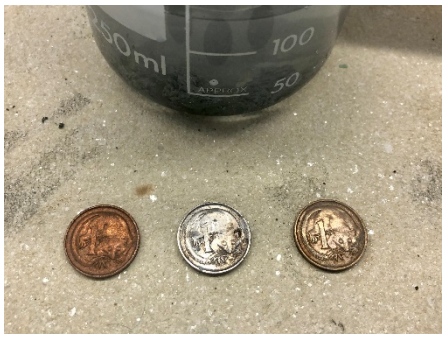
Turning copper coins “silver” and “gold”

Description



Students coat a copper coin by galvanisation with zinc, changing the coin’s colour to silver. The coated coin can then be heated with a blowtorch, and the zinc and copper react to form brass, which has a gold colour.

Curriculum topics

- Redox reactions
- Alloys
- Bonding (metals)
- Chemical reactions

Materials

These quantities are enough to make four coins (or more, see teaching notes)

- Four copper coins
- 250 mL beaker
- 100 mL of 6M NaOH solution
- 12.5g zinc powder
- Metal tongs
- Glass stirring rod
- Bunsen burner, blow torch or portable burner
- Hot plate
- Mass balance (for Zn powder)
- Heat mat

Safety

Eye protection, gloves and a lab coat MUST be warn at all times for this experiment.

Sodium hydroxide
Danger – EXTREMELY corrosive. Causes severe burns and eye damage. Solution is extremely corrosive and can cause blindness.

Zinc powder

Danger – highly flammable. Powder ignites on heat. Very toxic to aquatic life with long lasting effects. CAUTION: spilled powder that is wiped with a dry paper towel can spontaneously ignite. After weighing, use a wet paper towel to wipe the area.

Hydrogen gas

Danger – highly flammable. Hydrogen is produced when zinc is added to hot sodium hydroxide.

Waste – the solution should be left to cool after you have finished the experiment. Then, the sodium hydroxide solution can be carefully rinsed down the drain with a lot of water. The solid zinc at the bottom of the beaker must be disposed of as hazardous waste.

Procedure

Before the experiment

1. Pre-prepare the 6M NaOH solution (240g NaOH per L of distilled water). Caution: this will get warm as the sodium hydroxide pellets dissolve.
2. Carefully pour 100ml of 6M NaOH into a beaker.
3. Immediately before the experiment, heat this solution to near boiling (70-80oC). The coins will not coat well if the solutions is prepared at room temperature.

The experiment

'Silver' coin

1. Take the beaker off the hot plate and rest on a heat mat. Carefully add 12.5 g of zinc powder to the hot base solution. The solution will fizz as some of the zinc dissolves, forming sodium zincate and giving off hydrogen gas (this step should be done AWAY from any exposed flames used for the ‘gold’ coin step below).
2. Carefully drop the coins into the hot solution containing sodium zincate and the remaining zinc powder. The coins must make contact with the powdered zinc at the bottom of the solution. If necessary use a glass rod to move the coins around.
3. Leave the coins until they are plated with a shiny coat of zinc. This will take about 2-3 minutes. Leaving the coins too long may cause lumps of zinc to stick to them.
4. Wearing gloves, carefully remove the plated coins with tongs or forceps. It may be difficult to see the coins in the grey sludge.
5. Rinse the coins under running tap water to remove traces of sodium hydroxide solution and sodium zincate. If running water is not available, dunk the coins in a large beaker of water. The coins will now look 'silver'. Pat dry the coins with paper towel.

‘Gold’ coin

6. Using tongs or forceps, hold a plated coin in the upper part of a hot flame for a few seconds until the surface turns gold. Turn the coin so that both sides are heating equally. As soon as the colour appears to be changing, remove from the flame – overheating will cause it to tarnish.
7. Allow the coin to cool on a heat mat before touching. If you did not heat too long, the coin will now look ‘gold’.

Teaching notes

The copper coins we used in this experiment were Australian 1 cent coins (~97% copper). These have long since been out of circulation, but are available online. Versions of this experiment we have seen have suggested to clean the coin first with steel wool to remove any corroded layer. But in our experience, this didn’t make much difference.

The amounts of reactant specified above will coat 4 coins with a shiny silvery layer. If you wish to avoid excess waste, the sodium zincate solution can be kept hot and be reused once or twice more to coat more coins, with slowly diminishing results.

The reaction between zinc and sodium hydroxide to form sodium zincate is as follows:
$Zn_{(s)} + 2NaOH_{(aq)} + 2H_2O_{(l)} \rightarrow Na_2[Zn(OH)_4]_{(aq)} + H_{2(g)}$

The plating reaction involves the reduction of zinc in zincate, which plates onto the copper coins. This is the reaction involved in galvanising iron. The plating reaction involves an electrochemical cell; it will not take place unless the copper and the zinc are in contact. The electrode reactions are:

At the zinc electrode (anode): $Zn_{(s)} \rightarrow Zn^{2+}_{(aq)} + 2e^-$
followed by complexing of the zinc ions with hydroxide as $[Zn(OH)_4]^{2-}_{(aq)}$
At the copper electrode (cathode): $[Zn(OH)_4]^{2-}_{(aq)} + 2e^- \rightarrow Zn_{(s)} + 4OH^-_{(aq)}$

The coating of zinc gives the impression that the coin is now coated with silver.

On heating the coin in the Bunsen flame, the energy is enough to mix the zinc present in the thin layer with the surface layer of the copper. This forms an alloy of zinc and copper (brass) at the outer section of the coin, giving the gold appearance to the coin. Brass is an alloy of copper containing between 18% and 40% of zinc. A similar zinc plating process is used industrially, but with cyanide ions rather than hydroxide ions as the complexing agent.

For chemistry classes not studying redox or electrochemistry, this activcity is also a good example of forming an alloy. However, when deciding to conduct this activity, the positives of having an exciting, colourful reaction should be weighed against the dangerous hazards present in this chemical practical, compared to most high school level practicals. It is not appropriate for younger year levels.

References

This activity was adapted from an activity from the Royal Society of Chemistry, available at https://edu.rsc.org/resources/turning-copper-coins-into-silver-and-gold/839.article (sign in required).