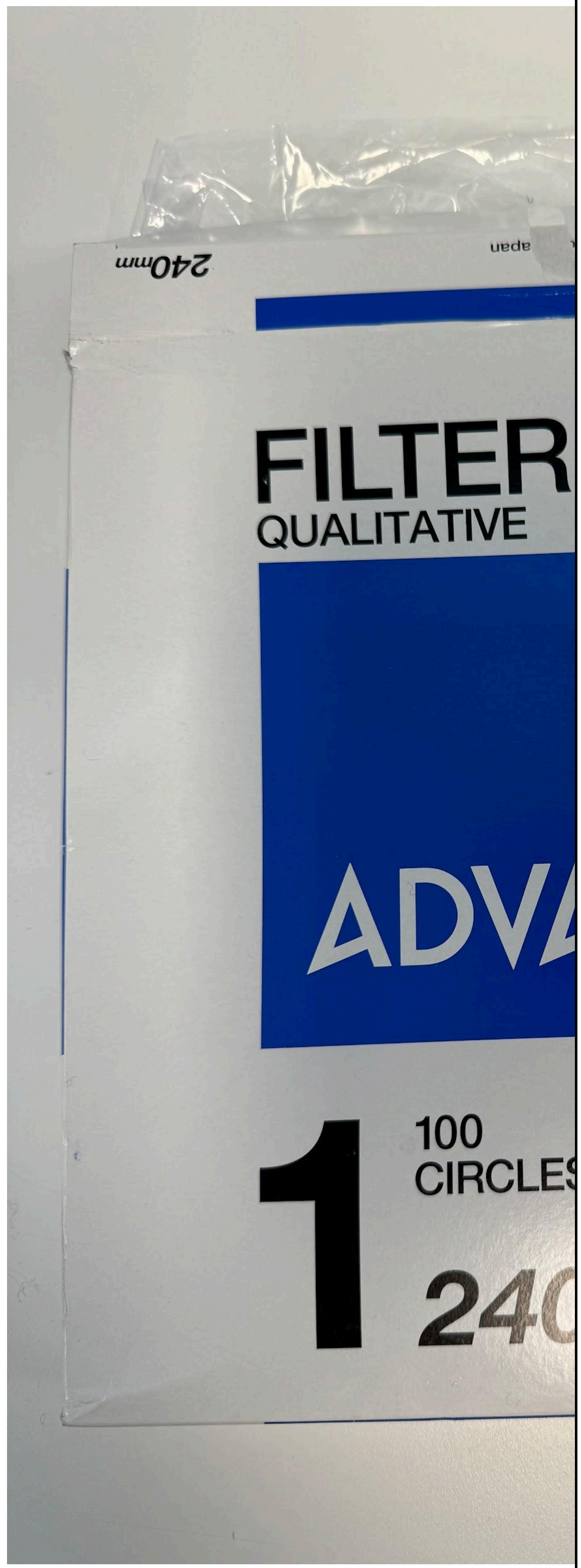
Materials	**Evidence**
10g of Alum	N/A

250ml Glass beaker	

1 Teaspoon	N/A
1 Heating Pad	N/A

1 Roll of White cotton thread	

1 Wooden Popsicle stick	

Filter paper	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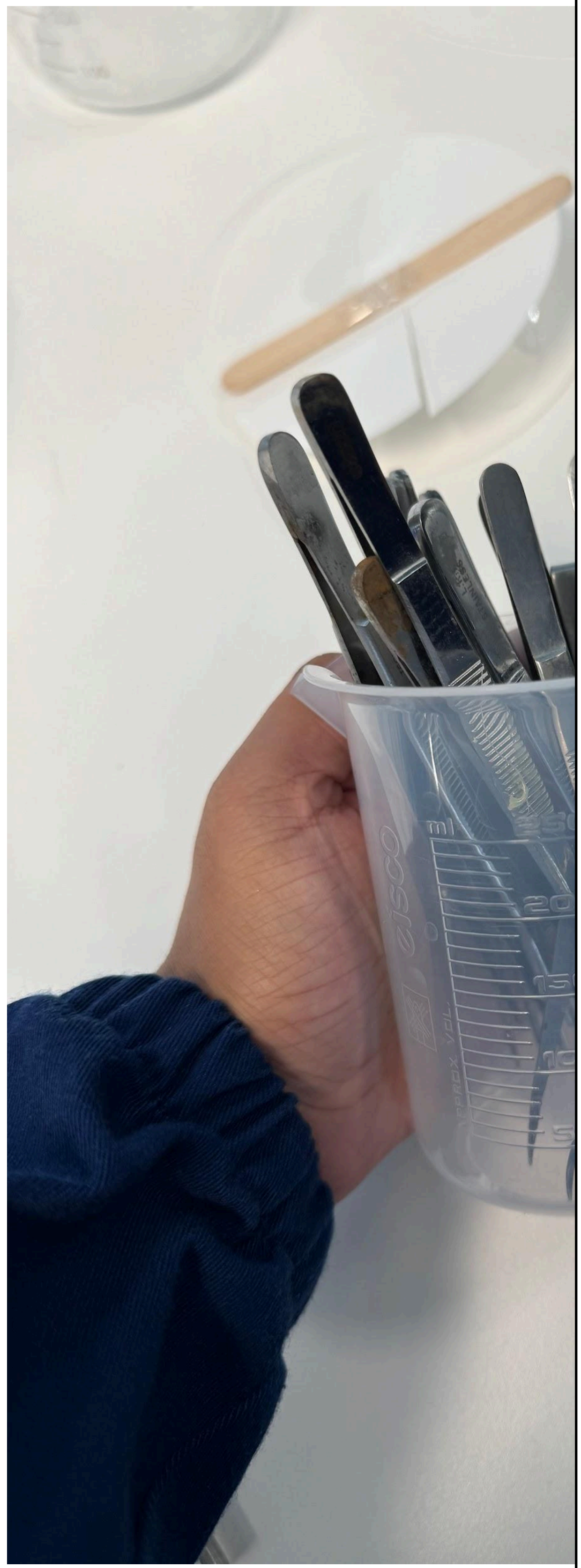
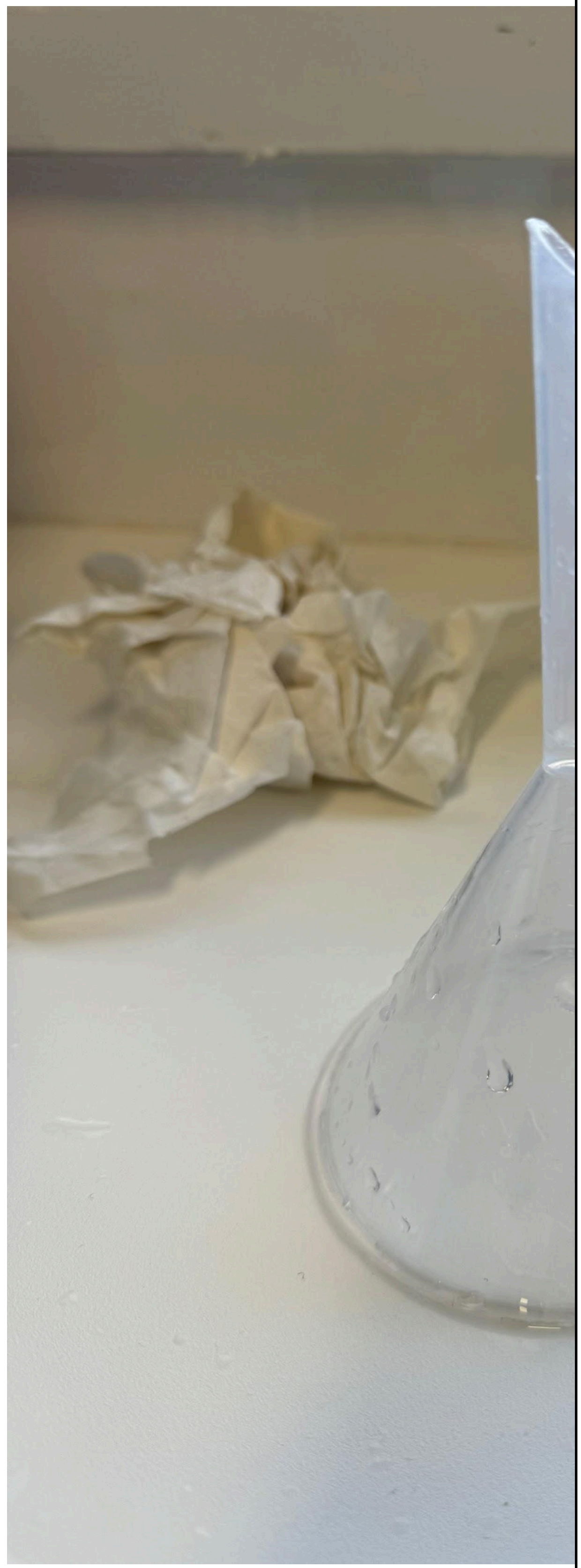
1 Tweezer	

125ml of Distilled Water	

Small sized plastic funnel	

Methodology

1. Weigh out approximately 10 g of alum, KA1 (SO4)2•12H20. (NOTE: 1 Tbsp. alum has a mass of approximately 10 g)

2. Place the alum into a clean 250-mL beaker. For each gram of alum in the beaker add 7 mL of water.(Note: one teaspoon of water = 5 mL; one tablespoon = 15 mL) Heat the mixture to approximately 60°C.)Stir until all the alum has dissolved. Should the mixture remain cloudy, let it stand for a few minutes to allow the suspended matter to settle.

3. Decant the clear solution into another clean 250-mL beaker. If necessary, heat the mixture, briefly, to completely dissolve all of the alum crystals.

4. Tie a piece of thread to a popstick & adjust the length of the thread so that not more than 1 cm is submerged. Place a pop stick on top of the beaker, cover the beaker with a piece of filter paper held and store in a water bath in the incubator at 24C. Crystals should form on the submerged thread, at the bottom of the beaker, or in both places within a few days or by the end of one week.

5. Remove the thread from the solution. Remove all the crystals except the best-formed one from the string. If a suitable crystal has not formed on the string, decant the solution, from the crystals at the bottom of the beaker, into a clean container. Inspect the crystals and select one that has a regular octahedral shape and smooth faces.

6. Loop a fine thread around the selected crystal and tie it with a knot. Save several of the remaining crystals as reserve, in case anything happens to your first choice seed crystal. (wrap or place in a small plastic bag to keep them from drying out.)

