



Antibacterial properties of the halogens: teacher notes

Education in Chemistry

Sustainability in chemistry 2021

Goal 6: ensure availability and sustainable management of water and sanitation for all.

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Chlorine is commonly used in water treatment to kill bacteria and all the halogens are known to have antibacterial properties.

The aim of this experiment is to use a microbiology experiment to investigate the antibacterial properties of solutions of the halogens. The experiment is in two parts which should be planned for lessons around a week apart.

Preparation

Before the lesson prepare agar plates and lawn them with suitable bacteria, eg *S. aureus*.

Use a hole punch to produce discs of filter paper. Put these into 3 petri dishes labelled chlorine, bromine and iodine. Add 1–2 cm³ of each halogen water to the petri dishes. Solutions do not need to be freshly prepared for this experiment, stock solutions can be used. You should always use the most dilute solution possible to obtain the desired result. Refer to SSERC/CLEAPSS Hazcards and recipe sheets.

Apparatus

To be completed in pairs. Apparatus quoted is per pair.

- One prepared agar plate
- A pair of tweezers
- A marker pen that will write on plastic
- Graph paper
- Paper discs soaked in each halogen solution
- Access to a Bunsen burner and heat mat
- A small beaker of ethanol, kept away from the Bunsen burner

Hazards

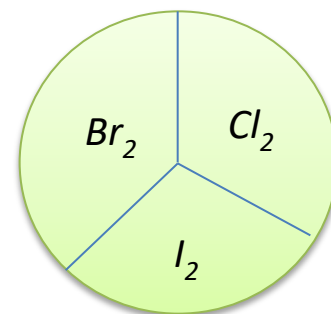
Teachers and technicians are advised to carry out their own risk assessments guided by school procedures and the protocols outlined by local advisory bodies such as CLEAPSS/SSERC.

This experiment should be carried out in a well-ventilated lab. Halogen solutions may release small amounts of gases, however at the volumes and concentrations in this experiment this is unlikely to be significant. Eye protection should be worn.

Ethanol is flammable. The experiment should be set up with Bunsen burners at one end of the benches. Ethanol should be placed away from the Bunsen burners.

Method

1. Collect your agar plate.
2. On a piece of graph paper draw around the bottom of your plate and cut out the circle of paper.
 - a. Divide the circle of paper into 3 portions with a pen.
 - b. Label each portion Cl_2 , Br_2 and I_2 as shown in the diagram.
 - c. Secure it to the bottom of your agar plate with sticky tape and/or a couple of dots of glue.
3. Sterilise your tweezers by dipping them in ethanol and then put them into the Bunsen burner flame (they will be hot after this!)
4. With clean, sterile tweezers, collect a disc of filter paper soaked in $\text{Cl}_2(\text{aq})$ and place it in the middle of one portion of the agar plate.
5. Rinse your tweezers with water and then dip them in ethanol and put them back in the flame.
6. Repeat step 4 with paper discs soaked in Br_2 and I_2 . Remember to sterilise your tweezers between discs.
7. Put the lid on your plate. Seal your plate by putting pieces of tape at 3, 6, 9 and 12 o'clock. Make sure your names are on it. Give the plate to your teacher for incubation.



Analysis of results

Your teacher will return your agar plate. Bacteria should have grown on the plate except in places where the substances on the discs have acted as antibacterials. Look for areas on your plate around the paper discs that show no bacterial growth, where you can still see through the agar to the graph paper below. This is called a zone of inhibition.

Look at each of the paper circles. Count the number of small squares in the zone of inhibition around each one. Make a table of your results.

Conclusion and questions

1. The aim of this experiment was to find out which aqueous halogen, chlorine, bromine or iodine is best at acting as an antibacterial. Write a conclusion for your experiment, remembering to refer to your results.

This will depend on what is observed but a sample conclusion is given below. Take care to ensure students refer to the results when writing their conclusion.

According to this experiment, bromine is the best halogen at acting as an antibacterial. The largest zone of inhibition (size = ...) of S. aureus was seen for the bromine water sample.

2. State some limitations of your conclusion.
 - Only one type of bacteria is used in this experiment.
 - Halogen water samples have different concentrations.
 - Inhibition of bacterial growth is only studied over a week; ideally different timeframes would be studied.
3. Consider a water storage tank for a small village. Draw a table and evaluate the advantages and disadvantages of each halogen for purifying the water in the tank using the results from this experiment and your knowledge of the halogens.

Halogen	Advantage	Disadvantage
Chlorine	Colourless at low concentrations	Can bleach materials like plastics and fabrics
Bromine	Best at inhibiting the growth of <i>S. aureus</i> .	Has an orange colour that might be off-putting for consumers
Iodine		Has an orange colour that might be off-putting for consumers

4. Bromine tablets are commonly recommended to people who are travelling in countries where the water is known to contain harmful bacteria. Why do you think bromine is not more commonly used in water treatment?

Bromine in water is orange in colour. Consumers might think that the water is dirty.

5. Iodine solution is used to kill bacteria on the skin prior to operations. What property of iodine solution makes it particularly suitable for this use?

Iodine in water is highly coloured and it stains skin. This means that surgeons can see easily that the skin has been disinfected before they cut the skin.

Extension questions (16–18)

6. Write an equation to show the equilibrium established when chlorine is dissolved in water.



7. Describe the redox behaviour of chlorine in this equilibrium.

As an element, chlorine, Cl_2 has an oxidation number of 0. Following the reaction it has an oxidation state of +1 in HClO , showing the chlorine has been oxidised. In HCl it has an oxidation state of -1, the chlorine has been reduced. This simultaneous oxidation and reduction is a special kind of redox behaviour called disproportionation.