Colourful electrolysis

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An interesting introduction to the **electrolysis** of **brine** (**sodium chloride solution**). Students use Universal Indicator to help them follow what is happening during the reaction.

Lesson organisation

This experiment works well if students are directed to make detailed observations and then attempt to explain for themselves what they think is happening.

The main issue is likely to be the availability of sufficient U-shaped test tubes.

Apparatus and chemicals

Eye protection

Each working group will require:

U-shaped test tube
Clamp and clamp stand
Carbon electrodes and electrode holders, 2 of each
Electrical leads, 2
Power pack
Beaker (100 cm^3)
Spatula
Stirring rod

Students will need access to:

Sodium chloride (salt)
Universal indicator (**Highly flammable**)
Distilled water

Technical notes

Hydrogen (**Highly flammable**) Refer to CLEAPSS® Hazcard 48
Chlorine (**Toxic, Dangerous for the environment**) Refer to CLEAPSS® Hazcard 22A and 47B.
Sodium hydroxide (**Corrosive**) Refer to CLEAPSS® Hazcard 91
Universal indicator solution (**Highly flammable**) Refer to CLEAPSS® Hazcard 32 and Recipe card 36

If electrode holders are not available, another suitable means of securing the electrodes could be used. Do not use bungs because the products are gases.

If distilled water is a problem, then tap water could be used. But it may affect the colours produced, especially in areas with hard water.

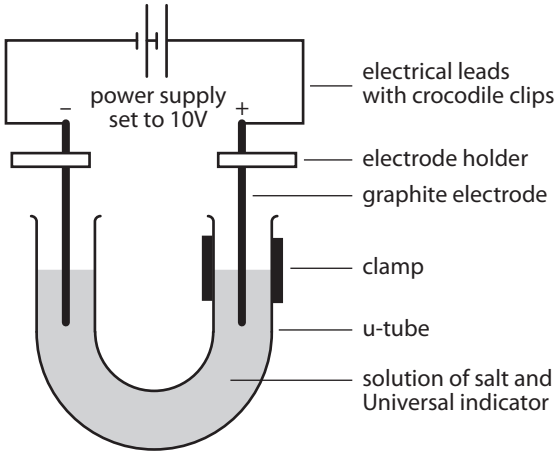
Procedure

HEALTH & SAFETY: The products produced by this reaction are all more hazardous than the reactants. Hydrogen is **Extremely flammable**, chlorine is **Toxic** and **Dangerous for the environment**, and sodium hydroxide is **Corrosive**. Ensure that the current is turned off a soon as a trace of chlorine is detected.
Chlorine (**Toxic, Dangerous for the environment**) can be a problem for asthmatic pupils. If the directions in the procedure notes are followed then very little chlorine is produced. Sodium hydroxide is **Corrosive**. Ensure that students wear eye protection, especially when they are clearing up the experiment.

a Put about 75 cm^3 distilled water into the beaker. Add about 2 heaped spatulas of sodium chloride.

b Stir until the salt dissolves. Then add several drops of Universal Indicator solution. Stir to mix thoroughly. You need enough indicator to give the water a reasonable depth of green colour.

c Pour coloured salt solution into the U-shaped test tube and clamp it as shown in the diagram.



d Wash the carbon electrodes carefully in distilled water and then fix them so that there is about 3 cm of electrode in each side of the U-tube – see diagram. This is most easily done using electrode holders.

e Attach leads and connect to a power pack set to 10 V.

f Turn on the power pack and observe closely what happens. A piece of white paper held behind the U-tube can help. Make sure the U-tube is kept very still during the experiment.

g **Turn off the power as soon as you notice any change** at the positive electrode, or when you smell a 'bleachy, swimming pool' smell. This will probably take less than 5 minutes.

Teaching notes

This experiment is an interesting introduction to the electrolysis of brine. It is probably best not used as the first electrolysis that students encounter. They would really struggle to explain for themselves what is going on. It could be followed by the electrolysis of salt solution in industry.

Students should be able to notice bubbles of gas at each electrode. At the positive electrode, the indicator turns red initially, and is then bleached to colourless. This indicates the presence of chlorine. At the negative electrode the indicator turns purple. The remainder of the solution stays green.

The product at the negative electrode is hydrogen. This can be difficult for students to understand.

Some of the water will ionise, that is, turn to hydrogen (H^+) and hydroxide (OH^-) ions.

When the sodium chloride is dissolved in water, the ions forming the ionic solid separate out. This means that there are actually 4 ions present in the solution: H^+, OH^-, Na^+ and Cl^-.

The negative ions are attracted to the positive electrode. The chloride ions are discharged (giving chlorine) in preference to the hydroxide ions. These are left behind in solution.

At the negative electrode, the hydrogen ions are discharged (producing hydrogen gas) in preference to the sodium ions. These are also left behind in solution. Thus sodium hydroxide solution remains. This is the cause of the purple colour of the indicator at the negative electrode.

In time, the green colour of the indicator in the middle would change too, as the ions diffuse through the resulting solution.

Equations:

$2H^+ + 2e^- \rightarrow H_2$ [negative electrode, cathode]

$2Cl^- \rightarrow Cl_2 + 2e^-$ [positive electrode, anode]

$H_2O \rightarrow H^+ + OH^-$

Reference

This experiment has been reproduced from Practical Chemistry:
http://www.practicalchemistry.org/experiments/intermediate/oxidation-and-reduction/colourful-electrolysis,54,EX.html