7. Redissolve the remaining alum crystals in the alum solution, heating to about 60°C, as described in the first step of this procedure. If all the alum does not dissolve, you may have to add a minimum amount of water. Add 5 mL (1 teaspoon measure) of water and warm the solution back to about 60°C. If necessary, add additional water in 5 mL increments, warming the solution between additions, until all the alum dissolves. Allow this solution to cool to 24C.

8. Suspend your choice seed crystal in the cool solution, cover the beaker with filter paper, and keep the beaker undisturbed for a week. If your solution is not saturated at the time you add your seed crystal, the crystal will begin to dissolve and may be lost. To prevent such an undesirable occurrence, observe the solution in the vicinity of the seed crystal after its placement into the solution

9. Inspect the alum crystal and solution regularly. If the crystal has stopped growing, and other crystals have formed on the bottom of the solution, remove the crystal and warm the solution to dissolve the additional crystals. You may try to increase the size of your crystal by removing it from the solution each week and either redissolve any crystals that have formed or suspend it in a fresh, saturated alum solution

10. To keep large crystals completely submerged you might have to prepare larger volumes of alum solutions always maintaining the ratio of about 1 g of alum to 7 mL of water

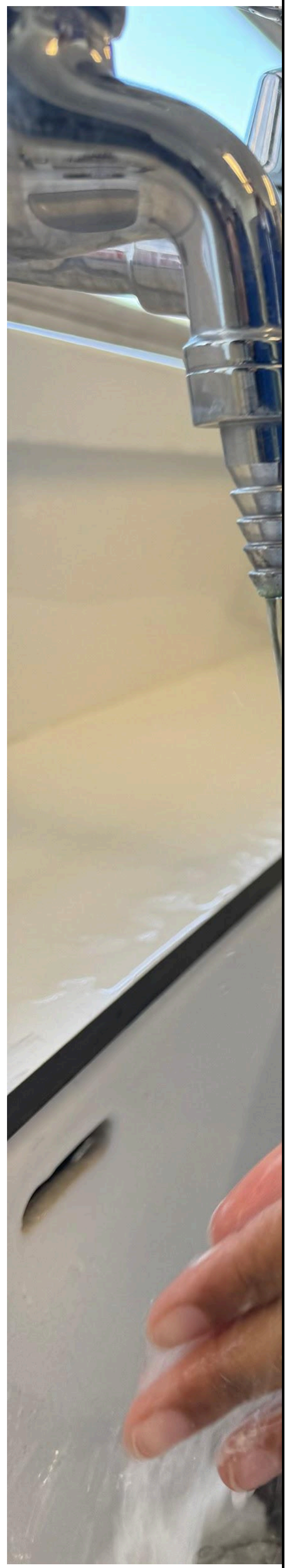
Safety Hazards and Precautions

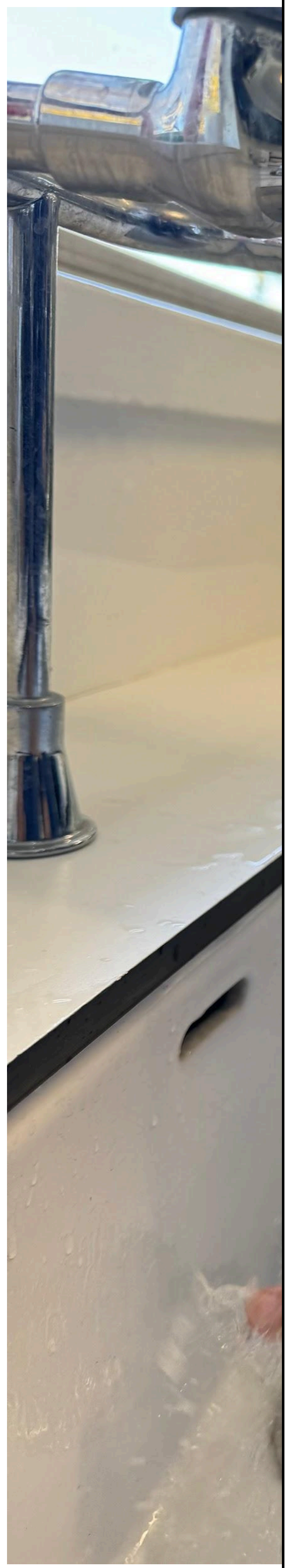
Safety Hazards	**Precautions**
Burns ● Boiling water is used to assist in saturating the alum solutions. ● Severe burns can occur if the hot water or solution is mishandled.	● Handle all equipment, containers, and solutions with great care, using heat resistant gloves or tongs to avoid direct contact.
Inhalation Hazard ● Inhaling alum powder can irritate the nose, throat, and lungs.	● Maintain a safe distance from the alum powder to avoid inhalation. Work in a well ventilated area or use a fume hood.
Eye Injury ● Potash alum can cause eye irritation and severe ocular injury.	● Wear safety goggles at all times when handling alum powder or solutions.
Ingestion Hazard ● If consumed, potash alum could cause severe internal complications, which can be fatal.	● Handle all equipment and solutions with care to avoid accidental ingestion. Keep alum away from any body openings. Conduct the experiment under a fume hood.
Cutting Hazard: ● Alum crystals can have sharp edges and corners, posing a potential cutting hazard.	● Use caution when handling and manipulating the alum crystals. Consider wearing cut resistant gloves if necessary.

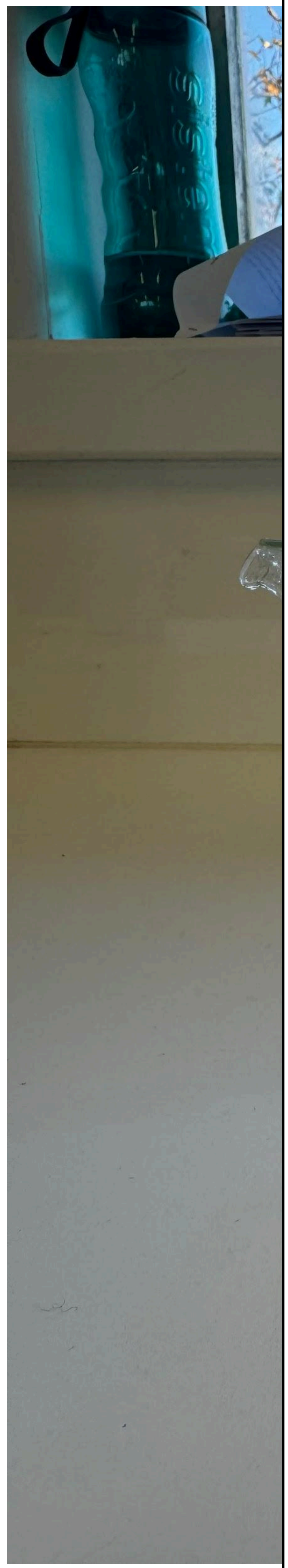
Disposal: ● Properly dispose of any alum waste, solutions, or crystals according to local regulations for hazardous materials.	● Do not pour alum solutions or dispose of crystals down the drain, as they can potentially contaminate water systems.

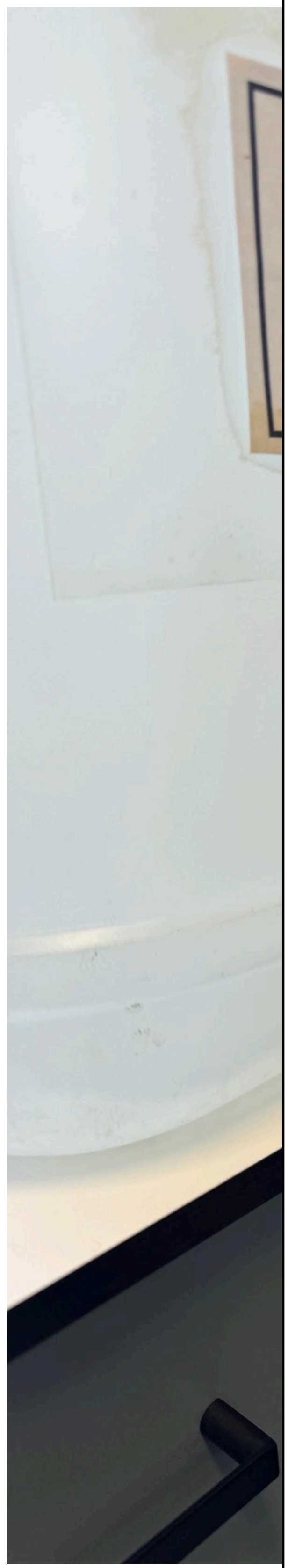
By following these safety precautions, we are able to minimize the risks associated with working with alum crystals and solutions throughout the experiment.

Growth Progression and Results Per week
Date and time **Progress and Observations** **Evidence**
Signed

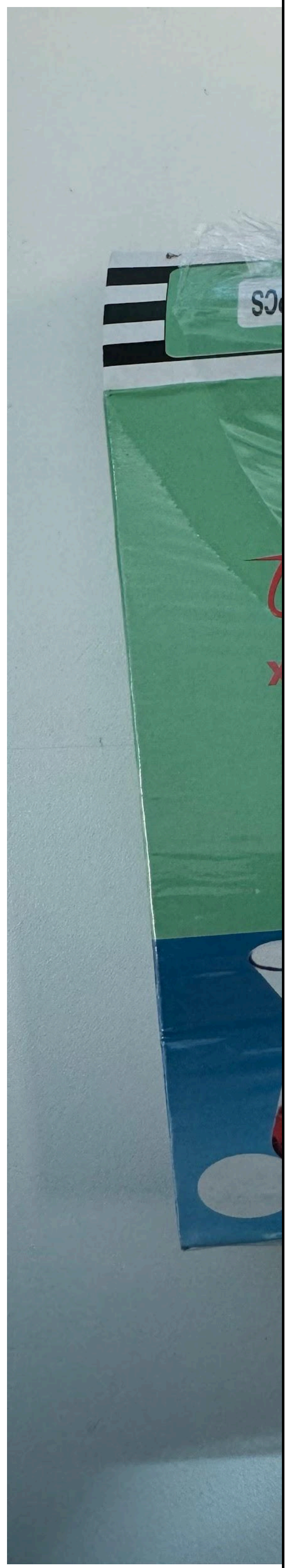
22/05/24	We conducted our experiment on the 22 of May. We began by following the procedure of growing the alum crystals. The solution of the Alum crystals was pre-made, as students before us had made an extra quantity. We then supported and helped the alum crystals grow by assisting it with a thread and popstick. In which we wrapped the thread around the popstick several times and taped it down with clear tape. We also ensured that the length of the string was up to requirements and was not more than 1cm in the solution. We then placed a sheet of filter paper over the 250ml glass beaker to prevent cross contamination of dust and other small particles that are in the air from entering and mixing into our solution. The paper filter used for the beaker acted as a barrier and prevented contamination.		





