Development of a Cost-effective Chemical Method to Regenerate Spent Super Absorbent Polymer (SAP)
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Abstract:
In this experiment, we investigated the regeneration of spent SAP from a diaper. Two methods were employed in this experiment, namely (i) the acid-alkali method and (ii) the electrolysis method.
In the first method, different molarities of NaOH as well as different volumes of HCL and NaOH were used in the investigation. HCL reduces the absorptive capacity of the SAP as it lowers the pH value of the SAP. The water absorption capacity of the super absorbent polymer reaches maximum in the neutral pH range of 6 to 7. As a result, the neutralization of the acid and alkali helps to restore the SAP's ability to absorb water. It was determined that the molarities and volumes of acid and alkali affect the results of the experiment.
In the second method, different voltages were applied across the graphite plates in each procedure to determine the volume of water released. By investigating different methods and making different hypothesis during the experiments, all the results are shown in this paper.

Introduction:
Super absorbent polymers (SAPs) are compounds that can absorb water and swell into many times of their original size and weight. SAPs are widely used in personal hygiene products especially baby diapers, and approximately 75% of the superabsorbent polymers in the world used are sold in diaper products. In one infant's lifetime, approximately 8,000-10,000 disposable diapers will be used where each diaper takes approximately 500 years to degrade in a landfill. These diapers need to be exposed to air and sun to allow the paper to decompose. Furthermore, thirty percent of a disposable diaper is plastic and not compostable. Even recycling plants can only handle 400 of the 10,000 tons of diapers, which are not completely recyclable. In this experiment, we investigated the regeneration of spent SAP from a diaper in an effort to reduce pollution caused by such waste removal. Two methods were employed in this experiment, namely (i) the acid-alkali method and (ii) the electrolysis method

Hypothesis
Experiment on acid and alkali: The lower the concentration of Sodium Hydroxide (NaOH) added, the higher the regeneration rate of the diaper.

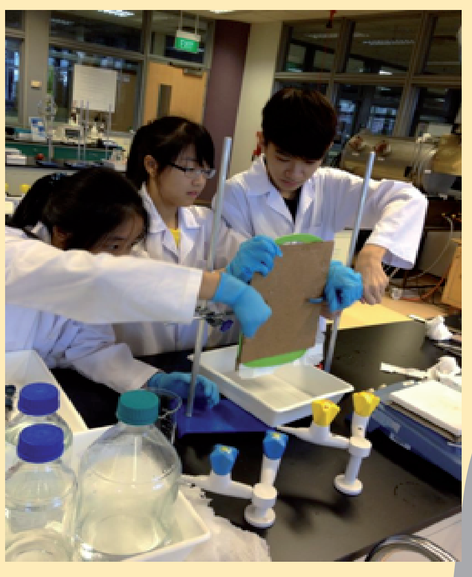
Procedure
1. Weigh dry diaper and record down
2. Add 400ml of deionised water to diaper
3. Weigh diaper and record down
4. Add 1 M Hydrochloric acid (HCL) to diaper evenly and wait for 5 minutes
5. Remove water released from diaper
6. Weigh diaper after water is released
7. Calculate volume of water released
8.Neutralise diaper with Sodium Hydroxide (NaOH)
9.Squeeze water out of diaper
10.Weigh diaper after water is released
11.Calculate volume of water released
12.Add deionised water into diaper again, until water starts leaking out
13.Calculate percentage of water regenerated

Materials:
Sodium hydroxide, hydrochloric acid(1M), de-ionised water,measuring cylinder, gloves, spectacles,flask,electric,balance, dropper, clamp, retort stand, cardboard

