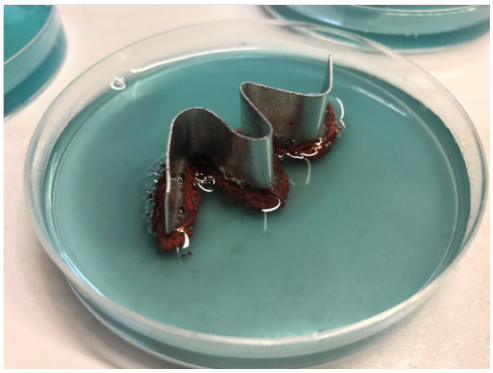
Copper crystals grown on aluminium sheet

Description



Students take a piece of aluminium sheet bent into a wave-like strip (or any shape they wish) and lower it into a petri dish containing an agar gel with Cu^{2+} ions. Over the next 5-60 minutes, intricate branched copper crystals will grow on the aluminium surface. Students can observe the crystal growth in real time with a hand-held digital microscope.

Curriculum topics

- Chemical change
- Reactivity series
- Redox reactions
- Displacement reaction
- Energy

Materials

To make <u>four</u> copper-agar plates (it is easier to make an agar solution for 4 groups at once)

- Four 2 cm x 15 cm pieces of thick aluminium sheets (0.5mm thickness)
- Four 10 cm petri dishes
- 125 mL beaker
- Glass rod
- Hot plate
- Heat mat
- Optional – Digital microscope (or smart phone)
- Blue Agar solution, pre-prepared, 100ml solution
    - 2 grams dry agar
    - 11.2 grams $CuSO_4.5H_2O$ **
    - 0.9 grams $CuCl_2$ **
    - 100ml water

** Alternatively, 12.5 grams of $CuSO_4.5H_2O$ and 0.6 grams of NaCl can be used. See teacher notes below.

Safety

Copper (II) chloride, anhydrous 

Danger - Harmful if swallowed, in contact with skin, can cause skin irritation. Very toxic to aquatic life with long lasting effects, so all agar solutions should be disposed of and not washed down sink.

Copper (II) sulfate, pentahydrate 

Warning - Harmful if swallowed, can cause skin irritation. Very toxic to aquatic life with long lasting effects, so all agar solutions should be disposed of and not washed down sink.

Waste – Do <u>not</u> wash agar solutions down sink. All metal-containing solutions should be disposed of as hazardous waste.

Procedure

Before the experiment

Pre-prepare the blue copper-agar solution.

1. Add 2 g of dry agar to 100ml distilled water in a beaker and heat to about 90°C until dissolved.
2. Add 11.2 g $CuSO_4.5H_2O$ and 0.6 g $CuCl_2$ to the solution after it has cooled slightly. Note: do not add the copper salts while heating because the agar will not gel.
3. Stir a glass rod until all the salts dissolve.
4. Once dissolved, take off the heat.
5. The solution will set as it cools.

The experiment

1. Re-heat the blue copper-agar solution on the hot plate. If available, this could be done in a microwave.
2. Take the 1 – 2 cm x 15 – 20 cm pieces of 0.1 – 0.5 mm thick aluminium sheet and bend them into 'wave-like' shapes (or interesting 'curvy' shape) .
3. When the solution can be easily stirred with a glass rod, take it off the heat and pour into four different petri dishes (to a depth of approximately 0.5 cm).
4. Lower the aluminium wave shape into the agar solution with the long side down. The agar may set fairly quickly, so you might need to push the aluminium into the solution.
5. Over the next 5 - 60 minutes watch the copper crystals grow on the surface of the aluminum sheet. Optional: Use a handheld digital camera or a smart phone to get a close-up look at the reaction as the crystals form.

Teaching notes

Copper is less reactive than aluminium, so the aluminium reacts and turns the blue copper ions in solution into brown copper metal. This type of reaction is called a displacement reaction (in this case a copper−aluminum displacement reaction). It is not a quick reaction, but over time (15-20 minutes) copper branches will start to grow off the sides of the aluminium sheet. The aluminium goes into solution at the same time, but this is colourless so cannot be seen. The surface of the aluminium sheet becomes pitted, but because of the copper crystals this can also not be seen.

The chemical equation for the reaction is $2Al_{(s)} + 3Cu^{2+}_{(aq)} \rightarrow 2Al^{3+}_{(aq)} + 3Cu_{(s)}$

It is best to pre-prepare the blue agar solutions. It can take a while to heat and dissolve the dry agar. In terms of safety, it is also better for students to not handle the copper salt powders. It is easier to prepare batches of the blue agar, which can then be poured into several petri dishes for different groups of students. If it sets too early, it can be reheated to melting point to pour into a petri dish and the experiment will still work. The agar solution may set very quickly, so students will need to push the aluminum if it has already set. The copper crystals will still grow, but not as large.

The original experimental source suggested an alternative blue agar solution mix, if you wanted to avoid using copper (II) chloride. 12.5 grams of $CuSO_4.5H_2O$ and 0.6 grams of NaCl can be used as an alternative, but in our experience, it did not work very well. The authors suggested the blue agar solution should be 2% w/v agar, 0.5M Cu^{2+} and 0.1M Cl^- solution for the best reaction rate.

The students can be encouraged to draw the crystal shapes that form. The copper crystal structure is easier to see with a handheld digital microscope or even a smart phone camera. Crystals will continue to grow for several hours.

References

This activity was modified from the following citation.

Xu, X., Wu, M., Wang, X., Yang, Y., Shi, X. & Wang, G. (2016). Experimenting with a Visible Copper−Aluminum Displacement Reaction in Agar Gel and Observing Copper Crystal Growth Patterns to Engage Student Interest and Inquiry, *Journal of Chemical Education*, 93, 1612-1615.