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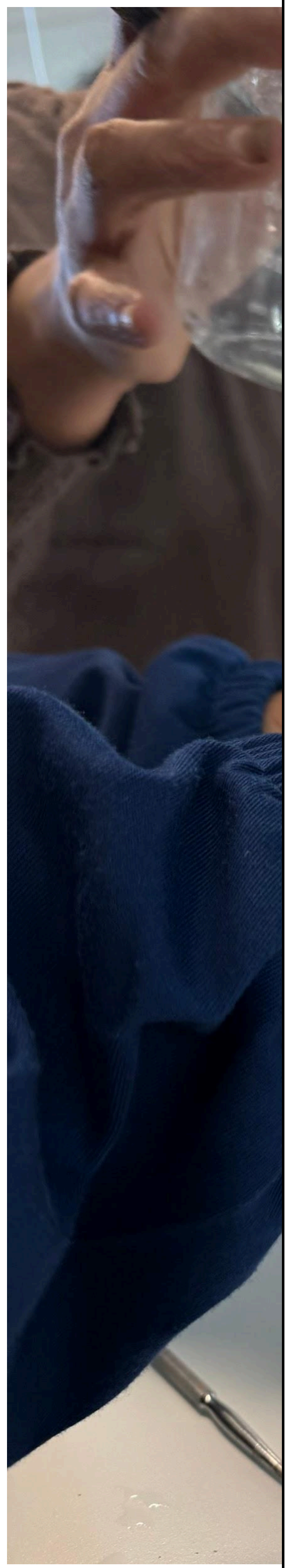
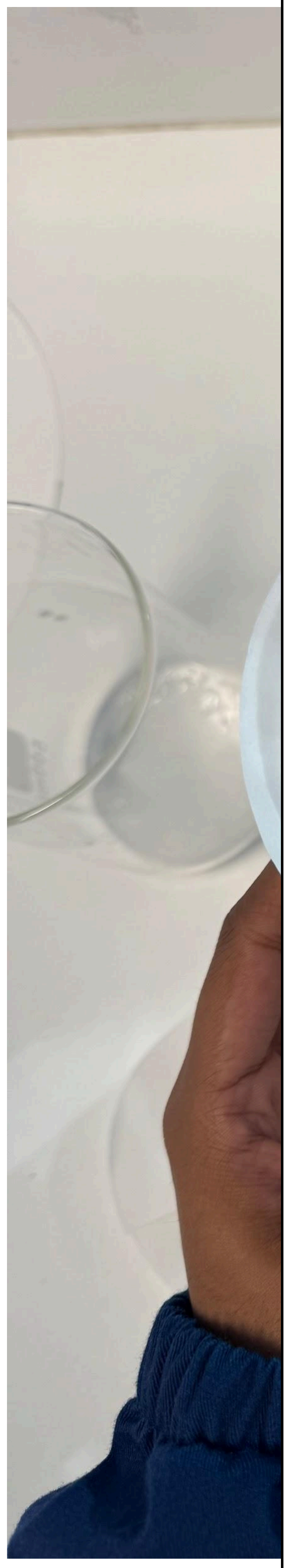
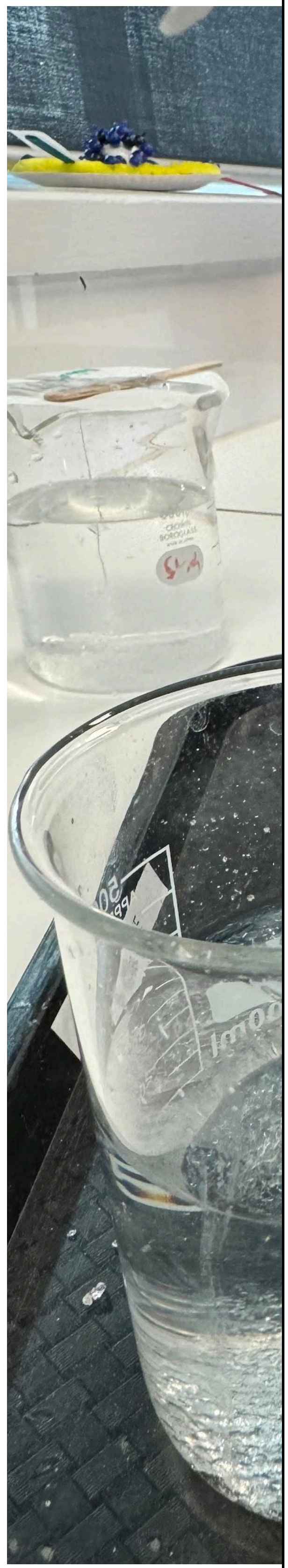
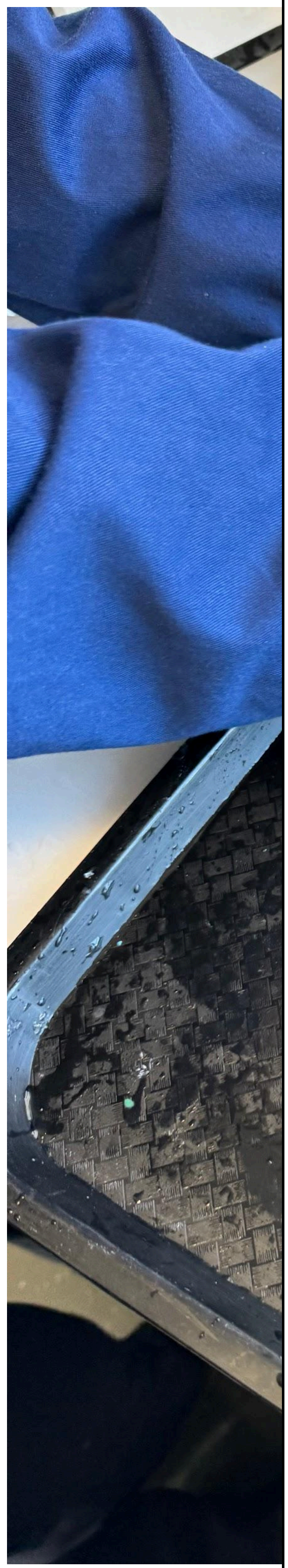
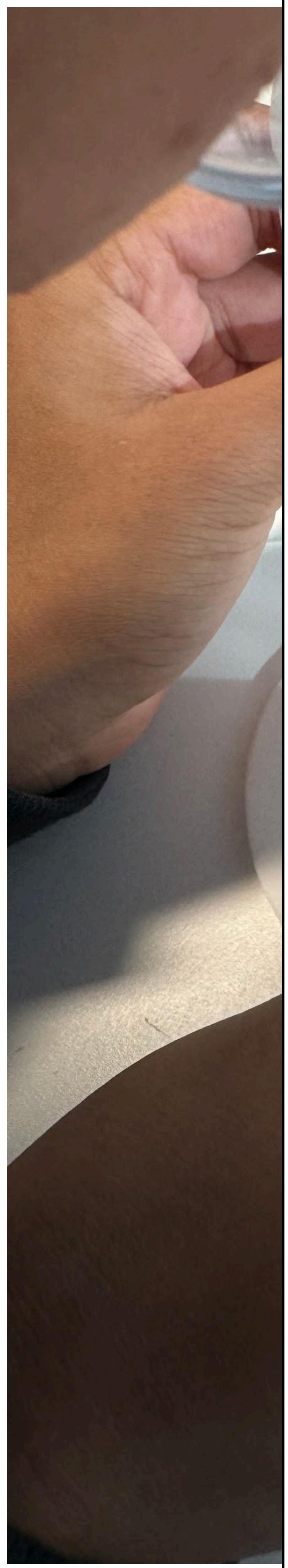
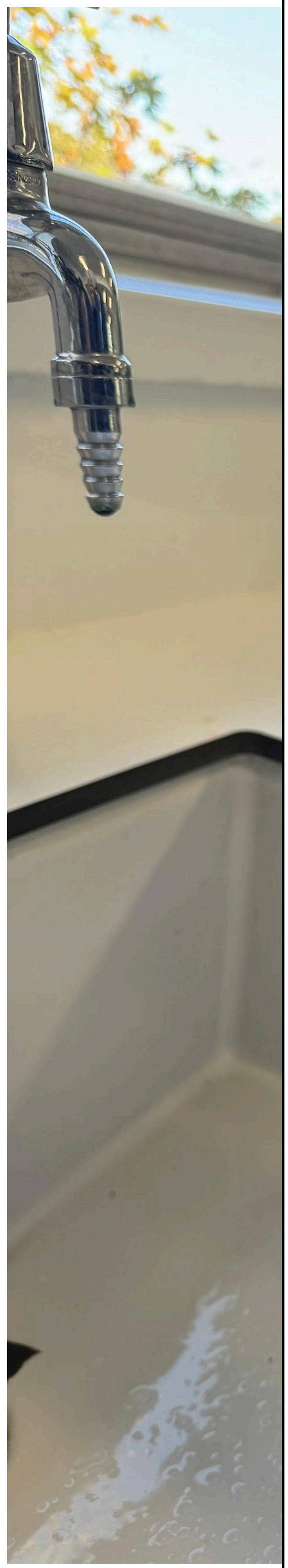