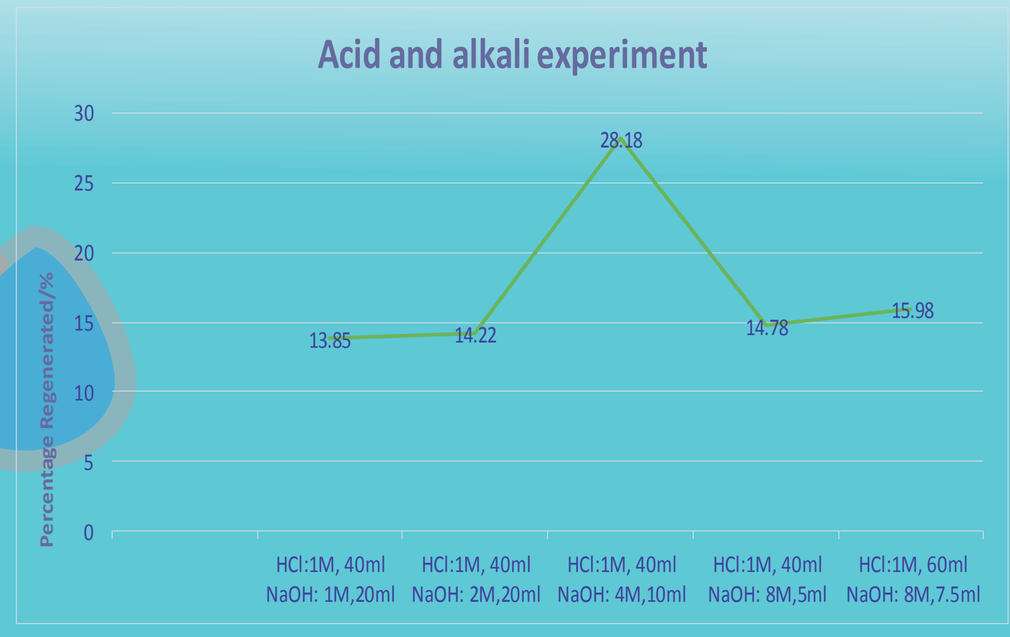
Discussion:
The results show that the regeneration of SAP is not successful. In general, the acid and alkali experiment is based on the water absorption capacity of the SAP. If the pH is lower, the SAP will be less capable to absorb water or solution due to the presence of more ions. Thus, water will be released out, Besides, with higher volume of NaOH (amount of solute remains the same) the solution can be more evenly spread, the neutralisation is more completed. In conclusion,if the pH of the acid is low enough to release all the water out and the nuetralisation is ideally completed, the regeneration is possibly successful.

Hypothesis:
The higher the voltage, the more the amount of water released. This allows more water to be absorbed back into the super absorbent polymer, hence a higher regeneration percentage of the super absorbent polymer

Procedure:
1.Extract Super absorbent polymer(SAP) from diaper
2.Weigh the SAP
3.Add 300ml of deionised water into SAP and weigh again
4.Place SAP between the two graphite plates, making sure that SAP comes into direct contact with the graphite plates
5.Connect anode and cathode set respectively to positive and negative outlets of DC power supply
6.Apply a constant voltage across the two electrodes (use 10,15,20 volts to test)
7.Collect water released in a water tub situated below the test apparatus
8.Stop electrolysis after 1 hour
9.Weigh the SAP and find out the amount of water released
10.Add water back into the de-swelled SAP until it starts leaking
11.Weigh the SAP and calculate the regeneration rate



Experiment discussion:
Based on our results, the higher the voltage, the higher the regeneration rate. Because when you send an electric current through the polymer, it creates an electric field, causing the anions to go to the positive electrode and cations to go to the negative electrode. Hence, the gel near the positive electrode expands to react to the charge density difference. The gel will thus contract at the opposite pole, causing the gel strip to bend toward the positively charged side. With increasing applied voltage, the driving force for movement of ions increases, leading to more ions being attracted to the electrodes. This results in increasing concentration of ions in the released water and also increasing its conductivity.



ELECTROLYSIS EXPERIMENT

pH	Voltage/V	Percentage Regenerated (V2/V1) /%
5	10	43.9
5	15	44.6
5	20	44.7
5	20	45.6

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Conclusion for acid and alkali:
The results show that the regeneration of SAP is not successful. From the table, the highest regeneration rate is 28.18% when using 40ml 1M hydrochloric acid and 10ml 4M sodium hydroxide. The acid and alkali method is less effective in the regeneration of SAP. In the future, other chemicals may be used to improve the regeneration rate.

Conclusion for electrolysis:
The higher the voltage, the better the absorption, resulting in a higher regeneration rate. The experiment using a voltage of 20V achieved the best regeneration rate of 45.6%. The experiments using voltage of 5, 10 and 15 had a lower regeneration rate.