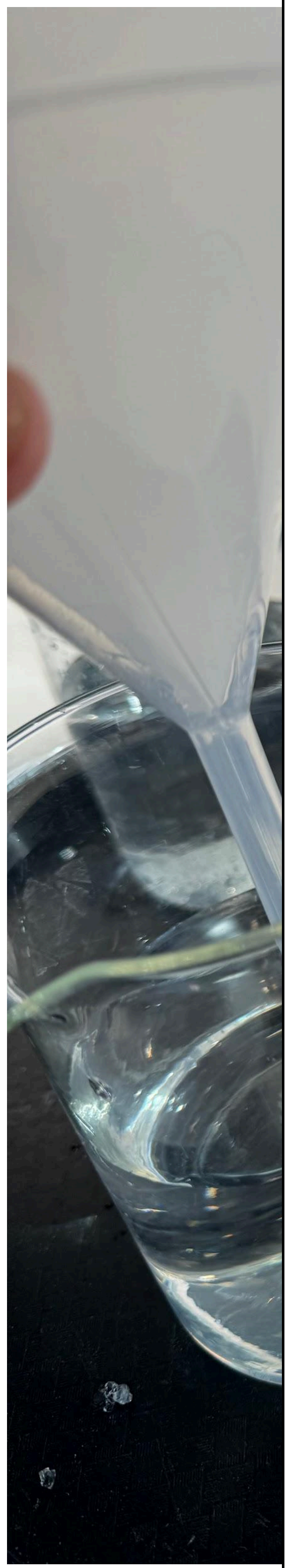


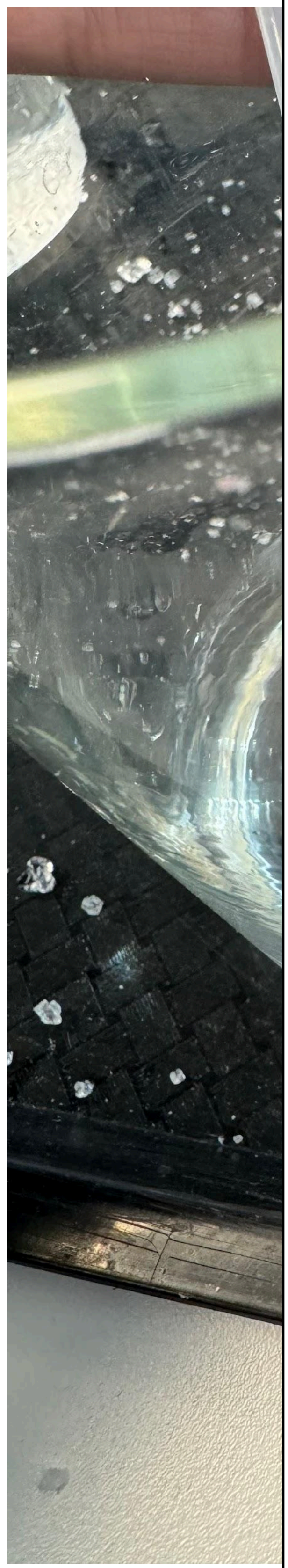
29/05/24	From observation it was clear a lot of drastic changes had occured in the 1 week duration. As there were crystals forming on the long piece of string, to solve this issue we transferred the popstick and thread from the solution above a plastic sanisted tray and used metal tweezers to remove all the crystals. Leaving our best formed crystal seed and then placing the pop stick with the long piece of string back into the solution to continue to grow. Another observation made was the formation of the new alum crystals at the bottom of the beaker, which were clumped together, but were still moveable and were each separate pieces. We placed all our crystals from the solution that were sitting on the bottom of the beaker onto a clean surface where we then selected a crystal to continue to grow. To select the crystal we were going to		

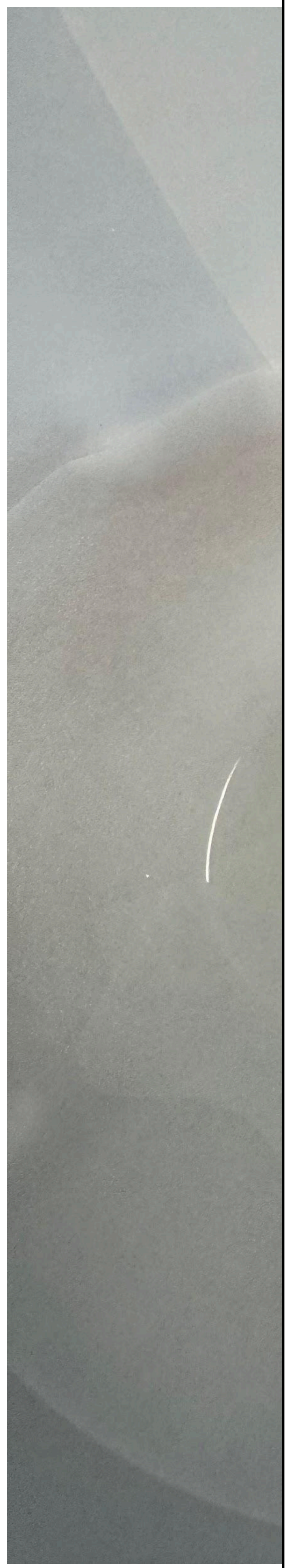
	further grow, we referred back to the success criteria and selected the most octahedral crystal that was clear, had a good shape, sharp edges and had smooth surfaces. Once we had selected our crystal we had chosen from the criteria of being an octahedral crystal we attached it onto the end of the long piece of string. We then carefully selected some crystal to keep as a reserve just in case anything happened to our first choice seed crystal, and kept them in a plastic dish to prevent the crystal from drying out. We were able to skip step 7 as we alread had a lot of spare alum solutions, as the groups before us had prepared extra. We then left the solution undisturbed to further grow.		

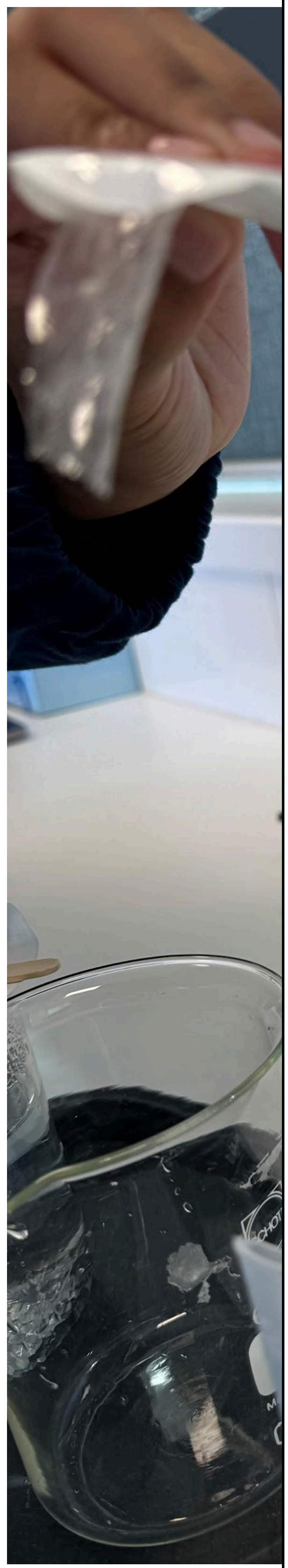


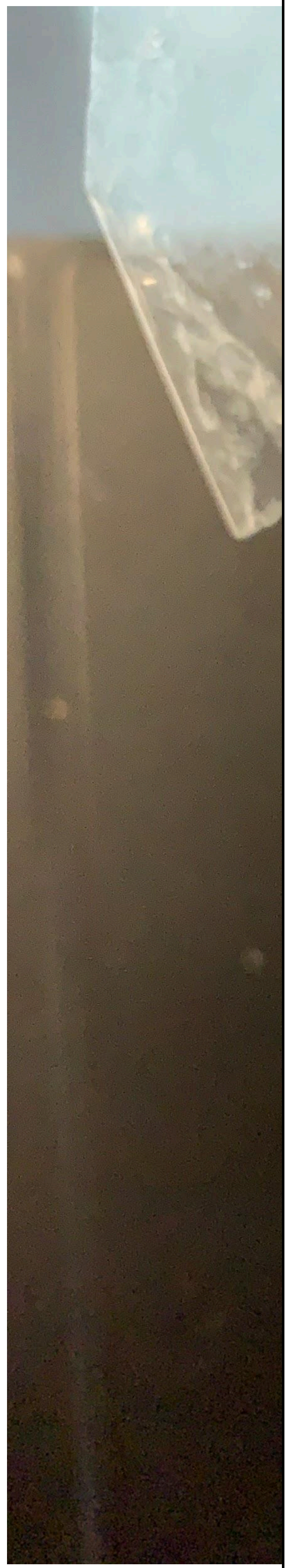




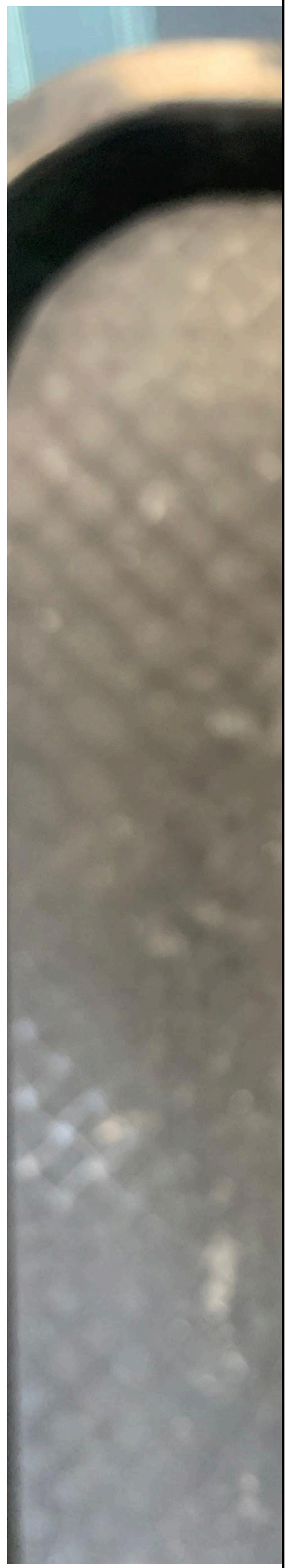


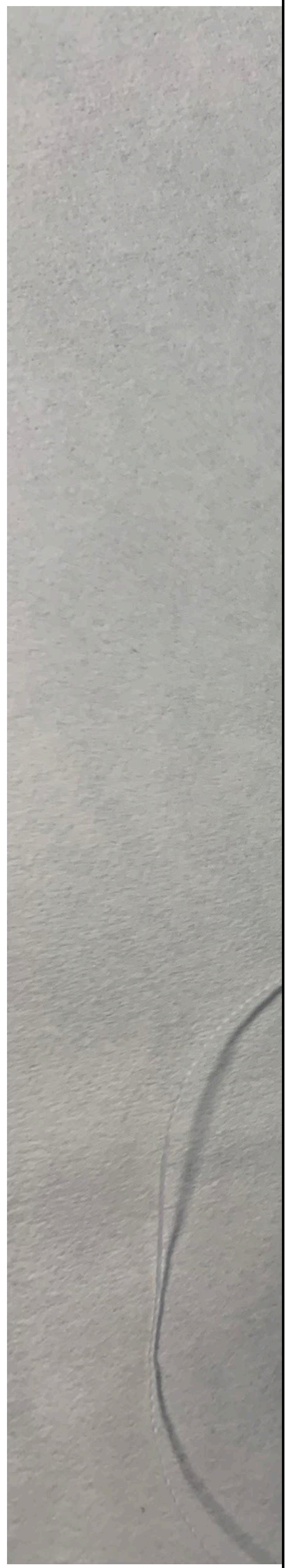
			

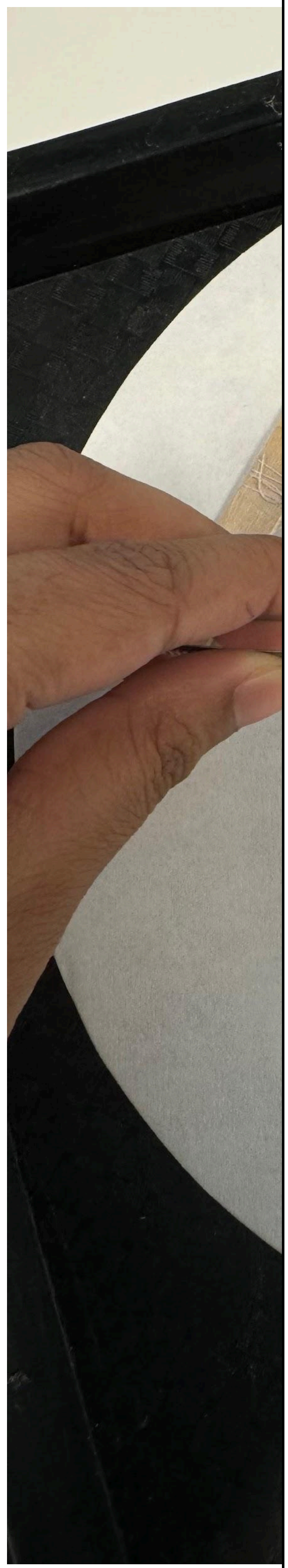
05/06/24	During this day we filtered the alum solution. In this process we utilized filter paper, a funnel and a 250ml glass beaker. Both the funnel and the 250ml beaker were washed and cleaned prior to use. This was to prevent contaminations, so the use of the beaker or funnel would not affect the results of the crystal growth. Once the alum solution was filtered into the other clean 250ml glass beaker. We observed the crystal and its growth. The crystal had no points and had a small yet smooth surface. Once we were done observing we placed the crystal back in the alum solution.		

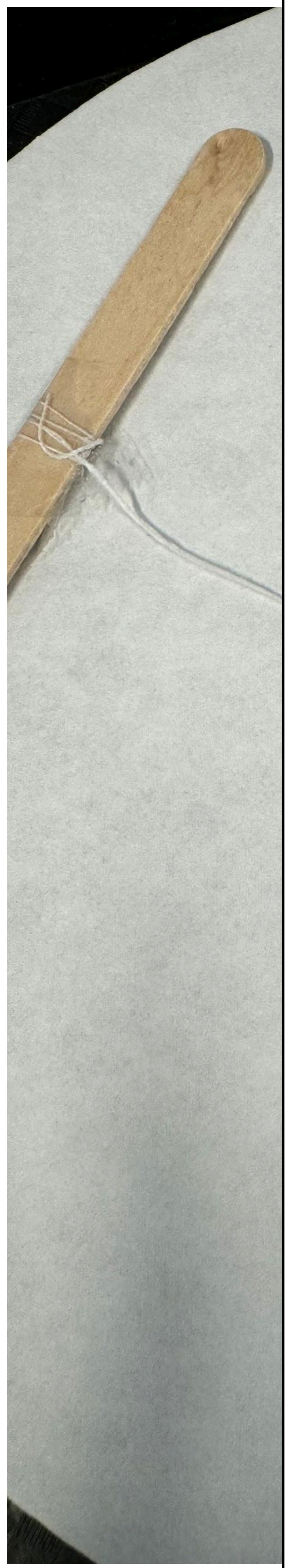
			

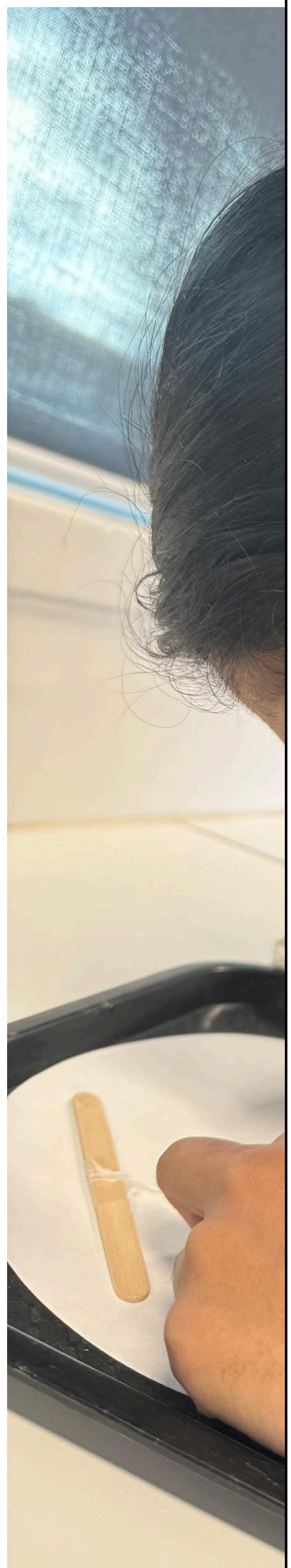
			

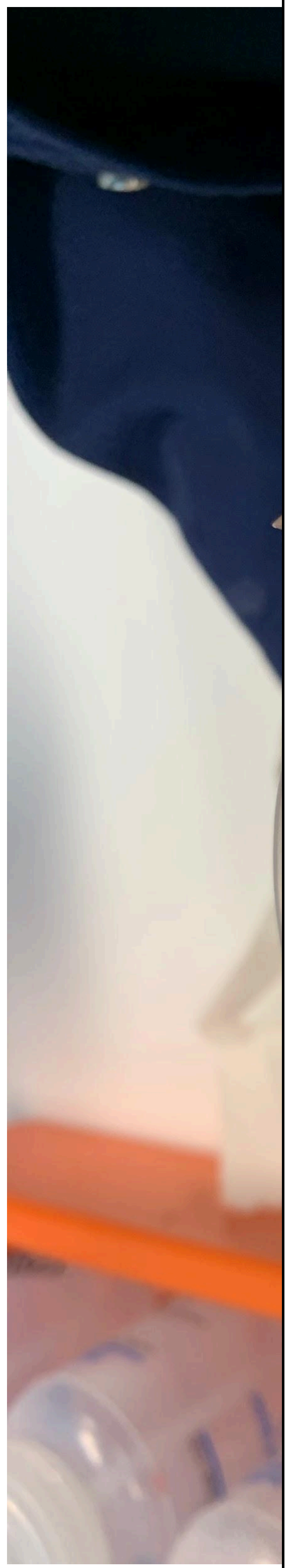


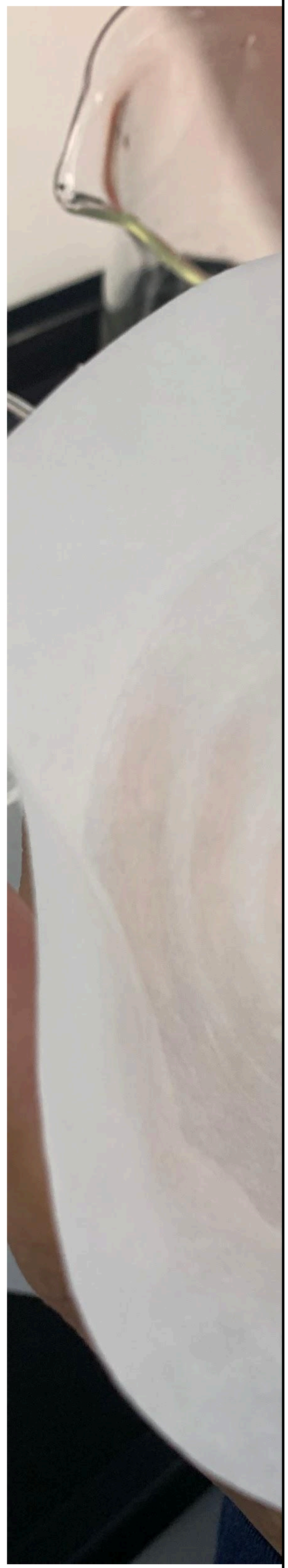


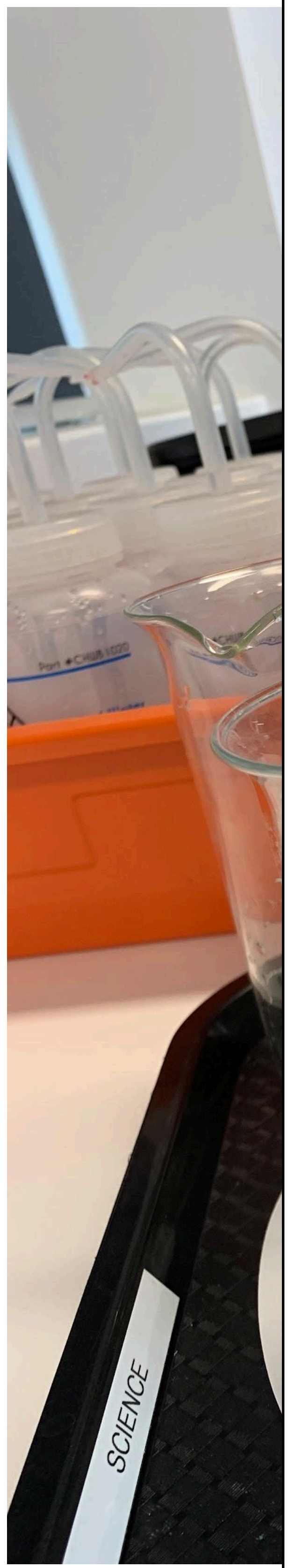
			





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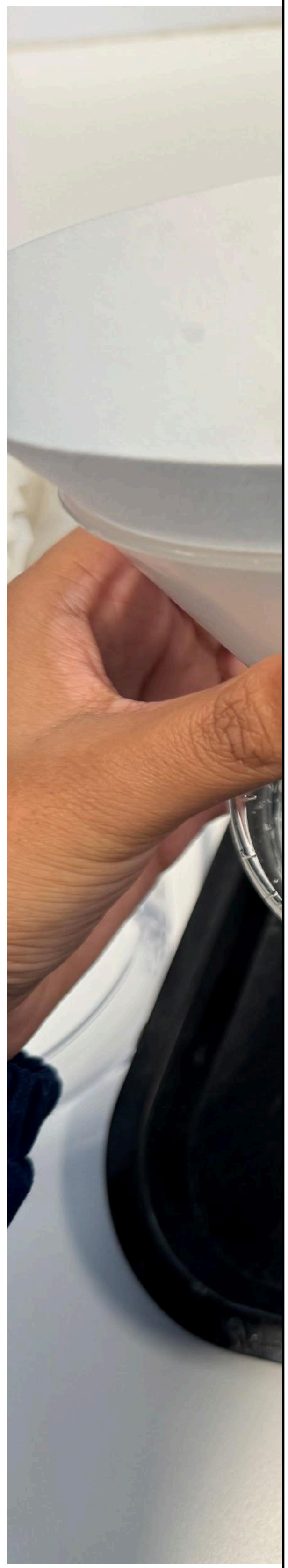
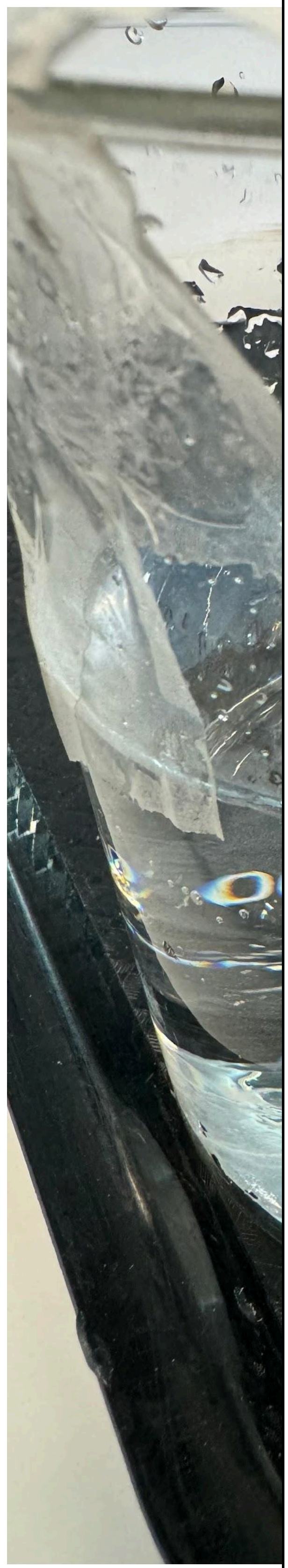
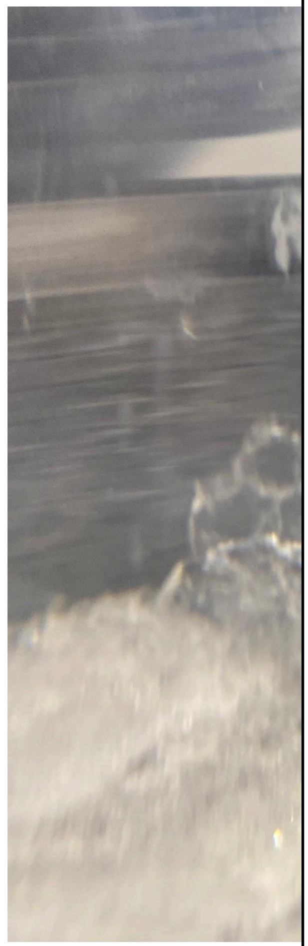
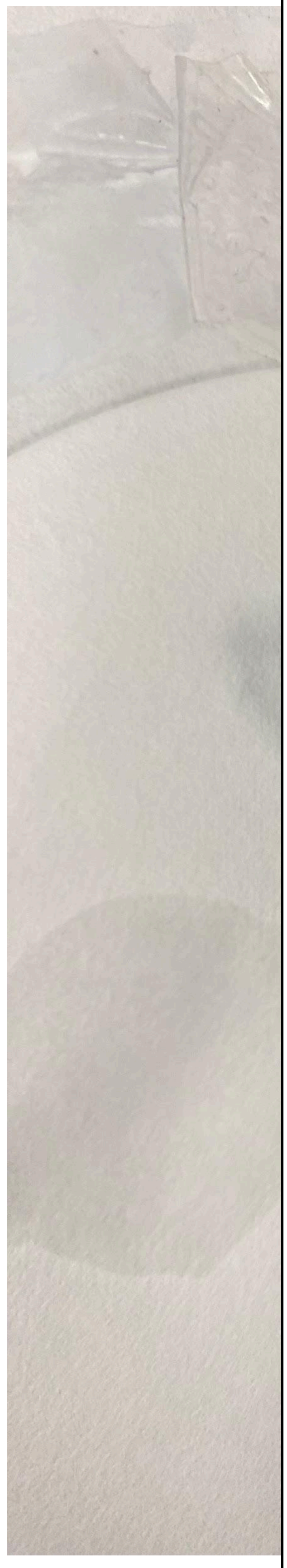


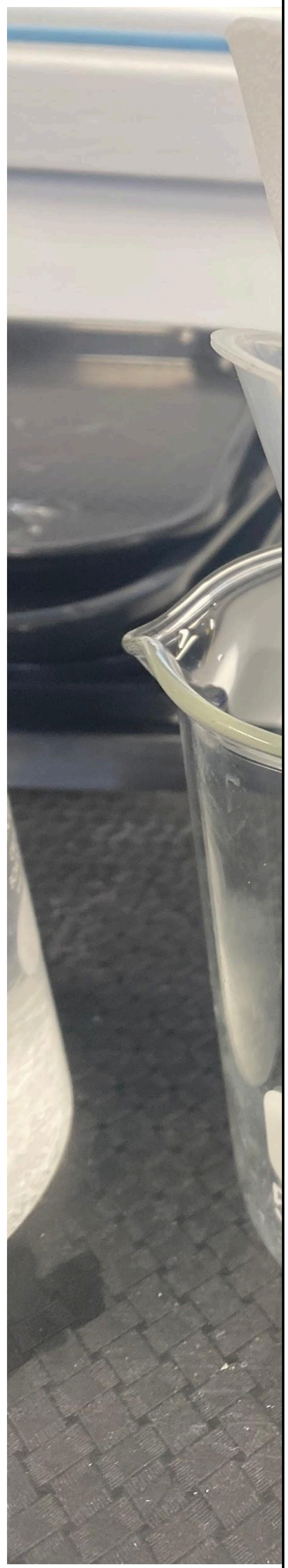


12/06/24	Today was a repetition of the filtration process, which included washing and cleaning the funnel and the 250ml glass beaker with distilled water prior to use, to avoid any cross contamination. We then filtered the alum solution with a filter paper into the other cleaned beaker and repeated the process for 3 times, ensuring the solution was clean.		
19/06/24	During the exam period, we were unable to attend the laboratory and monitor the crystal formations. This prevented me from recording the intended data points and making the required observations to document the growth and development of the alum crystals.		

26/06/24	Today was just a repetition of the same process of filtration. Consisting of washing and cleaning the funnel, beaker with discoed water. Further than filtering the alum solution with a paper filter in the funnel into the new beaker. From observation we were able to see that other crystals had started to form on the string. To best enhance the conditions for our main singular alum crystal we removed the other insignificant crystals by using tweezers and crushing them off the white string. Allowing just the main alum crystal on the string to continue to grow.		



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		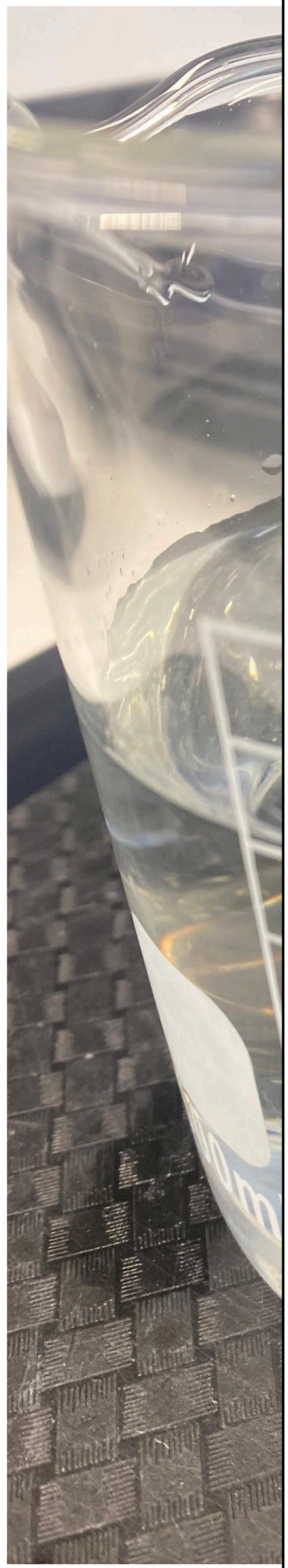	

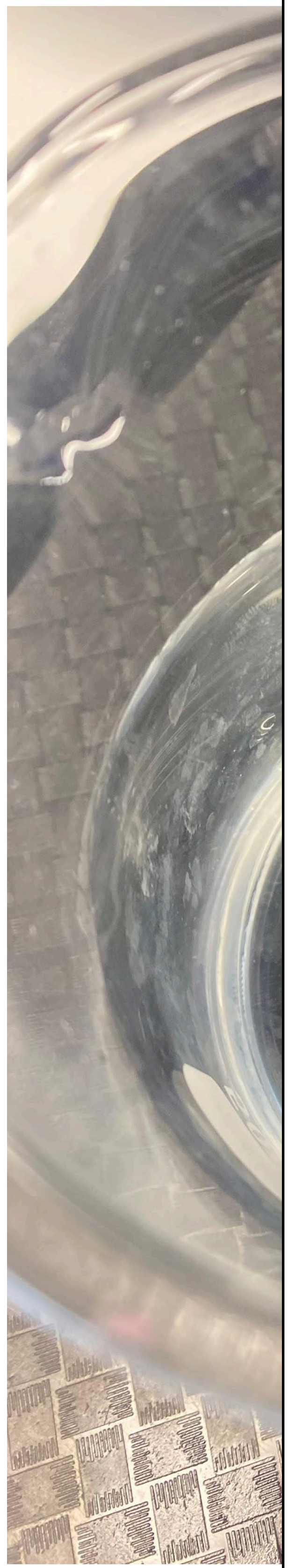

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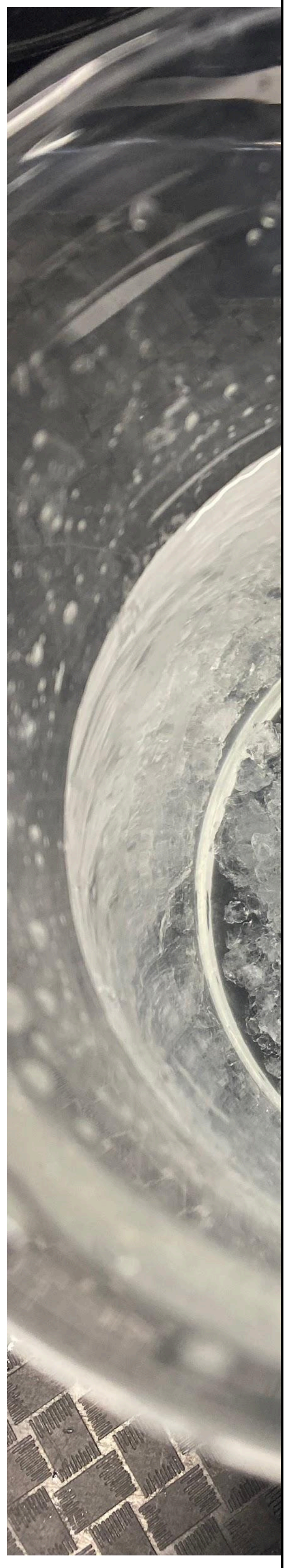
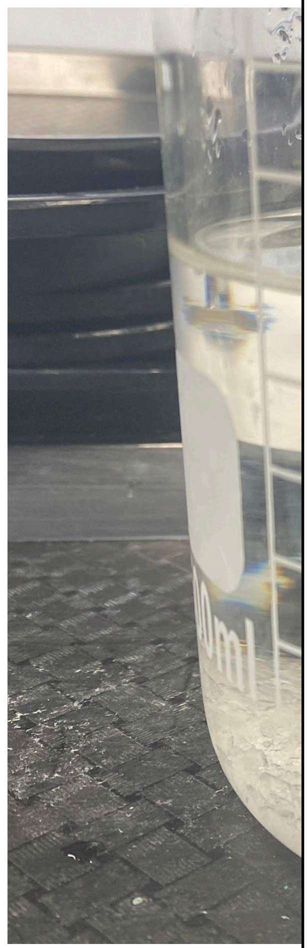
			

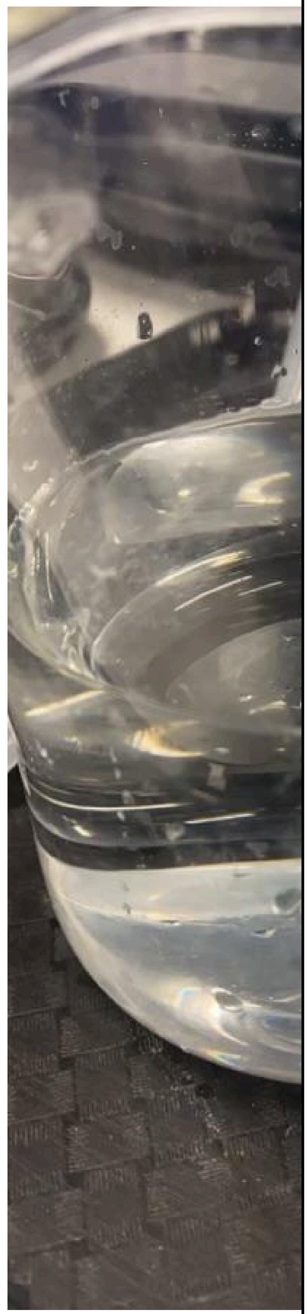
			

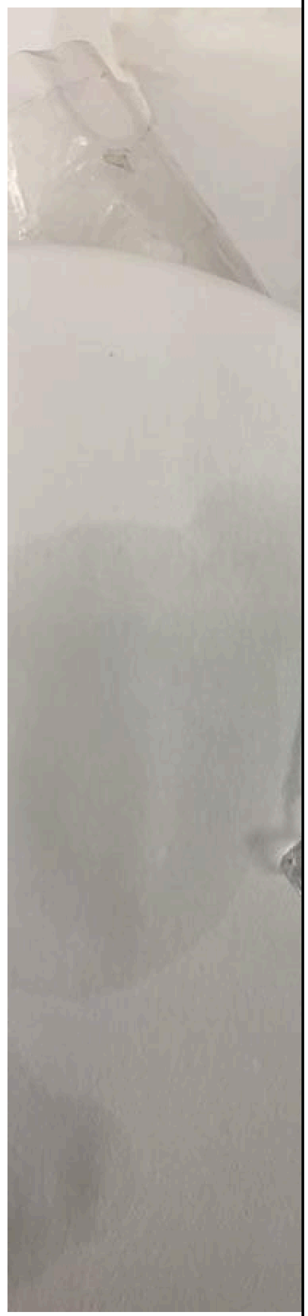
			

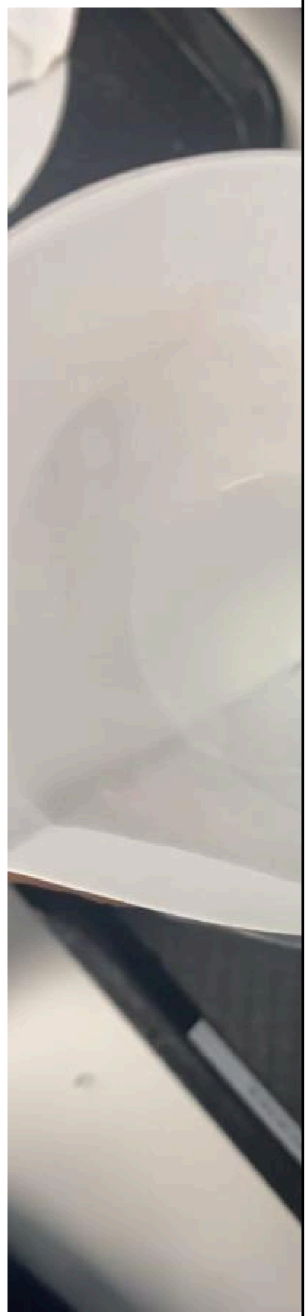
			
03/07/24	Today was a repetition of our cleaning and filtration process. By just repeating the same process of filtration which included washing and cleaning the funnel, beaker with distilled water. As well as filtering the alum solution with a large and then smaller filter. Unexpectedly the process took longer than usual due to contamination of dust been growing it the water from the last	————————	

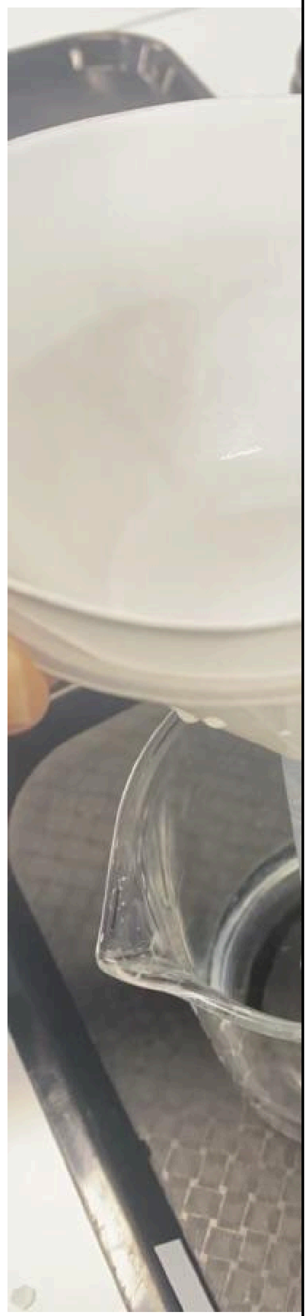
	time we had checked in on our alum crystals In order to decontaminate the solution we filter the solution multiple times and use a thicker and thin paper filter and layer them over.		
10/07/24	Unfortunately, due to the school holidays, we were unable to attend the laboratory and directly observe the growth of the alum crystals over the designated time period. As a result, we did not have the necessary recorded data or measurements to report on the progression and final characteristics of the crystal formations.	————————	

17/07/24	Unfortunately, due to the school holidays, we were unable to attend the laboratory and directly observe the growth of the alum crystals over the designated time period. As a result, we did not have the necessary recorded data or measurements to report on the progression and final characteristics of the crystal formations.		

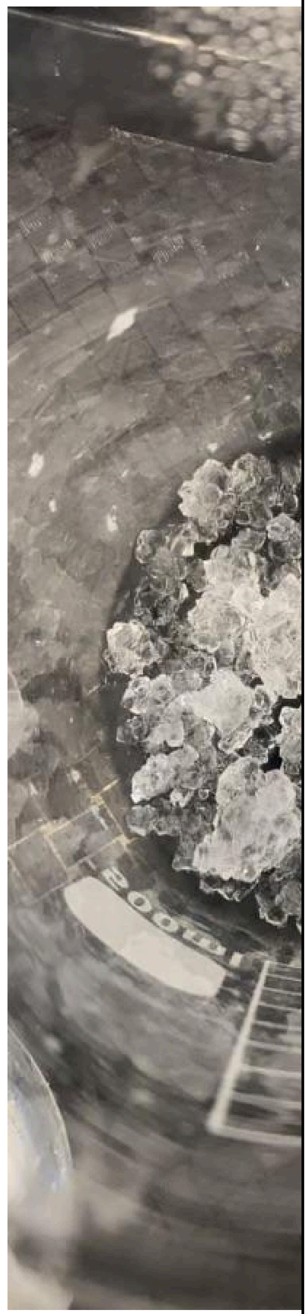
24/07/24	Today was the final day before our crystals were sent off. Today we removed the alum crystal from the solution, and patted the alum crystal dry with a paper towel carefully ensuring no paper being stuck to the crystal before placing it into an airtight ziplock bag with our names on them.		

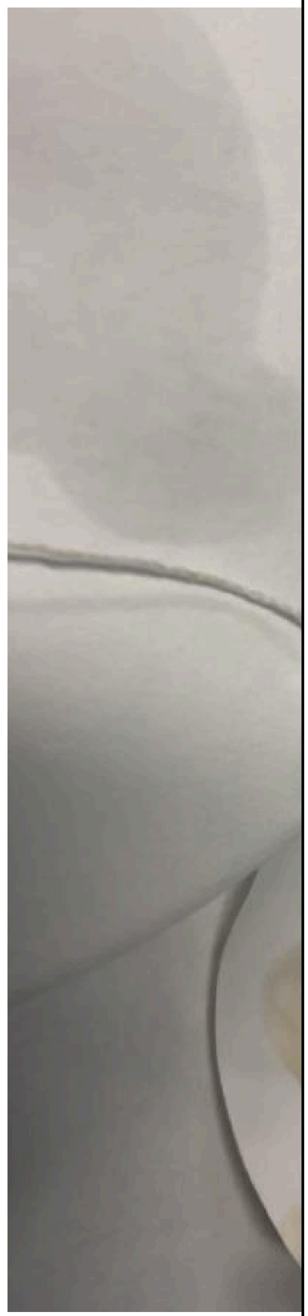
			

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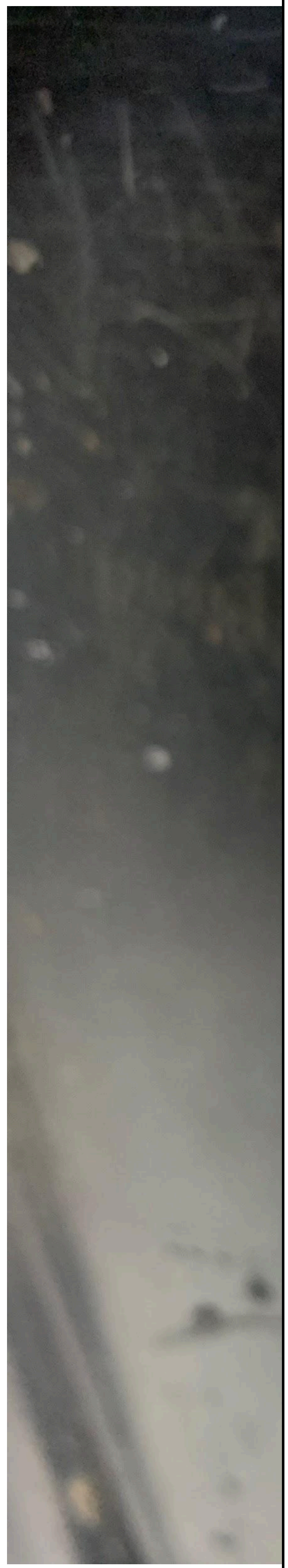
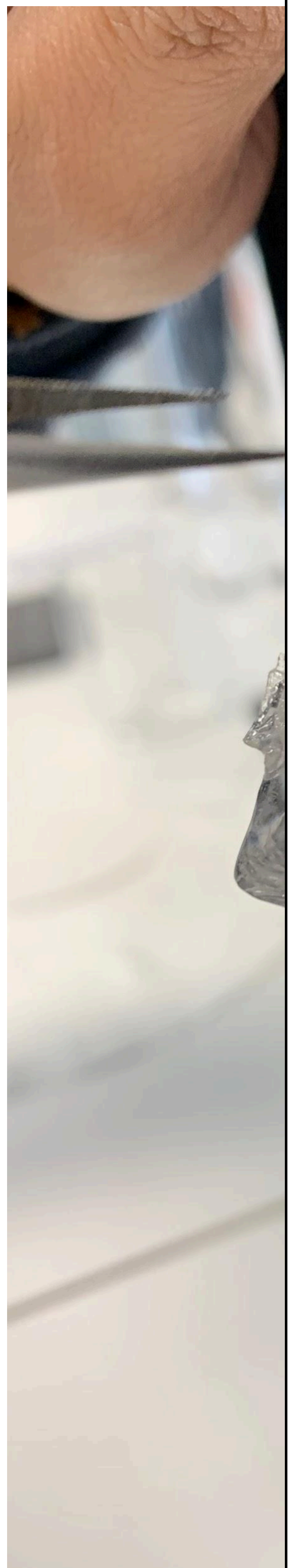
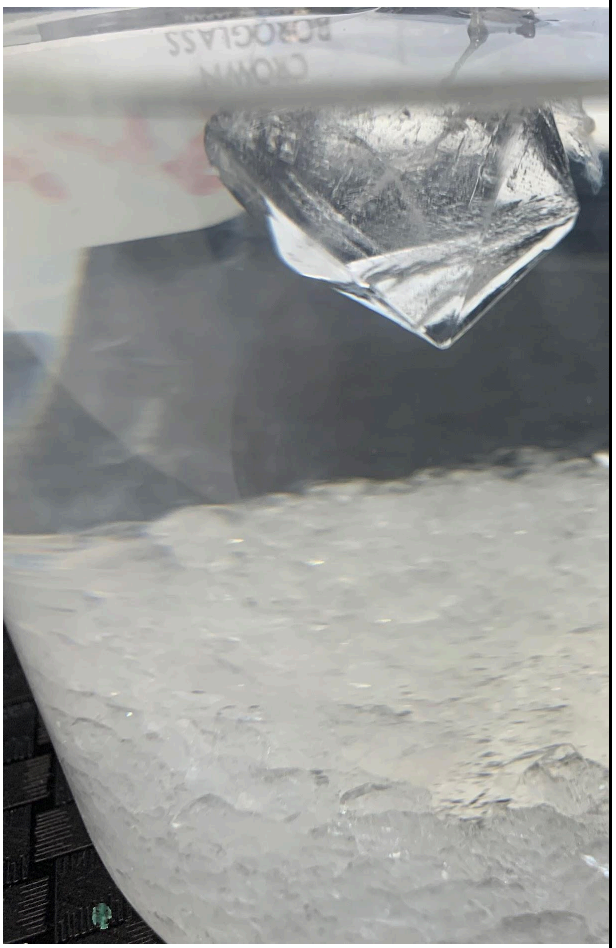




Final Crystal

	The final shape of the crystals was a 3D diamond shape, with some sharp vertices, with a smooth surface. The color of the crystal was transparent and see through, despite being a little cloudy. The final measurement of the crystal was approximately 45mm, meaning it was able to grow to at least the 9mm requirements.

Discussion

During the course of the crystal investigation, we faced a few challenges that required our problem-solving skills and required us to place corrective measures. The most occurring and difficult challenge that we encountered was the process of filtering the concentrated alum crystal solutions, as there were impurities present in the solution.

During our first filtration, we discovered impurities in the water that we used to create the alum solutions. It was vital for us to get rid of these impurities or any contaminants as they could interfere with the growth, structure, purity, and clarity of the crystal and not give us consistent results. Impurities or contaminants put the crystal at risk of becoming cloudy and potentially giving us, not an ideal crystal that meets the requirements of the investigation.

To overcome this problem, we created a thorough filtering process by using high-quality filter paper. Doing so allowed us to remove the majority of visible impurities, contaminants, and mould ensuring that the solution remained as pure as possible. When filtering our solution we were consistent with how many times we filtered the solution as we filtered the solution three times as well as using two filter papers to double filter to ensure visible impurities and contaminants to reduce the effect of them on the crystal growth. In addition, we took some extra measures to clean all the laboratory equipment we used with distilled water before use. Taking this precaution helped to reduce any impurities or contaminants that may have been present on the glassware, forceps or any other surface.

We recognised the importance of putting measures into place to help decrease the risk of cross-contamination, we also recognised the importance of our group members washing their hands thoroughly before touching the crystal solutions and any equipment. By putting all these measures to maintain the standard of cleanliness, we were able to significantly reduce the percentage of unwanted impurities and contaminants in our experiment.

These measures/corrective measures were effective as the filtration and visual inspections of the alum solutions upon observation were revealed to be clear and there was an improvement in clarity and purity. The crystals grown from these purified solutions will give reliable data that accurately reflect the growth of the crystals, as multiple measures and strict protocols have been put in place for equipment cleaning and personal hygiene throughout the 10 weeks to prevent the effect of impurities and contamination on the crystal growth. The crystals grew with clarity and the required shape which shows that.

Evaluation

Overall, the method we had used to grow the alum crystals was quite effective shown through our 10 week time period of the alum crystal growth. The repeated filtration process has helped remove impurities and produce clear, high quality crystal solutions. The grown crystals have a smooth surface and the required octahedral shape indicating the purification steps worked well.

Although the issue with dust contamination during the latest filtration session implied that there was still room for improvement in maintaining a clean and controlled experimental environment.

Improvements such as;

1.Improve workspace cleanliness

- Utilizing an enclosed setup to filter the solutions and grow the crystals. This will help minimize airborne particles.

- Thoroughly clean and sterilize all equipment before each use to prevent contamination.

- Wear protective gear such as gloves and lab coats to avoid any contaminants.

2. Investigate the source of dust:

- Identify any potential sources of dust or particles in the lab and take steps to decrease them.

3. Optimize the filtration process:

- Try different filter types or sizes to improve impurity removal methods.

By implementing these improvements, we will be able to create a cleaner and more controlled environment for growing the alum crystals. This will help ensure the reliability and reproducibility of our experimental results, allowing us to conclude and have high quality data and more accurate conclusions.

Conclusion

Based on the findings and results from the crystal growth experiment, the hypothesis is supported by the results. The careful control of the solution restrictions led to the successful growth of large, well-formed alum crystals within the specified 10-week timeframe. From this experiment, we can conclude that maintaining a high standard of cleanliness of the solution has a significant impact on the growth and clarity of the crystal. From research, we learnt that impurities and contamination can have a significant effect on the growth and more specifically the clarity of the crystal. By putting procedures and strict protocols in place we were able to eliminate any visible impurities that may have affected the growth of the crystal.

While the overall crystal growth process has been successful, the isolated incident of dust contamination during the second latest filtration session suggests that there is still room for improvement in maintaining a clean and controlled environment for the crystals. Some improvements we should consider in the future to enhance the method are: creating and putting more rigorous cleaning and decontamination protocols for the workspace and equipment can help improve the validity of results. Investigating the source of the dust contamination and putting in place measures to help eliminate or if not eliminate, reduce the levels of dust. Lastly researching alternative filtration techniques/process or equipment to possibly find better methods of filtration or equipment to help improve the consistency and reliability of the results.

By addressing these areas for improvement, the alum crystal growth experiment method and equipment used can be further polished to help produce high-quality, large alum crystals that meet the required size and clarity, while ensuring a clean and controlled environment for the growth of the crystal.

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